Improving Open Yard Storage in Salwa Facility Using Facility Layout Method

By

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Engineering Management Master Program

College of Engineering

Qatar University

Spring 2014
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(200403191)

THIS THESIS IS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE MASTER OF SCIENCE IN THE ENGINEERING MANAGEMENT PROGRAM AT QATAR UNIVERSITY

Supervisor: Dr. Fatih Mutlu

Co-supervisor:
Engineering Management Master Program

College of Engineering

Qatar University

Spring 2014

DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations, which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at Qatar University or other institutions.

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Name : Khalil A. Nasser____________

ID No. : 200403191________________

Date  : 12/06/2014________________
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IMPROVING OPEN YARD STORAGE IN SALWA FACILITY USING FACILITY LAYOUT METHOD

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Date : 12/6/2014
APPROVAL FOR SUBMISSION

I certify that this project report entitled “IMPROVING OPEN YARD STORAGE IN SALWA FACILITY USING FACILITY LAYOUT METHOD” was prepared by KHALIL A. NASSER has met the required standard for submission in partial fulfillment of the requirements for the award of Master of Science in Engineering Management at Qatar University.

Approved by,

Signature : _________________________

Supervisor : Dr. Fatih Mutlu

Date : _________________________

Signature : _________________________
To my nation and my people... To Palestine and Palestinians

To my family, which never gave up supporting me

To my professors, I will never be able to pay you back

To Maysaa Saker, you raised me up
I would like to acknowledge the efforts of the following persons who contributed to this project and had a great impact on the completion of the project:

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ABSTRACT

IMPROVING OPEN YARD STORAGE IN SALWA FACILITY USING FACILITY LAYOUT METHOD

Khalil A. Nasser,

Qatar University, 2014

Supervisor(s): Dr. Fatih Mutlu

Replace these abstract template lines with your own abstract words. Under Format, the Abstract section’s Font settings are 12-point font size, Regular font style and Times New Roman font and no Effects. You are supposed to follow the same style as here throughout your text. That is, same font, same paragraph and line spacing properties, same page borders.

Your abstract should not only include what the project is about but also include your design methodology and major results and findings. The abstract should not exceed one page.
ABSTRACT

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1. Introduction

Qatar Engineering & Construction Company (Qcon) is the leading National EPC & Maintenance Contractor in the Oil & Gas, Petrochemical, Fertilizer and Power industries. Formally known as MECON and was established in 1975. Since then, Qcon has contributed immensely to the hydrocarbon infrastructural development in Qatar. In an ambitious move, the management has decided to expand the company business in the GCC region and establish a new branch in UAE. The branch company was awarded a 3 years contract for main plant turnaround term contract and successfully accomplished its first shutdown job in Das Island on January 2014.

1.1 Manpower and Business

Qcon employs over 5,000 skilled personnel on permanent basis that are supplemented by short-term personnel as required to meet project needs. These human assets along with the well-equipped fabrication facilities empowered Qcon to deliver wide range of services for the oil and gas clients. The main services provided by Qcon are as the following:

- EPC Projects (Engineering, Procurement & Construction).
- Construction (Civil, Mechanical, Electrical & Instrumentation).
• Pre-Commissioning, Commissioning and Start up Services.
• Maintenance (Asset Management, Shutdowns & Technical support)
• Medium and Heavy Steel Fabrication.
• Fabrication offshore structures, including topside production facility.

1.2 Facilities and Assets

This section views the backbone of Qcon operations. Each successful company has—beside its precious human assets—good facilities that provide the employees the proper environment to deliver their tasks safely, effectively and according customer expectations. The section representation will start with equipment assets and end up with a detailed description of Salwa Facility, the one related to this project scope.

1.2.1 Plant and Machinery

Qcon has a large fleet of plant and equipment, which includes cranes up to 400 tons capacity (and access to larger ones), welding machines, compressors, generators, light towers, backhoes, plate compactors, concrete mixers, formwork. All equipment is owned, operated and maintained Qcon, and meets all customer and national certification requirements.
1.2.2 Temporary Facilities

Qcon has sufficient temporary facilities to undertake several large projects simultaneously. This includes site offices, ablution blocks, lunchrooms, stores, site fabrication shops, and all the infrastructure necessary to operate them.

1.2.3 Marine & Heavy Structural Fabrication Yard

The Qcon Marine Fabrication Yard is 135,000M2 divided into 4,500 square meters of covered workshop, a 200 meter long marine jetty suitable for berthing marine vessels (jack-ups, workboats, barges, tugs etc), and loading structures. It is capable of accommodating vessels of up to 6.5 meters draught at low tide; and loading out heavy structures and integrated topside decks with a maximum weight of 9,000 tons, which is accomplished over a piled concrete launching pad.

The yard has an open fabrication area of 98415 sq. meter for the assembly of all jackets and decks small and large size components with 22,000 sq.m used as material storage area to accommodate the projects Bulk materials. The production capacity of the yard is 16,000 tons per year.

The facility is equipped with a self-ejecting jack pneumatic control system for rolling and handling of pile sections. It also can handle pipes up to 100 Mtrs length and up to 84” diameter pipes, with capacity up to 120 ton Pile sections.
1.2.4 Headquarters (Salwa Facility)

The heart of Qcon; Salwa facility is located in the industrial city, south of Doha and occupies an area of 40200 square meters. It is the place where all company operations are controlled. It includes administrative buildings, fabrication and storage facilities such as head office building, fabrication shops, main warehouse, plant and machinery servicing workshop…etc. The main concern in this project is the open yard located in the center of Salwa facility.

Onshore Fabrication Shop

Central fabrication shop at Salwa, is an ASME Certified PP, R, S, U and U2. It is well equipped with overhead crane, sub-arc welding machines, shear press and plate rolling machine. It includes Welding School, for qualification of procedures and testing and qualification of personnel. Furthermore, it has also smaller and specialized mechanical, electrical, hydraulic, instrumentation and woodwork shops.

Open Yard

Qcon has an open yard in the middle of Salwa facility with an area of 4285 $m^2$ divided into two zones

- Materials Storage zone (A): includes 35 containers and open area for light equipment maintenance.
• Heavy equipment service zone (B): contains variety of heavy equipment and their accessories.

For the past two years and due to the rapid expansion in Qcon business, the open yard gradually became congested with a mixture of large number of old materials and new coming equipment. At the present time, the area is not capable to accommodate for the new demand and became recently a source of concern. The project will be an opportunity to reassess the current situation and come up with simple solution at lowest possible cost.
2. Problem Definition

In this section, the open yard will be deeply investigated at all levels starting from its location in Salwa, characteristics, contents and procedures it is operated with. The aim will be to identify the problem statement and define the project aim through a comprehensive study of the open yard and the activities taken place within its boundaries.

2.1 Terminologies and Definitions

To avoid any confusion that may occur due to the different terminologies used within the same area dealt with. The following diagram will be the guide to identify what is meant by every sub-area in this project. As can be seen below, every sub-area was given a unique code to be identified with. Hereafter, the used terms will represent the following meanings:

- Open yard: the area to be studied in this project and located between head office and Plant & Machinery department. This yard consists of two main areas:
  - Storage Area (A): the area dedicated for material Storage, repair and maintenance. It is facing the head office side and divided to two zones:
    - Storage Containers Zone (A1)
    - Maintenance Zone (A2)
- Heavy Equipments Service Area (B): the area dedicated for heavy vehicle maintenance and parking. This area is facing the plant and machinery department.

According to the previously mentioned classification and with the help of AutoCAD software, the exact area of each zone was identified based on the last version of Salwa facility layout drawing provided by QCON facility management. Table 1 below shows the area of each zone.
<table>
<thead>
<tr>
<th>Zone</th>
<th>Code</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Yard</td>
<td>-</td>
<td>4280</td>
</tr>
<tr>
<td>Storage Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>2070</td>
</tr>
<tr>
<td>A1 Container Zone</td>
<td></td>
<td>1735</td>
</tr>
<tr>
<td>A2 Maintenance Zone</td>
<td></td>
<td>335</td>
</tr>
<tr>
<td>Heavy Equipments’</td>
<td>B</td>
<td>2210</td>
</tr>
</tbody>
</table>

### 2.2 Zones Briefing

A decade back, the open yard was almost empty and used for temporary laydown of materials as well as parking heavy equipments. As QCON’s market share was getting larger, a decision was made to perform the tarmac works and prepare the open yard to be a temporary storage area for shutdowns and projects materials. Since that time, the company business continued to grow but without any revision for the new requirements, area layout or materials flow. The following section will provide a brief description of each zone and its function and contents.
2.2.1 Container Zone (A1):

Consists of 35 adjacent storage containers of 40 ft. standard size. Some of which are loaded with materials and equipments, others are empty or under restoration process to be used in shutdowns or projects. The number of these containers can vary from time to another based on the work load, however 28 containers are permanently found in Salwa facility.

2.2.2 Maintenance Zone (A2):

An open space in the middle of the storage area which meant to be a place to perform the maintenance activities for hydro jetting and other light mechanical equipments in addition to a shed for exchanger tube pulling process. Due to the poor management for the area it turned to be a skip for damaged materials and accordingly, the space dedicated for maintenance was reduced dramatically.

2.2.3 Heavy Equipment Servicing Area (B)

An area dedicated for heavy equipment parking and servicing. It is a property of Plant and Machinery (P&M) department, however its original boundaries contain now at least 4 storage containers which belong to logistics department. The numerous number of equipments and reduced space occupied by storage containers affected the P&M operations and promoted this issue to be a main concern of management.
2.3 Current Situation

This part is concerned with the procedure governing and activities taking place in the open yard. The understanding of activities along with the open yard layout were critical to identify the problem statement and shape the project goals. The study of present condition of the open yard will include:

- Overview of logistics department -managing storage zone (A1)- procedure of material of material issuing and releasing.
- Material tracking and reporting.
- Material handling practices.
- Issues and concerns regarding preceding processes.

2.3.1 Logistics Department

The sole responsible for ensuring the supply of materials for projects and shutdowns. The main reason behind separating it from main warehouse is to reduce the bureaucratic paperwork and chain of signatures needed to release or receive the materials. When investigating on day to day tasks, the separation seems to be more of physical nature only since both departments share the same tools and procedures to perform their tasks. The logistics department offices are located in plant and machinery area and has 35 containers located in front of the warehouse as shown in figure 1.
2.3.2 Material Tracking

The logistics department has limited manpower and relying mainly on a senior material controller and two material controllers to receive and release materials in addition to initiate purchase orders for unavailable items. The physical work including picking up, storing and verifying materials is done by a team of three helpers. The number of team members can vary since they are involved in other tasks in Salwa facility. Materials controllers have access to a locally built in logistics software. This program is a modified version of Waterwheel inventory tracking software and provides the following information:

1. Location
   a. Which storage container, if it is in Salwa facility.
b. Which site (based on project number).

2. Classification of material (Electrical, safety, hydro jetting…etc.)
   a. Every material category has a certain code, these codes will be revealed in data collection chapter.

3. Amount or quantity of material issued or returned.

4. Material tracking note number, will be known hereafter as MTN number.

5. Dates of material issue and return.

6. Material status (good, need repair or retired), applicable only for non-consumables.

The data to perform the analysis for this project was extracted from the above mentioned tracking software. Based on several meetings with QCON logistics personnel and while analyzing data imported from the tracking software, some problems were spotted. They can be divided into two categories:

- Problems related to the software itself:
  * The software interface is not user-friendly.
  * There are only two licenses available for three employees beside complications when both work at the same time which is a productivity killer.
- The programming for some functions is poor and lead to corrupted or meaningless data. This issue is very clear when it comes to materials units and date formats. The corrupted data were a crucial barrier from expanding the analysis of data in this project.

**Problems related to the utilization of the software:**

- The material controllers are not properly trained to use the software to its maximum limits.
  - Reporting tools are not being utilized.
  - The original background of staff does not seem to be related to their job.

- The data entry process is poor and does not follow a certain system. Many records could have been easier to be analyzed if data entry process was unified.

### 2.3.3 Material handling

Qcon has a large variety of materials handling equipment, ranging from cranes and forklifts to small trays. However, due to the unsuccessful storage strategy and congestion at storage area, these material handling equipments are underutilized compared with their potential abilities. There was no systematic approach for selecting
2.4 Problem statement

It was noticed that the open yard at Salwa facility is suffering from the following problems:

- Lack of space dedicated to heavy equipment, especially after updating the fleet recently.
- The storage containers are not set in a systematic manner which lead to complicate the handling of the materials.
- Poor utilization of storage zone. In fact, there is no proper system for placing the container nor shelving materials in the storage containers.
- Absence of proper housekeeping and segregation of waste materials within the area.

2.5 Project Aim

To rearrange the open yard layout to achieve better utilization of the available space and provide smart and economical solutions to ease materials workflow in the storage area. The secondary and byproduct goal will be to save more space for equipment servicing area.
3. Literature Review

This section has not been finalized yet, the topics that is going to be included are:

1. Warehouse operations
2. Warehouse design
3. Pivot tables and its importance in data analysis
4. Relationship/flow matrix

4. Project Methodology

After an extensive research on the best methodologies to start solving the problems facing QCON in its open yard, the Be SAFE method was selected to kick off as it is related to the project subject and mainly dealing with data collection which gives a better understanding of the problem. The be SAFE is originally a term stands for studying:

- Space: size and configuration of available area
- Activities: needed to accomplish the process
- Flow: the process order of routing
- Equipment: what are needed equipment for the process
The Be SAFE method philosophy is simple and straightforward which perfectly suits QCON case. The main problem with the open yard was the spontaneous decision to be used as a storage area for projects and shutdown materials as well as the randomness of applying that decision. A quick look at the nature of the problem statement will reveal that the situation would not have risen if Be SAFE was applied.

Since Be SAFE is more of an outline or a roadmap, it has to be more detailed with specific targets. Hence, the project approach will cover the following aspects:

**4.1 Space Calculations**

As the project target is to rearrange the open yard so that it can accommodate for heavy equipments and ease the materials flow, the physical characteristics must be well defined to guide the reshaping process.

- Defining the open yard areas and its different zones
  - Calculating the current areas of each zone
- Finding the materials storage capacity
  - Calculating the inner area of the storage containers.
    - Calculating the net storage volume available of each and all containers respectively.
    - Consult concerned personnel if new containers or more storage volume is required.
• Finding the required space for the heavy equipment.

4.2 Activities listing

4.2.1 Warehouse processes

In spite of the fact that almost all warehouses and storage facilities share the same processes, this section will be dedicated to study the current procedures QCON is adopting. The main purpose is to figure out the weaknesses and suggest future improvements that suits the company needs and the nature of its business and operations. The order of warehousing and material storage processes in QCON can be listed as the following:

• Receiving of materials, this process includes:
  
  o Material validation and inspection: most of equipments and specialized tools are made to meet specific requirements according to international standards. Product certificates and testing documents are very important to ensure compliance with desired quality and capabilities. Added to that, most of the time QCON will be requested to show these documents to clients for the same purposes.

  o Item recording: material controllers will be responsible to register all material entering or leaving Salwa facility using a material tracking software.
• Material Storage: every received item is sent to a certain container according to the item code of the item which represents to which material category it belongs.

• Picking process: when an item is requested with material issue voucher, a material controller or his subordinate picks requested items from the storage containers.

• Material Handling: the process where materials are physically transferred from or to storage containers using manual or operated handling means.

• Packing: it is the process in which requested items are prepared and packed for loading.
  
  o This process is not widely performed and usually done when it is necessary. This does not reflect poor practice as materials and equipments used in the construction industry are of heavy duty nature.

• Shipping of materials: when the requested materials are loaded on the transport vehicle and given facility exit permit to deliver the ordered materials to the project site. The receiving party should confirm the delivery of the materials and equipments by signing off the delivery note.

After viewing the warehousing processes in QCON, it will be beneficial to shed light on the main procedure of concern in any warehouse which is the material receiving and releasing procedure. In fact, this procedure summarizes almost all the preceding processes.
4.2.2 Material Receiving/Releasing Procedure

The logistics department mission is to supply, store and deliver required materials, tools and equipments to projects and turnarounds without failure and according to end-user requirements. The process of receiving or issuing the materials and equipments from the stores can be represented as the following:

- Issuing material for a project site
  - Material request is received from project management including
    - Material specifications
    - Quantity
  - Sr. Logistics controller will check for availability of materials on the system
    - If materials are available
      - The material issue note will be generate
      - Store document controller will prepare required materials certificates
      - Store keeper will gather and pack the materials
      - A delivery note will be received signed from project manager
    - If material is not available
• A purchase request is sent to procurement department to supply the material and charge the cost from the project budget

• Receiving Materials from site received with delivery note
  o Following checks will be done by store keeper:
    ▪ Materials received against the delivery note
    ▪ Inspect materials/tools and equipment
      • Check received materials against delivery note
      • File the materials/equipments certificates
      • Segregate, store good items and repair items as required
      • Label and register retired tools/equipment before discarding them
  o Logistic controller will record the data in the logistics software
  o Upon the availability of manpower, tools and equipment will be maintained or repaired

4.3 Flow Data

The core of the project where extensive calculations of inbound and outbound materials will be analyzed to be used in later stages to re-arrange the storage containers to achieve:
• Space saving: as seen in figure the containers are not organized in well-structured manner, there is a lot of space wasted by improper placement of containers and because of waste materials. By re-placing the containers properly, there will be potential opportunity to fully utilize the area.

• Smother work flow for stored materials by shorten the travel distance of material pick up process. The placement of containers was random and not following any system.

4.4 Equipment and Handling

It is one of the substantial elements in warehousing, obviously the efficacy of the materials flow will be directly affected by the handling methods used. QCON has a wide range of material handling equiments but not adequately been used. It will be interesting to verify if the proper equipments are used or not and how the situation can be improved.

Based on personal experience and meetings with staff working in Salwa facility, it was found that the material handling process is based on common sense and the long experience of material handling crew. However, standardizing material handling process can add a great value to QCON operations and support the project goals
towards enhancing the materials flow and ensure the handling process is done properly and safely.

4.5 Data

In this section, all required data will be collected and arranged in an organized manner in order to ease the data analysis in later stages. The start will be with the storage containers dimensions and capacity. After that, a detailed representation will be provided for the containers classification according to stored materials.

4.5.1 Containers Data

As mentioned previously, Qcon is mostly using 40ft standard size containers. The containers raw data can be shown in the following table:

<table>
<thead>
<tr>
<th>40ft Container Data</th>
<th>Dimensions (m)</th>
<th>Length</th>
<th>Width</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(m)</td>
<td>12.00</td>
<td>2.35</td>
<td>2.40</td>
</tr>
<tr>
<td>Area ($m^2$)</td>
<td>28.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume ($m^3$)</td>
<td>67.68</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1- 40ft Standard Container Data
Based on several visits to the open yard in Salwa facility, 35 containers were recorded. The storage containers were checked from inside to measure inner dimensions and calculate the maximum storage areas and volumes. At this point, it is important to shed the light on the point that all containers’ shelves which have been checked in different companies were of the same dimensions, shown in table. It still under investigation if it is based on an international standard or not. The container’s capacity data can be summarized in table.

<table>
<thead>
<tr>
<th>Shelves Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
</tr>
<tr>
<td>(m)</td>
</tr>
<tr>
<td>Shelf Area ($m^2$)</td>
</tr>
<tr>
<td>Volume ($m^3$)</td>
</tr>
</tbody>
</table>

**Table 2 - Shelves Data**

<table>
<thead>
<tr>
<th>40ft Container Storage Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelves per Container</td>
</tr>
<tr>
<td>Area of shelf</td>
</tr>
<tr>
<td>Volume of Shelf</td>
</tr>
<tr>
<td>Max Storage Volume / Container</td>
</tr>
</tbody>
</table>

**Table 3 Container Storage Capacity**
As mentioned before, the past visits to Salwa showed that the storage area has 35 containers. If it is assumed that only 33 of which are capable for material storage while the others are empty or dedicated for outside jobs, then with the assistance of table and, the maximum storage volume for 33 containers will be \( 1078.5 \text{ m}^3 \) based on 64 shelves per container.

Based on the previous data, container utilization check and questioning Qcon staff, it was found that the main problem is the organization and layout of the containers positioning, not the dedicated volume for storage purposes.

4.5.2 Material Tracking Data

Data were extracted from QCON material tracking system for the period starting from August 1st to December 11th 2013. It is believed that the range of data is providing a reliable basis for this project for the following reasons:

- The data were the most recent and reflecting the current flow of materials.
- The business demand within the mentioned period is the highest among the year.

The work load and accordingly the demand on materials are decreased on summer season (May to August) due to:

- Frequent stoppage of work caused by extreme hot temperatures. It is important to mention that QCON has been always committed to safety
regulations at work sites and is considering work force safety as its first priority.

- Reduced work hours in the holy month of Ramadan.

The raw data was converted to MS Excel format to start the analysis. It is important to mention the data fields used to perform the analysis:

- Item Code: a symbol consists of two letters, defines the material category of the item. The following table explains the meaning of each code.

<table>
<thead>
<tr>
<th>Code</th>
<th>Full Representation</th>
<th>Nature of Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>Consumables</td>
<td>Consumable materials which of one time use.</td>
</tr>
<tr>
<td>CT</td>
<td>Container Tools</td>
<td>Tools containers dedicated for shutdowns</td>
</tr>
<tr>
<td>EL</td>
<td>Electrical</td>
<td>Electrical materials</td>
</tr>
<tr>
<td>GT</td>
<td>General Tools</td>
<td>Wide range of tools for common tasks (hammers, saws… etc.)</td>
</tr>
<tr>
<td>HJ</td>
<td>Hydro Jetting</td>
<td>Tools and equipments used in hydro jetting job</td>
</tr>
<tr>
<td>HT</td>
<td>Hydra-Tight</td>
<td>Tools and equipments of Hydraulic Tightening Team</td>
</tr>
<tr>
<td>LR</td>
<td>Lifting &amp; Rigging</td>
<td>Wide range of rigging tools and accessories</td>
</tr>
</tbody>
</table>
Safety gears ranges from ear plugs, escape hoods to fire extinguishers.

Mainly used for hydro testing and other limited and specialized tasks.

- Description: material / Equipment name and specification.
- Unit: of which the item is quantity is measured by.
- Quantity: number of items issued.
- Last location: the last recorded place of the material, marked with Salwa or the project number.
- Issue Note: the material request number which is a document contains all the recorded data.
- Status: indicates the direction of materials flow, inbound or outbound.
- Transaction date: represents the date of material request initiation.
Due to the poor programming of the material tracking software, some data flaws occurred during migrating the data to MS Excel. Those corrupted data were successfully detected and corrected. It is important to stress on that the corrected data were of empty cells, wrong date format and missing / wrong units which did not affect the data accuracy.

**4.6 Handling Factor**

After assuring the accuracy and integrity of the obtained data from the material tracking software, it was time to analyze the data in order to understand the situation. The analysis strategy followed can be summarized as the following:

1. Developing Handling Factor to standardize material handling process.
2. Applying Handling Factor to available data.
3. Study the relationship between different material categories by developing a flow matrix based on handling factor.
4. Generate new layout options based on the flow matrix.
4.6.1 Definition

This term has been developed in this project to determine the suitable handling means for stored items while being picked. The main aim was to define a methodology to select the best handling approach based on items’ quantity, dimensions and weight to achieve better material flow and consequently, improve productivity. Accordingly, the handling factor can be defined as: handling methodology indicator calculated based on the combination of dimension, weight and quantity of picked items, aims to ensure smooth and safe materials flow.

4.6.2 Development Strategy Using 5S

To develop handling factor meant to build up a systematic approach to be used as a guidance for all future material handling activities. It had to be well structured and flexible to meet the requirement such a dynamic field like energy maintenance and construction. 5S Japanese method was followed as a guide to work on the handling factor development. It was selected since it is a method used to streamline processes without compromising contentious improvement and sustainability. The steps undertaken can be summarized as the following:

1. **Sort**: The process involved skimming the majority of key items, conducting a research on their weight and dimension specifications, studying material handling styles and finally classifying item to certain categories.
2. **Shine**: all faulty and insignificant items’ data were swept away from the master data sheet. There were 14 item codes, 4 of which are having less than 10 items per category which are common indeed can be found in other codes. Accordingly, the number of item codes was reduced and other data discrepancies issues were solved resulting in reducing complicity and insignificant future data analysis.

3. **Set**: for the classification of materials into categories took place in the sorting stage, every category was bounded with specific limits in terms of weight and dimensions. These limits were set carefully taking in consideration standard practices and safety.

4. **Standardize**: after setting the limits of the process, it was time to set the rules of its operation. Materials weight and dimension categories were combined to form the handling factor, the sole guide for material handling selection. In addition, the HF was treated as a foundation to standardize the handling related practices such as safety precautions and usage of critical lifting plans.

5. **Sustain**: to ensure the proper utilization of the proposed material handling method. There will be a set of recommendations to the management including:
   
   a. Evaluating the proposed idea as a pilot project among a team representing professionals from logistics, plant and machinery, facility management and safety departments.
b. Revalidating the pilot project after 6 months and modify it shall it is advised.

c. Enforcing the selection of handling factor within the material tracking sheet.

d. Generalize this method in all QCON sites.

4.6.3 Model

The process started with gathering the required data which of them are required and valuable to the handling factor, accordingly:

1. Ordered Items were skimmed, sorted and classified according to two major aspects which are the most important to material handling process:

   a. Dimension: it was decided to classify all materials to four categories each having a unique letter as shown the table # below.

<table>
<thead>
<tr>
<th>Code</th>
<th>Specification Limits (m)</th>
<th>Selection Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.1 x 0.1 x 0.1 or less</td>
<td>Material can be picked using one hand</td>
</tr>
<tr>
<td>B</td>
<td>0.35 x 0.35 x 0.35 or less</td>
<td>Material can be handled using both hands</td>
</tr>
<tr>
<td>C</td>
<td>1 x 1 x 1 or less</td>
<td>Material can be handled by group of two persons or an equipment</td>
</tr>
<tr>
<td>D</td>
<td>More than 1 x 1 x 1</td>
<td>Material to be handled using an equipment</td>
</tr>
</tbody>
</table>

Table 4 HF Dimension Criteria
The selection criteria were based on the human capabilities of handling objects. The visibility and maximum width to carry were taken in consideration.

b. Weight: The basis of the classification was the capacity of handling means. In order to eliminate any confusion, weight categories were given numbers instead of letters, the details are shown in table# below:

<table>
<thead>
<tr>
<th>Code</th>
<th>Specification Limits</th>
<th>Selection Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40 Kg or less</td>
<td>Manually handled with attention to posture and body possession</td>
</tr>
<tr>
<td>2</td>
<td>500 Kg or less</td>
<td>Handled using simple mechanical lifting tools</td>
</tr>
<tr>
<td>3</td>
<td>1 ton or less</td>
<td>Requires light lifting equipment</td>
</tr>
<tr>
<td>4</td>
<td>5 ton or less</td>
<td>Require professional lifting equipment with a trained lifting workers</td>
</tr>
<tr>
<td>5</td>
<td>More than 5 ton</td>
<td>Require critical lifting procedures, equipments &amp; expert workers</td>
</tr>
</tbody>
</table>

Table 5 HF Weight Criteria

The result of combining the studied preceding elements will be the handling factor. To give the handling factor a physical meaning, it was linked to the technique of material handling exists in QCON. As mentioned before, QCON has no problem at all in terms of equipment availability and diversity. Accordingly, the following matrix was prepared to explain what type of handling will be assigned to each handling factor.
Before touching on the details of handling, it is important to mention that the absence of some handling factor combinations such as (A3, A4, B5…etc.) was expected since their dimension and weight elements were unlikely able to exist in almost any known item. For example, it is impossible to find an “A3” item with a volume of $0.001\,\text{m}^3$ and weighs $+1$ ton. It is important to mention the parameters taken in consideration –beside HF- while selecting material handling method for each material order, the key elements are as the following:

1. **Suitability**: the method or equipment should match or exceed the specifications of the calculated handling factor.

2. **Practicality**: In a simple case, It is impractical to book a crane for two hours to lift few items which can be loaded using a trolley or a light forklift.

3. **Cost**: pretty much related to practicality, using any heavy equipment has a cost –even if it is an in-house job. The very generic breakdown of cost will include:
   
a. **Operational Cost**: operator and rigging team man-hour and fuel costs.

Table 6 Handling Factor

<table>
<thead>
<tr>
<th>HF Dim. vs. Weight</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1 worker</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>B</td>
<td>1 worker</td>
<td>2 workers</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>C</td>
<td>+2 workers</td>
<td>Trolley</td>
<td>N/A</td>
<td>Forklift (7T)</td>
<td>N/A</td>
</tr>
<tr>
<td>D</td>
<td>+2 workers</td>
<td>Trolley</td>
<td>Forklift</td>
<td>light Crane (+5T)</td>
<td>Crane or More</td>
</tr>
</tbody>
</table>

| Table 6 Handling Factor |

Before touching on the details of handling, it is important to mention that the absence of some handling factor combinations such as (A3, A4, B5…etc.) was expected since their dimension and weight elements were unlikely able to exist in almost any known item. For example, it is impossible to find an “A3” item with a volume of $0.001\,\text{m}^3$ and weighs $+1$ ton. It is important to mention the parameters taken in consideration –beside HF- while selecting material handling method for each material order, the key elements are as the following:

1. **Suitability**: the method or equipment should match or exceed the specifications of the calculated handling factor.

2. **Practicality**: In a simple case, It is impractical to book a crane for two hours to lift few items which can be loaded using a trolley or a light forklift.

3. **Cost**: pretty much related to practicality, using any heavy equipment has a cost –even if it is an in-house job. The very generic breakdown of cost will include:
   
a. **Operational Cost**: operator and rigging team man-hour and fuel costs.
b. Indirect Cost: the crane rental rate including maintenance, testing and certification costs.

The following table views the justification for each handling method:

<table>
<thead>
<tr>
<th>HF</th>
<th>Method / Equipment</th>
<th>Justification and Tips</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Manual Handling 1 worker</td>
<td>The item is within normal human lifting capabilities. It can be done in safe and effective manner without need of lifting aids.</td>
</tr>
<tr>
<td>B1</td>
<td>Manual (2 workers)</td>
<td>Weight is beyond 1 worker capabilities, yet can be handled by a group of two using mechanical lifting means such as lifting tray to ensure even weight distribution and smooth handling.</td>
</tr>
<tr>
<td>C1</td>
<td>Manual – Group of 2-3 workers</td>
<td>The dimension of item makes it unsafe and difficult to be handled. A group of 2 or 3 workers will enhance safety and shorten handling time.</td>
</tr>
<tr>
<td>C2</td>
<td>Trolley</td>
<td>As the weight is nor dimension are no longer within manual handling limits, a trolley is the suitable tool for those material groups.</td>
</tr>
<tr>
<td>D2</td>
<td>Forklift – Boom truck</td>
<td>1T weight promotes the usage of light lifting equipments which do not require certified riggers nor lifting procedure, yet safety precautions must be followed.</td>
</tr>
<tr>
<td>D3</td>
<td>Heavy forklift (7T) or Light crane (+5T)</td>
<td>Semi-critical lifting and handling process, the selection between equipments will be based on the shape and dimension of the item. As known, forklift has limited capabilities compared with cranes. Certified rigger must supervise the handling task assisted by safety watch and lifting area must be</td>
</tr>
</tbody>
</table>

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barricaded. No critical lifting procedure required.

D5  Heavy crane + trailer  the HF factor leave no choice but to use the big guns, the tips will be as the following:

- Critical lifting procedure must be prepared by rigging foreman / rigging engineer to decide on:
  - a. Number of cranes (Some tasks need balancing crane)
  - b. Capacity of cranes to be used
- Job site must be checked vs. lifting safety analysis document before the commencing of the task to ensure safe working conditions.
- A safety officer and a certified rigger must be on site during the lifting and handling task.

Table 7 Handling Factor – Justification and additional requirements

4.6.4 Application on Current Data

The method of application is very simple and uses one of the most common logical functions in MS Excel which is “IF” function. Before applying the function to the data, both weight and weight were identified for each type of items. The source of these data was the material/equipment data sheet provided by the vendor or the international standards for items such as flanges and fittings. The steps toward identifying HF for each item are explained in the following example:
An order was raised for 5 blind flanges of 1” diameter and pressure rating of 150lb/in².

As per international standard ASME B16.5:

- **Dimension:** diameter=0.11m, thickness= 0.018m ______________ Category “B”
- **Weight:** 1 Kg ____________________________ Category “1”

For 5 flanges:

- **Dimension:** category “B”__________________________ Total volume is larger than 0.1 m³ less than, 1 m³ , category “B” can handle 150 pieces of this item.
- **Weight:** category “1”____________________________ Total weight is less than 40Kg, category “1” can handle 40 pieces of this item.

Accordingly the function logic will be as the following:

- **Dimension:** if the order quantity is more than 150 piece, dimension category will be C, otherwise, it is B.
- **Weight:** if the order quantity is equal to or more than 40, weight category will be 2, otherwise it is 1.

After obtaining the weight and dimension categories, there will be a programmed cell which will combine the two categories and represent the handling factor as shown in the figure below. Furthermore, IF function was used again to define the method of material handling based on the HF symbol and according to the defined procedure developed previously in this section.
The figure below shows the results applied to current materials flow data. IF function format is shown in the upper red box. The blue color boxes are showing the combination of HF with reference to the dimension and weight categories obtained by applying IF function.

<table>
<thead>
<tr>
<th>ITEM code</th>
<th>Descriptions</th>
<th>UN</th>
<th>QTY</th>
<th>Statuses</th>
<th>Trans. Date</th>
<th>Dim</th>
<th>Weight</th>
<th>combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>HOSE ARGON</td>
<td>ROLL 2</td>
<td>OUT</td>
<td>4-Nov-2013</td>
<td>B</td>
<td>1</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>HOSE ARGON</td>
<td>ROLL 1</td>
<td>OUT</td>
<td>11-Dec-2013</td>
<td>B</td>
<td>1</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>ANTIRUST LUBRICANT SPRAY (WD-40)</td>
<td>EA 120</td>
<td>OUT</td>
<td>26-Sep-2013</td>
<td>C</td>
<td>2</td>
<td>C2</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>ANTIRUST LUBRICANT SPRAY (WD-40)</td>
<td>EA 24</td>
<td>OUT</td>
<td>19-Oct-2013</td>
<td>C</td>
<td>1</td>
<td>C1</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>ANTIRUST LUBRICANT SPRAY (WD-40)</td>
<td>EA 24</td>
<td>OUT</td>
<td>4-Nov-2013</td>
<td>C</td>
<td>1</td>
<td>C1</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>ARGON TORCH BACK CUP-SHORT</td>
<td>EA 30</td>
<td>OUT</td>
<td>13-Oct-2013</td>
<td>A</td>
<td>1</td>
<td>A1</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>ARGON TORCH SET</td>
<td>PC 2</td>
<td>OUT</td>
<td>1-Sep-2013</td>
<td>B</td>
<td>1</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>ARGON TIG TORCH SET</td>
<td>PC 1</td>
<td>OUT</td>
<td>21-Nov-2013</td>
<td>A</td>
<td>1</td>
<td>A1</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>BAG JUMBO</td>
<td>EA 5</td>
<td>OUT</td>
<td>21-Nov-2013</td>
<td>C</td>
<td>1</td>
<td>C1</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>BROOM BRUSH SOFT HANDLE :</td>
<td>PC 3</td>
<td>OUT</td>
<td>4-Nov-2013</td>
<td>B</td>
<td>1</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>BINDING WIRE GI :</td>
<td>ROLL 15</td>
<td>OUT</td>
<td>13-Oct-2013</td>
<td>B</td>
<td>1</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>BINDING WIRE GI :</td>
<td>ROLL 3</td>
<td>OUT</td>
<td>2-Nov-2013</td>
<td>B</td>
<td>1</td>
<td>B1</td>
<td></td>
</tr>
</tbody>
</table>

As of now, handling factor definition, purpose and application to stored items were clarified and justified. The current challenge will be to relate the previously work done on HF with the scope of the project which is clearly to optimize the open yard by modifying its layout. The plan followed to achieve this aim is summarized in the points shown below:

1. Applying HF to each item order in all Material Tracking Notes MTNs.
2. Find the handling factor and method of handling for each Material Tracking Note
3. Use pivot table to represent the data from material category point of view since every material category is stored in different containers.

4. Develop flow matrix for the different material categories

5. Study the relationship between material categories based on flow matrix

6. Generate new layouts for the containers based on the flow matrix

7. Select best layout that guarantees smooth flow of material.

End of report