OPTIMIZING SPARE PARTS PROCUREMENT TO ENHANCE EQUIPMENT AVAILABILITY

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Abstract—During operation all equipments in Plant need spare part to replace its damage element to maintain Plant Availability. Variation in spare part, spare part's life service, and procurement lead time tend to increase number of spare part request. On the other hand, huge number of inventories has no direct correlation with plant availability as the fact that many break-down equipment need extended repair time due to unavailable spare part. Inventory also became main topic on company performance especially on financial side. This paper will discuss spare part procurement method on Steel Making Plant that projected able to maintain and increase Plant Availability and concern to inventory level. The working method started by spare part classification, inventory policy for each spare part classification, and procurement method. Spare part classification according to three mains criteria, which are: usage value, critically, and usage frequency. Spare part will divide by 27 different classes to decide inventory policy. These are three inventory policies: with-out stock, one piece stock, and more pieces stock. Spare part procurement method should able to support defined inventory policy and concern to vendor availability. There are some spare part procurements method alternatives that have individually strong and weak point. For evaluate spare part procurement method use "Kepner-Tregoe Decision Analysis" and to analyze potential problem that may rise from chosen procurement method is “Adverse Consequences”.

Keywords: spare part, equipment availability, inventory, spare part classification, inventory policy, spare part procurement method.

1. Introduction

Company History: PT Krakatau Steel Tbk is the first integrated steel plant in Indonesia, established by the government of the Republic of Indonesia on August 31, 1970. PT Krakatau Steel Tbk has integrated production process, processing Iron Ore into semi-finished products that used as raw material for the downstream industrial sector. Currently, PT Krakatau Steel Tbk has 7 factories consist of 4 plants and 3 mills, as follow:
- Direct Reduction Plant (DR Plant)
- Slab Steel Plant (SSP, has two plants; SSP-1 & SSP-2)
- Billet Steel Plant (BSP)
- Hot Strip Mill (HSM)
- Cold Roll Mill (CRM)
- Wire Rod Mill (WRM)

The plants and mills are use to process raw material iron ore (ferrous oxide ore), Lump Ore, Scrap metal, & HBI into a finish products such as Hot Rolled Coil (HRC), Cold Rolled Coil (CRC), and Wire Rod (WR).
Table 1.1. Product application.

<table>
<thead>
<tr>
<th>Product</th>
<th>Specification</th>
<th>Major Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRC</td>
<td>Thickness: 1.8 – 25 mm, Width: 600 – 2080 mm</td>
<td>Automotive, Construction &amp; Fabrication, Pipe &amp; Tube, Ship Building, container</td>
</tr>
<tr>
<td>CRC</td>
<td>Thickness: 0.2 – 3 mm, Width: 672 – 1250 mm</td>
<td>Home Appliance, Automotive, Drum, Galvalum, Tin Plate, Enamel Ware, Pipe &amp; Tube, Roof Construction</td>
</tr>
<tr>
<td>Wire Rod</td>
<td>Diameter: 5.5 – 20 mm</td>
<td>Nail, Bendrad, wire-mesh, Shafting bar, Welding Electrode, Bolt &amp; Nut, Spring Bed</td>
</tr>
</tbody>
</table>

Scope of business: the scope of business unit where become the observation in this paper is Steel Making Plant consisting Billet Steel Plant, Slab Steel Plant-1, and Slab Steel Plant-2.

These plants are use to melt-down sponge iron and other raw materials (scrap metal, Lump Ore, & HBI) and process them into Billet Steel dan Slab Steel. The processes consist of Melting, secondary, and casting. Melting process takes place in the Electric Arc Furnace (EAF), in this process material phase has change from solid to liquid. After reaching the castings temperature (1620°C), the liquid steel is poured into a container called ladle to undergo a secondary process. Secondary process takes place in a Ladle Furnace dan RH Vacuum Degassing. The function of this process is to purify the liquid steel, adding alloys to make steel with desire specification, and reduce dissolved gasses in liquid steel.

The next process is casting that will change liquid steel into billet steel and slab steel, the main equipment in this process is Continues Casting Machine (CCM).
Table 1.2. Main Equipment of Steel Making.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Year of Operations</th>
<th>Installed capacity (TPY)</th>
<th>Main Equipment (unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>EAF</td>
</tr>
<tr>
<td>BSP</td>
<td>1979</td>
<td>500,000</td>
<td>4</td>
</tr>
<tr>
<td>SSP-1</td>
<td>1983</td>
<td>1,200,000</td>
<td>4</td>
</tr>
<tr>
<td>SSP-2</td>
<td>1993</td>
<td>800,000</td>
<td>2</td>
</tr>
</tbody>
</table>

Business issue: Although three plants of Steel Making have similar production process and main facilities. They have significant differences in: year operational that will lead great differences in level technology were used, plant builder, original equipment manufacturer (OEM), and design capacity. The entire factor will lead differences in installed equipments, equipments characteristic, maintenance method, and spare parts.

Table 1.3. Comparison of steel making main equipment

<table>
<thead>
<tr>
<th>Issue</th>
<th>Plant</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BSP</td>
<td>SSP-1</td>
<td>SSP-2</td>
<td></td>
</tr>
<tr>
<td>Main Builder</td>
<td>SMS</td>
<td>SMS</td>
<td>Voest Alpine</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>Germany</td>
<td>Germany</td>
<td>Austria</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>1979</td>
<td>1983</td>
<td>1993</td>
<td></td>
</tr>
<tr>
<td>Capacity (TPY)</td>
<td>500,000</td>
<td>1,200,000</td>
<td>800,000</td>
<td></td>
</tr>
<tr>
<td>Main Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EAF:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Number</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>- OEM</td>
<td>SMS</td>
<td>SMS</td>
<td>VAI</td>
<td></td>
</tr>
<tr>
<td>- Furnace Capacity</td>
<td>65 ton</td>
<td>120 ton</td>
<td>120 ton</td>
<td></td>
</tr>
<tr>
<td>- Furnace speed</td>
<td>135 min/heat</td>
<td>150, upgrade to 90 min/heat</td>
<td>110 min/heat</td>
<td></td>
</tr>
<tr>
<td>- Transformers Cap</td>
<td>30/36 MVA Mechanic</td>
<td>60/66 MVA Mechanic</td>
<td>93 MVA Hydraulics</td>
<td></td>
</tr>
<tr>
<td>- Electrode regulation control</td>
<td>Analog System</td>
<td>Upgrade to Hydraulics</td>
<td>Upgrade to PLC &amp; HMI</td>
<td></td>
</tr>
<tr>
<td>- Automation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ladle furnace</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Number</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>- OEM</td>
<td>VAI</td>
<td>VAI</td>
<td>VAI</td>
<td></td>
</tr>
<tr>
<td>- Ladle Capacity</td>
<td>65 ton</td>
<td>120 Ton</td>
<td>120 Ton</td>
<td></td>
</tr>
<tr>
<td>- Transformers</td>
<td>15 MVA Hydraulics</td>
<td>30/36 MVA Hydraulics</td>
<td>22 MVA Hydraulics</td>
<td></td>
</tr>
<tr>
<td>- Electrode regulation control</td>
<td>PLC &amp; HMI</td>
<td>PLC &amp; HMI</td>
<td>PLC &amp; HMI</td>
<td></td>
</tr>
<tr>
<td>- Automation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Steel Making Plants are shall always ready for operating to produce Billet Steel and Slab Steel with appropriate quality, quantity, time, and transfer price. The readiness plant to operate is characterized by Plant Availability (PA). According to “Buku saku Maintenance Management PT Krakatau Steel Tbk”, Plant Availability is the presentation duration of the plant is ready to operate against the total available time.

\[
PA = \frac{CT}{CT + OH + PM + Delay}
\]

Where:
- CT = Calendar Time
- OH = Time for Over-Haul
- PM = Time for Preventive maintenance
- Delay = Time taken to repair the damage

A high PA will achieve by excellent maintenance method (to optimize overhaul and preventive time) and lowering delay. Spare part has important rule to stressing delay. Availability spare part will prevent delay by replacing them before break-down and reduce break-down time by replace damaged part rather than repair. The constraints in spare part preparation are OEM variation, manufacturing year and level technology will increasing number of variety spare parts, and number of spare that can be used in two or more plant (common spare) become very little. According to spare part data base courtesy of maintenance service division, at year 2011 for Steel Making plant have number of listed spare part (having material code) as table below:

<table>
<thead>
<tr>
<th>Material codes numbers (Item)</th>
<th>BSP</th>
<th>SSP-1</th>
<th>SSP-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.822</td>
<td>7.563</td>
<td>12.793</td>
<td></td>
</tr>
</tbody>
</table>

Fulfillment of all spare parts stock (inventory) become dilemma, the more spare part inventory would affect to corporate financial, on the other hand tightening spare part inventory will affected to
equipment reliability and tend to production stoppage. The distance spare part maker affected procurement lead time, longer lead time push increasing procurement number and tend to increase spare part inventory. Predicted spare part life service and sudden failure will increase spare part procurement complexity and the final result is increasing spare part inventory. The problems encountered in spare part management as follow:

- Budget constraint for spare part procurement.
- Variation of spare part is very peruvian.
- The duration of spare part procurement lead time.
- Spare part failures often un-predictable.
- Spare part inventory was rose, but spare part shortage in the plant is often happen.

Figure 1.3. Steel making spare part inventories.

Table 1. 5. Number of spare part contract PT Krakatau Steel Tbk in year 2011

<table>
<thead>
<tr>
<th>Contract number</th>
<th>Number contracted spare part</th>
<th>Number moving spare part</th>
</tr>
</thead>
<tbody>
<tr>
<td>43 contracts</td>
<td>4439 item</td>
<td>717 item</td>
</tr>
</tbody>
</table>

2. Business Issue Exploration

A. Conceptual Framework

This paper will discuss “Optimizing Spare Part Procurement to Enhance Plant Availability”. The term of “optimizing” is pushing spare procurement until certain level which effectively increases Plant Availability with concern to reduce inventory and budget constraints. Spare part procurement in term of “when, what, how, and how much” is influence by several factors such as: procurement lead time, spare part life service, spare part variety, and anticipating for sudden failures of plant equipment, etc.

Figure 2. 1. The frame work for “Optimizing spare part procurement to enhance Plant Availability”.

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The approach method used for Framework for optimizing spare part procurement is as follows: Spare part procurement beside for replacement damage equipments parts in order to maintain and increase Plant Availability as well, has the effect of increasing inventory. During the effort to increase Plant Availability is often push to procure spares part more than needed quantity, and many of them became slow moving inventory. For that reason it is necessary to establish optimal spare part procurement method that able to shift and focused planning for spare part procurement to the direction of enhances Plant Availability (Shift the arrow to the right). Planning for spare part procurement that meet the plant operational needs begins with spare parts classification. Spare part classifications are concern to usage value, critically, and frequency used to determine inventory and service level policy that will be used to maintain Plant Availability. Spare part procurement realization carry out by spare part procurement method that supports increasing Plant Availability and flatness inventory level. The optimizing each steps of spare part procurement to improve Plant Availability in corporate wide use Enterprises Resources Planning (ERP) SAP R-3.

Classification of spare part.
Spare part classification is very important to determine group of spare parts with have specific character relating to spare part procurement planning pattern that assist to service level and determination number of inventory. According to Bacchetti (2010): 15, Method for spare parts procurement as bellow:

![Fig. 2.2. Pattern for spare part procurement](image)

Spare part classification according to Mladen (2010), 501 are:
- Spare part usage value (ABC classification)
- Spare part critically (V, E, D group)
- Spare part frequency usage (F, S, N group)

**Spare part usage value (ABC classification):** ABC classification divided spare part into three groups A, B, and C based on multiplying spare part number and periodically unit cost e.g. annual. ABC classification becomes (Börjesson & Svensson, 2011: 44):

<table>
<thead>
<tr>
<th>Group</th>
<th>Percent of spare part</th>
<th>Percent of the value of inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10 - 20</td>
<td>70 - 85</td>
</tr>
<tr>
<td>B</td>
<td>20 - 30</td>
<td>10 - 25</td>
</tr>
<tr>
<td>C</td>
<td>60 - 70</td>
<td>5 - 15</td>
</tr>
</tbody>
</table>

So procurement for the "group A" spare part should be controlled regularly and stringently by top management, conducted value analysis, estimation requirement, shorten procurement lead time, and minimized inventory number. Group B normal supervision, and group C is provided by using method as simple as might be (Ono, 2005).

**Spare part critically:** spare part divided into three group: Vital (group "V"), Essential (group "E"), and Desirable (group "D"). The parameters used to evaluate the spare parts criticality consists of several criteria (Mladen, 2010):

**Spare part critically base on productivity:** based on the effect of spare part failure to plant operational continuity.
- Vital group is spare part that their failure will impact to:
  - Plant operational stoppage.
  - Un-tolerated decrease the process efficiency.
  - Un-tolerated decline the product.
- Group Essential is spare part that their failure will cause significant decline productivity but does not stop the overall plant operations.
• Desirable group is spare parts that have no significant effect to the productivity and quality of the products, so that might be possible at some time spare parts is not available in the warehouse.

**Spare part critically base on ease of purchase:** these classification bases on the procurement lead time:

- Vital group: procurement leads time more than nine months.
- Essential group: lead time procurement lead time more than two weeks but less than nine months.
- Desirable group: spare parts are very easy to procure (lead time of less than two weeks).

**Spare part critically base on safety:** grouping spare part base on the influence of environmental safety, labor, and other.

- Vital group: lack of these spare parts will harm to environment, employee, and other equipment.
- Essential group: lack of these spare parts will cause equipment function stoppage but not danger to employee.
- Desirable group: Lack of these spare parts does not affect the safety of employee, environment, and equipment.

**Spare part critically base on inventory:** divided into two groups, fist group is spare parts that easy to deteriorate their quality and operational functions, so it is risk to keep in extended time. Second group is very heavy and big spare part that potentially problem on transportation and storage.

The final grouping spare part determined by the highest critically level (Vital, Essential, Desirable) base on productivity, ease to purchase, and safety.

**Frequency usage spare part:** have very important role in spare part procurement planning and necessary to group based on number of spare part requirement in unit time, usually a year. By this criteria spare part divide into three groups (Nakajima, 1989):

- Group F (fast moving) for often used (more than four times a year)
- Group S (slow moving) for spare part that have usage frequency less than four times a year.
- Group N (non moving) for rarely used spare part (one spare part for more one year)

**Inventory policy and service level:** according classification base on: usage value, critically, and usage frequency, there are 27 spare part classify combinations (Mladen, 2010), each has distinct characteristics that can be used to determine the inventory model. There are three basic spare part inventory policies:

- Without stock: this is the best policy because requires less capital and storage place but need a reliable supplier.

  This policy can be applied at the conditions as below:

  a. Cost incurred due to lack spare part less than storage cost for average time between spare parts requires.
  b. High usage value (group A) and slow moving in usage frequency (group S) spare part.
  c. Medium usage value (group B) and slow moving in usage frequency (group S), and excluded high critically (group V) spare part.
  d. Low usage value and low frequency usage and critically class spare part.

- One piece in stock: management policy that procures spare part directed when the stock is used. This policy generally use to:

  a. Critical spare parts with medium frequency usage.
  b. Medium usage value and medium frequency usage spare part.
  c. Small usage value, medium usage frequency, and low level of critically.
  d. Small usage value, medium usage frequency, and high or medium level of critically spare part.

- More pieces in stock: management policy to store more than one spare part. In this policy is necessary to determine inventory level, safety stock, inventory control pattern, and spare parts procurement system. History usage spare part analysis is essential to determine wheatear requirement pattern close to constant requirement pattern or occasional requirement pattern. For constant requirement pattern procurement suitable to use EOQ (economic ordering quantity) method and for occasional requirement pattern the requirement spare part approaching with "dynamic order replenishment models".
**Spare part procurement pattern:** base on inventory model create suggestion for spare part procurement policy that suitable with their typical characteristic and able to simplify procurement process, reduce lead time and procurement cost respectively with deeply concern to the quality of spare part. The spare part procurement pattern divided by two main issues, namely:
- Planning for amount and timing of spare part procurement.
- How to purchase spare part.

**Spare Part Procurement Scheduling:** the important thing in spare part procurement is when spare part will be purchased and how much. For spare part with nearly constant consumption rate, the procurement can be easily predicted and the amount approaching using equation for Economic Order Quantity (EOQ).

Spare part consumption are often un-defined, it is closely related to many cause of failure pattern. These conditions make the decision of when and how many spare part procurements more difficult. For approaching estimating procurement timing using estimate life time base on history procurement data and spare part characteristic or estimating the remaining life time, this method prior to procure expensive spare part, vital critically and slow in usage frequency.

**Spare Parts Procurement Method:** the methods to purchase spare part are generally classified into individual order and permanent stock method (Nakajima, 1989: 254). In Individual order method, spare part purchased only when require. While in permanent stock method spare part will continuously procure, permanent stock method will automatically fill the stock, whenever stock condition bellow the stock level that have been set.

Permanent stock method generally base on "fixed quantity" and "fixed period". Another method used in this method including partial delivery method and deposit system that made by certain contract with vendor.

![Spare part procurement method](image)

**Figure 2.4. Spare part procurement method.**

8. **Analysis of Business Situation**

To explore the framework “Optimizing Spare Part Procurement to enhance Plant Availability” described below are constituent factors based on the conditions at the plant.

**Spare parts requirements:** One of maintenance activities is replacement equipment’s part or component damaged or below the specified tolerance. Those activities require spare part. In order to optimize the spare part procurement should consider the following:

**Lead Time Variations:** Lead time will influent to ordering amount especially for spare part with long lead time and or the life time below lead time, the longer lead time the lower ordering amount accuracy.

In the daily activity lead time became more variety because of: spare part are not common in market, obsolete, a new brand that will be substitute, etc. Those variation makes the determination ordering amount to be order in one purchase request became bias. For anticipation arrival delay which consequently to equipment break-down, it is often procure spare part more than number need that could potentialy increase inventory.

According to history for spare part procurement year period 2008 to 2012 for Slab Steel Plant 2, which total 2951 purchase requests and total value Rp. 78.833.490.029,00 obtain the following results:
Figure 2.5. Pie diagram spare parts lead time according to arrival numbers, N = 2951 spare parts.

Figure 2.6. Pie diagram lead time spare part procurement Vs price., Value total : Rp. 78.833.490.029.00

- Procure spare part with lead time less than one month is 39% of 2951 PR, but the spare part value only 5% of Rp. 78.833.490.029.00. It shows spare part with short lead time are generally spare part with relative low value e.g. fuse, bolt, nut, gasket, v-belt, o-ring, etc.
- Procurement spare parts with lead time above three months is 42% from 2951 PR and has value 84% from Rp. 78.833.490.029.00. In this area lead time variation is high and the value is also high. This condition will potentially increase in inventory and decrease in Plant availability, for several reasons:
  o To anticipate the shortage of spare parts due to long lead time, spare parts ordering tendencies arise more than necessary.
  o The spare part arrival potentially missed from the replacement schedule, that result spare part unable to install. For example: spare part arrives over the overhaul schedule, so the spare parts cannot be install. This situation makes not only delayed spare part cannot install, but also the supporting spare part are not install even their arrived before overhaul.
  o Break-down equipment because replacements spare part post-pone.
  o Prolong break-down time, un-available spare part need more time to repair rather than replace. Also these situation reduce equipment reliability, because often parts are repaired is under the standard and potentially break down at any time.

**Variation of life service:** On the normal operation, many of spare part are designed to have certain life time (bearing, pump, roll, etc) that make easy to estimate replacement time. However the normal conditions are not always happen, because of dynamically plant operational and the correlations one equipment to the other and supported each other, the spare part life service became un-uniform. It is closely related with sudden failures to equipment or their supported equipment, which lead variation in life service. For example in normal condition (installation, lubrication, and proper alignment) the life service bearing for main Induction Draft Fan in Dedusting Plant up to three years, but if any up-normality appear on lubrication system or mistake in installation procedure the bearing will be damaged within three months. Another example under normal operating condition the life service of spray nozzle cooling can reach 5 years, but in case of operation failure happen “Break-out” which is the liquid steel broke out of its skin and flow over the nozzle arrangement, the nozzles will be instantly damaged.
Fault conditions are very influence to estimated amount of spare part order, and become more complex as the fact that operational failure cannot be predicted. Over anticipation will potentially increase inventory, while under anticipation tend to prolong break-down time because of inadequate spare parts.

**Variation of spare parts:** Steel making consists of three plants that built with differences in year, main builder, and technology level. None of the major equipments “electric arc furnace, ladle furnace, and continuous casting machine” equal each other. And the result is very little spare part that can be used together (common spare) and the spare part variation rise very high (see table 2. 1). With a great deal number of spare parts, it is making no sense to provide stock all spare part in ware house a long a time. It is necessary to decided spare part to order, ordering time, and ordering amount that meet with plant requirement.

**Sudden Failures:** in daily operation sudden failures is something that very difficult to avoid, even methodical maintenance pattern have been applied for those equipment.

<table>
<thead>
<tr>
<th>Table 2.2. Frequency failure for steel making plant.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delay Frequency (times)</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2001</td>
</tr>
<tr>
<td>2002</td>
</tr>
<tr>
<td>2003</td>
</tr>
<tr>
<td>2004</td>
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<td>2006</td>
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<td>2007</td>
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<td>2008</td>
</tr>
<tr>
<td>2009</td>
</tr>
<tr>
<td>2010</td>
</tr>
<tr>
<td>2011</td>
</tr>
</tbody>
</table>

![Figure 2.7. Steel making delay maintenance](image)

Sudden failures are causing by: production process disturbances (e.g. break-out, furnace leaks, furnace over tilting, etc.), effect from damage or un-normal condition of supporting equipment (e.g. un-normality in cooling, rotating, vibration, etc.), external factor (e.g. black-out), and characteristic of spare parts that cannot predicted (e.g. fuse, instruments card, etc). To avoid losses due production process stoppage, all failure should be handle, damage spare part should replace before failures happen. Those activities require existence of “spare part on hand” in plant. Determination the “safety” amount of this spare part is very important because its effect to inventory, the higher safety
factor the higher inventory result. It is very important to set the optimum point between inventory value and safety factor against sudden failures.

**Budget Constraints:** Since go-live 2nd step SAP on August, 2010 and enterprise status changes become public company in the same year. All maintenance activities (Maintenance Work Order / MWO) have refers to budget availability, as well as spare part procurement. This condition push to selection spare part that will procure reviewed and filtered again more closely.

In term of spare part Procurement, lowering budget mean the tolerance to mistake in spare part procurement, amount, and procurement timing to be tighter. Any mistake in spare part procurement will reduce the ability to procure another spare part and increase inventory.

![Spare part procurement budget](image)

**Figure 2.8. Spare part procurement budget.**

**Classification of spare part:** as mention above, spare part classification is very important to grouping spare part with typical specific characteristic that related to spare part procurement planning pattern, determination of service level, and amount of inventory.

**Inventory Level Policy:** Inventory level policy used to determine allowable limits of inventory amount and kind of spare part which should always available in ware house with certain amount. Inventory level determination should take into account spare part safety stock to sudden requirement and usage value.

**Spare Part Procurement Pattern:** Spare part procurement pattern is used to determine the efficient procurement system according to spare part classification to support optimizing plant availability and inventory.

**Root of Problem:** in the frame of “Optimizing Spare Part Procurement to Enhance Plant Availability” there are two mains issues that will pursue, that are: “controlling inventory” and “Increasing Plant Availability”. In effort to pursue that target there are some symptoms that contradiction with efforts that normally ask for to pursue Optimizing Spare Part Procurement to Enhance Plant Availability (Undesirable Effect, UDE). And necessary to find out the root of problem that causing un-desirable condition exists. For deep evaluate the real plant condition and to find out root of problem for un-optimal spare part procurement will used diagram “Current Reality Tree” (CRT). Choosing CRT to find out root of problem, based on the CRT advantages as follow (Dogget, 2005):

- Logical, simple, and there are less of them to consider.
- Give stress to intuition and emotion without skewing because process based.
- It was able to pinpoint root causes while identifying causal interdependencies.
According to root cause analyze using CRT obtained several roots cause causing un-optimal spare part procurement and decrease Plant Availability as follow:

- SOP not exists.
- SOP not re-newer.
- Assuming that SOP only for junior employee.
- Obsolete spare part.
- Lack of inspection
- Production failures
- Budget constraint.
- Lack spare part management.

Root causes that direct influence to both Plant Availability and Inventory are:

- Obsolete spare part
- Lack spare part management

According to the Frame work, the relevant root causes for optimizing spare part procurement to enhance plant availability are only for those that influence to both Plant Availability and Inventory. For focusing effort for solution to improve existing condition and according to corporate organization’s scope who competent to do. In the final project is only deal for solution to “lack spare part management”, with main reason are:

- Influence to both Plant Availability and Inventory.
- Responsibility of maintenance department.
- Inventory was increase.
- Plant Availability that represents by delay maintenance higher that 3%
- Lot of problem with extended repair time because of un-available necessary spare part.
- Lack of forecasting for contract represent by lot of unusable contract item.
- There is no guidance line for inventory policy (stock or non-stock item).

Improving spare part management projected able to provide spare part on time and meet requirement quality, so reduce breakdown frequency as result as ability to replace un-standard spare part and shorten delay time as result maintenance method change from repair to replacement.
Improvement in spare part management also improve spare part database that useful to spare part forecast for spot procurement and create contract. Standardization spare part specification will help for easier procurement and matching with specific vendor. The final result of improvement spare part management will enhance Plant Availability with decrease delay maintenance below 3% (Frampton, Benchmarking World-Class maintenance) and reduce inventory up to 10% a year to meet with company goal.

3. Business Solution

C. Alternative of Business Solution

The main activities on alternative business solutions of spare part management are spare part classification and determination alternative for spare part procurement.

**Spare part classification:** The spare part classification activity become the most important step to optimizing spare part procurement to enhance equipment availability and reduce inventory as whole, because this activity serve as corner stone to the next process. The best spare part classification is able to reduce spare part variation, determination spare part procurement date, and number of inventory for particular spare part. Inventory policy for each spare part class as follow:

- Without stock: ADN; ADS; AEN; BDN, BEN; CDN
- One piece in stock: AVS; AVN; AES; ADF; BV5; BVN; BES; BDS; CVN; CEN; CDS.
- More pieces in stock: AVF; AEF; BVF; BEF; BDF; CVF; CVS; CEF; CES; CDF.

**Spare part procurement strategy:** To get the best solution for optimizing spare part to improve equipment availability and reduce inventory need spare part procurement strategy that match with spare part classification. Spare part procurement strategy should able to procure spare part meet with quantity, quality, and moment when spare parts are needed. Below some alternative for spare part procurement strategy that can be use for optional strategy to enhance equipment availability and reduce inventory:

- Spot purchase
- Long term contract
- Flexible or Option contract
- Just In Time
- Consignment
- E-commerce
- Three party logistics
- Price contract
- Maintenance out-sourcing

D. Analysis of Business Solution

According to alternative business solution it this necessary to evaluate all available alternative to matching with the actual condition in order to achieve best an smooth business solution realization.

**Spare part classification and inventory policy:** The initial step to determination business solution for optimizing spare part procurement to enhance equipment availability is to analyze spare part classification. Based on work instruction (WI) for spare part planning and procurement, SAP process flow for maintenance work order (MWO), spare part break-down or shortage impact for productivity, safety, environment, procurement lead time, storage life time, and usage frequency. The spare part can be divided into criteria as follow:

- **Usage Value:**
  - A : spare part price above Rp. 100,000,000
  - B : spare part price between Rp. 2,500,000,00 to Rp. 100,000,000
  - C : spare part price bellow Rp. 2,500,000
• **Critically:**

Table 3.1. Critically classification.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Productivity</th>
<th>Procurement lead time</th>
<th>Safety</th>
<th>Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1</td>
<td>Plant stoppage, un-tolerance plant efficiency and qualities decreased.</td>
<td>Lead time more than 9 months</td>
<td>Danger to person, equipment, and environment.</td>
<td>Quick decay</td>
</tr>
<tr>
<td>K2</td>
<td>Significantly decrease plant production, but not plant stoppage.</td>
<td>Lead time between 2 weeks to 9 months</td>
<td>Stoppage plant, but not danger to person</td>
<td>Long storage Life time</td>
</tr>
<tr>
<td>K3</td>
<td>Not significant influent</td>
<td>Lead time bellow 2 weeks</td>
<td>Not influence to person, equipment, and environment</td>
<td></td>
</tr>
</tbody>
</table>

β V : one of sub critically on K1  
β E : max sub critically on K2  
β D : Sub critically on K3

• **Frequency:**  
  β F : frequency usage more than 4 per year.  
  β S : frequency usage less than 4 per year.  
  β N : frequency usage less than 1 per year.

**Inventory policy (example)**

• **Without stock**
  • AEN: SI6670000097 - LOAD CELL, FORCE-WEIGHT -220VAC:20-200 T/H  
  • BDN: SE4140000316 - FAN, VANEAXIAL-2CC2312.1AA1-TYPE-0.48KW

• **One piece in stock**  
  • AVS: SM4320001093 - PUMP, RADIAL PISTONS *230L-315BAR-1450RPM  
  • BVS: SM5340000423 - PLATE, MENDING 45X900X207MM-CU AGO IP

• **More pieces in stock**  
  • BVF: SM3422001063 - JACKET, ROLLER, SEGMENT - D150X370MM  
  • CVF: SM3433000069 - NOZZLE, WELDING TORCH - SDS36F - GEGA

**Spare part procurement policy:** To determine spare part procurement solution that match with the inventory policy, it is necessary to know spare part procurement method that support the policy and practically can be deploy due to supporting facility near the company (e.g. vendor availability, distant vendor to company, commitment, etc.).  

In the word of spare part procurement, time for spare part requirement often not predicted well, it is a huge advantage for company when Just In Time can fully apply. Unfortunately it is very rare to find
vendor in Cilegon area that able to deliver let say one piece small hydraulics control valve with hundreds in variety model, life time more than two year with price only for hundreds dollar every time when plant needed. And the valve often should import from other country. To make Just in Time more visible to implementation with consider to number of spare part variation and vendor capability to supply, modification is necessary especially for lead time delivery. The lead time delivery as result of agreement between company and vendor to decided vendor commitment to supply spare part for certain period of time e.g. 1 week, 1 month, or 3 months since user releases a requirement. The other procurement concept for alternative business solution are spot purchase, long term contract, flexible or option contract, consignment, e-commerce, three party logistic, and price contract will analyzed to take decision for most suitable method for inventory policy. Outsourcing method excluded in procurement method but one alternative for maintenance and management equipment method.

Decision analysis.
All process for decision analysis and decision making consists of: Decisions Analysis, Adverse Consequences, and Potential Problem Analysis. In this paper, Kepner-Tregoe Decision Analysis will use to analysis then to decide all alternative spare parts procurement methods to get the most suitable method. The advantages using Kepner-Tregoe Decision Analysis are: easy to use, have two step analyses (must and want) that make simpler analysis decision because if some alternatives doesn't pass must criteria they no need to analyze farther with want criteria, very reliable and flexible because must and want criteria can be design to fulfill all analytical aspects necessary to support decision analysis purpose, and according to want criteria and its weight that have been set make the alternatives solution can be rank and easier to make decision and second opinion.

During decision analysis process involved persons from plant maintenance, spare control, maintenance service, and spare part procurement department. The fist activity is establishing must and wants criteria, then deciding rating for want criteria and its weight. All mentioned activities done by brainstorming using Nomine Group Technique (NGT) according to their work experience.

Kepner-Tregoe Decision Analysis
Main Criteria (Must):
- Visible to deploy.
- Compatible with company system.
- Comply with GCG
The chosen criteria to make sure that procurement method is actually able to adopted with less or no difficult modification in our procurement system (ERP) and comply with government regulation.

Additional criteria (Want):
- Inventory: the best procurement method is the smallest or no inventory additional.
- Delivery certainty: procurement method should able to assure delivery time.
- Procurement process easiness: procurement method should user friendly especially for set-up new spare part procurement.
- Originality quarantine: procurement method should able to prove that supplied spare parts are always original.
- Price: the best procurement method is the best value of money.
- Technical support: procurement method should provide technical method and information for scope: enhance spare part life time, improve employees knowledge according to supplied spare part technology, newest technology, failure analysis when spare part break-down, etc.
- Flexibility: range scope of spare part that can be supply with particular procurement method.
- Vendor availability: easiness to vendor selection and number of vendor available.
The first step to built table for Kepner-Tregoe Decision Analysis is deciding weight for wants criteria. Using (Nomine Group Technique) NGT wants criteria is weighted according to rank of influence to inventory policy. The NGT members are:

1. Chief Engineer Central Maintenance
2. Chief Engineer Steel Making Maintenance
3. Senior Engineer Steel Making Maintenance
4. Superintendent Automation
5. Superintendent Water Treatment Plant
6. Superintendent Maintenance Planning & Controlling
7. Superintendent Maintenance SSP-1
8. Superintendent Maintenance SSP-2
9. Spare-part Controller SSP-1
10. Spare-part Controller SSP-2

Table 3. 2. Summary NGT result for want criteria weighted

<table>
<thead>
<tr>
<th>Want Criteria</th>
<th>Without Inventory</th>
<th>One Inventory</th>
<th>More Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory</td>
<td>5</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Delivery certainty</td>
<td>8</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Procurement process</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Originality quarantine</td>
<td>8</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Price</td>
<td>10</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Technical support</td>
<td>6</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Flexibility</td>
<td>8</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Vendor availability</td>
<td>9</td>
<td>9</td>
<td>8</td>
</tr>
</tbody>
</table>

Then a second step is deciding rating each procurement system to all want criteria as tables below:

Table 3. 3. Summary NGT result for want criteria rating.

<table>
<thead>
<tr>
<th>Want Criteria</th>
<th>Spot Purchase</th>
<th>Long Term Contract</th>
<th>Flexible or Option Contract</th>
<th>JIT</th>
<th>Consignment</th>
<th>E-commerce</th>
<th>3 Party Logistic</th>
<th>Price-Universal</th>
<th>Price-Consignment</th>
<th>Price-3 Party Logistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>8</td>
<td>5</td>
<td>10</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Delivery certainty</td>
<td>5</td>
<td>4</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>5</td>
<td>7</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Procurement process</td>
<td>3</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>10</td>
<td>8</td>
<td>3</td>
<td>10</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Originality quarantine</td>
<td>4</td>
<td>4</td>
<td>9</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Price</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td>10</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Technical support</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>8</td>
<td>4</td>
<td>9</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Flexibility</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Vendor availability</td>
<td>9</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Kepner-Tregoe Decision Analysis for each inventory policy as table below:

Tabel 3. 4. Kepner-Tregoe Decision Analysis for without inventory policy.

According to the analysis rank for procurement method for without inventory policy as follow:
Spot Purchase, E-Commerce, Just In Time, Long-Term Contract, Price Contract, Flexible or Option Contract, Consignment, and 3 Party Logistic.

Then the preferred procurement alternatives are: Spot Purchase and E-Commerce.
Table 3.5. Kepner-Tregoe Decision Analysis for one piece inventory policy.

According to the analysis rank for procurement method for one piece inventory policy as follow: Just In Time, Consignment, Flexible or Option Contract, Long-Term Contract, Price Contract, Spot Purchase, E-Commerce, and 3 Party Logistic. Then the preferred procurement alternatives are: Just In Time and Consignment.

Table 3.6. Kepner-Tregoe Decision Analysis for more pieces inventory policy.

According to the analysis rank for procurement method for more pieces inventory policy as follow: Just In Time, Consignment, Price Contract, Flexible or Option Contract, Long-Term Contract, Spot Purchase, E-Commerce, and 3 Party Logistic. Then the preferred procurement alternatives are: Just In Time and Consignment.

**Adverse Consequences:** For each analysis base on inventory policy, two highest score will used as favorite alternative and to sharper analyses, again these methods will re-analyze using “**Adverse Consequences**” method to evaluated potential threat for chosen procurement method.

According to the Kepner-Tregoe Decision Analysis result for each inventory policy there are two different basic procurement characteristics appears, no establish contract (non-contract) for without inventory policy and establish contract (contract) for one piece inventory and more pieces inventory policy. Based on these situations the criteria to evaluated potential threat should be able to evaluated two different characteristics as follow:

Evaluate criteria for non contract:
- Cancelled Purchase Order
- Delay in delivery time
- Supplied spare part different with specification.
- Spare part quality.

Evaluate criteria for contract:
- Forced to buying the remaining spare parts in end of contract.
- Spare part shortage due to quota limit exceeded.
- Vendor an unable to supply spare parts in contract period caused by force major (e.g. increasing fuel price)

Simulation evaluates criteria, combine with severity, and probability will result threat. Then the total threat can be use for evaluating tool to re-checking procurement method. Usually the more safe to implement is the less total threat.
Adverse Consequences for procurement method for spare parts with without inventory policy as follow:

Table 3.7. Adverse Consequences for without inventory policy spare parts procurement method.

<table>
<thead>
<tr>
<th>Threat Factor</th>
<th>Probability</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot Purchase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-Commerce</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancelled Purchase Order</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Delay in delivery time</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Supplied spare part different with specification</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Insufficient spare parts quality</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>171</td>
<td>187</td>
</tr>
</tbody>
</table>

Results from table is Spot Purchase has less number than E-Commerce, seem that Spot Purchase less potential threat and safer than E-Commerce, but consider again from Kepner-Tregoe Decision Analysis, E-Commerce have advantages in number of inventory, easiness in procurement, and more competitive in price. The decisions for procurement without inventory policy spare parts can be like this:

a. Spot Purchase used to purchase without inventory policy spare parts which has usage value class "A" (price more than Rp. 100.000.000,00) and "B" (price between Rp. 2.500.000,00 to Rp. 100.000.000,00), "C" (price bellow Rp. 2.500.000,00) class that not available for E-Commerce.
b. E-Commerce can be widely used for purchase without inventory policy spare parts which has usage value class "B" and "C".

Then Adverse Consequences for procurement method for spare parts with one piece and more pieces policy as follow:

Table 3.8. Adverse Consequences for spare parts with one piece and more pieces policy spare parts procurement method.

<table>
<thead>
<tr>
<th>Threat Factor</th>
<th>Probability</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>JIT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consignment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forced to buying the remaining spare parts in contract</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Spare part shortage due to quota limit exceeded</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Vendor was unable to supply spare parts in contract period caused by force major (e.g. increasing fed price)</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>125</td>
</tr>
</tbody>
</table>

Information from table announces Just In Time method has less total threat than Consignment, it is simply to decide that Just In Time method is less risk to deploy. According to Kepner-Tregoe Decision Analysis, Consignment has advantages in flexibility and vendor availability that means some spare parts witches are unavailable to supply by Just In Time has possibility supplied by consignment. And for farer flexibility and vendor availability these two method (Just In Time and Consignment) practically less than other contract method (Price Contract, Flexible or Option Contract, Long-Term Contract) that has consequence many of spare parts will not able to supply by Just In Time and Consignment. In that area Price Contract, Flexible or Option Contract, Long-Term Contract should be deploy to fulfill the rest of spare parts procurements.
Then the decision for procurement spare parts with one piece and more pieces policy can be done as follow: using Just In Time for all spare parts that has available vendor to supplied. Than establish consignment contract for spare part that can’t supply by Just In Time, and finally use another contract (Price Contract, Flexible or Option Contract, Long-Term Contract) to fulfill the rest spare parts.

**Potential problem analysis:** After taking decisions it is essential to analyze potential problems that may occur. To minimize all risk possibility, prevention action, and contingency plant should find out. To do that “Potential Problem Analysis” can act as guidance to achieve best solution. Below the table for Potential Problem Analysis to solve potential problem for contract and non-contract system spare part procurement.

<table>
<thead>
<tr>
<th>Potential Problem</th>
<th>Possible Causes</th>
<th>Preventive Action</th>
<th>Contingency Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancelled Purchase Order</td>
<td>Vendor unable to supply particular spare part.</td>
<td>Data base vendor score</td>
<td>Vendor finalities.</td>
</tr>
<tr>
<td>Delay in delivery time</td>
<td>Vendor had obstacle to procuring spare part</td>
<td>Technical Clarification before bidding.</td>
<td></td>
</tr>
<tr>
<td>Procurement process longer than target time</td>
<td>Improve procurement system</td>
<td>Air fright for urgent spare parts</td>
<td></td>
</tr>
<tr>
<td>Supplied spare part different with specification</td>
<td>Un-clear spare parts specification</td>
<td>Improve spare parts specification</td>
<td>Variation purchase request</td>
</tr>
<tr>
<td></td>
<td>Vendor unable to read spare parts specification</td>
<td>Vendor commodity classification</td>
<td>Technical Clarification before bidding.</td>
</tr>
<tr>
<td>Lack Spare parts quality</td>
<td>Vendor using cheap spare parts source.</td>
<td>Improve spare parts specification</td>
<td>Vendor finalities.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Variation purchase request</td>
</tr>
</tbody>
</table>

Table. 3.9. Potential problem analysis for non-contract spare parts procurement.

<table>
<thead>
<tr>
<th>Potential Problem</th>
<th>Possible Causes</th>
<th>Preventive Action</th>
<th>Contingency Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forced to buying the remain</td>
<td>Number of remaining spare parts in contract big enough.</td>
<td>Improve contract planning.</td>
<td>Extend contract period.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table. 3.10. Potential problem analysis for contract spare parts procurement.
<table>
<thead>
<tr>
<th>Issue</th>
<th>Action</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendor not fulfill contract.</td>
<td>Un-competent Vendor.</td>
<td>Vendor not allow to bid</td>
</tr>
<tr>
<td>Delivery time delay</td>
<td>Un-sufficient vendor’s inventories.</td>
<td>Vendor’s ware house assessment</td>
</tr>
<tr>
<td>Lack Spare parts quality.</td>
<td>Mismatch spare parts classification with delivery time’s group.</td>
<td>Contract amendments</td>
</tr>
<tr>
<td>Spare parts shortage</td>
<td>Vendor using cheap spare parts source.</td>
<td>Mandatory to vendor for give spare parts sample or every contract item</td>
</tr>
<tr>
<td></td>
<td>Quota runs out.</td>
<td>Terminated contract and penalty for vendor.</td>
</tr>
<tr>
<td></td>
<td>Improve spare parts usage planning.</td>
<td>Contract amendments or spot purchase.</td>
</tr>
</tbody>
</table>

4. Conclusion and Implementation Plan

Implementation Plan

In order to implement business solution, it is necessary to establish working steps and schedule. The working steps should countable and comply with “Work Instruction” (WI) for planning and procuring goods PT Krakatau Steel (PBR-01 and PBR-02). Work schedule serve as guidance for activities that should be done and who is responsible. Work schedule also contains step by step activities and time frame to estimate time duration of activity, evaluate problem and potential problem that could rise and disturb implementing business solution, and prepare action to countermeasure and mitigate problem.
The steps for implementing business solution as follow:

Table 4.1. Tentative schedule to implementing business solution.

Table 4.2. Department responsible.

Plant Maintenance and Maintenance Service are divisions belong to Production Directorate, while Vendor and Import Management and Spare Part Procurement are divisions belong to Logistic Directorate. 

**Requirement of Human Resources**

**Human Resources:** To execute and support all activities above needed skill full employee and strong commitment from management. Table below show the requirement human resources for run the implementing business solution.
Table 4.3. Human resources requirements.

<table>
<thead>
<tr>
<th>Position</th>
<th>Maintenance Services</th>
<th>Spare Part Procurement</th>
<th>Vendor and Import Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive</td>
<td>Maintenance Supervisor</td>
<td>Buyer</td>
<td>Vendor Supervisor</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Equipment Buyer</td>
<td>Buyer Specialist</td>
<td>Vendor Specialist</td>
</tr>
<tr>
<td>Engineer</td>
<td></td>
<td>Supervisor</td>
<td></td>
</tr>
<tr>
<td>Space control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>General Manager</td>
<td>Manager</td>
<td>General Manager</td>
</tr>
<tr>
<td>Personnel Maintenance</td>
<td>Maintenance Manager</td>
<td>General Manager</td>
<td>General Manager</td>
</tr>
<tr>
<td>Manager Plan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance General Manager and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start up</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Technology:** to execute these implementing business solution, the technology necessary are:
- ERP / SAP R3
- Internet
- Microsoft Office

**Financial:** All activities mentioned above can be apply as individual objective for employee at those certain department, so become built in daily activities until the project complete. Base on that situation there are no additional cost for all activities, except assessment vendor activity that necessary to visit vendor to matching document and real condition according to vendor’s financial, management, inventory, ware housing, facilities, etc.

**References**


Inventory control, prod 2100-2110, Quoted on 7 November 2012 from:
http://www.poms.ucl.ac.be/etudes/notes/prod2100/cours/Part%205-Inventory.pdf.
Inventory management and control chapter 6, Quoted on 24 October 2012 from:
http://www.shodhganga.inflibnet.ac.in/bitstream/10603/703/12/12_chapter6.pdf.
Krav, S., Lean Inventory Control, Quoted on 24 October 2012, from
Makahanap, B. D, Sekilas Tentang Produk PT Krakatau steel, Knowledge Management PT Krakatau Steel.
Proses Cold Roll Coil, n.d., Pusdiklat PT Krakatau Steel, Tbk., Knowledge Management PT Krakatau Steel.
Syamil, A. Toyota Production System (TPS), Just-In-Time (JIT), and Lean Manufacturing Handout. Quoted on 9 September 2011 from: http://www.clt.astate.edu/asymil.