STANDARDIZING THE COMMISSIONING PHASE OF RTG CRANES TO IMPROVE PRODUCT SAFETY AND QUALITY

16WA RTG Commissioning procedure

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ABSTRACT

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ABSTRACT

Konecranes is one of the leading organizations in the lifting business whose origin dates back to the 1900s. Today the organization has grown and is able to serve different industries with high quality technical products and services to reach and exceed customer demands. To be able to sustain product efficiency and effectiveness, Konecranes has to ensure that products continue to show a steady improvement in quality and safety.

In alignment with the company's strategy, this thesis is intended to improve the quality and safety of RTG (Rubber Tired Gantry) cranes, by standardizing and improving the commissioning phase process during the crane assembly. The commissioning phase is a systematic one which occurs after a crane has been fully erected. During this process, the standard of the product can be confirmed before delivery. Therefore, effective standardization of this process will result in the quality and safety features of the product to be enhanced. In addition, technical knowledge was a key factor required to having this thesis completed. This technical knowledge helped to a large extent to understand the product's operations, also how and when to use which terms during the development of the commissioning phase process.

As this thesis was focused on developing and improving a phase, it was very important to participate and be involved in the current state of the commissioning phase in order to help to develop an understanding of what should be done for improvement. Materials used during this project included technical documents, and software programs which were related to the product. At the end, the result of this thesis is a refined commissioning phase process. Tasks were clearly defined and the procedures well documented including tasks to be done during the commissioning phase and how they should be performed.

The author of this thesis project was able to conclusively explain how and what should be done during the commissioning process. In this project, it was also stated that some developments can be done in the future, one of which includes improving the testing procedure relating to product accessories. Another future development project is recording details about any improvement made on the product in order to keep this document constantly up to date.

Keywords commissioning, start up and testing.

Pages **81** p. + appendices 3 p.

ACRONYMS

A – Amperes

CEN – European Committee for Standardization

CMS – Crane Management System

EBIT – Earnings Before Interests and Taxes

IEC – International Electrotechnical Organization

IP – Internet Protocol

ISO – International Organization for Organization

LED – Light Emitting Diode

LT – Long Ton

PA – Public Address system

PLC – Programmable Logic Controller

QA – Quality Assurance

RTG – Rubber Tired Gantry

SFS - Finnish Standards Association / Suomen Standardisoimisliitto

SOP – Standard Operating Procedure

SW – Software

SWL – Safe Working Load

TCP/IP – Transmission Control Protocol

V - Volts

VDC – Direct Voltage

CONTENTS

1 INTRODUCTION TO THE COMPANY

Konecranes is an engineering company that focuses on manufacturing lifting equipment. The company's history dates back to 1910 when KONE Corporation was founded as an electrical motor repair shop. Konecranes corporation later developed from the repair of motors to build the sizeable overhead travelling cranes in 1933, the manufacture of electric wire rope hoist was introduced in the 1936 and the introduction of harbor cranes into the product range which experienced tremendous growth in the 1950s. The Konecranes division was introduced into the corporation and the corporation spent the coming years growing, expanding internationally and acquiring companies in different countries. In 1994, Konecranes was formed as a result of a structural change within the KONE Corporation, when the corporation sold all operations of the crane divisions. However, KONE Corporation is not considered as Konecranes' mother company. After Konecranes establishment, it also became listed on the Helsinki Stock Exchange in 1996. Konecranes also started to grow by making company acquisitions and the first acquisition was made in Germany. The acquisition of more companies further projected the newly founded organization to provide an additional range of products and opportunities for growth in maintenance services to their customers. As years passed on until today, Konecranes has continued to grow into a reputable organization and into new emerging markets such as in the Asian and African regions expanding more and reaching more customers, providing lifting solutions and services. (Konecranes history 2013.)

1.1 Konecranes business areas

A business area simply describes how an organization has been divided into functional areas or units. The Konecranes organization focuses on two business areas, service and equipment. Each business area contributes a certain percentage to the entire business in Sales and EBIT (Earnings Before Interests and Taxes) as seen below; a description of business area division for the organization in year, 2012. (Konecranes Business Area 2013.)

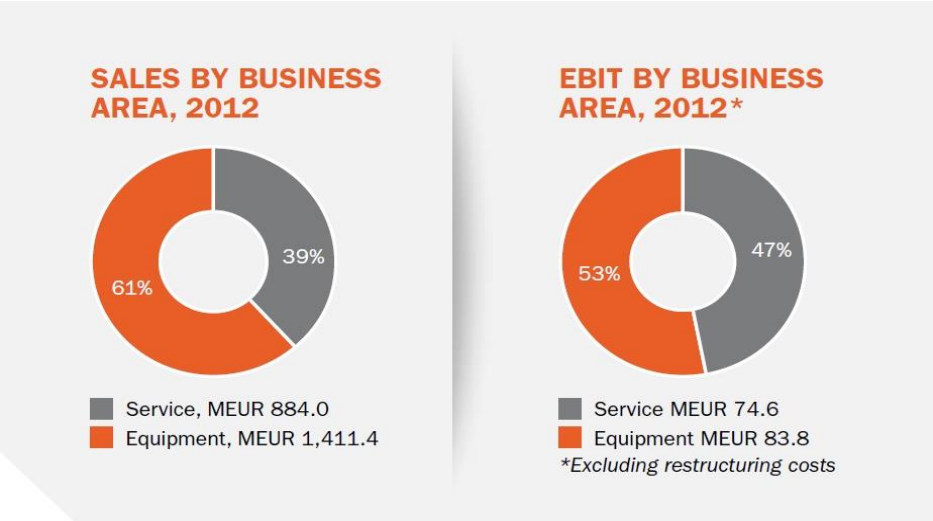

Figure 1 Sales and EBIT percentages for each business area (Konecranes Business area 2013).

1.1.1 Equipment

Equipment, one of the company's business areas offers crane equipment, components and material handling solutions to different companies in various industries. The equipment manufactured by Konecranes belongs to several categories: Overhead cranes, Hoists, Lift trucks, Nuclear cranes and equipment, Port cranes, Container handling equipment, Shipyard cranes, Bulk handling equipment and Workstation lifting products. (Konecranes Equipment 2013.)

1.1.2 Service

Through this business area, Konecranes offers services and maintenance of products to customers. The services are offered for all crane brands, port equipment and machine tools. The services offered by Konecranes helps to improve the relationship between the company and customers, therefore enabling Konecranes obtain a good market position and competitive advantage. (Konecranes Service 2013.)

1.2 Company strategy

Konecranes' strategy aims at providing customers with the best products and services. This is achieved by differentiation through services and technology innovation, lifting people by improving the capability of their employees and continuous investment in employee training, global footprint, dual-channel strategy, global demand-driven supply chain, and real-time information. (Konecranes Strategy, 2013.)

The company's strategy is divided into three main focus areas: mission, values and vision. Each main focus area includes statements which summarize what the strategy is, and how the company aims to implement the strategy. (Konecranes Strategy 2013.)

2 KONECRANES INDUSTRIES AND EQUIPMENT

As one of the leading companies in the sector, Konecranes serves several industries with a number of different products which is able to suit every of the customer's needs in their particular industry. These industries include: Automotive, Energy from Waste, Intermodal and Rail, Manufacturing, Mining, Nuclear, Petrochemical, Ports, Power, Pulp and Paper, Shipyards and Steel industries. (Konecranes Industries 2013.)

Though, the types of lifting machinery or equipment needed in the listed industries are different. Konecranes is also able to provide the industries with the right equipment in order to contribute to lifting their business by supplying the industries with what they need, when they need it and where they need it.

Konecranes provides their customers equipments of high quality standards which are suitable for the industry's processes. Their equipments have high safety standards, referencing organizations such as; International Organization for Standardization and European Standards. (Konecranes Equipment 2013.)

In addition, all the equipments are manufactured with the latest technology, thereby, keeping their customers and maintenance team abreast of the latest technology in vogue. The use of improved technology on the equipments will also help industries reduce their usage and consumption of energy. The improved technology also makes maintenance and troubleshooting an easier task for the maintenance personnel and for operators, the ease of operating the equipments.

2.1 Container handling equipment

Container handling equipment as mentioned in chapter 1.1.1 is one of the equipment categories manufactured by Konecranes. This category includes equipments or cranes that are designed for handling containers. The cranes manufactured in this category are: automatic stacking cranes, rail mounted gantry cranes, rubber tired gantry cranes, ship-to-shore gantry cranes, straddle carriers, yard IT for container handling (Konecranes Container handling cranes 2013.)

Of the crane equipments mentioned above, the Rubber Tired Gantry crane (RTG) shows an example of how Konecranes has proven to be smart in their design. The RTG is equipped with innovative features which improves the equipment performance and reliability, therefore reducing the cost of maintaining the equipments. (Konecranes Rubber Tired Gantry cranes 2013.)

The Konecranes RTGs are self-selling in the market, making the cranes known to customers and competitors as a leader. It has also being yielding results by breaking into markets in countries around the world, such as countries in continents like Africa, America, Asia and Europe.

2.1.1 Rubber Tired Gantry Crane and its use

The Rubber Tired Gantry crane is one of the equipments used to handle containers. The cranes are also primarily used to transport containers from one location to another location within a predefined stacking area, inside a container terminal. These cranes are the called gantry cranes because the load carrier or hoisting unit is able to travel together with the whole crane structure. Usually this hoisting unit is always attached to another unit called a trolley which carries and moves the hoist unit forward and backwards. See figure below, a detailed structure of a rubber tired gantry crane.

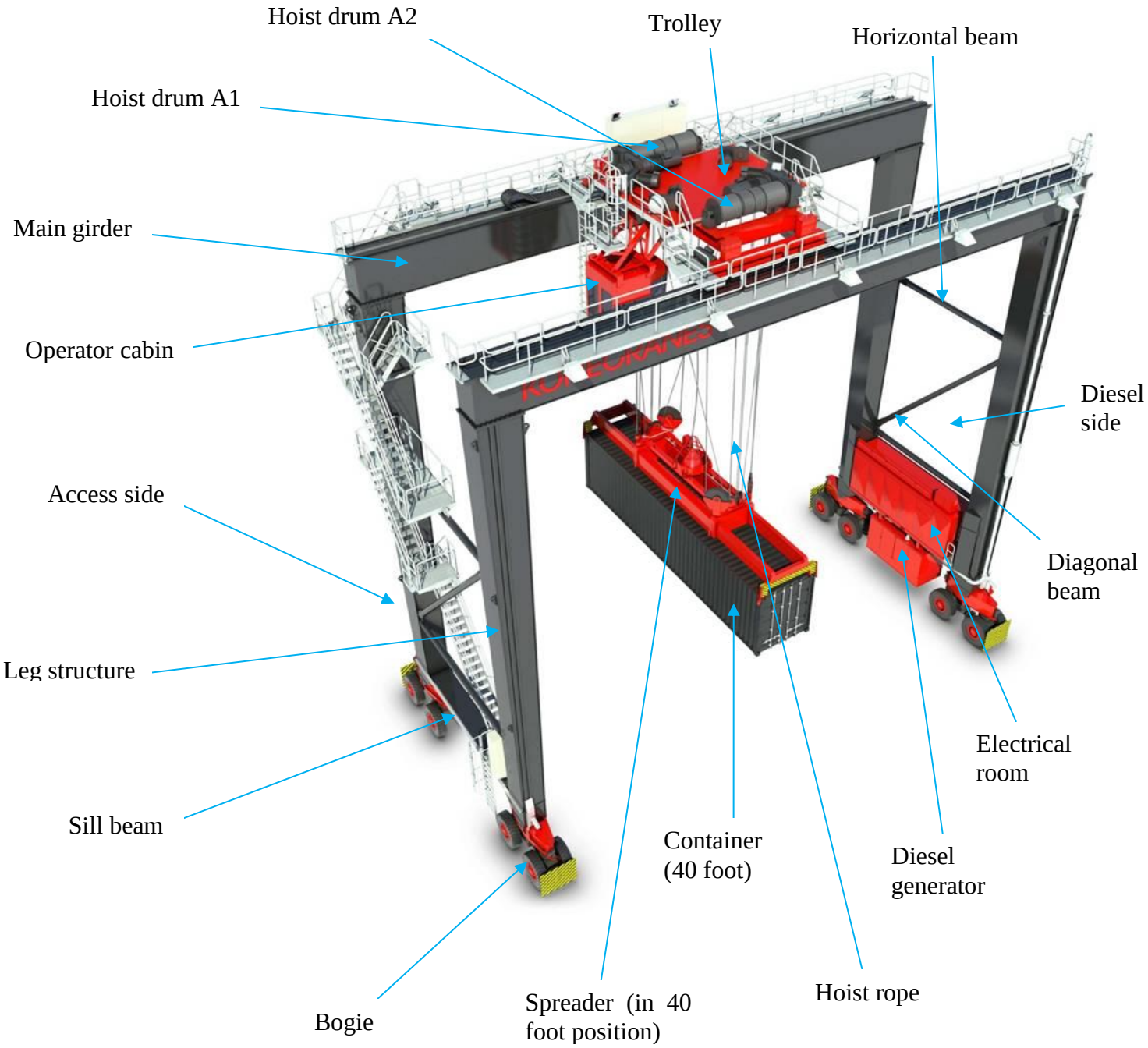

Figure 2 Rubber tired gantry crane with parts labeled

As illustrated in figure 2 above, the RTG does not use hydraulics or pneumatics technology. It operates mainly with electric motors. The use of electric motors allows for easy maintenance, easy troubleshooting and lower product cost of the RTG cranes. Konecranes' RTG energy consumption is also lower and can easily be controlled when compared to other competitors' RTGs. It can also easily be kept clean because of the absence of hydraulics technology. All these features make the Konecranes' RTGs one of the best options for customers.

Typically, a RTG is a good equipment to be used in terminals where the number and movement of containers are high. Usually in such cases optimization of space in the terminal is a very important issue. Using an RTG to optimize space will really help to properly arrange or stack the containers in the predefined stacking areas within the terminal. The containers can be stacked in rows, as high as five containers, see the figure below. There is also a possibility of moving one more container over the containers stacked five high. Note that Konecranes manufactures two models of RTG: 8 Wheeler and 16 Wheeler RTGs. For each model there are two types; the 8W and 8WA for the 8 Wheeler and 16W and 16WA for the 16 Wheeler. The major differences between the two models are the anti-sway system design and the number of gantry wheels.

Figure 3 Rubber tired gantry crane in container stacking operation (Konecranes Rubber tired gantry cranes 2013).

3 THESIS AND RESEARCH METHODS

The application of any research method requires that the author has specific theoretical and practical knowledge related to the thesis subject. Therefore, good theoretical and practical knowledge of both process and quality management were very critical during the research and actual work stages

of this thesis project. It is important to be able to merge the research skills with the theoretical knowledge to achieve the aims of the thesis.

This thesis aims to improve the commissioning phase as a whole by documenting the activities performed during the phase in detail. The research method chosen will help to get the best data collection method for the project and to know which data collected is needed during the project to avoid wasting time on irrelevant data. Hence, we are going to look through and gather information concerning the tasks to be completed, what devices and materials are needed and how the tasks in the process are to be performed. After collecting the information, we will be able to answer the following questions significant to this project:

- What the commissioning phase entail?
- What are the start up and testing stages?
- What activities are performed during the phase and stages mentioned above?
- What are the proper sequences of activities during the phase and stages?
- What are interlocks?
- What types of interlocks exist on RTGs?
- Functions of the interlocks?
- How do these interlocks enhance the safety features of the cranes?
- How will safety and quality be improved by this project?

The creation of the commissioning phase document will help improve the way the activities in the process are performed and show which activities precede the other one in the process. It will also help ensure that all necessary checks, especially those relating to safety and quality are conducted and that overall site operations can be standardized. Hence, the quality of the cranes sold to customers as well as the relationship with customers will be improved.

The manufacturing of an RTG involves the assembly of various electrical and mechanical parts. Some of the parts used in the assembly are procured from other suppliers while some other parts are designed and manufactured by Konecranes. All the parts arrive at the assembly site with the right specification, ensuring swift and efficient assembly. At a later stage, the commissioning phase of the RTG begins. It is also one of the most critical phases during the manufacturing of any RTG at Konecranes. The individual leading this phase should possess attributes such as good technical knowledge of the crane, an understanding of how the various functions of the crane should work, good organization and communication skills. This individual is normally the commissioning engineer.

3.1 Description of research method

This thesis project was based on a development project type. In simple terms, the author of this project was commissioned to make improvement on a process. In this case there was a set target and a clear goal for the project to be completed.

Development can be carried out on any product type, either on tangible or intangible products. It can also be about a process or an activity that will lead to the manufacturing of a product, as in the case of this thesis. Hence, a good in-depth understanding of the product or process to be developed is quite crucial.

When conducting a project such as this, research work needs to be conducted in order to have a clear knowledge of what is to be done, how it is to be done, and who are those responsible. There are two methodologies used when conducting research: qualitative and quantitative methodologies. These research methods are different in their applications and they also differ in the data collection methods. In other words, the type of research methodology to be used is influenced by the type of data to be collected, this idea will be explained further in the next chapter.

Since the author's task was not to develop a process from scratch, it was necessary for the author to be involved in how the process was conducted. From the understanding gathered during the involvement, the author could develop the process according to pre-set target.

3.2 Qualitative and quantitative methodologies

The qualitative method usually applies to research based on a real life scenario and the researcher using this method being required to observe, take notes and describe situations. Using a method such as this enables the researcher to gain knowledge about the task to be done. In most cases, this method is applied at the beginning of projects and a specific target group is chosen, but not randomly. When using this method the researcher can introduce techniques or tools which can be helpful to the research and help to improve the knowledge already acquired concerning specific areas in the research. Data collection can be done using any of these methods: interviews, reviews and case studies, observations, and biography studies. At the end of the research, the researcher should be able to come up with concrete theoretical conclusions and not generic ones. (Qualitative and quantitative research 2012.)

Quantitative research methodology differs from the qualitative, since with most qualitative researches materials are more readily available. Quantitative methodology simply implies that using this method requires counting or dealing with numbers and statistics. This method is used when the problem or the research being done has to deal with numerical facts. Therefore, the researcher uses any of the data collection methods: a survey by using questionnaires, interviews, experimental case studies, and observation studies to collect necessary data. It is important that the data collected are very accurate, acceptable, current and suitable because the data will serve as a basis for the conclusions for the research. (Qualitative vs. quantitative research 2012.)

If the data collected is not accurate, it is most likely that this will not be noticed during research since there may be no reference to compare the data collected but the overall outcome of the research will most likely be

flawed. After having used a quantitative research method, the researcher will be able to make logical conclusions based on the statistical analysis conducted using the data collected.

In some cases when conducting research for a project, both quantitative and qualitative methods are combined. In cases where such a project is new, the researcher will first have to develop a good knowledge of what is involved. Hence, the qualitative method will be used at an earlier stage of the research. When a firm knowledge has been developed, there may then be a need to conduct an analysis which may involve the collection of numerical data. This is mostly done during the core phase of the research. (Qualitative vs. quantitative research 2012.)

4 PROCESS MANAGEMENT

In order to understand what process management is all about, we must first have an interpretation of what a process is. A process can be defined as a set of related actions, properly structured and associated with each other by precedence with the aim of achieving a set target. In another way, we can also describe a process as a system which takes input and transform it into output. Processes are usually a part of an operation or we can say processes are embedded within an operation. If we look into any type of organization, we will find out that there are different types of operations, such as sales operations, purchasing operation, distribution operation, manufacturing operation, and marketing operation. Within each of the aforementioned operations are certain activities (or process steps) required for the operations to achieve the set desired result. For example within the purchasing operation, there exist the purchase order process, vendor selection process, and payment process.

We also described a process to be transforming inputs into outputs. So what are inputs and outputs? We can think about how simple equipment such as a printer and the complete printing process of a document using the. First, we insert a blank sheet of paper into the printer, send the file we need to print, the printer performs the necessary transformation, and then we get the printed document. In this case the inputs are the paper and information we sent to the printer and the output is the printed document from the printer. Usually inputs that are used into a process can either be material, information or customers. The outputs are usually what we get from the process after the inputs have been transformed during the process. These outputs are either products, services or a combination of products and services depending on the process or the operation. It is imperative to note that not all processes leads to the inputs to be physically transformed. In some processes the input's physical state will change to become outputs while in other processes the input's physical state does not change but it is still also transformed during the process into an output.

Inputs used in any process usually fall into two categories: transformed inputs and transforming inputs. Transformed inputs are those input that are transformed during the process as they go in and out of the process model and as explained above their physical state does not necessarily have to be

altered. Every process must always have a transformed input else there is no output. While transforming inputs are those inputs that help in the transformation of the transformed inputs during the process. Transforming inputs take part in the process by facilitating the inputs to be transformed into outputs. "There are two types of transforming resources that form the building blocks of all process. They are facilities – the buildings, equipment, plant and process technology of the operation – and people – who operate, maintain, plan and manage the operation." (Nigel, Stuart, Robert & Alan 2009, 11.)

Typically for processes to transform inputs into output, it would involve a certain set of activities. Since processes are different, obviously the activities involved in performing the different processes will differ from each other. For instance, the activities performed by the printing machine when printing a document is totally different from the set of activities that would be performed during the purchase process. Hence, every process has its own unique set of activities. As this thesis is focused on developing a commissioning procedure, in doing so we also have to go through the activities involved in the commissioning phase process. The commissioning phase involves two main stages or activities: crane start-up stage and testing stage. These two stages form the overall activities involved in the commissioning phase and each stage is further sub-divided into other stages which will be explained in details in later chapters.

So what are the inputs and outputs of the commissioning process? The transformed input into the commissioning process is the fully erected RTG. Transforming inputs are the tools and equipments used, materials and documents, facilities (erection site) and personnel (commissioning engineer). The output from the commissioning process is the fully commissioned RTG. Some of the inputs may be involved throughout the whole process such as the fully erected RTG, facilities and personnel. While some other inputs are only used at certain stages of the process or may even be used only once during the process such as some of the tools used and some of the documents used.

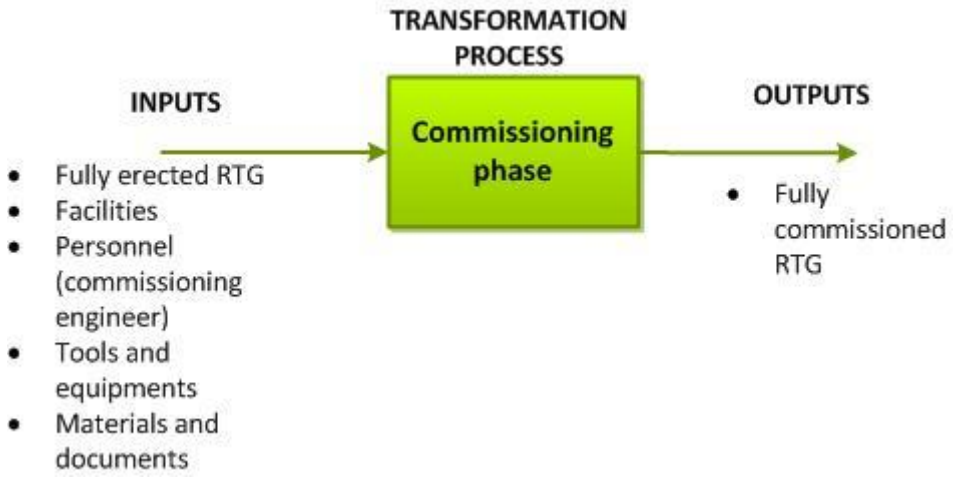

Figure 4 Inputs and Outputs of the commissioning phase process.

4.1 How processes are managed

We already understand that processes differ from each other as each process has its own unique activities. This is simply because every process normally has different outputs. As with the printing machine, the output is a printed document and the purchase process, the output is purchased good(s). Such difference explained above can be described as a technical difference between the processes. "However, processes also differ in terms of the nature of demand for their products or services" (Nigel, et al. 2009, 21). There are four features of demand that determine how a process will be managed: volume, variety, variation and visibility. (Nigel, et al. 2009, 21.)

Volume typically refers to the quantity of the output from the process, which is the quantity of products and/or services the process generates. Normally, a process with a high output volume will also involve highly repeated activities. As a result personnel involved in the process tend to learn the steps very well, unit cost of products can be lower, the process can be easily standardized, and cost of production can be reduced and so on. For example, the volume of output from the manufacturing of the RTG is somewhat low. If we will consider a fast food restaurant where the volume of output is quite high, this gives the restaurant a possibility of standardizing the process more easily and ensuring that their outputs (meals) tastes the same and not vary.

Variety is a description of the processes which produces products with high variety. In the restaurant for instance, where they are able to provide different types of meals with high quality. This will require that the personnel involved in the process have a high skill level and are also able to diversify into different variety of meal production processes. "A high level of variety may also imply a relatively wide range of inputs to the process and the additional complexity of matching customer requirements to appropriate products or services" (Nigel, et al 2009, 21). High variety processes typically means higher cost of production and higher unit cost of the products. Variety also means that products can be customized by the customers to what they want while also keeping the customization within the range of what the process can offer. The manufacturing of the RTG falls into the category of high customized products.

Variation refers to the level of fluctuation in the demand of the product from the process. Typically a process with a high variation in demand requires a lot of change in capacity from time to time. If the demands of products are unpredictable or very seasonal this creates more problem of allocating resources, thereby increasing the cost of production and unit cost of products. (Nigel, et al. 2009, 21.)

In relation to the RTGs, the demand of the RTGs varies quite much because it depends on the customers' growth and other varying factors. There may be peak demand periods and also low demand periods.

"Process visibility is a slightly more difficult concept to envisage. It indicates how much of the processes are ´experienced` directly by customers,

or how much the process is ´exposed´ to its customers" (Nigel, et al 2009, 21.). This principle in a way focuses on how much satisfaction the customer derives as a result of being exposed to the process. Some processes are more visible than the other. The exposure of the process to the customers also involves the level of communication the customers experience about the progress of the process. Hence, processes with higher visibility are usually more expensive. As with the commissioning of the RTG, we can say that some of the process stages are somewhat visible to the customer than the other. The visibility RTG commissioning also largely depends on the assembly site location, if the RTG is assembled at the customer's site or the company's site.

These four demand features also called the "four Vs", are some of the factors considered by operations or process managers to determine how a certain process should be managed. It is important to know that processes with high volume, typically are always low in variety, variation and level of visibility. While processes with low volume are typically high in variety, variation and level of visibility.

4.2 Process improvement and ownership

Process improvement is a necessity for any process run by organizations. The improvement to any process is to be done with certain considerations: the customers, eliminating process defects and increasing the process productivity. The customers are usually the next on the output side of the process or the customers can also be the direct end user of the product or service. Whenever a process is being improved, it is imperative that the company has the point of view of the customer (or determine the voice of customer). In other words, it is totally unnecessary to try to improve a process without thinking like the customer of the process. For instance, if a grocery store is trying to improve their customers' shopping experience and the store only thinks that the customers come into the store, pick the items, pay and then leave. The store is not properly thinking from the customers' point of view. Thinking from the customers' view point means thinking about what the customers experience should be immediately they step into the store, start and complete their shopping and step out of the store. (Donna 2009, 320.)

When driving a vehicle, someone has to take charge of the steering to ensure that the vehicle is steered in the right direction continually. When flying an airplane, there also has to be a pilot in charge of flying the plane. Similarly every process requires an owner. Ownership of a process means identifying who should take responsibility of the process. The process owner usually has a very good knowledge and understanding of the process, can make changes to the process (only when necessary) and is responsible to ensure that the customers are satisfied of the process output. (Donna 2009, 323.)

4.3 Process mapping and design

A map is a graphical representation usually used to explain a pathway to a place. A process map is also sometimes called different names such as process flowcharts, process flow diagrams and so on. "A process map is a graphical representation of all the steps involved in an entire process" (Donna 2009, 325).

With a process map, we can depict the current status of a process and clearly see what activities are to be done and in what sequence these activities are to be carried out. When a process has been mapped, we can easily see which activities precede which, be able to determine which activities are none value adding, and so on. In order to create a map for a process, certain techniques are used. These techniques have two main characteristics that they depict the process inputs (material or people or information) flow throughout the process and they also show the various activities which take place during the process. (Nigel, et al 2009, 143.)

Typically processes vary from each other in terms of their complexity and sometimes size. For instance, if we think about all the activities necessary for the complete production of a product from the purchase of the raw material (by the purchasing department) to the usage of the raw material (by the manufacturing department) for the production of the final products and compare to the printing process activities. We will observe that the product production process involves more activities than the printing process. This is why when designing large processes from scratch or mapping an already existing large process, it is usually done by dividing the map into different levels. Although, this is not necessary in all cases. The highest aggregated level is known as the highest level of the process map. Usually this highest level does not contain so much information because it is just drawn as a simple transformation process with less information. The next level (lower level) of the process which will describe the individual transformation process in the highest level is then mapped with more details included. This lower level can also be called an outline process map. (Nigel, et al 2009, 143.)

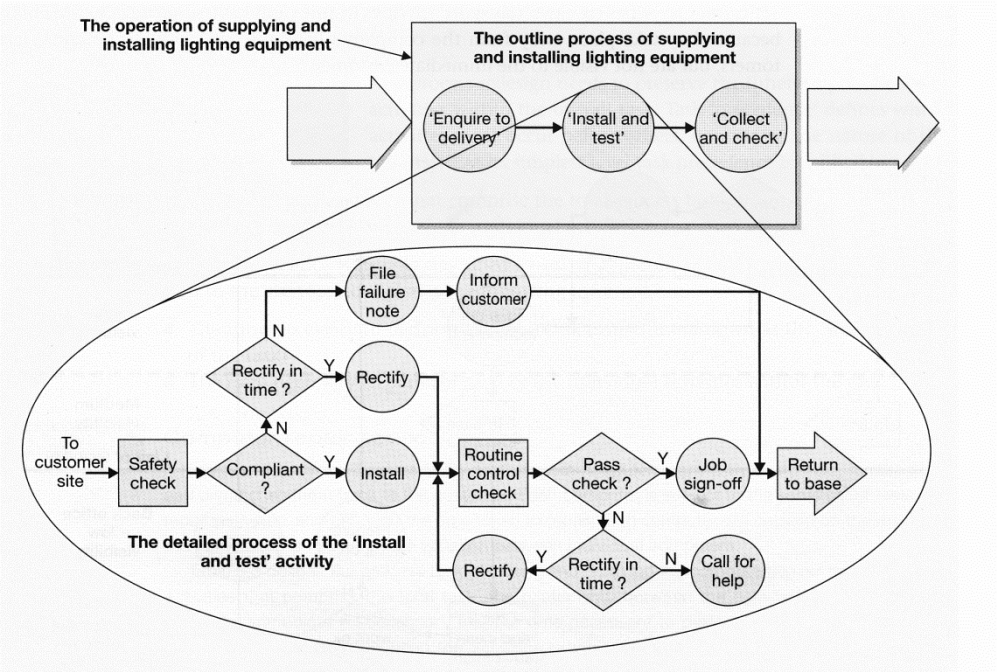

Figure 5 Example of higher and lower level process mapping (Nigel, et al 2009, 145).

Figure 5 above is a supply and installation process of lightning equipment. We can see in the figure that there are two different process levels. At the higher level, the process flow looks like a simple "input-transformation-output" flow. The second level explodes each stage at the higher level process into more details; in this case the "install and test" was exploded. Note that the figure above does not show the exploded process for the other higher level stages.

A further level from the outline process map can also be created. At this level, further description to the smallest details of the steps to be taken to complete each activity stage from the preceding higher level can be mentioned. This is usually done in processes, such as those of fast food restaurant. Usually process mapping at this level will include documents needed, tools to be used, time consumed and so on. (Nigel, et al 2009, 143.)

Creating or designing a process map is usually done following certain steps. These steps are quite easy and simple to follow.

1. First, we have to identify where the process starts and finishes.
2. Determine the process steps or activities. By using brainstorming methods for new process and observation for existing processes.
3. Arrange the process steps in the order in which they should be performed.
4. Use appropriate process flow diagram symbol.
5. Check for process reliability and possible improvement opportunities. (Donna 2009, 325.)

4.4 Benefits of process management

When an organization has its operations processes focused, they can easily achieve the process goals and most importantly the overall business goals. The overall business goals are achievable because personnel are aligned with the activities involved in the process and the activities are in alignment with the business strategy. From the personnel view point, since activities to be performed during the operation is properly mapped as a process, process owners can easily develop a very clear understanding of how their operation should run and their process goals. The personnel also understand why they have to stick to the process flow activities and know that following the process will help achieve the process goal. Also clear to the process owner, is the relationship that exists between the activities. An operation that is focused on its targets ensures that the customers are able to get what they want and that the customers are satisfied. The product quality also maintains the same standard all the time as long as there is no deviation from the process. Therefore, any improvement made to the process should have the same effect to the quality of the products the process has been used for. (Donna 2009, 316.)

During this thesis project work, the author aims to ensure that customer satisfaction can be improved by process improvement. Successfully completing the standardization of the commissioning phase process and documenting the result will help improve how the commissioning phase is being currently performed. The process will also be completed faster and the cranes delivered to the customer for testing are problems free. Avoiding hiccups and delay during customer testing.

Organization can also achieve good costs benefits, such as lower costs of running their operation, shorter process throughput time, more quantities of products can be easily produced, customer demands can be easily met, reduced labor work force and most importantly there a is room for constant improvement of the process.

5 PRODUCT QUALITY

One of the most important purposes of going through the rigorous exercise of creating a procedure is to ensure that cranes handed over to the customers go through a standard process and have been properly checked. Basically, one definition of quality can be described as the degree of satisfaction which customers derive from certain products. This means that the product should be able to do what it has been manufactured or designed to do. This is why the importance of the product quality is emphasized and we have to ensure that the customers are always satisfied with the products delivered to them and possibly supersede their expectations. (Bhat 2010, 6-7.)

For products such as an RTG, customers will assess the product quality using several criterions. In an effort to satisfy the customers, the company has to ensure that these criterions are met. Examples of the criterion include: product durability, speed, eases of operations, defect rates, safety

features and technical solutions. These criterions are not just assessed before handing over the crane to the customers. These criterions with which the company's customers measure the product quality should also be effective after the RTG has been handed over. Therefore, we must ensure that the commissioning phase is effectively performed accordingly in order to be able to capture potential problems thereby keeping the RTG problem free.

In addition, this commissioning procedure will also help to improve the product quality by capturing "infant" problems which the product may inhibit. Infant problems mean problems that occur during the start up of new equipments. Although, this does not occur in all of the products but such problems are likely to occur and are due to several reasons. One possible reason is as a result of defects carried over from the factory where the crane parts are manufactured. Finding these problems at their infant stage basically means finding the root cause of such problems and creating systemic fixes. Also avoiding the problems to last longer beyond the commissioning phase and not captured. The learning gathered from such infant problems can then be cascaded to other RTGs being commissioned as inspections, so that these problems can be captured and corrected earlier

5.1 Quality assurance

Quality assurance (QA) actually involves a systemic way of improving product quality. QA can be said as the set of activities put together in order to achieve a high quality product or service. Quality of any product or service is the obligation of everyone involved in the manufacturing of the product and services. Using this system will help to improve and ensure that the customers are satisfied plus an overall improvement in product quality. (Bhat 2010, 407.)

"Every organization should have a quality assurance system focused on achieving defect-free products and services that consistently meet specifications. A basic quality assurance system includes well-designed and documented procedures for product and process control, inspection and testing, control of measuring and test equipment (calibration) appropriate statistical techniques. ISO 9000 standards provide a basis framework for such a system." (Bhat 2010, 407.)

Quality is one of the important factors that differentiate products from other of the same type and also a reason for customer decision making to purchase a product. Therefore, it is imperative to ensure that quality of the product is of utmost concern during the manufacturing process of the product or service. Organizations try to impose the importance of product quality via different methods, such as creating and implementing quality policy, process improvement, creating standard operating procedures (SOP) and so on. As in the case of this thesis, the development of this commissioning procedure document can be described as a method with which the company intends to improve the RTG's quality. Another aspect to the quality assurance system is quality control. Quality control system is simply a system that helps to check and ensure that product quality is the

same as the set standard by the organization. It also involves checking for any defects in the product before it gets to the customers. Though, a company may develop a quality standard and procedure for product's quality to be monitored but some defective products for some reason, always find their ways to the finished product section and even to the customers. Sometimes such mistakes can be caused by the personnel or defective tools. This is why quality is also everyone's responsibility and the training of personnel about the quality control system will help spot those kinds of products. Another method typically used is to develop quality inspection methods or procedures to check for defective products. Customer satisfaction is a key to an organization's success. Therefore, the customers' satisfaction has to be at the core of the business. It is a huge task for a business to win over a customer. Hence, companies always try as much as possible to keep their customers. (Bhat 2010, 405-408.)

5.2 Quality and process development

From the chapters above, we can understand that companies use processes to develop the quality of their products. So the improvement of a process increases quality as much as it helps to save cost. Companies such as FedEx and Citibank have used this ideology to improve their customer's satisfaction. (James & William 2008, 333.)

In the case of this project, the impact on quality via the process is done by describing every activity and gathering all possible information about the activity. The author is required to work through the whole commissioning phase, collecting information such as:

- how individual activities are to be performed
- the importance of the activity
- tools and personnel needed to complete individual activity/process and input and output of the process stages
- is there any in-process measurement that has to be identified
- identify which activity is to occur before the other ones within the process

With the information listed above, we will now try to find out if the activities are actually done correctly and which of the activities should be improved by keeping the customer's interest in mind. (James & William 2008, 341 – 342.)

This simple rigorous exercise translates into improving the crane quality when all the processes involved in executing the commissioning phase have been improved. Therefore the activities performed during commissioning phase of any should now be the same, even if the commissioning engineer in-charge of the phases may be different. This implies that the commissioning phase has been improved and standardized. Ensuring that the RTG quality remains the same irrespective of where it has been assembled. In the future, any improvement that may be done to the process will be documented so that the translation into a more improved quality product can be realized for all RTGs.

6 COMMISSIONING PHASE

As we now understand this is a phase lead by the commissioning engineer and it is also a very essential phase in the complete manufacturing of the RTG before the RTG is handed over to the customer.

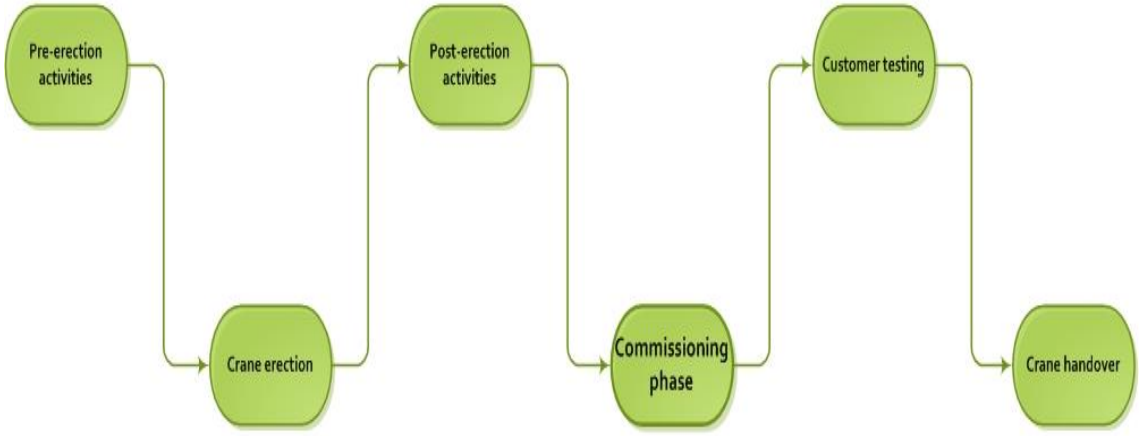

Figure 6 Crane assembly process showing the commission phase in the assembly process

The commissioning phase involves two main stages which are the start up and testing stages as seen in figure 7 below. The checking activities done during commissioning phase are divided into two types: Static checks and Dynamic checks. These check types is a general idea that also applicable when commissioning any new equipment. Static checks involve carrying out tests on equipment without (or before) energizing the equipment while the dynamic checks involves test to be done on the equipment after it has been energized. The type of activities carried out on the equipment in either of the two checks mentioned earlier depends on the type of equipment that is being commissioned. Normally, these checks may be a series of tasks or may just be a simple short set of tasks. In the case of equipment such as an RTG, quite number activities are involved.

The start-up stage which is the first of the commissioning phase involves checking and powering up the RTG. During this stage, activities are carried out are mostly of the static checks types mentioned earlier. The start-up stage is further divided into sub-stages where a certain stage in the process precedes another stage in the process (meaning that a stage is required to be completed before another stage starts).However, some stages can also be performed in parallel with others. During the start-up stage the main activities done are: pre-start-up checks, RTG power-up, fibre connection and program download. The tasks carried out and the list of activities performed during the start up stage will be further explained later on in this procedure. The second stage of the commissioning phase is the Testing stage and can also be called internal testing stage. The main activities during this stage include: operational test, set-up and interlocks and safety test. The main aim of this stage is to get the crane ready for checks and

tests supervision to be carried out with the customer. Once the crane has been internally tested, passed all necessary tests and has been certified by the commissioning engineer. Then the commissioning process is completed. The crane is now ready to be tested with the customer; this is known as the "customer testing" stage.

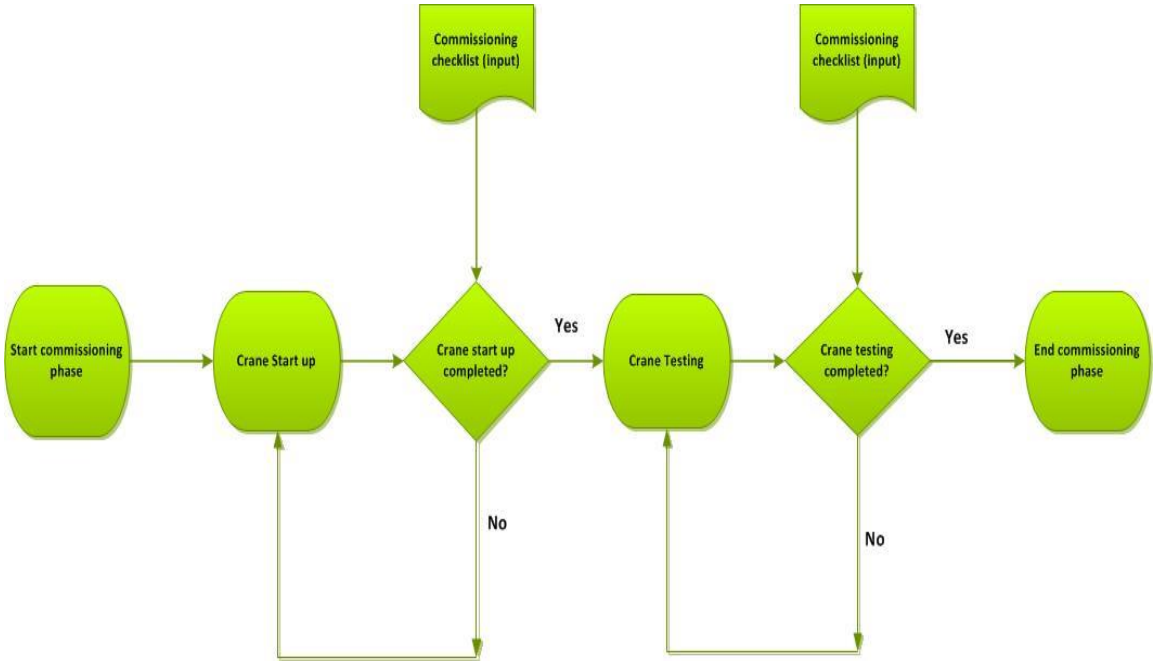

Figure 7 Commissioning phase process flow

After completing the stages during the commissioning phase, checks have to be conducted to confirm that the previous stage is completed, to be able to move on the next stage within phase. A commissioning checklist is used for the checks; see appendix 1. This checklist serves as an input to be used in predefined stages of the phase and also an output of the whole commissioning phase process. The checklist is made to be completed and approved by the commissioning engineer in charge.

A successful completion of the commissioning phase would mean that the RTG has been successfully assembled and tested. The crane has also passed all safety and quality standard tests required for the crane to be signed off to the customer. To achieve this success, it is important to have every material, tool and the right personnel available for the completion of all the stages involved in the phase.

It is also imperative to note that this commissioning procedure is written using the crane model 16WA (sixteen-wheeler) which was being assembled during the time this procedure was written. Therefore, if this procedure will be used for other sixteen wheeler cranes, there might be slight little differences. These differences may be noticed as additional equipments or accessories requested for by the customers. In the case of such differences, the commissioning engineer should refer to the automation personnel for brainstorming ideas

6.1 Safety

Safety is an important aspect during manufacturing of the various parts of the RTG and also plays an integral role in the assembly of the RTGs. Konecranes also ensures to follow all local and international safety regulations during all activities involving the assembly of the RTG. Irrespective of where the assembly is done, either at a Konecranes site or customer's site. Similarly, when designing the cranes, all necessary international and local standards stated in the design considerations for equipments such as an RTG are always followed. The international regulatory bodies include ISO (International Organization for Standardization), IEC (International Electro-technical Organization), CEN (European committee for standardization) and a local organization, SFS (Finnish Standards Association / Suomen Standardisoimisliitto). The safety requirements also encompass the use of the electrical hardware devices and software designs. (Haanpää, interview 1.4.2013.)

6.2 General description of tools and personnel required

Personnel

To complete these tasks it is important to have at least two trained persons:

- Electrical personnel
- Mechanical personnel

Having persons that have the operational, electrical and mechanical knowledge of the crane is very important as this will become useful during the phase. If the personnel listed above are not available the minimum requirement is have two electrical persons that have the operational, electrical and mechanical know-how of the crane.

Tools and Materials

Throughout the period of this process, certain tools and materials are needed to aid a fast and smooth completion. Below is a list of important tools and materials needed during the project:

Table 1 Tools

Tools (description)	Quantity (pieces)
Clamp on ammeter	1
Fibre optic tester	1
Grease gun	1
Measuring tape	2
Megger tester/Insulation resistance tester	1
Multi-meter	2
Phase sequence tester	1
Pressure gauge (0 to 10 bars scale)	1

Scope-meter	1
Set of flat head screw driver	2
Set of star head screw driver	2
Set of Allen keys (1mm to 8mm range)	2
Set of spanners wrench (6mm to 20mm range)	2
Side cutter pliers	2
Torque wrench	1
Walkie-talkie	2

Table 2 Materials

Materials (description)	**Quantity (pieces)**
Commissioning specification document	1
Crane electrical drawing	1
Diesel generator electrical drawing	1
Laptop with installed programs	1
Other equipment manual	1

Each person involved in completing the tasks should have their own basic personal tools such as screw drivers and pliers while the materials used can be shared amongst them. This is basically because a minimum of one tool will be needed at each stage of the procedure and the persons involved are not going to be at the same place all the time during the activities. However, one of each material listed will be enough for the phase, and the persons do not need to have one of each material all the time.

6.3 Crane start-up stage

It is important to note that the tasks performed in this stage follow the fact that some pre-checks have been done to the assembly parts at the factory. Some of the parts are delivered to the assembly site, pre-assembled. These parts are:

- Bogies
- Electrical room (E. room)
- E6 (Access side)
- Diesel generator
- Head-block (optional unit)
- Operator’s cabin
- Spreader
- Trolley

These parts comprises of mechanical parts, electromechanical equipments and electrical equipments. After the pre-assembly of these parts at the factory, the parts are tested to ensure that they work as they should and any faults found during testing in the factory are fixed. When the factory tests have been conducted successfully, the parts are then shipped to the respec-

tive sites where they should be delivered to. Obviously, since the parts have been tested and certified at the factory before transportation they do not necessarily have to be tested before they are assembled on site.

As we already know, this stage is the inception of the tasks to come after the complete assembly, erection and electrical wiring of the RTG. Although, all the phases involved after the erection are important but any mistake at this stage may cost a lot and maybe even prevent or prolong the completion of the commissioning phase. Hence, it is important to have everything and the right personnel for the successful completion of the stage. Below is a process flow of activities performed during the start-up stage. This start up stage is only about 25% of the whole commissioning phase.

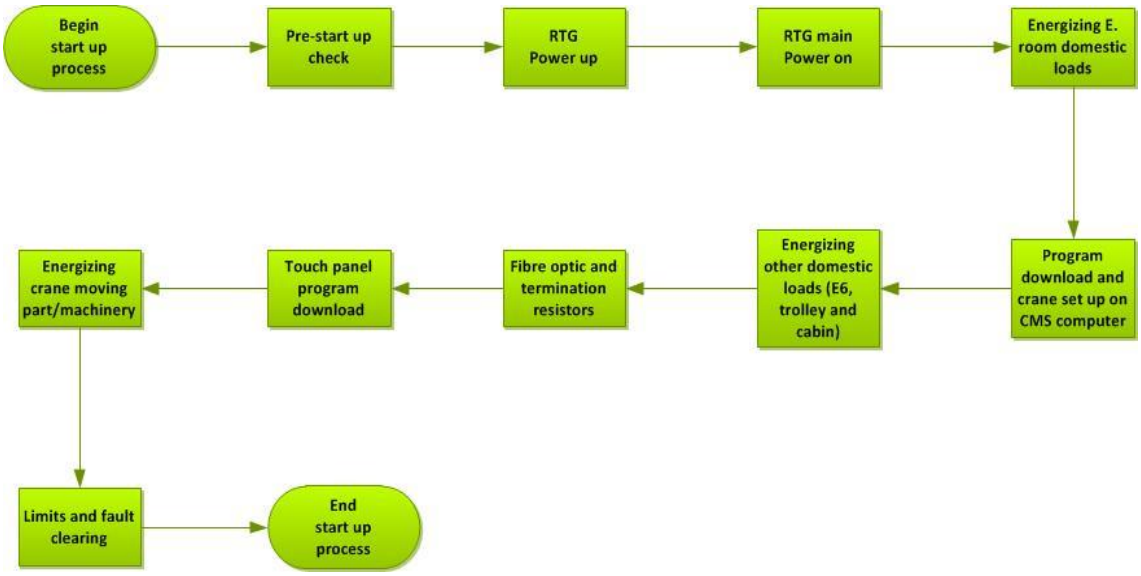

Figure 8 Start up stage process flow

6.3.1 Pre-start-up checks

This involves the first set of activities to be performed on the crane before energizing the crane. These checks are considered to be static checks (as explained earlier) and are conducted in order to ensure that the process of energizing the crane is problem free.

Diesel generator

Simple checks are conducted on the diesel generator irrespective of the factory check and test that has been done. These checks have to be conducted in order to capture any possible problems that might have happen during transportation and to replenish important solvents to operate the generator.

- Inspect oil filters.
- Inspect fuel filters.
- Check oil level and top up if necessary.

- Check fuel level and top up.
- Check coolant level and top up if necessary.
- Inspect for any leakage and repair if any is found.
- Measure the diesel generator battery voltages, should be 12 volts on each battery.

General inspection

- Check motor gear box oil level and top up if necessary.
- Inspect electrical wirings in E. Room, access side (E6), trolley electrical cubicle, operator's cabin electrical cubicle for any loose connections.
- Ensure that all circuit breakers in the electrical cubicles are in off positions.
- Check that all crane emergency stops are released.
- Check that diesel emergency stops are released.
- Ensure that "main isolator switch for crane" "O-Q1" and "main isolator switch for machinery" "O-Q2" are in off position.
- Measure the insulation resistance of the motors using the megger tester (this action is also called megger testing). This is usually done by the contracting company.
- Inspect bogie tires air pressure and pump the tires if needed.

Typically, the diesel inspections and checks can be done before the generator is assembled to the RTG. These activities on the diesel generator will typically take about 120 minutes. For the general inspections and checks, they should be done after the RTG erection is completed and these tasks typically should only take about 120 minutes to also complete.

6.3.2 RTG power up

After the pre-start-up checks have been completed and all checks confirmed okay, we can now move on to the next stage in the process which is powering up the RTG. This stage of the process involves energizing the crane, starting up the diesel generator to get power to the crane and then energizing the crane equipments. Obviously, this should be done following a predefined process, for example the diesel generator should be started to ensure there is power to the crane before switching on the breakers and not vice versa.

Diesel generator start up procedure

- Connect the diesel generator batteries using an 11mm spanner wrench.
- Switch on the battery switch, F22.
- Switch on diesel generator main disconnect, Q1.
- Switch circuit breakers in diesel generator cubicles to ON position.
- Switch on circuit breaker, D-F1 in E. room at location E1.6.
- Disconnect the can bus profibus cable, Z1-D7 from PLC rack in E. room.

- Turn “main control” switch key to ON position to switch on the diesel control module, “intelligence module”.
- Reset all faults shown on the intelligence module if any.
- Open all diesel doors, to be able to observe the generator.
- At this point, the generator start mode will be on manual mode (this means the generator can only be started from the module buttons) start diesel generator from intelligence module start button.

Figure 9 Diesel intelligence module

- With the diesel doors still opened, keep the generator running for a minimum ten minutes to observe for any problems in the diesel generator engine such as leakages.
- Stop the diesel generator after ten minutes.
- If any problem is observed while running the engine, stop the generator after the ten minutes run, let the generator cool down and then fix, if no problem was observed during the run.

The following steps below are not really necessary if the diesel intelligence program download have been done from the factory. But if the program is to be downloaded during this process, then the steps below should be followed to do the download.

- Now connect the RS 232 cable from laptop to diesel intelligence module to link up to the module and download the intelligence module program.
- After the program download, the generator start mode changes to “off”. To change the start mode, first enter the module password usually 1234, 0 or 1 and press enter.
- Change start mode to automatic mode and now generator can be started using the key switch.
- Start generator from the key switch.

If the program running on the module is the recent program, then only the start mode is needed to be changed to automatic. Therefore follow the steps below:

- The generator start mode is in manual as earlier mentioned, first enter module password usually 1234, 0 or 1 and press enter.
- Change start mode to automatic mode and now generator can be started using the key switch.
- Start generator from the key switch.

6.3.3 RTG main power on

Now that the diesel generator has been started and the engine is running, there should be a three phase voltage supply up to 500 volts supplied from the diesel generator through the main disconnect, Q1 of the diesel generator to the crane main isolation switch. Hence, we have to confirm that there is a three phase voltage supply present at the crane mains before energizing the crane. Typically the phase sequence can also be checked after checking the voltage using the phase sequence tester. But the phase sequence check would be been done by O-L1 (the device which is directly after Q1).

- Close E1.1 door and switch on "Main isolator for crane" O-Q1 on the door.
- There should be voltage present at the terminals and this can be measured at the input terminals 1, 3 and 5 of circuit breaker O-F102 at E1.2.

6.4 Energizing crane in sections

At this point we are sure there is voltage supply to the crane, all we have left to do is to switch on all circuit breakers in a sequential order to energize various sections on the crane one after the other. At this point, we must first understand that there are typically two types of loads present on the crane, they are the domestic loads or non-moving parts loads and moving parts loads or machinery loads. The idea of switching on the circuit breakers sequentially is to ensure safety of equipments and personnel. The main reasons for not switching on the machinery loads first and sequential switching are:

- To avoid sudden movement of moving parts machinery, it is therefore typically advisable to switch on domestic loads before other loads.
- To prevent sudden voltage surge from damaging equipments on the crane in a case where there might be a fault in wiring connections. Hence, when switching on circuit breakers, either for the domestic loads or the moving part loads it is important to note that higher rated breakers should be switched on before the lower rated breakers in the series circuit. This simply means that when switching on the breakers, we will start by first switching on the breakers which have higher trip settings in the circuit. Then, we will proceed to the next higher trip setting breakers in the series circuit and so on until we get to the bottom breaker of the circuit. For example, if we had circuit breakers of trip ratings 100A, 80A and 60A serially connected in the circuit. We

will first switch on the 100A breaker, then 80A and finally 60A but not vice versa.

We will also start to switch on the circuit breakers starting from the E. room and then we move on to other electrical cubicles on the crane until all are completed.

Personnel required

– Electrical personnel

Tools and materials required

– Laptop and cable accessories
– Crane electrical drawings
– Screw driver (flat head)
– Side cutter pliers
– 10 - 13mm spanner wrench
– Allen key set

6.4.1 Electrical room domestic loads

Starting with the domestic loads, this includes: lightning and heating control, lightning and heating for gantry side and lightning and heating for E. room. First, we will switch on the charging circuit, lightning, heating and air conditioning circuit for the E. room to get illumination in the room, PLC circuit and then other domestic loads energized. Below is a list of the sequence of the breakers to be switched on for domestic loads, the breaker locations and usage.

Table 3 Charging circuit

Breaker name	Location	Purpose
O-F102	E1.2	DC – circuit charging circuit
O-F01	E1.2	main supply feedback contactor
O-F3	E1.5	control transformer
O-F10	E1.5	charging circuit

Table 4 E. room Lightning and heating

Breaker name	Location	Purpose
T-F01	E1.5	main supply selection transformer
T-F011	E1.5	main supply selection circuit
T-F1	E1.5	transformer
T-F11	E1.5	gantry
T-F119	E1.5	electric room heating
T-F120	E1.5	electric room lightning

T-F123	E1.5	diesel heater etc
T-F124	E1.5	air conditioning unit

Table 5 Other domestic loads

Breaker name	Location	Purpose
T-F111	E1.5	power supply E6
T-F22	E22	power supply trolley and cabin
T-F114	E1.5	socket outlet
T-F115	E1.5	socket outlet
T-F116	E1.5	floodlights gantry
T-F117	E1.5	gantry and locking motor heating Bogie B and Bogie spare C
T-F118	E1.5	spare
T-F121	E1.5	gantry floodlights control
T-F122	E1.5	gantry travelling alarm bogie B/C
T-F125	E1.5	spare
T-F126	E1.5	spare
T-F127	E1.5	spare
T-F128	E1.5	spare
T-F129	E1.5	GPS power supply
T-F130	E1.6	main filter power supply
T-F131	E1.5	electric room PLC power supply
T-F02	E1.5	shore power selection transformer
T-F03	E1.5	phase relay
T-F012	E1.5	shore power selection circuit
O-F14	E1.5	spare

Table 6 PLC inputs, encoders and other systems

Breaker name	Location	Purpose
Z1-F1	E1.6	spare
Z1-F2	E1.6	encoder power supply bogie B/C
Z1-F11	E1.6	PLC inputs
Z1-F12	E1.6	PLC inputs
Z1-F13	E1.6	PLC inputs
Z1-F14	E1.6	master PLC fibre-optic interface
Z1-F15	E1.6	TOS system
Z1-F16	E1.6	CMS

6.4.2 Program download and Crane set-up on CMS computer

After switching on the circuit breakers above, we can now move on to performing other tasks, that is, program downloads and setting up the crane. First, we must download the PLC program and the Can bus program. Be-

fore downloading the PLC program to the master PLC module, we must ensure that the generator is running full speed, which is at least, 1500RPM. To run the generator at this required speed, “maintenance mode” has to be switched on and then download the can bus program and then select the crane “hybrid” function on the CMS computer. The generator can now run at idle speed of 800RPM (this will also normally during operation happen if the RTG has stopped to be in use for about 3 minutes).

Since the diesel generator will only run full speed until the can bus program is downloaded, hence it is logical to download the PLC program before downloading the can bus program.

PLC program download

First, we will have to configure the IP settings of the laptop so that the PLC device can be found, the IP configuration setting must be set to manual and not automatic (automatic is usually the default setting on the laptop). The procedure for the IP configuration described below is valid if windows operating system is used on the laptop.

Internet protocol configuration procedure

– Click on the “windows start icon” at the left bottom corner of the laptop screen to display the start menu.
– On the start menu click on “control panel”, usually a new explorer like in the figure below should display.

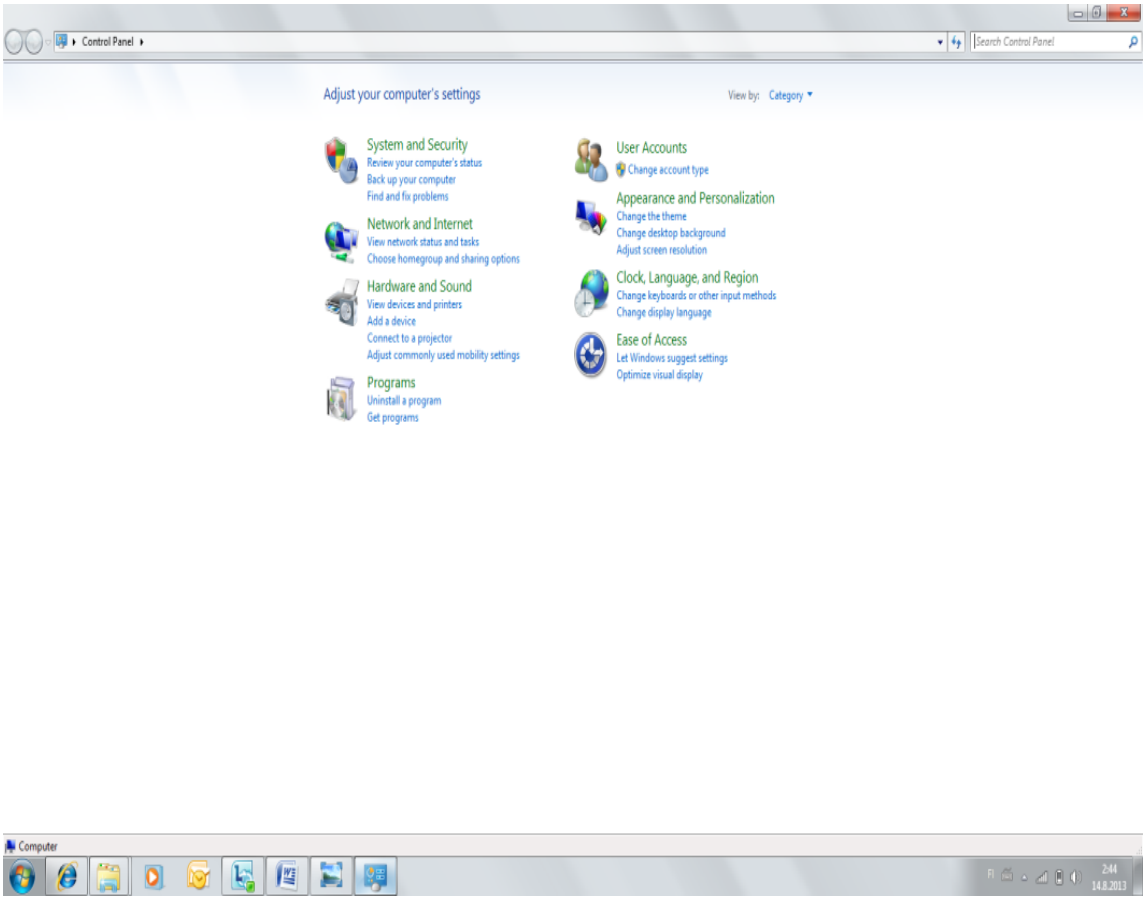

Figure 10 Control panel category view

– Click on the “category” drop down menu at the top of the page and select “large icons” from the drop down list. The page display should change to the view below.

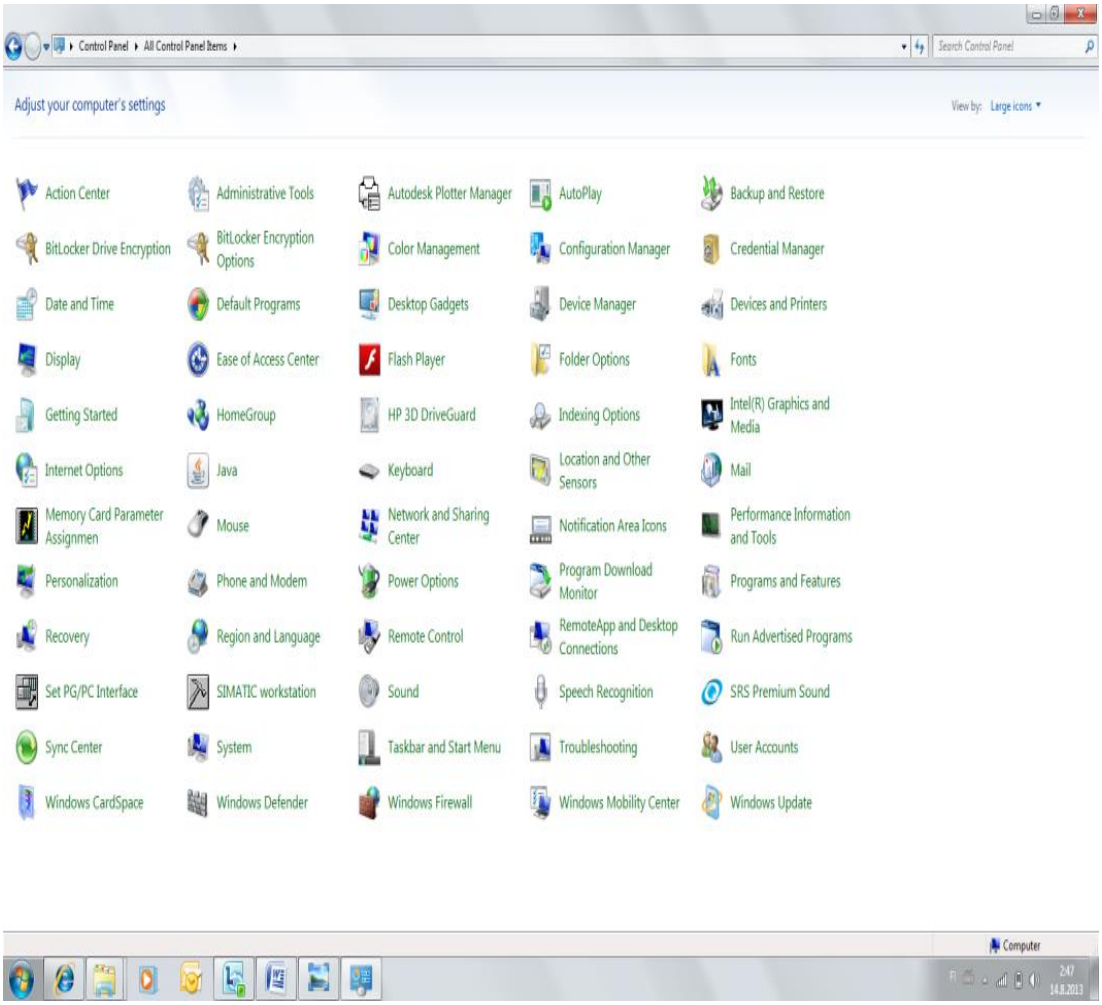

Figure 11 Control panel large icon view

– From the icon on this view select `Network and Sharing center` and the explorer should display a new page.
– On the new page, at the left side, select “change adapter settings” and a new page will display all the network connection methods used on the laptop.
– Now double click on “Local Area Connection Properties” and a dialog box “Local Area Network Properties” will be displayed.

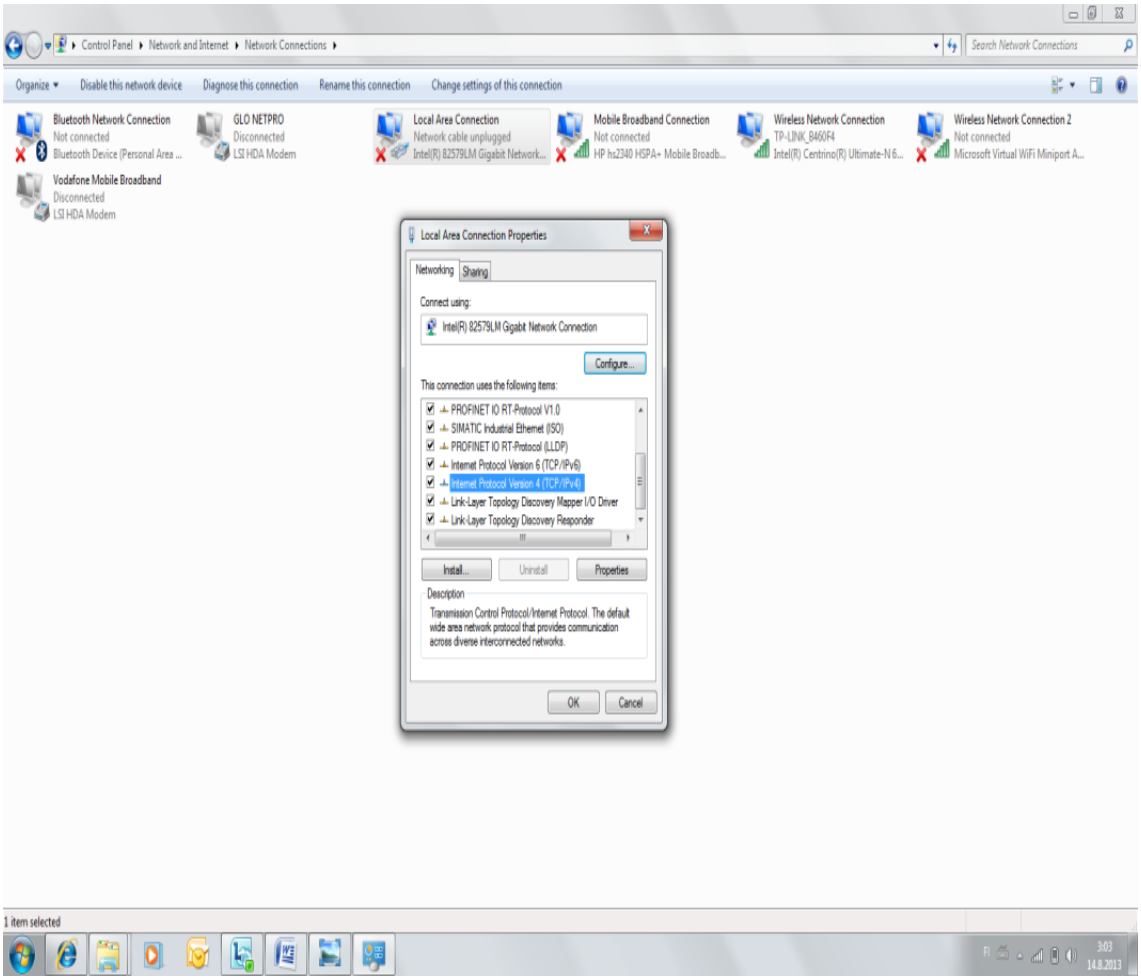

Figure 12 Local area connection properties dialog box display

– Again double click on “Internet Protocol Version 4 (TCP/IPv4)” from the list and an additional dialog box is displayed, “Internet Protocol Version 4 (TCP/ipv4) properties”.

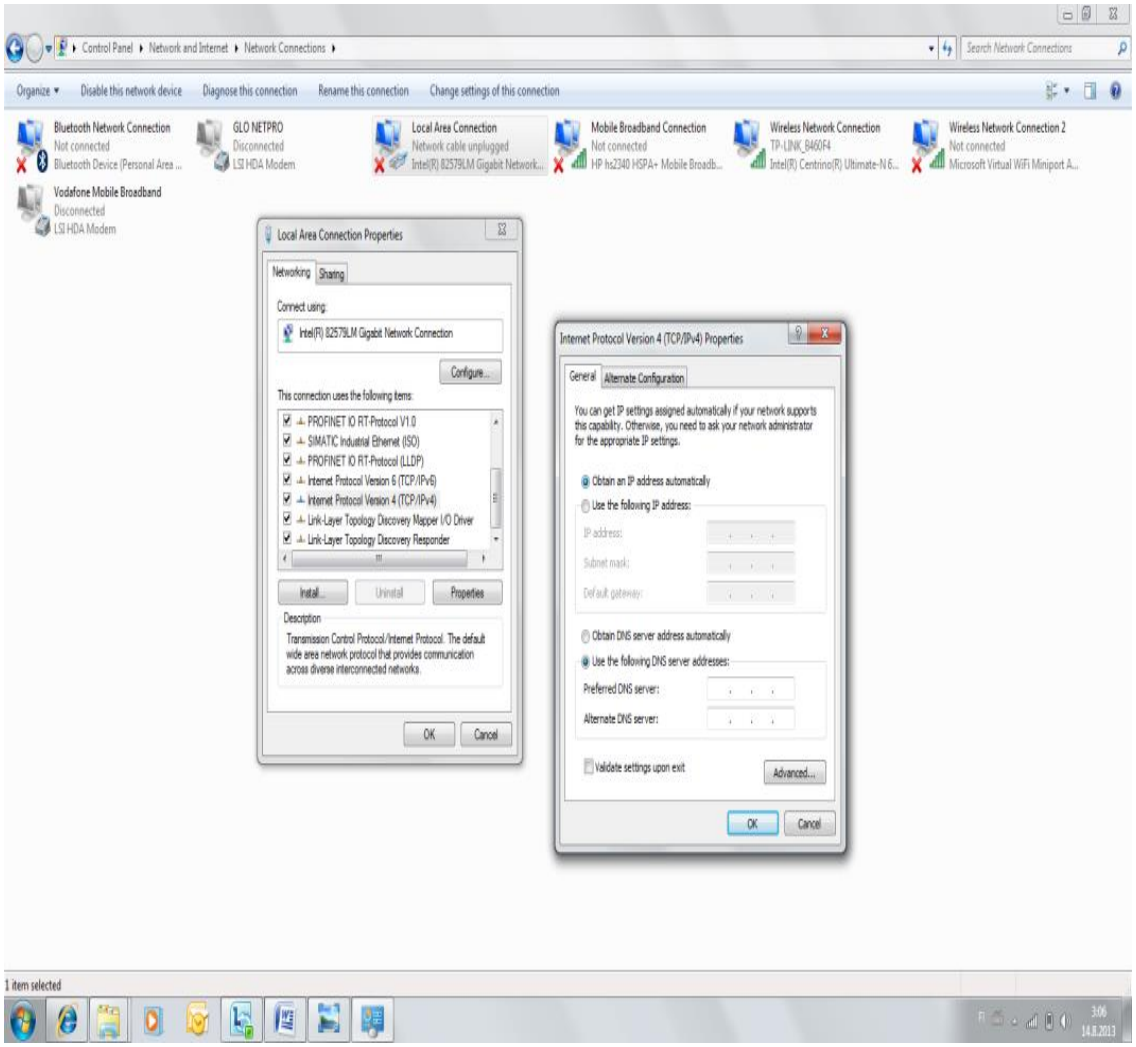

Figure 13 TCP/IPv4 properties dialog box

- In the new dialog box choose use the following IP address option below.
- Type in a new IP addresses 192.168.0.15. Note that only numbers from 15 and 50 can be used.
- Type subnet mask, 255.255.255.0 and then click the OK button.
- Also click OK on the “Local Area Connection Properties” and now the computer should be configured for this IP address and ready to use.

PLC program download procedure

- Connect an RJ45 cable from the laptop to the port in the E. room to establish connection with the master PLC.
- Put the PLC switch to stop.
- Open the “step 7 simatic manager” program on the laptop.
- Open the right program file to download.
- Click on “download user program to memory card”.
- Follow the further instructions and download.

- After download is complete reset the PLC.
- Then put the switch to run and wait for about 2 minutes for the PLC to be ready.

Note that the program download can also be done from the CMS computer if the Siemens simatic program has been installed on the CMS computer and the CMS computer is always linked to the PLC at all times.

Can bus program download

This program download task is also an optional task. This should have already been done at the factory as it should be normally but if it has not been done at the factory, follow the procedure below.

- Connect can bus module (Z1-D7) to the laptop using the RS232 cable to create a connection link.
- Open the can bus program from the computer.
- Select and open the right program software to be downloaded.
- Download the program and wait for download to complete.
- After the download is complete remove the RS232 cable and now connect the can profibus cable to the "can bus" port of the module.

Other programs such as for the hoist drive inverters, trolley drive inverters, skew driver inverters, "DYNACON" inverter and "DYNAGEN" drive inverter are not going to be downloaded because the program downloads are always done, tested and certified from the factory, therefore it would not be necessary to make another download.

6.4.3 Crane function set-up

Now that both programs have been downloaded, the other necessary crane set ups can now be completed. Crane function implies selecting the crane function and devices that are specific to the crane. All cranes manufactured by Konecranes have some basic set of devices and functions but additional devices and functions can be added to the crane based on the customer's need and specification. Hence, during this set-up, we will select what functions the crane has been built to have and what devices are to be in use on the crane.

To do this set-up the CMS computer has to be online and this can be checked simply from the CMS computer monitor at the bottom left corner of the screen. An icon indicates the status of the CMS; the icon color is red when the CMS is offline and green when it is online. When we have confirmed the CMS to be online, we then have to enter the administrator password "2140". After entering the password, two extra tabs will appear, "Settings" and "Bypass". First we will select which emergency stops are going to be used on the crane; using the mouse cursor first click on the "settings" tab, next click on the "CMS settings" tab and finally on the "E-stop" tab. A display such as in the figure below will appear on the screen. Now all we have to do is to check the box next to which emergency stop

will be in use on the crane and which of the contactors are going to be in use and select those.

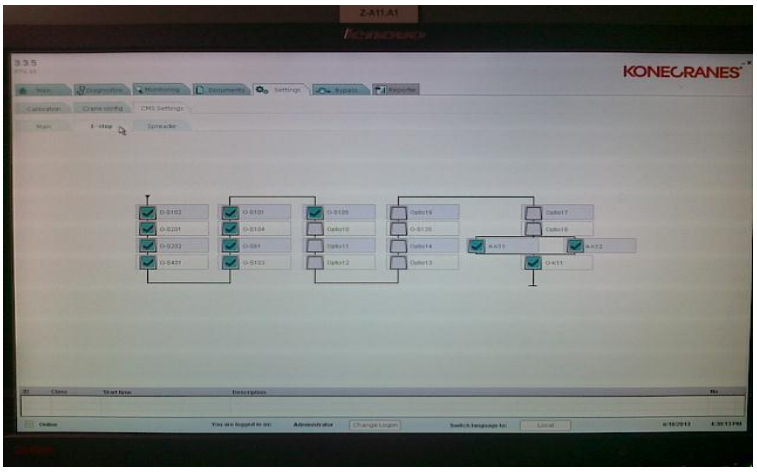

Figure 14 Emergency stop page on CMS computer

Next is to set-up the crane configuration. To get to the “Crane config” tab, first click on “settings” tab, click on the “crane config” tab and lastly “crane” tab. A display such as in the figure below will appear on the screen. Now we select which devices and functions which are to be used on the crane by checking the box next to the device or function. One very important selection that should be done now is the hybrid function for the diesel generator which was discussed earlier. If the hybrid box was checked, uncheck the box and check again, the diesel generator should immediately slow down to run idle speed since it is not in operational us.

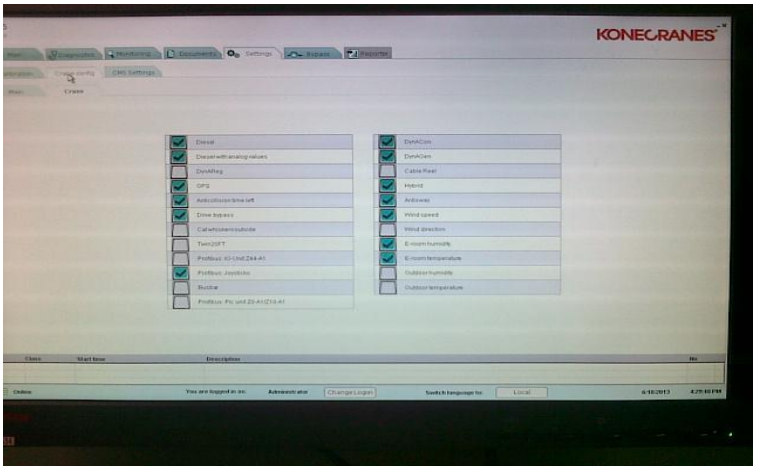

Figure 15 Crane config page on CMS computer

6.4.4 E6 domestic loads

After the domestic loads in the E. room have been switched on and other tasks have been completed, next is to switch on loads in other electrical cubicles. The next cubicle is the E6 cubicle.

Table 7 E6 Domestic loads

Breaker name	Location	Purpose
T-F301	E6	socket outlet
T-F318	E6	checker cabin
T-F319	E6	socket outlet
T-F302	E6	truck-lane floodlights
T-F303	E6	gantry and locking motor heating Bogie A and Bogie D)
T-F311	E6	walkway lights
T-F312	E6	cubicle heating and cooling
T-F313	E6	gantry travelling alarm bogie A/D
T-F314	E6	walk way light control
T-F315	E6	PLC power supply
T-F316	E6	spare
T-F317	E6	checkers cabin
T-F320	E6	camera

Table 8 PLC inputs, encoders and other systems

Breaker name	Location	Purpose
Z6-F11	E6	input, fibre-optic, encoder
Z6-F12	E6	encoder
Z6-F13	E6	pendant, outputs
Z6-F14	E6	remote PLC

6.4.5 Trolley domestic loads

The next circuit breakers to switch on are in the trolley electrical cubicle, E2.1 to E2.4.

Table 9 Domestic loads

Breaker name	Location	Purpose
T-F201	E2.4	cabin power supply and trolley
T-F202	E2.4	spreader power supply
T-F210	E2.4	maintenance hoist power supply
T-F203	E2.4	hoist A1 motor cooling fan
T-F204	E2.4	hoist A2 motor cooling fan
T-F206	E2.4	socket outlet
T-F211	E2.4	trolley floodlights, front
T-F212	E2.4	trolley floodlights, rear
T-F213	E2.4	trolley walkway lights
T-F214	E2.4	maintenance lights
T-F215	E2.4	cubicle lightning
T-F216	E2.4	spare

T-F217	E2.4	trolley motor heating
T-F218	E2.4	motor heating: hoist, traversing and skew motors
T-F219	E2.4	cubicle heating
T-F220	E2.4	alarm horn
T-F221	E2.4	trolley PLC power supply
T-F222	E2.4	cabin air conditioning

Table 10 PLC inputs, encoders and other systems

Breaker name	Location	Purpose
Z2-F21	E2.2	input
Z2-F22	E2.2	input
Z2-F23	E2.2	encoder power supply
Z2-F24	E2.2	interface
Z2-F25	E2.2	spare
Z2-F26	E2.2	spare

6.4.6 Operator's cabin loads

We now have to switch on the domestic circuits for the cabin. Basically, only domestic load switches are located in the cabin cubicle which means that all the breakers will be switched on in the cabin unlike in the E. room, E6 cubicle and the trolley cubicle. Below is a list of circuit breakers to be switched on which can be found in the E4 cubicle.

Table 11 Domestic loads and PLC circuit

Breaker name	Location	Purpose
T-F401	E4	cabin sockets 230V and stand-by heating
T-F402	E4	air curtains
T-F403	E4	air curtains
T-F404	E4	230V socket outlet/electric cubicle
T-F411	E4	seat heating and compressor
T-F412	E4	camera system
T-F413	E4	supply to PLC
T-F414	E4	supply to windscreen transformer
T-F415	E4	12VDC power supply
T-F416	E4	supply for windows heating
T-F417	E4	spare
T-F431	E4	heating for cabin glasses
T-F432	E4	heating for cabin glasses
Z4-F11	E4	PLC inputs
Z4-F12	E4	PLC inputs
Z4-F13	E4	PLC inputs

Z4-F14	E4	PLC inputs
Z4-F15	E4	PLC inputs
Z4-F16	E4	loudspeaker system
Z4-F17	E4	cabin LED light
Z4-F18	E4	cubicle light

Note that we have not checked any circuit breakers in the E5 and E3 cubicles because there are no breakers in the E5 cubicles and the E3 cubicle is located on the spreader. Since the spreader is still at a seemingly unreachable height, we will therefore not focus on the E3 cubicle until later on in the process.

6.4.7 Fibre optic, termination resistors and bus addresses

When all the domestic loads have been switched on the cubicles, as described above and the master PLC, slave PLC and other devices in the profibus circuit have been powered. Then we can move on to the connection of the fibre optics and checking the termination resistors dip switches of devices in the cubicles. Doing this will enable the master PLC link up or create the connection with the other devices within the profibus circuit. We can also check from the CMS computer, the progress of the profibus connection as the fibres are connected in the respective cubicles. To navigate to the profibus page on the CMS screen, we do not need to enter the administrator password. First click the “monitoring” tab and then click the “profibus” tab. A display of the profibus circuit should appear on the screen. Now using the electrical drawings, follow the fibre optic connections; to connect the right fibre optics to the right device and check the positions of the termination resistors dip switches. This fibre connection will also be done in the section order which the domestic loads breakers were switched earlier, that is moving from one cubicle to another.

Note that there are different sets of the fibre optics and some are color coded while others are only number. Usually there are two sets of fibre optic cable, cable numbers “595” and “596” runs from the E. room to the trolley cubicle (one of these set is usually a spare). Another set of the fibre optic cable runs from the trolley cubicle to the cabin cubicle; cable number is “810”. The last set runs from E6 to E. room, which cable’s number is “670”. It is also important that while connecting each fibre cable, to check that the status LEDs are on after connecting each fibre cables. Therefore we can have one personnel checking the profibus connection status from the CMS in the E. room while the other personnel can focus on the fibre cable connections.

Basically the termination resistors dip switches of some devices have been connected from the factory and are also preset from the factory. However, we will also include some of those devices in our checks. The position which the dip switches should be can be checked from the electrical drawing. Normally the dip switch for the termination resistor should be in ON position if there is only one profibus cable connected to the termination resistor or OFF position if there are two profibus cable connected to the termination resistor.

The bus addresses are also important inspections that will be conducted. Although, not all bus addresses will be checked as these addresses should normally be preset from the factory. Hence, a quick check on the bus addresses of the devices listed below is imperative. Also below is a list of devices that the fibre cables are to be connected to.

Table 12 E. room fibre optic connections

Breaker name	Location	Purpose
A1-D1		hoist one encoder optical fibre receiver
A2-D1		hoist two encoder optical fibre receiver
E-D1		trolley traversing optical fibre receiver
Z1-X01		phoenix contact converter
Z1-X02		phoenix contact converter
Z1-B20		phoenix contact Ethernet switch
X1W		fibre optic connector

Table 13 E. room termination resistors

Breaker name	Location	Purpose
Z1-A1		master PLC module
Z1-X01		phoenix contact converter
Z1-D7		can bus module

Table 14 E. room side bus address

Breaker name	Location	Purpose
Z1-D102		bogie B digital input detector
ZR3-B1		bogie B absolute encoder
ZR4-B1		bogie B absolute encoder
Z1-D103		bogie B digital input detector
ZR5-B1		bogie C absolute encoder
ZR6-B1		bogie C absolute encoder

Table 15 E6 fibre optic connection

Breaker name	Location	Purpose
Z6-X101		phoenix contact converter
Z6-B20		phoenix contact Ethernet switch
N-A35		optical fibre transmitter

Table 16 E6 termination resistors

Breaker name	Location	Purpose
Z6-X101		phoenix contact converter
Z6-A1		interface module

Table 17 E6 / Access side bus addresses

Breaker name	Location	Purpose
Z1-D101		bogie A digital input detector
ZR1-B1		bogie A absolute encoder
ZR2-B1		bogie A absolute encoder
Z1-D104		bogie D digital input detector
ZR7-B1		bogie D absolute encoder
ZR8-B1		bogie D absolute encoder

Table 18 E2 fibre optic connection

Breaker name	Location	Purpose
A1-D2		hoist one encoder optical fibre transmitter
A2-D2		hoist two encoder optical fibre transmitter
E-D2		trolley traversing optical fibre transmitter
Z2-X01		phoenix contact converter
Z2-B20		phoenix contact Ethernet switch
X2W		fibre optic connector

Table 19 E2 termination resistors

Breaker name	Location	Purpose
Z2-A1		interface module
Z2-X01		phoenix contact converter

Table 20 E2 bus addresses

Breaker name	Location	Purpose
ZA1-D3		hoist one position encoder
ZA2-D3		hoist two position encoder
ZB1-B3		skew position encoder
ZB2-B3		skew position encoder

Table 21 E4 fibre optic connection

Breaker name	Location	Purpose
Z4-X01		phoenix contact converter
Z4-X02		phoenix contact converter

Z4-B20		phoenix contact Ethernet switch
N-A20		optical fibre receiver

Table 22 E4 termination resistors

Breaker name	Location	Purpose
Z4-A1		interface module
Z4-X01		phoenix contact converter

It is imperative to know that in some cases not all the fibre optic cables listed above are needed to be connected. Examples are fibres for devices N-A35 and N-A20, which are used for camera on the crane. Since the camera is an optional device on the crane, some customers may not require it.

6.4.8 Touch panel program download

Z4-A5, the "Proface panel" (operator's touch panel) should now be on and if the Ethernet circuit has been correctly done, there should be Ethernet connection link established with the touch panel already. But the touch panel cannot be used until the program is also downloaded. The program download can be done from the electrical room via the CMS computer or using a laptop. It can also be done in the operator's cabin by directly connecting to the touch panel device using a laptop computer. Appendix 2 describes the program download procedure for the touch panel.

6.4.9 Energizing the moving parts

At this point, we have powered all domestic loads and downloaded all programs. Next task is to energize the moving parts also called the machinery. This will involve switching on the remaining circuit breakers that power the moving parts circuits. Follow the steps below energize the moving parts.

Table 23 Moving parts

Breaker name	Location	Purpose
O-Q2	E1.1	main isolator switch for machinery
O-F11	E1.5	main contactor
O-F12	E1.5	machinery on trolley
O-F13	E1.5	machinery on gantry
R-F1	E1.3	hoist motor A1 and gantry drive
R-F2	E1.3	hoist motor A1 and gantry drive
R3-F1	E1.4	gantry motor 3
R4-F1	E1.4	gantry motor 4
R5-F1	E1.4	gantry motor 5
R6-F1	E1.4	gantry motor 6

O-F71	E1.5	locking pin machinery
S3-F1	E1.5	gantry motor 3 locking pin
S4-F1	E1.5	gantry motor 4 locking pin
S5-F1	E1.5	gantry motor 5 locking pin
S6-F1	E1.5	gantry motor 6 locking pin
R-F71	E1.5	travelling brakes
AB-F7	E1.5	hoist/skew/trolley brake supply
R1-F1	E6	gantry motor 1
R2-F1	E6	gantry motor 2
R7-F1	E6	gantry motor 7
R8-F1	E6	gantry motor 8
R-F76	E6	travelling brakes
S1-F1	E6	gantry motor 1 locking pin
S2-F1	E6	gantry motor 2 locking pin
S7-F1	E6	gantry motor 7 locking pin
S8-F1	E6	gantry motor 8 locking pin
A1-F7	E2.1	hoist A1 brake
A2-F7	E2.1	hoist A2 brake
B1-F11	E2.3	motor 1 selected
B2-F11	E2.3	motor 2 selected
B-F7	E2.3	brake supply400V
E-F11 and E-F21	E2.3	traversing motors
E-F7	E2.3	brake supply 400V

At this point, all circuit breakers have now been switched on and all crane sections should be energized.

6.4.10 Limit switches adjustment and faults clearing

There are several limit switches on the crane and each of them works for a specific purpose. In this task, we will only focus on few of the limit switches. The intent of this task is to correctly position (or adjust) the actuation lever of the switches so that they actuate the switching mechanism whenever the levers are triggered.

Adjust actuation lever for all cat whisker limit switches (R-S01, R-S03, R-S05, and R-S07) on the bogies. Below are figures which show the cat whiskers actuation lever (white colored) before and after the lever adjustment.

Figure 16 Cat whisker and actuation lever before adjustment

Figure 17 Cat whisker and actuation lever after actuation

We should also conduct quick checks (and adjustments if necessary) on the limit switches for the ladder O-S10, diesel doors, shore power T-S01, cabin side access gate O-S05, and cabin access gate gantry side O-S07.

Finally to complete this stage, we have to check that there are no active faults that can prevent us from operating the crane. Though, after adjusting the cat whiskers and checking the other switches, the active faults that appear on the CMS computer screen should now be fewer. Some faults will still be active and can be seen on the screen, these faults will not prevent some of the basic crane operations that are going to be checked during the next stage of the process. Hence, we should be able to start the crane "DRIVES" in order to check the basic crane operations, crane safety features and complete crane operational set-ups. Note that on completion of this stage, the commissioning phase would have been twenty five percent (25%) completed.

6.5 Crane testing stage

This stage is also being called the internal testing stage because it is solely performed by Konecranes' personnel only. As earlier mentioned, the main activities performed at this stage are: Operational test, Crane set up, and Interlock and safety tests. The main activities altogether make up the remaining 75% of the commissioning phase. However, the operational test makes up about 15%, the crane set up makes up about 50% and the interlock and safety makes up the last 10%.

Figure 18 Simple crane testing stage process flow

During this stage, we will test all the crane operational functions, to ensure that the crane works as it should and problems can be spotted and fixed immediately. Some of the operations are: bogie turning, crane movement (gantry) at different bogie positions, hoisting operation, traversing (or trolley) operation and so on. We now move on to the crane operational set ups, which involve limits adjustment, setting the operational boundaries on the crane and invariably enhancing the crane operations and safety features. The interlock tests can also be called the safety tests. We have to ensure that all the safety features (which include operational interlock) work as they should because this is an important value of the Konecranes RTG. We must ensure that all safety devices are in place and this is one reason why all the previous tasks should be carried out as explained.

Having known all these, we are now set to operate the crane. But first, we have to put on the "DRIVES". Drives is a term used to generally describe all the moving parts of the crane and when we switch on the drives, we have energized the control circuit which also means that we can now initiate operational commands to the moving parts of the crane. The drives can be started from four different places: the E. room (CMS computer), E6 pendant, trolley cubicle and operator's cabin. Normally, the operator's cabin is where the drive should be switched on whenever the crane is intended to be used for operational purpose while the other three locations are intended for use only when any sort of maintenance task is to be carried out on the crane. Because starting the crane from any other location beside the operator's cabin will bypass some functions and the crane operator has to be careful when operating the crane from any of the other three locations.

Furthermore, the crane can operate in two modes, the maintenance mode (designed only to be used for maintenance activities) and the normal mode (designed for the crane normal operation). When carrying out the tasks in this stage, it is preferable to do this using the crane normal mode because in maintenance mode some devices and functions on the crane are bypassed, therefore if there is a problem we may not notice this in maintenance mode. Especially with the operational set ups, they should not be done in maintenance mode. If we do this in maintenance mode and there

was a damaged device we may not see the impact of this device until we go back to normal mode and this will surely lead to rework and wasted time. This is because some devices are bypassed in maintenance mode.

6.5.1 Operational tests

Operational test is checking means checking operational functions of the crane. We will check the emergency stop, bogie operations, gantry operations, hoist operations, trolley operations. Normally, when performing these tests, we do not expect any problem to occur. However, we may experience some problems and these problems should be solved immediately. Care should be taken when performing these operations, ensure that gantry, hoist and trolley operations are performed at low speed or so that the crane moving parts do not move fast.

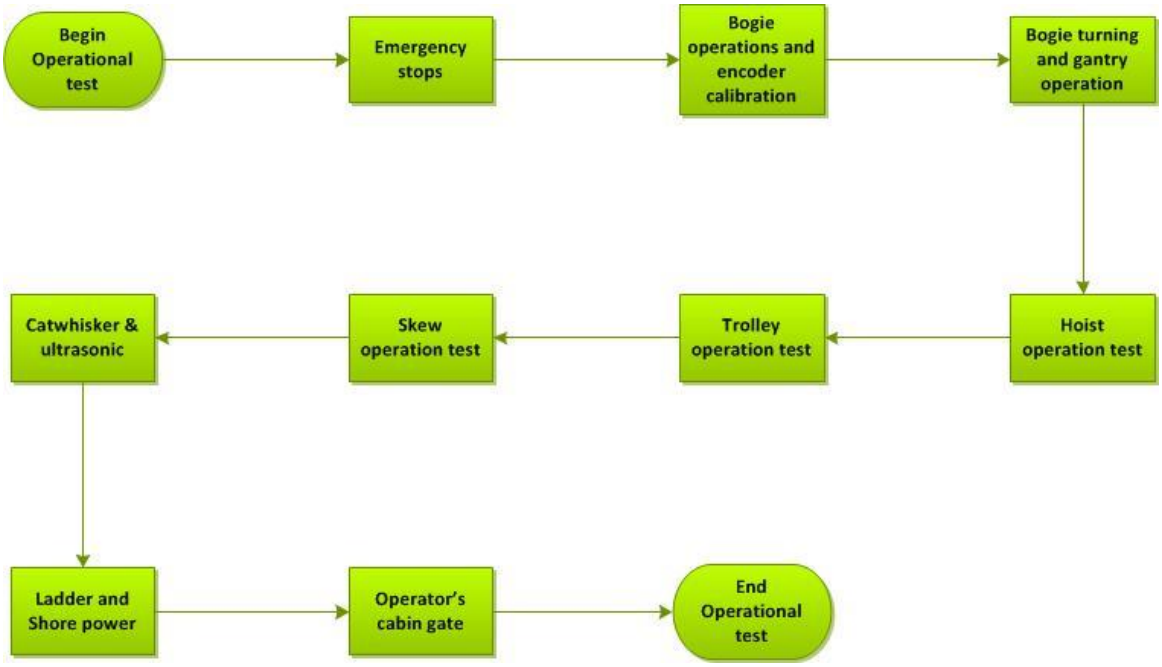

Figure 19 Simple operational test process flow

Emergency stop

To complete this task, one personnel is to check the faults in the E. room while the other personnel activate the emergency stop switches.

Personnel required

- Electrical personnel
- Mechanical / electrical personnel

Tools and materials required

- Screw driver (flat head)
- Screw driver (start head)

- Crane electrical drawings

Procedure

- Activate the E. room emergency stop switch, O-S105. Check on the CMS screen that the emergency stop fault is displayed and that the emergency stop circuit is inactive.
- Also check from the CMS screen that contactor O-K11 is inactive.
- Release the emergency stop switch to activate the emergency stop circuit and also check that the fault disappears from the CMS screen.
- Repeat the steps above for emergency stop switches: O-S102, O-S104, O-S61, O-S103, O-S201, O-S202 and R-S8
- Push the diesel engine emergency stop switches in the cabin, D-S471, the engine should shut down.
- Reset fault and restart diesel engine. After the engine has started, push the emergency stop at the diesel control panel and the diesel engine should shut down.

Now, restart the faults and start up the diesel engine after the check is completed. Note that any problem encountered must be corrected immediately.

Now, before we go any further, we will select the RTG program type for the crane. This will be done from the touch panel Z4-A5. Follow the steps below:

- First enter maintenance password “0202” and press enter, a new icon will appear “service”.
- Follow the path to the RTG type page.
- Select the type, in this case 16WA.
- Close the page to go back to the main menu.

We also have to switch off the following switches: E-S479 for trolley anti-sway, R-S478 for gantry anti-sway, R-S476 for the GPS and M-S477 for the spreader.

Bogie operations and encoder calibration

During this test, we will check all operations performed with the bogies, such as the directions of the locking pins, wheel turning directions on all bogies and bogie turning to different modes. We will also calibrate the bogie encoder in order to get accurate readings when turning the wheels. Note that this encoder calibration can also be done from the CMS computer. See the calibration steps below.

- First switch on the drives.
- Enter maintenance password “0202” and press enter, the “service” icon should appear.
- First select “service” icon, and then select “single mode” icon to go to the single mode page.

After completing the steps above and we have got to the single mode page, we will notice that the encoder values are not zero. These values are incorrect (they can only be zero if they have been calibrated). Now check the "up" and "down" indicators for the locking pins, all the down indicators should have a "1" status because all locking pins are down. We should also notice the "ON" and "OFF" buttons which are used to switch the single mode operation, on and off.

When performing this task, it is very important to confirm that the locking pin goes in the right direction when it is being operated and also important to check that the wheels turn in the right direction when operated. Pins and wheels that go in the wrong directions should be corrected immediately.

- Select the "ON" button to switch on the single mode operation.
- Now select "1" (this means wheel number 1) to switch on to wheel 1.
- Select "calibrate" and the encoder value for this wheel should change to "0.0".
- Twist the left joystick clockwise to raise locking pin up. The locking pin up indicator should now change to "1" when the pin is fully up.
- Push the left joystick to the right to see that the selected wheel turns clockwise; the encoder value should also change as the wheel turns. A little push is only required as the intent is just to ensure that the wheel turns and the direction it turns is correct.
- Now push the left joystick to the left, to get the wheel back to the locking pin position. We can stop when the encoder value is anywhere from negative 0.5 to positive 0.5).
- Twist left joystick counterclockwise to lower locking pin and the down indicator should now change to "1".
- Now select "1" again to switch off the wheel.
- Repeat the steps above for wheels number two through eight.
- After completing all the wheels, select the "OFF" button to switch off the single mode operation.

Bogie turning and gantry operations

After confirming that the wheels turn correctly when operated, we can now check the automatic wheel turning operations. We will also check some other gantry operations at the same time. The four bogie positions that will be checked are: normal, cross, turn, and park position. The bogie position at this point before any movement is always the normal position, as this is the position of the bogies during erection.

During this bogie test, we will check that:

- The beacon light flashes during the bogie turning operations and any of the gantry travel operations.
- The gantry alarms, sounds during the bogie turning operations and any of the gantry travel operations.

Bogie test procedure

- Switch on the drives.

- In bogie normal mode, gently push the left joystick to the left to gantry travel slowly to the left and then stop.
- Now, push the joystick to the right to gantry travel slowly to the right.
- When crane comes to halt, select bogie cross position and observe the behavior of all the bogies during this operation.
- When all bogies are in cross position, gently push the left joystick forward to gantry travel slowly forward and then stop.
- Now push the joystick backwards to gantry travel slowly backwards.
- When crane comes to halt, select bogie normal position and observe the behavior of all the bogies during this operation.
- When all bogies are in normal mode, select bogie turn mode and observe the behavior of all the bogies during this operation.
- When all bogies are in turn position, gently push the left joystick to the left to slowly turn the crane counterclockwise.
- And then to the right turn to slowly turn the crane clockwise.
- When crane comes to halt, select bogie normal position and observe the behavior of all the bogies during this operation.
- When all bogies are in normal mode, select bogie park mode and observe the behavior of all the bogies during this operation.
- When all bogies are in park mode, select bogie normal mode and observe the behavior of all the bogies during this operation.

Hoist operational test procedure

Note that there is no real need to perform the hoist operation for long, since the intent here is only to check.

- Switch on the drives.
- Gently push the right joystick forward to slowly lower the spreader down.
- Gently push the right joystick backward to slowly raise the spreader up.
- On the right joystick press the trim button and hold the button down. At the same time push the joystick left to trim spreader left side down and then also push to the right to trim the spreader right side down.

Trolley operations test procedure

- Switch on the drives.
- Ensure that bogies are in normal mode.
- Gently push the left joystick forward to traverse forward slowly and also try to observe any strange behavior or sounds.
- Gently push the left joystick backward to trolley backward slowly and also try to observe any strange behavior or sounds.

Skew operation test procedure

- Switch on the drives.
- Enter maintenance password and the service icon will appear.
- Select the service icon and then select “skew” to go the skew page.

- Select the “ON” icon to switch on the skew single mode.
- Select button “1” on the touch panel to select skew motor one.
- While pressing the skew button on the left joystick twist the joystick clockwise and check that the spreader rotates clockwise.
- While still holding the skew button, twist the joystick counterclockwise and check that the spreader rotates counterclockwise.
- Release joystick and push button “1” to deselect skew motor.
- Push button “2” on the touch panel to select skew motor two.
- While pressing the skew button on the left joystick twist the joystick clockwise and check that the spreader rotates clockwise.
- While still holding the skew button, twist the joystick counterclockwise and check that the spreader rotates counterclockwise.
- Release joystick and push button “2” to deselect the skew motor.
- Select the “OFF” icon to switch the skew single mode and exit from the page.

If the spreader is noticed to turn counterclockwise when it should turn clockwise when any of the two motors is selected, this should be noted so that the direction of rotation of the motor can be changed afterwards.

6.5.2 Miscellaneous

This part involves checking the functionality of some safety device such as the cat whiskers, ultrasonic sensors and limit switches for the ladder, shore power and operator’s cabin gates. During this test, especially the limits at the gate and gate locks, it is important to ensure that the switches actuate properly. Therefore any necessary adjustments should be made.

Cat whiskers and Ultrasonic

- On the CMS computer, click on “monitoring” and then click on “gantry” to get to the gantry page.
- Go to bogie, A, corner, actuate the cat whisker limit by moving the actuation lever and release.
- While doing the step above, check that the relevant switch indicator status changes on the screen from “1” to “0” at the same time when the switch is actuated and it changes from “0” to “1” when the lever is released.
- Next, block the ultrasonic sensor view at corner A. To do this stand at about 60cm in front of the sensor to activate the sensor and then unblock to deactivate.
- While doing the step above, check that the right ultrasonic indicator status changes from “1” to “0” when the view is blocked and changes from “0” to “1” when unblocked.
- Repeat the cat whisker and ultrasonic sensor tests of others at bogies B, C and D corners.

Ladder and Shore power

- Remain on the gantry page of the CMS screen.

- Remove the E. Room access ladder to deactivate limit switch and check that the indicator on the screen changes from “0” to “1”.
- Now stow the ladder to activate the switch and check that the indicator changes from “1” to “0”.
- Remove shore power plug from the socket to deactivate the limit switch and check that the indicator changes from “1” to “0”.
- Insert the plug back into the socket to activate the switch and check that indicator changes from “0” to “1”.

Operator’s cabin gates

- Open cabin side gate and check from the operator’s cabin screen that gate lock Z-S411 and limit switch O-S05 events are displayed.
- Close the cabin side gate and confirm that the events mentioned above disappear or become inactive.
- Open gantry side gate and check from the operator’s cabin screen that gate lock Z-S101and limit switch O-S07 events are displayed.
- Close the cabin side gate and confirm that the events mentioned above become inactive.

Note that at the end of this operational test, the commissioning phase would then be forty percent (40%) completed.

6.6 Crane set up

This set up involves setting up the encoders and limits switches to ensure that the crane operational functions work as required. Here, we will set-up the load cells, hoist limits, trolley limits, and skews limits. Note that all values used here are in meters, the only exception is the load cell calibration and all set ups are going to be described to be done from the operator cabin.

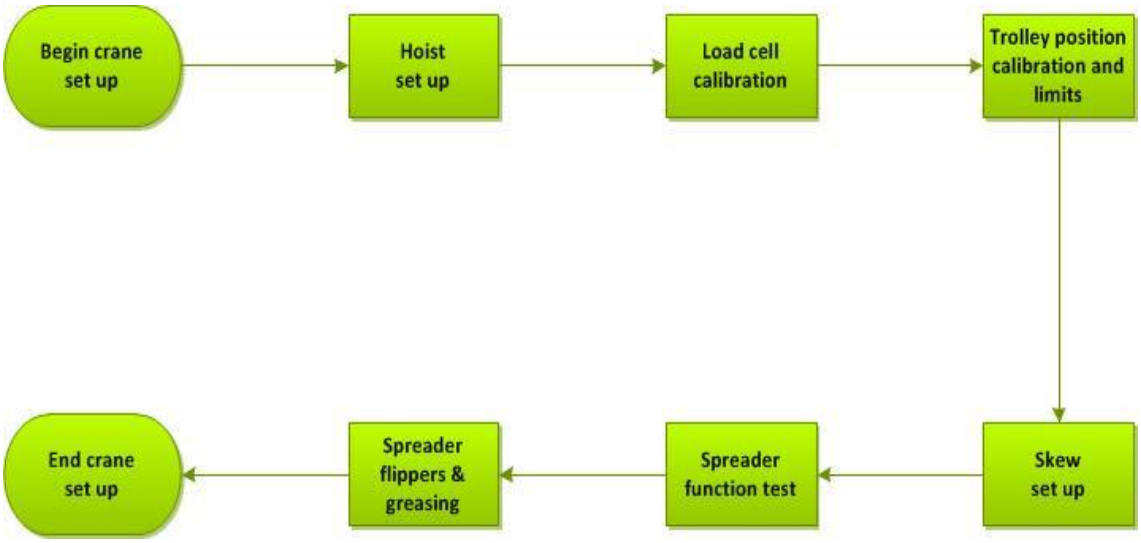

Figure 20 Simple crane set up process flow

6.6.1 Hoist set up

The limits for the hoists are either software initiated or hardware initiated depending on the limits. There are also two absolute encoders, one for each hoist motor. Before the limit adjustment, we have to calibrate the encoders so that the readings of the encoder from both hoists motor change concurrently.

Personnel required

- Electrical personnel
- Mechanical / electrical personnel

Tools required

- 10mm spanner wrench
- 13mm spanner wrench
- 2.5mm allen key wrench
- 4mm allen key wrench
- Screw driver (small flat head)
- Measuring tape

First, we will do these tasks below

- Ensure that the drive switch is off.
- Unscrew encoder guard box bolts and remove box. This box is beside the hoist brake.
- Open the hoist limit switch box cover.
- Check that the encoder coupling is tight and does not slip. This can be done by just trying to turn the coupling (it should be firm) and checking the lock screws are tightened.
- Slacken the limit switch lock nut to release the limit switch cams.

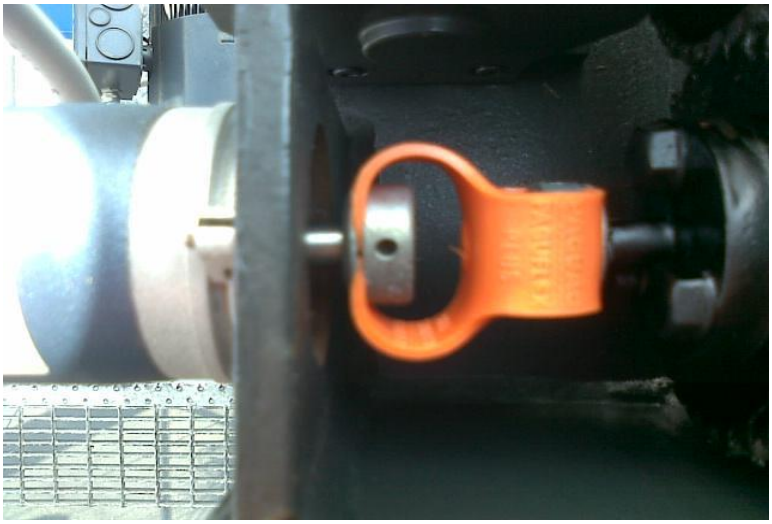

Figure 21 Encoder coupling

The purpose of doing the above tasks is to ensure that we get accurate hoist position values when hoisting and also to adjust the cam when we have.

Hoist position calibration

If while performing this task, the up stop limit or emergency stop limit is activated, then go to the cam assembly and turn the cams by hand so that the cam sides are down and then the drives can be restarted.

- Switch on the drives and check that crane maintenance mode is activated.
- Slowly drive the crane to an area with a leveled ground as possible.
- Lower the spreader until it is just below the sill beam of the access side, as seen below.

Figure 22 Spreader in leveled position with the sill beam

- While other personnel observes, try to level the spreader using the sill beam as a reference, ensuring that the spreader is straight when compared with the beam.
- When the above has been achieved, lower the spreader to measure one meter from spreader to ground level. Confirm the distance by measuring from twist-lock frame to the ground.

Figure 23 A spreader side shown at a meter to ground level

- Confirm measurement from at least two sides of the spreader, for instance side B and C.
- Enter maintenance password “0202”, to enable additional service functions on the hoist limit page.
- Select “monitoring” and then select “hoist limits”.
- If it is certain that the spreader has been correctly leveled and it is at one meter from the ground, push the “calibrate” button and check that hoist 1 and hoist 2 values change to “1.00”.

Hoist limits

It is recommended that two persons perform this task but one person is also able to perform the task. In the event of two persons performing this task, one person checks the status of the limits from the operator’s cabin touch panel while the other person does the actual limit adjustment. Four limit adjustments will be made for each hoist; one adjustment will be made on each hoist at a time. Always, we will start with the hoist calibra-

tion limit adjustment (done at 8.00 meter spreader height from ground level). Next is the hoist up stop limit adjustment (done at 18.40 meter spreader height from ground level), emergency stop limit adjustment (done at 18.50 spreader height from ground level) and down stop limit adjustment (done while the spreader on the ground with slack rope). There are five cams on each limit switch assemblies. From left to right: the first cam is a spare, the second cam is for down limit, the third and biggest cam (also the lead cam) is for eight meter calibration limit, fourth cam is for up stop limit and the fifth cam is for emergency stop.

Now, we have to adjust the cams so that they activate the switch at the appropriate spreader heights.

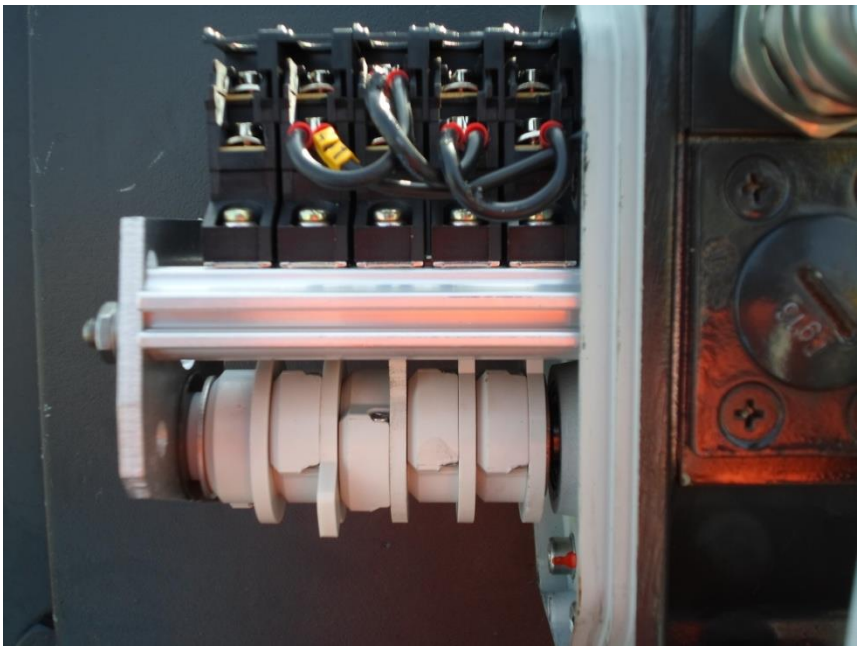

Figure 24 Hoist limit switch cams

8.00 meter calibration limit.

- Check that the drives switch is on, service mode is active on the touch panel and crane maintenance mode is on. If maintenance mode is not on, the crane will always try to level the spreader every time.
- Hoist up slowly until both hoist positions values are 8.00 meter and stop. Ensure that the required value is got while hoisting up only because of the gearbox backlash.
- At hoist one cam assembly, turn the 8.00 meter calibration cam screw so that the cam rotates counterclockwise.
- Continue turning the screw and stop immediately the cam activates the switch (the switch makes a click sound when activated). We can also confirm this by checking that the status for the 8.00 meter calibration limit changes to “1” when the switch is activated on the hoist limit page.

Note that the adjustment must be stopped immediately the click sound of the switch is heard or when the status for the limit is activated; "1" on the hoist limit page of the touch panel.

- Tighten the cam assembly lock nut to the required torque limit.
- Repeat this same cam adjustment procedure on the hoist two, cam assembly. Tighten the cam lock nut to the required torque limit when it is done.
- Now after both hoist cams have been adjusted, we have to check that the adjustment was properly done.
- Slowly lower the spreader, until both hoists one and two 8.00 meter calibration indicator changes to "0" and stop.
- Now slowly raise the spreader, while raising check at what spreader height does the 8.00 meter indicator for both hoists activate.

Note that the limits must be adjusted so that both hoist limits reach the 8.00 meters height at the same time. Only a tolerance of positive or negative 0.01 meter is acceptable if necessary, ensuring that the tolerance of the height difference between hoist 1 and 2 is positive or negative 0.01 meter. If these criterions are not met, the set-up must be repeated on the hoist that does not meet the criterion until it is properly done.

If the calibration set up is properly done, next is to set up the hardware stop limit, the height at which the hardware limit and the safety limit are activated depends on the RTG's lifting height, which can be found on the "rating plate" of the crane. In other words, the height at which this hardware limit will be set up is dependent on the lifting height of this spreader. Remember that the cam assembly lock nut must remain tightened all through the rest of the cam adjustments.

- Raise the spreader up slowly until the software limit stop is reached at 18.20m spreader height from ground level. Now, hoisting up is not possible, only hoisting down is possible.
- On the hoist limit page, select the "SW bypass" button to enable the hoisting up operation.
- Hoist up the spreader until the height reaches 18.40 meter for both hoists values, ensure that the value is gotten while hoisting up only as before.
- On the hoist one cam assembly, turn the "up stop limit cam screw" so that the cam rotates counterclockwise.
- Continue turning the screw and stop immediately the cam activates the switch (the switch makes a click sound when activated). We can also confirm this by checking that the status for the up stop limit indicator changes to "1" when the switch is activated on the hoist limit page.
- Repeat this same cam adjustment procedure on the hoist two, cam assembly.
- Now after both hoist cams have been adjusted, we have to check that the adjustment was properly done.
- Slowly lower the spreader, until both hoists one and two 18.40 meter up stop limit changes to "0".

- Now slowly raise the spreader and while raising check the value at which the spreader height of the up stop limit indicator for both hoists activate.

Similar to the hoist calibration limit, both up stop limit indicators must be activated at the same time for both hoists and the their activation values should be 18.40 meter, a possible tolerance of positive or negative 1 acceptable.

After the completion of the up stop limit cam, we are going to set up the emergency stop limit cam. Now that the up stop limit is reached, hoisting up will be impossible but it will be possible to hoist down. But to set up the emergency stop limit, we have to hoist up more. Therefore, the maintenance mode has to be made active to set up the emergency stop limit.

- Check that the maintenance mode is still on, if not, put it on.
- Hoist up slowly until the hoist position values of both hoists reach a value of 18.50 meter. While hoisting to the required height, simultaneously monitor the distance between the top of the spreader (or head block) and underneath the trolley to confirm there is considerable gap between them.
- On the hoist one cam assembly, turn the emergency stop limit cam screw so that the cam rotates counterclockwise.
- Continue turning the screw and stop immediately the cam activates the switch (the switch makes a click sound when activated). We can also confirm this by checking that the status for the emergency stop indicator changes to “1” when the switch is activated.
- Repeat this same cam adjustment procedure on the hoist two, cam assembly.
- Now after both hoist cams have been adjusted, we also have to check that the adjustment was properly done

Note that the drives will be off because the emergency stop circuit has been triggered. Push the reset push button A-S13, in the trolley E2.1 cubicle to reset the circuit.

- Start the drives.
- Slowly lower the spreader until both hoist one and two, emergency stop limit change to “0”.
- Now slowly raise the spreader and while raising check the spreader height value at which the emergency stop limit indicator for both hoists activate.
- Repeat the emergency stop limit set up for both hoists if they do not activate at the 18.50 meter. Although, a tolerance of negative 2 is acceptable and the most important thing is that the hoist activation value must not be greater than 18.50 meter.

Finally on the hoist, is to set up the down stop limit cam. After the emergency stop limit has been completed, we can put off maintenance mode and also remember to remove the SW bypass.

- Check that the drives switch is on and maintenance mode is off.
- Slowly hoist down until the spreader touches the ground.
- To slack the rope, push the slack rope button at the same time pushing the right joystick to slack the hoist rope.
- Continue to slack the hoist rope until both hoist position values reach about negative 0.13 meter.
- On the hoist one cam assembly, turn the down limit cam screw so that the cam rotates clockwise.
- Continue to turn the cam until it activates the limit switch and stop immediately. Just as the previous cams, this can also be checked from the hoist limit page. The down stop limit indicator should change to "1" when the switch is activated.
- Repeat this same cam adjustment procedure on the hoist two, cam assembly
- To check, slowly raise the spreader up until the down stop indicator changes to "0"
- Slowly lower the spreader again until the down stop limits for both hoists are activated.
- If they do not activate at the same time repeat the set up procedure until they both activate at the same time. Tolerance of positive or negative 2 is acceptable.

After all the cams have been set up, we can now hoist the spreader through all the limit heights to check that the set ups were properly done.

6.6.2 Load cell calibration

There are four load cells on the trolley assembly, each one measuring the load on each rope. ZA1-B1 and ZA1-B2 for hoist one and ZA2-B1 and ZA2-B2 for hoist two. Each rope load cell measures a certain amount of load and to measure properly the load cells have to be calibrated. Also so that the net load measured by the four load cells is the same as the actual spreader weight (although there might a little difference). If this set up is not done, the load cells may assume that there is either no load or too much load thereby affecting the crane hoist operation. The usual problem is that the net load measured by the load cells collectively is lower than the net load of the spreader and the typical symptom is that the hoist operation is slow during operation.

The set up may be done either from the E. room or from the operator cabin, but this procedure will be described for set up to be done from the operator cabin. Typically this calibration may be required to be done several times. To do this calibration correctly, we need to know how much load each load cell measures as the rope "weight rope" and "spreader weight". Because each rope is situated at each load cell, therefore, each load cell measures own rope weight plus the spreader weight. The spreader weight is evenly distributed amongst all the four load cells. This means that since the spreader weight is about 12tonnes, the spreader weight carried by each load cell is approximately 3tonnes. The spreader weight depends on the type of the RTG. This spreader weight measured by the load cells will ei-

ther be the spreader weight only or the weight of the spreader plus head block (if the head block is used).

Calibration procedure

- Switch on the drives, enter maintenance mode password “0202” and do not switch on maintenance mode.
- Lower the spreader down to ground level, until spreader touches the ground.
- Slacken the rope, just a little to relief the load cells from the spreader weight; this means the load cell will only be measuring the rope weight.
- On the touch panel, select “service” and then select “load cells” to open load cell page; each load cell is displayed to be on four corners on the touch panel screen.
- Note the rope weight on each of the load cells; it should normally, about 1tonne.
- Remain on this page and hoist up the spreader. Stop just as the spreader lifts up from the ground.
- Now check the weight on each of the load cells from the touch panel screen (this new weight should be greater than the rope weight), let us call this measured weight “X”
- Now subtract the rope weight from the “X” (“X” – rope weight). Now note the value for each of the load cell.
- Whatever value got from the above mathematical expression, let us call this “Y”. This is what the load cell assumes to be the spreader weight carried by each rope.
- Each load cell should measure a spreader weight of about 3tonnes.
- If “Y” is less than 3tonnes. Subtract “Y” value from the 3tonnes (3 - Y). But if Y is greater, the equation is Y - 3.
- The value got from above, say “Z”, for each load cell, is what should be added to (or subtracted from) each load cell value on the screen to calibrate the load cells.
- Still on the load cell page, select rope 1; an indicator bar should appear. Add “Z” to the current value of the load cell (X + Z).
- Value from the above addition is now the final calibration weight for “rope 1” load cell. Now, set the load cell value to value that was derived from the equation.

Note that if the value, Y is greater than 3tonnes. The calculation will be done in the form Z – X instead of (X + Z).

- Repeat the steps above for rope 2, rope 3 and rope 4 and set the load cell values.
- After all ropes have been done, cancel the load cell page and raise the spreader to about 13 meters height and lower the spreader again to about 2 meters to check if the calibration was properly done.
- If the symptom such as slow hoist speed occurs, then we may need to recalibrate in order to compensate.

It is important to know that the load cell values or weight should be the same values or almost equal after calibration.

6.6.3 Trolley position calibration and limits

For the trolley calibration and limit set ups, there are magnetic switches and limit switches needed to complete this procedure. There are two magnetic switches, one for the forward travel direction of the trolley and the second for the backward travel direction of the trolley. The backward magnetic switch (when activated by the green magnet) triggers the back slow down of the trolley speed and re-calibrates the trolley encoder when the switch travels over the magnetic only when the trolley travels in the backward direction. The forward magnetic switch (activated by the red magnet) is only responsible for trolley speed slow down when trolley is travelling in the forward direction. The forward magnet (red magnet) is also responsible for regulating the maximum travel distance (can be found on the rating plate) of the trolley, which is also dependent on the project. There is only one limit switch, which is responsible for the forward and backward stop limits. The limit switch is triggered by the cam at either the forward position or backward position. First part of the procedure is to do the position calibration while the second part involves setting up the stop limits. The position calibration set up involves positioning the magnet at exactly where it should be when the magnetic switch travels over it.

Figure 25 Trolley backward limit magnet

Figure 26 Trolley forward limit magnet

Personnel required

- Electrical personnel
- Mechanical / electrical personnel

Tools and materials required

- 10mm spanner wrench
- 13mm spanner wrench
- Measuring tape
- Two 17mm spanner wrench

First, we will start with the backward slow down. To this calibration, we need to define a reference point as the starting point of the trolley because whenever the magnetic switch travels backward over the green magnet, the trolley position is re-calibrated to be at 2.97 meters from the reference point. The reference point we have to define is always the trolley gate position, which means that whenever the trolley is at the trolley gate position it is at its starting point, “0.00”. Therefore, will have to travel over the green magnet to find out where the trolley gate position (or the 0.00 point) is.

Procedure

- Switch on the drives, check maintenance mode is inactive and bogies should be in normal position.
- On the touch panel screen main menu, select monitoring and then trolley limit to open trolley limits page.
- Slowly trolley forward by pushing the left joystick, forward.
- Continue to trolley forward until the backward magnetic switch travels over the green magnet.

- Stop and push the left joystick backwards to slowly start to trolley backwards and travel over the back magnet. When the switch passes over the magnet; the backward slow down status on the limit page should change to “1”.
- Continue to trolley backwards until the cabin trolley gate is in line with the gantry cabin access gate, as in the figure below

Figure 27 Gate aligned when trolley is at gate position

- Try to get the gates as aligned as possible as seen in the figure above.
- Now, note the trolley position value from the trolley limit page, say X (if not sure about the value, drive the trolley forward and backward again to re-check the value)

Since we want the gate alignment as the “0.00” position, we will now have to do the set up by moving the green magnet either forward or backward depending on the value of X. Hence, only one of the two steps below will be done depending on value of X.

- If X is greater than 0.00, we have to move the green magnet backwards by the value of X; so if X is 0.05 (5cm), then we move the green magnet backwards by 5cm.
- If the X is less than 0.00, we have to move the green magnet forward by the value of X; so if X is 5cm, then we will move the green magnet forward by 5cm.

Ensure that the magnet is properly tightened on the rail and set the rail properly so that the switch passes properly over magnet. After the magnet adjustment has been done, continue with the procedure below.

- Drive the trolley forward to go over the magnet until the backward slowdown status changes to “0” and stop.
- Drive trolley backwards to go to the gate position, the trolley software stop should automatically stop the trolley when the trolley position value gets to “0.00”.
- Check that the gates are still properly aligned when the trolley stops at the gate position.

Note that it may be required to do some more little adjustment of the magnet if the gates are not aligned. When this is complete, we can now move on to set up the backward stop position.

- Now the trolley should be at trolley position of 0.00.
- Enter maintenance password “0202” and go to trolley limit page.
- Select the “SW bypass” to activate the software bypass.
- Slowly drive trolley backwards to a trolley position value of negative 0.05 meter and stop.
- Now position the limit switch actuation lever down, as seen in the figure below.

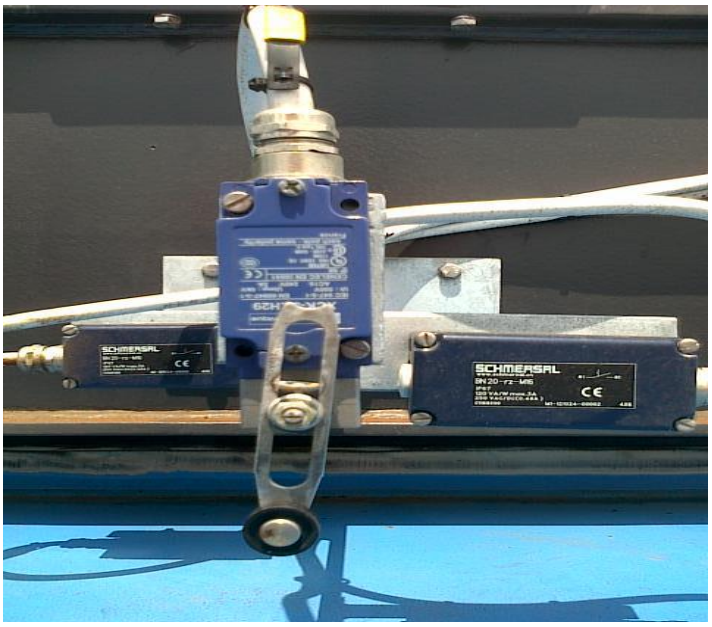

Figure 28 Trolley forward and backward stop limit switch with actuation lever positioned

- Now, slacken and move the backward stop limit cam, to push the limit switch actuation lever.
- Stop just when the limit switch is activated, this cam movement can be done several times to be sure that it exactly actuates the limit switch when you stop, a click sound is heard when the switch is activated. This can also be confirmed by the other person checking the status of the backward stop limit indicator on the trolley page; it changes to “1” when the switch is activated.
- When the cam is properly set with the limit switch, tighten the cam to remain in that position

- To check, drive the trolley forward until the switch is deactivated (or the backward stop limit indicate on the screen is “0”). Then drive backwards again to check at what trolley position does the backward stop limit indicator change status from “0” to “1”; this position should be at about -0.05 meter on the screen.
- If the trolley position is not -0.05 meter on the screen, we will repeat the procedure until we get it at the value.
- After this has been done, remain at the backward stop limit position and confirm that the two rear trolley wheels are still on the main girder rails as seen in the figure below.

Figure 29 Trolley wheel on rail (still shows some gap on the rail)

- After completion select the “SW bypass” to deactivate software by pass.

Now the trolley backward calibration and set up has been completed, next is to do the forward set up calibration.

- Remain on the trolley limit page.
- Trolley forward to a trolley position value of 18.20 meters.
- Remaining at this trolley position, slowly slide the red magnet backwards, under the forward slow down magnetic switch until the indicator on the touch panel screen changes to “1”. This can be done several times to get the exact magnet position when the switch is activated.
- Note the right magnet position and lock magnet in that position, ensure that the magnet is properly on the rail and properly underneath the magnetic switch.
- To check, drive the trolley backward slowly until the forward slowdown indicator status changes to “0”.
- Now trolley forward and check at what trolley position value does the forward slow down indicator status change to “1”
- The trolley position must be at “18.20”. If the position is incorrect, repeat the set up procedure.

When the forward slow down has been set up and properly completed, next is to set up the forward stop limit

- Remain on the trolley limit page, trolley forward more until the trolley reaches the forward software stop position; 21.16 meter.
- Now select the “SW bypass”.
- Again slowly trolley forward more until the trolley position is at 21.21 meter and stop.
- Now, slacken and move the forward stop limit cam to push the limit switch actuation level.
- Stop just when the limit switch is activated. This cam movement can be done several times to be sure of the exact position the limit switch is actuated (a click sound is heard when the switch is activated). This can also be confirmed by the other person checking the forward stop limit indicator status on the trolley page; it changes to “1” when the switch is activated.
- When the cam is properly set with the limit switch, tighten the cam to remain in that position.
- To check, drive the trolley backward until the switch is deactivated or the forward stop limit indicator changes to “0”. Then drive forward again to check at what trolley position does the forward stop limit indicator changes status from “0” to “1”; position should be 21.21.
- If the trolley position is not 21.21, repeat the procedure until it is properly set up.

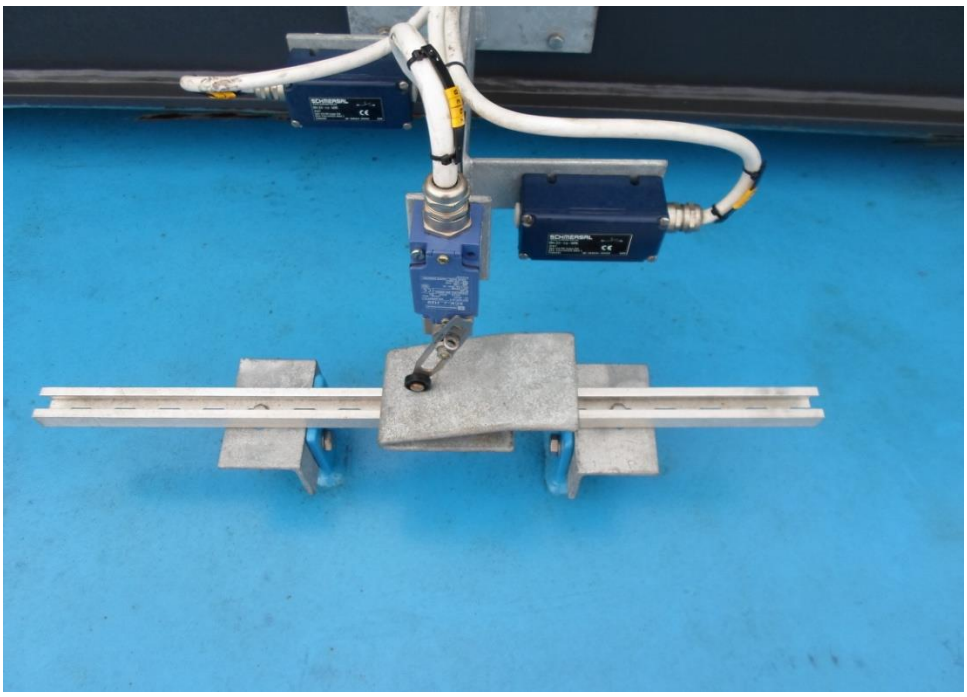

Figure 30 Trolley hardware limit switch shown actuated in forward end position after set up

- After this has been done, remain at the forward stop limit position and confirm that the two front trolley wheels are still on the main girder rails, as done previously for the rear wheels.

- After completion select the “SW bypass” to deactivate software by pass.
- Trolley backwards to trolley gate position.
- Place the guard plate (in the figure below) over the magnetic switch and tighten in position, to protect the switches from mechanical damage and rain.

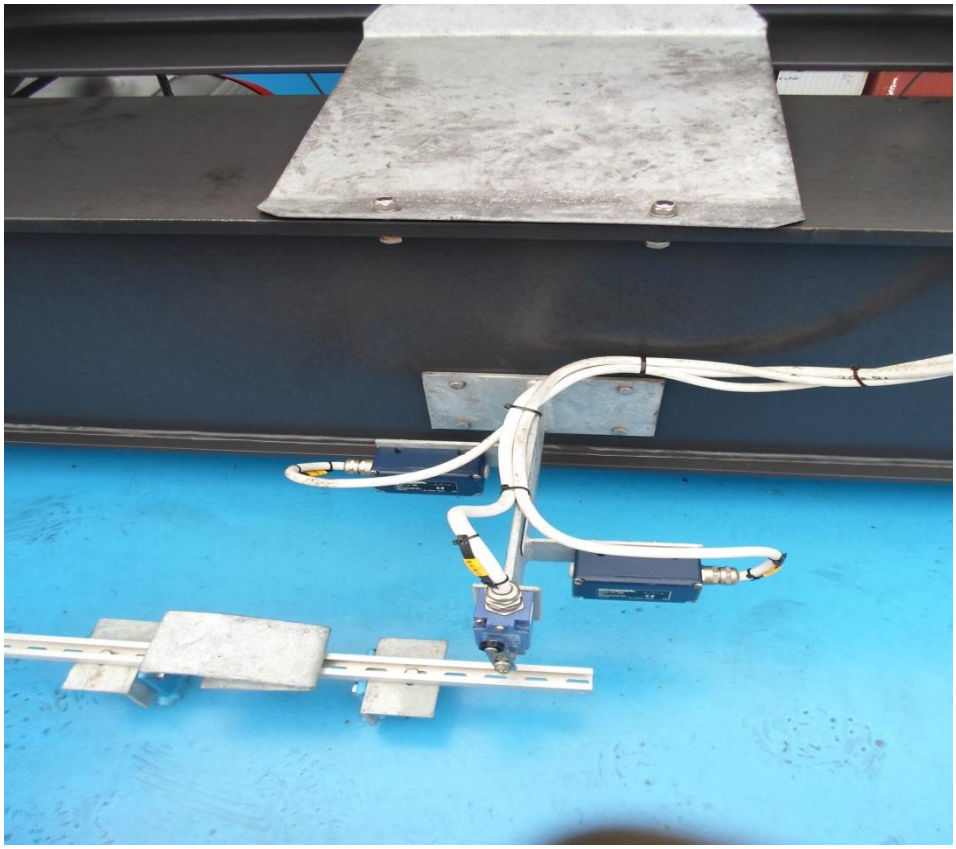

Figure 31 Magnetic switch guard plate shown in picture yet to be placed in guard position

After all the tasks have been done, we have now completed the trolley set ups.

6.6.4 Skew set up

Remember that during the operational tests, we have confirmed the direction of rotation of the skew motors and also checked that both motor work properly. We are now left to complete the skew set up. There is one encoder on each skew motor, which gives the feedback value of the skew motor position and there are also two limit switches, one on each skew winch; each responsible as an hardware stop limit in a case where the skew goes beyond the software limit.

Personnel required

- Electrical / mechanical personnel

Tool required

- Two 13mm spanner wrench

Procedure

- Remove the two skew limit switch stoppers from each of the skew winch (four stoppers in total).
- Switch on the drives and check that maintenance mode is inactive.
- First trolley forward to about 1.00 meter.
- Lower the spreader to the sill beam level, in order to use the sill beam as a reference to check the horizontal straightness of the spreader.
- Skew the spreader until it is horizontally straight, also using the sill beam as a reference.
- Enter maintenance password and go to the skew page.
- Select skew motor 1 to activate the motor.
- Select calibrate on the page, the motor skew position changes to “0.0” after calibration.
- Select skew motor 2 to activate the motor.
- Select calibrate on the page, the motor skew position changes to “0.0” after calibration.
- Now, go to the main page on the touch panel.
- Select “angles” as one of the screen displays (this includes skew angle positions), the skew position should be “0.0 degree” now
- To check the calibration, skew full clockwise, the skew operation should stop automatically when the skew position reaches a value of “5.6 degrees”.
- Skew full counterclockwise, the skew operation should stop automatically when the skew position reaches a value of “-5.6 degrees”.
- Return skew to the 0.0 degree position (we can also use the skew reset button). This is now the spreader primary position at 0.0 degree.
- If the check does not work as described above repeat the calibrate procedure again.

Skew hardware stop limit

- First, set the limit switch actuation levers of switch for both winch one and two, so that the lever roller side is down; as seen below.

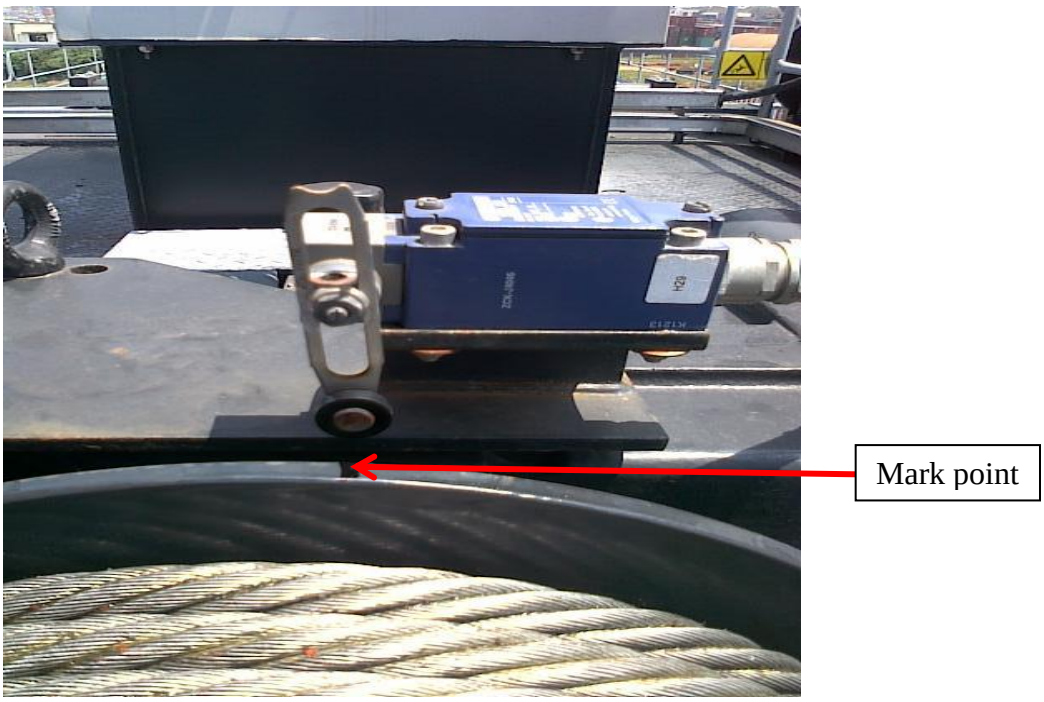

Figure 32 Skew hardware stop limit switch with the actuation lever positioned

- Mark winch one and two position just under the limit switch lever (this is to help note the direction of winch rotation), see the figure above.
- Skew full clockwise until skew position software limit is reached, 5.6 degrees.
- Position and tighten the stopper of both skew winches, so that the stopper will activate the switch if it skew goes past the software limit.
- Now, skew full counterclockwise until skew position software limit is reached, -5.6 degrees.
- Position and tighten the stopper of both skew winches, so that the stopper will activate the switch if it skew goes past the software limit.
- Now, skew the spreader back to the “0.0 degrees” position.

On completion of the skew set up and the spreader is set to skew zero (0.0) degree position, we will notice that each limit switch actuation lever will be just in the middle of the two stoppers on each winch. Now that set ups have now been completed, we are can now proceed to checking the spreader functions.

6.6.5 Spreader function test

The spreader is normally factory tested and should be in good working condition before it is transported. Basically, we will only need to check all the spreader devices. Also depending on the project, the spreader arm can be set to four different positions: 20 foot, 30, foot, 40 foot and 45 foot positions. All selection options are available on the crane but in this procedure only the 20 foot and 40 foot positions are discussed.

Procedure

- Switch on spreader switch, M-S477.
- Switch on the drives.
- Lower the spreader to about 0.50 meter.
- Switch on spreader main isolator switch.
- Open spreader cubicle to switch on all circuit breakers.
- Check that spreader emergency stop is deactivated.
- On the right hand console, push the "40 foot" button to extend.
- After full extension of the spreader, push the "20 foot" button to retract the spreader.
- Extend the spreader to 40 foot, push the spreader emergency switch during the extension operation to test the emergency switch.
- Release emergency and retract spreader back to 20 foot position.
- Note and fix any problems that may occur.

Now, all operational tests, calibrations and set ups have been done and completed. Before leaving the cabin, we have to raise the spreader up to about 13 meters height and check that trolley is at trolley gate position.

6.6.6 Spreader flippers and Greasing

The spreader is normally delivered to the erection site without the flippers attached to it. Hence, the flippers are to be attached at this stage. To do this, the spreader has to be lowered to a workable height and then the flippers can be fixed to the spreader.

Some mechanical parts of the crane are to be greased in order to aid swift movement of the mechanical parts and also prevent rust. These parts are greased using special grease types, therefore it is very important to ensure that only the specified grease types are used when greasing. The parts to be greased include: hoist ropes, hoist drums grooves, skew ropes, spreader chain, trolley wheel bearings, skew machinery bearings, gantry bogie king pin bearings, gantry wheel bearings and electrical room door. However some of these parts may have been greased already during the cranes erection.

After the tasks above have been completed, the commissioning phase has now reached about ninety percent completion (90%).

6.7 Interlocks and safety tests

This testing process stage involves testing the crane interlocks and covers the remaining 10% of the commissioning phase. The interlocks are electrically triggered functions of the crane which acts as a form of safety feature for the crane. These interlocks are controlled by both hardwired control and software program. There are different interlock functions on the crane for the different operational functions of the crane, they include: gantry interlocks, trolley interlocks, hoist interlocks, spreader interlock and emergency stops. We will also inspect other operational safety features of the

crane such as the crane SWL, overload test, and speed test (with load and without load). In order to complete this stage, we will have to make use of a "test specification manual" (see appendix 3). The manual includes crane safety tests and other tests that must be done to certify the crane quality.

The specification manual is divided into six chapters and each chapter will be further described separately. Note that the test specification manual used during this test is usually the same used during the final test with the customer. This specification manual is a standard test manual developed to test all RTGs before they are delivered to the customers. In the following chapters, we will see the procedures of how to perform the tasks in the specification manual. A minimum of 2 personnel is required for the completion of the tasks during this stage. The use of basic tools such as screw drivers, side cutters and pliers may also come in handy at some point.

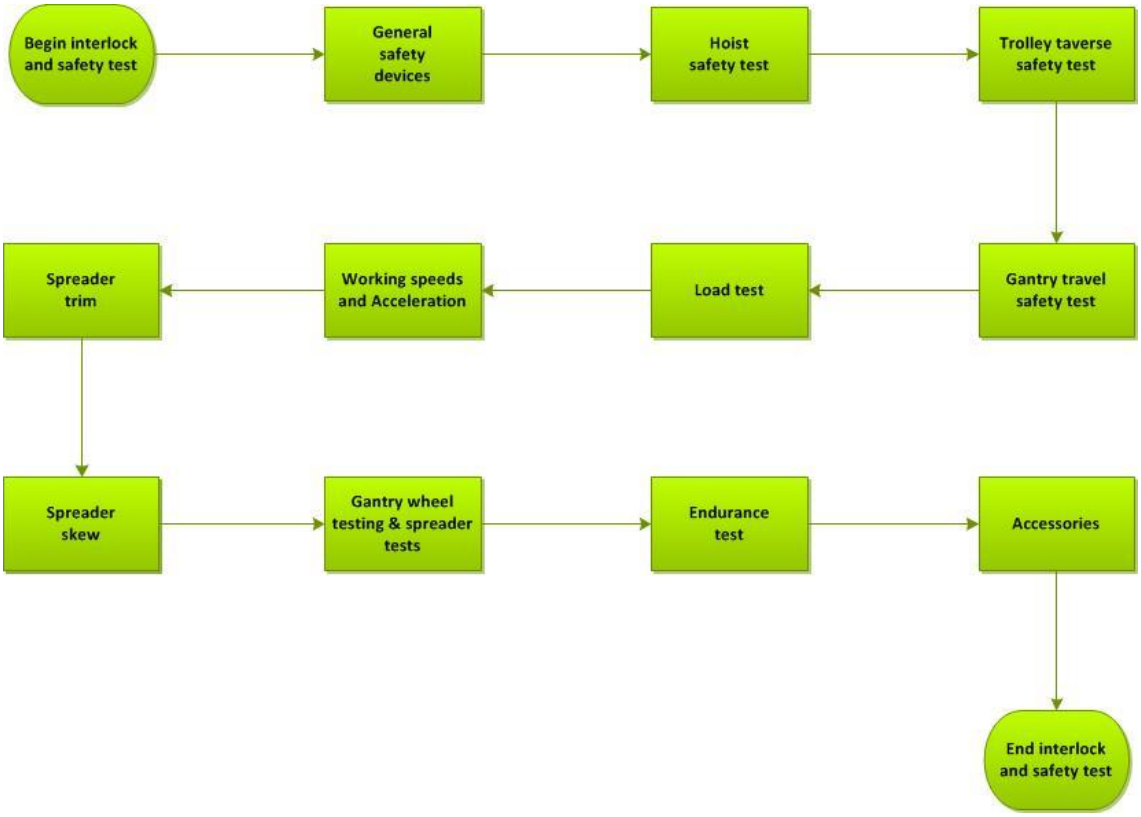

Figure 33 Simple interlock and safety test process flow

6.7.1 General safety devices

First we will start with the inspection of all general safety devices on the crane, these are: emergency stops, hazard plates and warning horns. To perform the emergency stops inspection, the drives will be switched on, any of the crane operations will be performed and then the emergency stop will then be pushed during the operation. Note that this test should be performed only in crane normal operation mode and not maintenance mode. Only use maintenance mode when specified.
Procedure

Emergency stops

- Switch on the drives from the operator's cabin.
- Slowly gantry the crane to any desired direction, and while performing the gantry operation push the operator's cabin E. stop switch (R-S8).
- The drives should shut down after pushing the E. stop and stopping the gantry operation.
- Release the E. stop and start the drives to repeat the test with all other crane E. stops.

Diesel emergency stops

- Switch on the drives from the operator's cabin.
- Slowly perform any of the crane's basic operation and push the diesel emergency stop, D-S471, in the operator's cabin.
- This will cause the diesel generator engine to shut down.
- Restart the engine and repeat the steps above to test the diesel E. stop at the diesel panel.

Next is to check that all the hazard plates are present at their respective locations on the crane. The operator cabin's warning horn and travel alarm can be inspected in parallel with the emergency stop inspections.

Warning horn and travel alarm inspection

- Switch on the drives.
- Press the warning on button on the right joystick and listen to hear the horn sound.
- Gantry the crane to any direction. During the operation try to listen for the travel alarm sound. There is one alarm located at each bogie corner.

6.7.2 Hoist safety

This check involves simulating the specific faults in order to confirm that the devices and software commands are triggered when a fault occurs. Some tests at this stage also require that the hoist limit set up is completed.

Fault test procedures

Hoist motion prohibited if hoist brake(s) not released

To also perform this task, a simulation is required and this can be done using either hoist 1 or hoist 2 brake modules, A1-G7 or A2-G7 respectively.

- First, check that the drives are off
- In the trolley cubicle E2.1, remove the fuse from any of the brake modules, A1-G7 or A2-G7.
- Switch on the drives from the operator's cabin.

- With the joystick try hoisting in any direction.
- A motion prohibited fault should display, stating that; a hoist brake is not released.
- Once confirmed, switch off the drives and return brake module fuse.

Over speed switch

For this task, any of the hoist drive inverters can be used: AR1-A1 and AR2-A1. Also avoid touching any of the cards with bare hands as this may damage the electronic devices on the card. An electrostatic discharge hand glove can be used when removing the card from the inverter.

- Hoist up the spreader to height of about 11 meters.
- Switch off the drives and check that the hoist inverters, AR1-A1 and AR2-A1 are off.
- Open the cover of any of the inverters to access the speed supervision card unit.
- Configure the dip switch setting to set for over speed trip.
- Switch on the drives from the operator's cabin.
- With the joystick try hoisting in any direction.
- A hoist speed supervision fault should display while hoisting, therefore preventing and stopping the hoist operation.
- Switch off the drives and wait until the inverters turns off.
- Return the speed card unit dip switch setting back to normal
- Close the inverter cover

Other tests

- Switch on the drives from the operator's cabin
- First, hoist down at full speed and continue to the hoist down until the speed slows down to confirm "**Lower slowdown**"
- After the hoist slows down, continue to hoist down until the spreader touches the ground.
- Use the slack rope bypass button and still hoisting down to slack the rope.
- Hoisting should stop when the down limit is reached to confirm "**Lower normal stop rotating limit switch**".
- Now, slowly hoist up and continue until the spreader does not touch the ground anymore, at spreader height of about one meter.
- Hoist up at full speed until the speed slows down to confirm "**Upper slowdown**".
- Continue to hoist up until the software stop limit is reached.
- Enter the maintenance password, navigate to hoist limit page and activate the SW bypass.
- Continue to hoist up until the up stop limit is activated to confirm "**Upper normal stop rotating limit switch**".
- Now, switch on the maintenance mode and once again continue to hoist up until the hoist limit emergency stop is activated to confirm "**Upper emergency stop rotating limit switch**".

- When the check is complete, push the reset button in the trolley cubicle.
- Switch on drives, deactivate the SW bypass, switch off maintenance mode and lower the spreader.

6.7.3 Trolley traverse safety test

Procedure

- Switch on the drives from the operator's cabin.
- Hoist up the spreader to height of about 13.50 meters.
- With the trolley at the access side end, traverse forward at full speed towards the diesel engine side.
- Continue to traverse and check that the speed slows down when approaching the diesel engine side to confirm "**Slow down limit, access side**".
- Now enter the maintenance password, navigate to trolley page and select the "SW bypass" to activate bypass.
- Continue to traverse forward; to check that the trolley operation stops at the end stop limit to confirm "**End stop limit, access side**".
- Now remove the SW bypass to deactivate.
- Next, start to traverse backwards to the access side at full speed to check the backward slow down and confirm "**Slow down limit, diesel engine side**".
- Continue to traverse backwards to trolley position to confirm "**Trolley parking position**"
- Now select SW bypass to activate bypass.
- Start to traverse backwards to check that the trolley operations stops at the end stop limit to confirm "**End stop limit, diesel engine side**"
- Traverse backwards to park position.
- Remove the SW bypass
- Traverse forward to about three meters and stop, check that trolley side gate and the gantry side gate cannot open.
- Now, traverse backwards to trolley park position.
- Open the trolley side gate and try to traverse to any direction; the trolley operation should be inhibited.
- Open gantry side gate and again try to traverse to any direction; the trolley operation should be inhibited.

6.7.4 Gantry travel safety

Procedure

- Switch on the drives from the operator's cabin.
- Put bogie selector switch to park position to change bogie position.
- Try to gantry the crane in any direction to confirm "**Gantry travel prevented if all bogies not in same mode**" this operation should be inhibited.
- Return bogies back to normal position.

- Enter maintenance password and navigate to bogie single page screen.
- Switch on single mode and select any of the bogie wheels from the screen.
- Raise the locking pin of the selected wheel up.
- Leave the pin in raised position and switch off single mode.
- Now, try to gantry the crane in any direction to confirm "**Gantry travel prevented if at least one locking device open**" this operation should be inhibited.
- Switch on single mode select the same wheel and put the locking pin back down.
- Remove the E. Room access ladder from the rack.
- Try to gantry travel the crane in any direction to confirm "**Gantry travel prevented if E-house ladder not in rack**", this operation should be inhibited.
- Put the E. room access ladder back to the rack.
- Open anyone of the diesel doors.
- Now, try to gantry travel in any direction to confirm "**Gantry travel prevented if not all diesel house doors closed**", this operation should be inhibited
- Close the diesel door(s) opened earlier.
- Remove shore power plug from the socket, try to gantry travel in any direction to confirm "**Gantry travel prevented if shore power plug is not stowed**", this operation should be inhibited.
- Put the shore power plug back in the socket.
- With the bogie position in normal mode, slowly gantry travel in any direction.
- While travelling actuate corner, A, cat whisker switch to confirm "**Cat whisker limit switches**", the gantry operation should stop.
- Repeat the last step above to check cat whiskers at corners B, C and D.
- To confirm "**Ultrasonic sensor, forward detection approx. 6 m**", create an obstruction about 60cm in front of corner A ultrasonic sensor and slowly gantry travel in towards the obstruction.
- The operation should be inhibited, repeat the step for corners B, C and D.
- Now slowly gantry travel in any direction, during the operation check that the alarms and beacon lights at corners A, B, C and D are working to confirm "**Travel alarm bells and beacons**".

6.7.5 Load tests

Dynamic load test (125 % of S.W.L.)

The safe working load for the crane is 40LT but based on the specification manual a 25 percent increase of load test has to be conducted. Hence, a test load of 50 tonne load is needed for this test.

Note that the weight of the test load used also depends on the project, as the value of the safe working load may be different. Therefore a different weight value will be needed for this test in the case of another project.

Procedure

- Have a 50 tonne loaded container placed under the crane.
- Enter maintenance password on the CMS computer.
- Navigate to the CMS setting tab to enter the change for the crane "maximum load" setting from 40LT to 50LT.
- Switch on the drives from the operator's cabin.
- Lower the spreader on the loaded container and activate the twist locks.
- Lift up the load container from the ground to a height of about 50cm
- Hold container at the height for about 5 minutes.
- Lower the container and release the twist locks.
- Change the load setting on the CMS back to 40LT.

Tests of overload protection (110 % of S.W.L.)

If a flat rack was used in the previous load test, it is easier to just reduce the load on the flat rack for this test rather than changing the container (if a container was used). A test load of about 44 tonne is needed for this test.

Procedure

- Place the 44 tonne load container under the crane.
- With the spreader pick up the load and hoist load up.
- An overload fault should be displayed because the load is more than 40LT; the hoisting up operation will be inhibited.
- Also check that the trolley operation is inhibited.
- Lower the load back on the ground and release the twist locks to raise the spreader up.

6.7.6 Working speeds and accelerations

During these tests, the driving operations are done in a slightly erratic manner. Therefore care must be taking when performing this procedure and the test area should be cleared. Also when performing this test, either hoist upward direction or downward direction can be done first and the same applies to the trolley and gantry tests.

Hoist speeds / acceleration / deceleration procedure (without load)

- Switch on the drives from the operator's cabin.
- Navigate to the hoist page on the CMS computer and click on the "speeds" tab.

Hoist maximum speed

- First, drive the hoist to about 13 meters height.
- Hoist the spreader down at full speed by pushing the joystick to the end.

- While the hoisting at full speed, check the hoist speed value reached on the hoist speed page of the CMS; this should is the maximum speed
- Compare the value above with the contractual speed value written on the specification document.
- Hoist spreader up at full speed and also check that the maximum speed value reached matches that in the specification document.

Note that this speed value can be changed from the settings page of the CMS computer if the value is either lower or higher than the contractual value required.

Hoist acceleration and deceleration

- Go to the desktop screen page of the CMS computer.
- Open new Microsoft offices excel worksheet.
- Press the "CART" button when prompted and a tool opens on the excel worksheet.
- In the "discrete values" box, by double clicking select A1 for the hoist test (note that either A1 or A2 can be selected).
- In the time box enter 30 seconds and press the start button on the excel worksheet.
- Now hoist up, pull the hoist joystick instantly (not gradually) from zero speed position to full speed position so as to check the hoist up acceleration time.
- When hoist maximum speed is reached, instantly (not gradually) release the joystick from the full speed to zero speed position to check the deceleration time.
- When the hoisting operation stops, press the "trend" button on the CMS screen.
- An acceleration/deceleration time graph will be displayed on the screen.
- Check that the acceleration and deceleration times match the contractual values. The graph can be closed after the check is done.
- Repeat these steps above but this time conduct the test to check acceleration and deceleration in hoist downward direction.

Hoist speeds / acceleration / deceleration procedure (with load)

This test is similar to the test previously done. The only difference is that it has to be done with load. The weight of load stated in the specification document should be used. In this case the weight is 40 tonnes. Use the same procedure described for the hoist maximum speed and hoist acceleration and deceleration above, just ensure that the procedure is done with the hoist handling the required test load.

Trolley traversing speed / acceleration / deceleration (without load)

With respect to this specification manual used, the trolley traversing test without load in reverse direction and trolley traversing with load in forward direction operations are both omitted in this specification document.

However, this procedure will include details of the omitted checks stated above since they may be included in other specification manuals for other customers. When performing this test, it is a good practice to ensure as much as possible that the trolley speed test is done in somewhere around the mid-point of the main girder rails.

- Switch on the drives from the operator's cabin.
- Navigate to the trolley page and click on the "speeds" tab on the CMS computer.

Trolley maximum speed

- Hoist spreader up to about 13 meters height, in order to avoid too much swing during the test, and maintain this spreader height throughout this trolley procedure only if stated otherwise.
- From trolley gate position or from about one meter trolley position, trolley forward until the maximum speed is reached.
- While at maximum speed, check the maximum speed reached from the CMS computer and compare with the contractual value on the specification document.
- Also trolley backwards (reverse) until full speed is reached, check the maximum speed reached and compare the value with contractual value.

Trolley traversing acceleration and deceleration

- Go to the desktop screen page of the CMS computer.
- Open new Microsoft offices excel worksheet.
- Press the "CART" button when prompted and a tool opens on the excel worksheet.
- In the "discrete values" box, by double clicking select E1 for trolley (note that either E1 or E2 can be selected).
- In the time box enter 30 seconds and press the start button on the excel worksheet.
- Trolley forward instantly (not gradually) from zero speed position to maximum speed position to check the acceleration time.
- When trolley maximum speed is reached, instantly (not gradually) release the joystick from the full speed to zero speed position to check the deceleration time.
- When the trolley traversing operation stops, on the CMS screen press the "trend" button.
- An acceleration/deceleration time graph will be displayed on the screen.
- Check that the acceleration and deceleration times match the contractual values. The graph can be closed once the check is done.
- Repeat these steps but this time conduct the test to check acceleration and deceleration in trolley traversing backward direction

Trolley traversing speed / acceleration / deceleration (with load)

The test procedure for the trolley traversing without load is similar to this trolley test with load; just as in the case of the hoist speed test. The purpose is to check trolley speed with the specified test load weight. After picking the load, ensure that the spreader is hoisted to a height of about 13 meters before starting the trolley speed test; the reason as already mentioned is to reduce the swing as much as possible.

Gantry travel speeds / acceleration / deceleration

This test procedure requires the use of a large area because during this test procedure the crane will be driven to attain full speed in bogie normal position.

- Switch on the drives from the operator's cabin.
- Navigate to the gantry page and click on the "speeds" tab on the CMS computer.

Gantry travel maximum speed

- Hoist the spreader up to about 13 meters and traverse to about 1 meter trolley position to ensure visibility to all gantry sides.
- Gantry to the right until maximum speed is reach.
- While at full speed check that the maximum speed value reached during the travel is the same as the contractual value on the manual.
- Now, gantry full speed to the left and check that the maximum speed value reached is the same as the contractual value.

Gantry travel acceleration and deceleration

- Go to the desktop screen page of the CMS computer.
- Open new Microsoft offices excel worksheet.
- Press the "CART" button when prompted and a tool opens on the excel worksheet.
- In the "discrete values" box, by double clicking select AR1 for trolley (note that either AR1 or AR2 can be selected).
- In the time box enter 30 seconds and press the start button on the excel worksheet.
- Gantry travel to the right instantly (not gradually) from zero speed position to maximum speed position to check for acceleration time.
- When maximum speed is reached, instantly release the joystick so that the gantry travel speed reduces to zero, to check for deceleration time.
- When the gantry travel operation stops, on the CMS screen press the "trend" button.
- An acceleration/deceleration time graph will be displayed on the screen.
- Check that the acceleration and deceleration times match the contractual values. The graph can be closed once the check is completed.
- Repeat the steps described above but this time gantry travel to the left to check acceleration and deceleration of gantry travel in the left direction.

6.7.7 Spreader trim

The spreader trim operation is one which simply involves the operation of one hoist motor at a time depending on the side of the spreader being trimmed. There is also a certain trim angle that the spreader must reach when trimmed which also correlates with a certain length measurement. This measurement must be checked to confirm that the required trim angle for the operation can be reached at all times. Note that the spreader measurements checked during this procedure is done using the spreader twist lock corner as the datum point.

Procedure

- Switch on drives from the operator's cabin.
- Lower the spreader to about 1,5 meters. Ensure that the spreader is leveled and at zero trim position.
- Extend the spreader arm 40 foot position.
- At the right side of the spreader, measure the spreader distance to the ground level, A.
- Slowly trim the right side of spreader down to its full trim position.
- Measure the new spreader position to the ground level, B.
- Find the difference between values A and B, the value must be the same as the contractual value.
- Also confirm from operator's monitor screen and CMS that the trim angle is the same as the contractual value.
- Trim the spreader right side back up to return the spreader to height, A, measured previously.
- Confirm that the spreader is straight and that the spreader's distance to ground is A.
- Now, slowly trim the right side of spreader up to its full trim position.
- Measure the new spreader position to the ground level, B.
- Again find the difference between values A and B, the value must be the same as the contractual value.
- Also confirm from operator's monitor screen and CMS that the trim angle is the same contractual value.
- Return the spreader back to leveled position.

6.7.8 Spreader skew

When the skew command is given, the spreader is seen rotating either clockwise or counterclockwise depending on the direction command. When the spreader is skewed, the skew angle can be seen on the operator's monitor screen and on the CMS. This spreader rotation is also equivalent to a certain length when measured and should also be confirmed. To do this procedure, a straight object such wood of dimension, of about 20cm by 20cm by 60cm is needed. There is no special object for this, so if we get anything close to that dimension, that should also be usable. The imperative thing is that the object should have a straight edge and should be long enough for its purpose.

Procedure

- Switch on the drives from the operator's cabin.
- Traverse forward a bit to create some gap for the spreader when skewed.
- Lower the spreader to a height of about 1 meter from the ground level.
- Extend the spreader arms to 40 foot position.
- Ensure that the spreader is at zero skew position and place the wood straight side at flipper C corner of the spreader, so that the wood straight edge rests on the flipper.
- Once again, ensure that the spreader is steady and not swinging while the wood rests on the flipper.
- Now, slowly skew the spreader clockwise to the maximum skew position while the wood remains stationary.
- Wait for the spreader to stop swinging.
- Now measure the distance between the wood and the flipper (at its new position).
- Confirm that the value measured is the same as mentioned in the specification document. Also confirm that the skew angle shown on the operator's screen and the CMS.
- Return the spreader back to skew zero position and wait until the spreader is steady.
- Place the wood straight side at D corner of the spreader.
- Slowly skew the spreader counterclockwise to the maximum skew position while the wood still remains stationary.
- Wait for the spreader to stop swinging.
- Now measure the distance between the wood and the flipper (at its new position).
- Confirm that the value measured is the same as mentioned in the specification document. Also confirm that the skew angle shown on the operator's screen and the CMS.
- Finally, return the spreader back to skew zero position.

6.7.9 Gantry wheel testing and spreader tests

The gantry wheel testing to be conducted at this stage is the same as that conducted earlier, during the bogie turning test at the "operational test" stage. Therefore these tests have been done already and a repetition will not be necessary at this stage. The spreader tests will also not be necessary to repeat since the operation has already been done several times.

The spreader interlock test simply means testing the spreader emergency stop functionality. To do this test, if the spreader arm is at 20 foot position, extend the spreader arm to 40 foot position and push the emergency stop during the extension operation.

Miscellaneous tests and visual checks include only visual checks of some simple devices. For example, the floodlights only have to be switched on to check if they are working, the fire extinguisher should be checked if it has been place at its location and so on. Devices such as the intercom have

been already tested. Very important at this stage is to confirm that the oil levels in the units mentioned are good and the areas to be greased have been effectively greased. It is important to have done the insulation test earlier so that any possible problems can be captured early. However, the test values should be duplicated in the specification manual.

6.7.10 Endurance test (100 % of S.W.L. With spreader)

The endurance test can also be said as a reliability test. This test is done to ensure that the crane work efficiently without problem for a specified period of time. Usually, the endurance test done for eight hours and the crane is expected to operate problem-free for eight hours. To perform this test, a considerable large space is needed and test load(s) are required. The aim is to basically run the equipment for several hours. When the crane is continuously operated for a long period of time for the first time, there is a likelihood of the crane to experience infant problems. Any problems encountered should be fixed and the endurance test should be continued or repeated if needed. Always refer to the specification documentation in use to confirm what tests are required to be done during the endurance test and the time agreed.

This test does not necessarily have to be performed now because an endurance test will be performed with for the customer. However, it is good to run the crane for some few hours after all the tests are completed.

6.7.11 Accessories

This is basically the last set of task for this stage. Some of the accessories are optional devices and are only installed if the customer request for these additional devices. In other words, some tasks at this stage are optional since the installation of these devices is dependent on the specification of the crane ordered by the customers.

PA system, Intercom system and Camera system

PA system procedure

- In the operator’s cabin, connect the speaker wire to the amplifier, connect microphone to the amplifier and connect PA system amplifier power supply.
- Switch on the amplifier and set the selector switch to “intercom”.
- Speak to the microphone, and try to confirm that sound is produced from the speakers.

Intercom system procedure

- First check that the intercom system operator’s cabin is on and that the RJ45 cable is connected to the intercom unit in the checker’s cabin.

- Dial the intercom speaker number to dial the speaker and speak to microphone to check if it is working. After the check remember to press "C" to cancel the call.
- While another person is in the checker's cabin, dial the intercom unit in the checker's cabin and communicate with personnel, after the check cancel the call.
- Now, call the intercom unit in the operator's cabin from the checker's cabin and test that the system also works.

Camera system procedure

- Check that the camera system monitor is switched and that there is a video feed on monitor.
- Now, switch on the drives and put bogies to normal mode.
- Gantry crane to the left and check that the left side (corner C) camera feed video feed in displayed on the monitor.
- Gantry crane to the right and check that the right side (corner B) camera feed video feed in displayed on the monitor.

Note that there is a possibility of encountering some problems during the testing stage described in this chapter but any problems or faults should be fixed as soon as possible. When all tasks have been completed, the commissioning phase has reached a hundred percent (100%) completion.

6.8 Customer testing

This is the phase where the equipment has to be tested in the presence of the customer. The purpose of the customer's presence here is to conduct checks on the crane while following predefined test procedure which has been agreed upon both by Konecranes and the customer. There is a standard test specification document which in this case will likely be the same as that which must have been used during the internal testing. The customer can include some checks which they may want to be conducted during the test (but this should have been agreed earlier before this test). The customers will check that devices requested to be installed are present on the crane and that all necessary operations work as they should, so that any outage found can be fixed before handover of the crane.

The tests conducted include operational functions, interlocks and safety tests, and so on. Basically, these tests must have been done earlier, in order to avoid problems during customer testing, as this may prolong this test phase than it should normally be.

7 CONCLUSION

In conclusion, as it has been stated through this thesis, we were able to explain what the two literature parts of this report stand for and how the research method used during the project was suitable for the project. We could see from the actual work documentation, how the knowledge on process management was utilized during the thesis project. The author was

able to apply the process knowledge acquired to develop a process flow and also set the right precedence for the activities carried out during the process. Using research skills, the author was able to ask important questions related to the thesis project and learn more about the commissioning phase. Therefore, the author was able to create a narrow path and focus in order to achieve the thesis results. Being able to combine this literature and research knowledge will lead to an improved process with products (cranes) of standard quality.

Properly adhering to this procedure will aid in achieving a successful commissioning. This procedure was written based on RTG 16WA, which is the typical model of cranes which have been delivered to the West African market. This however, does not mean that this procedure cannot be used for other Konecranes' RTG models. Furthermore, this aforementioned model is different from the model that may be delivered to other parts of the world or even other cranes with the same model, but this procedure can still be used for those cranes. Most differences with crane models, RTG 16 or other types lie on the devices been used and even a crane of the same model but different types may also be equipped with different equipment. This will definitely alter the electrical drawings, which means some additions to or subtractions from the electrical drawings. The procedure also shows that customer satisfaction is put into consideration during the process of assembling the RTG, starting from the delivery of the erection stage, erection of the crane until the commissioning phase of the crane.

Furthermore, this thesis has provided better perspectives into the processes involved in the commissioning phase and describe the activities for processes in details. Hence, this documented procedure can also serve some other important purposes, such as:

- the document can be used for training purposes about the commissioning phase, especially for new company employees and even for old employees newly assigned to the RTG manufacturing department
- the document's can be used as a manual that can be archived and consulted upon whenever needed
- the document can be used as a manual for the commissioning engineer and other site engineers to enable them follow the progress during the commissioning phase
- the document also gives an assurance that commissioning has been conducted to detail without leaving any stone unturned

In addition continuous development is one of the features of a good process. This means that there can be areas within the commissioning phase that can still be developed (and even further development of this procedure). Examples of some development ideas the author suggests include:

- In the future updating the procedure so that it will cover all the accessories that were not included into the project when this procedure was written

- Making changes to the commissioning procedure document when necessary, whenever there are any development changes that may affect the commissioning procedure
- Finding opportunities to reduce the total time used during this phase. This will be easy to achieve if the procedure is used as a guide consistently.
- Overall, constant review of the document periodically.

Hence, Konecranes as well can benefit a lot from using this document as their customers. Because this document explains the commissioning phase in simpler details, that makes it easier for the technical personnel to easily handle the process. Now the completion rate can be measured easily and the whole process completed in a timely manner, therefore, translating it into improved customer satisfaction.

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COMMISSIONING CHECKLIST

DATE:

CRANE #:

PROJECT #:

CUSTOMER:

COMMISSIONING ENGINEER IN CHARGE:

Checks to be completed before start up

Before starting up the crane, some checks have to be done prior. This start up phase is the first in the commissioning process and it is a phase critical to others in the commissioning process. Therefore it is necessary to perform these tasks in order to avoid re-work in the later parts of the process, as explained in the commissioning manual.

1	Inspect diesel generator oil filters	☐
2	Inspect diesel generator fuel filters	☐
3	Check diesel generator oil level and top up if necessary	☐
4	Check diesel generator fuel level and top up	☐
5	Check diesel generator coolant level and top up if necessary	☐
6	Check that generator batteries measure up to 12 Volts	☐
7	Check motor gear box oil level and top up if necessary	☐
8	Inspect electrical wirings electrical cubicle for any loose connections	
	E1. Room,	☐
	E2 trolley electrical cubicle	☐
	E4 operator's cabin	☐
	E6 (Access side)	☐
	E5	☐
9	Check that the wind shield liquid tank is topped up	☐
10	Ensure that all circuit breakers in the electrical cubicles are in off positions	☐
11	All crane emergency stops are released	☐
12	Diesel emergency stops are released	☐
13	Isolator switch for crane O-Q1" and main isolator switch for machinery "O-Q2" are both in off position	☐
14	Bogie tire air pressure inspected	☐
15	Check that all programs needed to be downloaded are available	☐
16	All materials needed for commissioning are available	☐

Checks to be completed during and after start up

This part of the included checks that should be conducted after start up has been completed. Doing this will help to confirm that the start up phase has been conducted successfully and we can now proceed to the testing phase, as explained in the commissioning manual.

1	Diesel generator started and running	☐
2	All domestic loads are switched on	
3	Programs have been downloaded and are running	
	PLC program	☐
	Can bus program	☐
	Proface panel program	☐
4	CMS settings	
	Emergency stops selection	☐
	Crane "config" settings	☐
5	All necessary fibre optic are connected and termination resistors and bus addresses checked	☐
6	All machinery loads are on	☐
7	CMS documents have been replaced with the correct documents of recent versions	☐

Checks to be completed during and after operational test

These tasks are to be conducted after the operational tests have been completed. The operational tests are done in order to check the operational functions of the crane after start up. This stage of the process is explained in the commissioning manual.

1	Emergency stop circuit works	☐
2	Bogie encoder has been calibrated	☐
3	Bogie turning operation have been checked	☐
4	Bogie gantry operations have been checked	☐
5	Hoist operations works	☐
6	Trolley operations works	☐
7	Skew operation works	☐
8	All limit switches actuation lever have been set and properly adjusted	
	Cat whicker limit switches	☐
	Diesel doors limits switches	☐
	Ladder limit switch	☐
	Shore power limit switch	☐
	Operator's cabin gates	☐
9	Drives can be switched on	☐

Checks during and after the crane set up

These checks are to be conducted first after the crane set up and then after internal testing as explained in the manual (meaning after completing the tests using the test specification manual) explained in chapter 6.6 and 6.7 of the commissioning manual. The intent of these checks is to ensure that the crane has been successfully tested in all areas before testing with the customer.

1	Check that the hoist limits set ups have been completed	☐
2	Check that load cell calibrations have been completed	☐
3	Check that the trolley limit set ups have been completed	☐
4	Check that skew setups completed	☐
5	Spreader test completed	☐
6	Spreader flippers installed	☐
7	Interlock and safety test completed according to the test specification manual	☐
8	Rated load on spreader is used for testing	☐
9	Accessories installed and tested	☐

RTG IS NOW READY FOR CUSTOMER TESTING / ACCEPTANCE TESTING

COMMISSIONING ENGINEER SIGNATURE:_____

PLACE AND DATE:_____

Appendix 2

PROFACE PANEL POGRAM DOWNLOAD POCEDURE

This appendix page is intentionally left blank because it contains company’s confidential information

Appendix 3

This appendix page is intentionally left blank because it contains company’s confidential information