ISBN: 978-623-92201-0-5

ANALYSIS TO REDUCE POTENTIAL DEAD STOCK OF MAINTENANCE REPAIR & OPERATION (MRO) INVENTORY IN PT BADAK NGL

Mohamad Farouk Riza[12] and Nur Budi Mulyono[1]
[1]School of Business and Management, Institut Teknologi Bandung, Indonesia
[2]PT Badak Natural Gas Liquefaction, Bontang, Kalimantan Timur
Email: mohamad.farouk@sbm-itb.ac.id

Abstract. PT Badak NGL is a non profit company to operate the Bontang LNG Plant in East Kalimantan, the main job is to liquify the natural feed gas to become the Liquified Natural Gas (LNG). As the operator with at cost scheme, the efficiency and effectiveness of budget utiliziation is one of PT Badak NGL's performance KPI, including the efficiency of material Inventory stored in Warehouse. PT Badak NGL's main inventory consist only the Maintenance Repair & Operation (MRO) material such as chemical and sparepart of equipment. According to the 2017 benchmarking result, Inventory performance of PT Badak NGL is below the average, especially on the Inventory Value aspect. Last 5 years data shows that total Inventory Value is around US$ 35 Million, but 73% of them is classified as the Potential Dead Stock (PDS); materials that more than 5 years stay in the warehouse. The Turnover Ratio is around 70% which means, only 70% come out (utilized) while the remaining 30% stays in warehouse, this happen every years and makes contribution to the PDS. According to this condition, the business problem in this paper is "Inefficient MRO Inventory due to large PDS Materials over the years in PT Badak NGL. Using the Ishikawa (fishbone) Diagram and Focus Group Discussion, the main contributor of the problem is the Inventory Method and Policies. Several alternative solutions have been developed and using Kepner-Tregoe Decision Analysis there are two solutions that should be conducted immediately to reduce the PDS; Apply Impairment Method and Recategorize Materials. Potential Problem Analysis is also conducted for those two solutions to anticipate any potential problem occurred and the choice of contingency plans. The implementation plan has also developed with the target can be finished by six months.

Keywords: inventory, Kepner-Tregoe, MRO, PT Badak NGL, LNG, Potential Dead Stock

INTRODUCTION

According to the 2018 World LNG Report, in 2017 the number of LNG Exporting Country grows to18 including Indonesia, while the number of LNG Importing Country are also grow to 36 countries (*International Gas Union, 2018*). With the growth of the LNG Business, the competition in this business is getting tight and all companies always trying to make improvement at any aspect in order to make the LNG price more and more competitive. One of the improvement is to reduce the cost, including cost reduction in the inventory aspect.

The classic challenge and problem for MRO inventory is about the effeciency and effectiveness of inventory, how precise the prediction and forecasting of the material usage is the most difficult part, because we do not know when and how some of material(s) is needed as most of them are used during equipment breakdown, therefore the setting up optimum level availability MRO inventory is a big challenge for us, too conservative will impact to the high cost (procurement, handling and storage) and could lead to waste materials, but less available will sacrifice the plant reliability, long downtime period and loss of production that will costly more. The performance of MRO inventory can be seen from the inventory cost, the turn over ratio of inventory and service level of the requirement. In many organizations, MRO inventory accounts for a significant slice; as much as 40% of the annual procurement budget (*MMH Staff, 2013*). Unfortunately, most of purchased materials usually stay quite longer in warehouse waiting for issue because there in no repair or maintenance needed, some of them even stay more than 5 years in the warehouse and we called it Potential Dead Stock (PDS) materials.According to the 2016 benchmark among 13 LNG Plant companies that contributed to the 80% LNG production in the world, PT Badak NGL's position (BTA) in term of inventory value is higher (worse) than the average inventory value (LNG Avg) as shown in the figure below (*Philip Towsend Associated, 2017*). That figure shows us that the inventory value in PT Badak NGL is still has opportunity to be reduced.

ISBN: 978-623-92201-0-5

Figure 1. Benchmark of Value Inventory
(Operational Performance Badak LNG 2016-PTAI)

All functions in PT Badak NGL have the same objectives which is maintain the plant can be operated without interruption or running with 100% plant availability. In order to achieve the objective of that function, warehouse shall be able to supply MRO materials anytime the plant needed, particullarly if there is a breakdown on the equipment and need sparepart to repair it as soon as possible. According to the challenge and problem above, there is opportunity for PT Badak NGL to make more effective inventory through the inventory policy strategy and improvement.

The scope and objective of this paper is to share the MRO Inventory Problem in PT Badak NGL, especially the excessive of Potential Dead Stock, and how solve this problem. Analysis and action taken are based on the method of Kepner-Tregoe Decision Analysis and Potential Problem.

LITERATURE REVIEW

Inventory (Stock).

Inventory means a physical stock of goods kept in store to meet the anticipated demand (P.Vrat, Material Management, Springer Texts in Business and Economic, 2014). P. Vrat also said that it is necessary to have physical stock in the system to take care of the anticipated Demand because non-availability of materials when needed will lead to delays in Production or projects or services delivered. However, keeping inventory is not free Because there are opportunity costs of "carrying" or "holding"inventory in the organization. Thus, the paradox is that we need inventory, but it is not desirable to Have inventory It is this paradoxical situation that makes inventory management a Challenging problem area in materials management. It also makes a high inventory Turn over ratio as a desirable performance indicator.
There are several types of inventory:

a) Raw Material Inventory
b) Bought-out-parts (BPK) inventory
c) Work-in-Progress (WIP) inventory
d) Finished goods inventory
e) Maintenance, repair, and operating (MRO) supplies.

(P.Vrat, Material Management, Springer Texts in Business and Economic, 2014).

Economic Order Quantity (EOQ).

Economic Order Quantity model is one of the proved useful in optimizing resources and minimizing cost. The EOQ model has been previously defined by Dervitsiotis (1981), Monks (1996), Lucey (1992) and Schroeder (2000) as the ordering quantity which minimizes the balance of cost between inventory holding cost and reorder cost (*Promise A Ordu, 2014*).

The EOQ formula is given below:

ISBN: 978-623-92201-0-5

$$Q = \sqrt{\frac{2DCo}{Cc}}$$

Where:
Q = Order Quantity
D = Demand
Co = Ordering Cost
Cc = Carrying Cost

Inventory Turn Over Ratio.

Inventory turnover is a critical performance metric to assess the effectiveness of inventory management. Because it is so extensively used as a diagnostic tool, it is imperative that inventory turnover is calculated using appropriate and valid techniques. *(C. Madhusudhana Rao and K. Prahlada Rao, Inventory Turnover Ratio as a Supply Chain Performance Measure, 2009).*
The formula to calculate inventory turnover is shown as follow:

$$\frac{Cost\ of\ Goods\ Sold\ from\ Stock\ during\ the\ past\ 12\ months}{Average\ Inventory\ Investment\ during\ the\ past\ 12\ months}$$

In the term of MRO, the goods sold means the issued inventory to be used by the customer

Service Level

For a company to meet the requirements of the service level that wants to provide, it focuses on the following individual goals: readiness to deliver, delivery time, delivery flexibility, reliability, and quality. Readiness to deliver is the ability to satisfy a requirement on time. Readiness to deliver can be measured in different ways, depending on the company's focus. If the company wants to measure readiness to deliver according to the number of units sold, the formula is:

$$Service\ Level\ = \frac{the\ number\ of\ quantity\ delivered\ in\ time}{the\ total\ quantity\ of\ the\ demand} \qquad (2.7)$$

(Alin Constantin RĂDĂŞANU, Inventory Management, Service Level and Safety Stock)

The service level is other inventory performance tools to measure the ability of inventory to satisfy the need of the customer. The higher value of service level, the higher customer needs are fulfilled.

METHODOLOGY

The main idea is to evaluate the existence of the non-moving materials called Potential Dead Stock (PDS), evaluation is based on the inventory performance such as Turn Over Ratio, Service Level and Inventory Value. The Evaluation is also considered the benchmark result, common practice and standard if any. The result of analysis will become the recommended improvements for either the Procured Materials method and Inventory System Method.

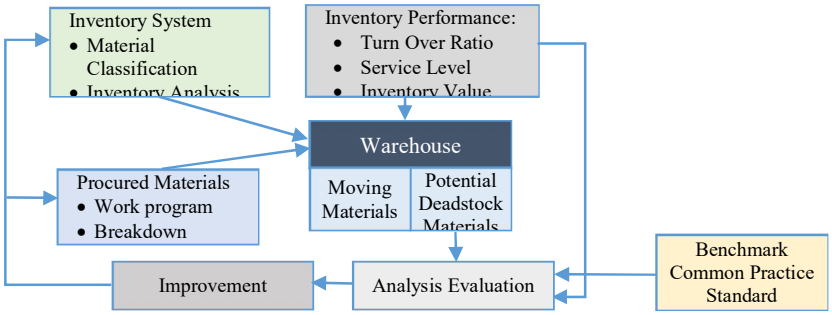

Figure 2. Conceptual Framework

To make the conceptual framework happened, the flowchart of research methodology is developed as shown in the figure below. The research methodology is developed based on the root cause analysis approach, as the best method to solve the problem. The methodology is started from defining the clear problem, find out the cause(s), generate possible solutions, make prioritized solution using Kepner-Tregoe Decision Analysis, including their Potential Problem, and finally ended with the implementation plan. it consists of several stages to be conducted and methodology involved to solve the business problem.

ISBN: 978-623-92201-0-5

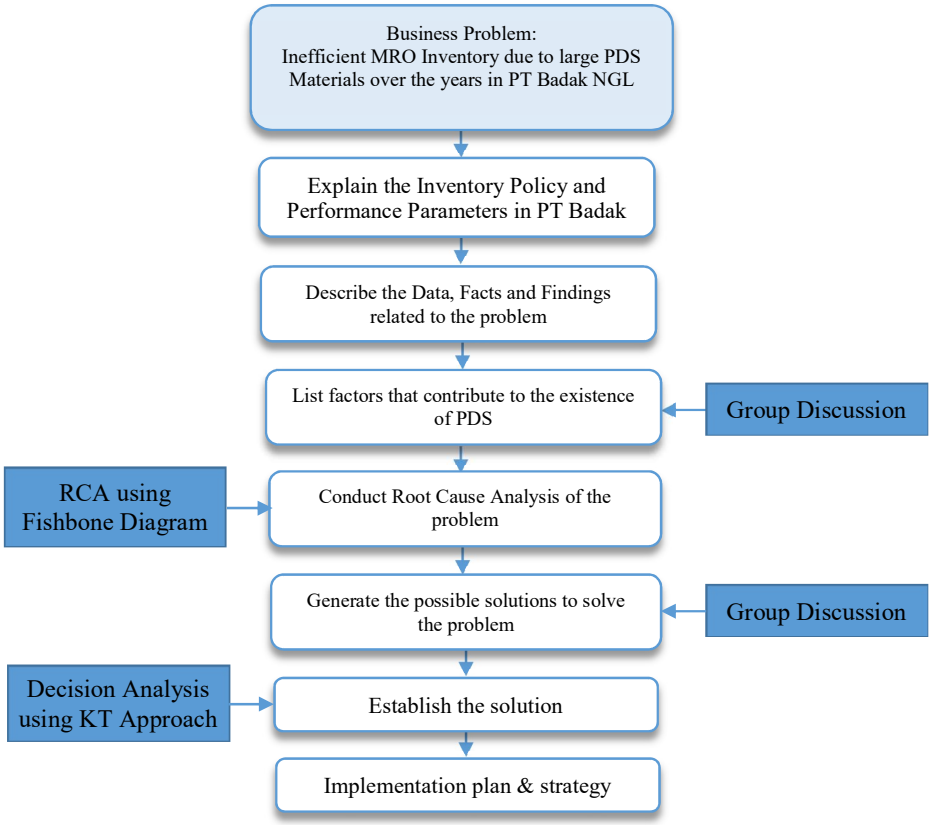

Figure 3. Research Methodology

FINDINGS AND ARGUMENT

PT Badak NGL is a producer of liquefied natural gas (LNG) and liquefied petroleum gas (LPG). It was established on 26 November 1974 as a limited liability company. PT Badak NGL is headquartered in Jakarta, with a sole production facility located in the Municipality of Bontang, Province of East Kalimantan. All of PT Badak NGL's operational areas are located within the jurisdiction of the Republic of Indonesia. PT Badak NGL is a nonprofit entity, whose assets are fully owned by the Government of the Republic of Indonesia, under the Ministry of Finance. Supervision of the management of assets is carried out by PT Pertamina (Persero), based on the Decree of the Minister of Finance No. 92/KMK/06/2008 dated 2 May 2008 on the Determination of Ex-Pertamina Assets Status as State Property. PT Badak NGL does not undertake any commercial activity. The management of production, commercial, and financial planning activities with respect to PT Badak NGL's operations is carried out by a separate entity called the Joint Management Group (JMG) (PT Badak NGL,2016) Liquefaction Process at PT Badak NGL starts from receving feed gas delivered by gas producers (Pertamina Hulu Mahakan, Eni, Pertamina Hulu Sanga Sanga and Pertamina Hulu Kalimantan Timur) through 57 km long of 4 pipelines to the Knock Out Drums (KOD) of PT Badak NGL plant site in Bontang. In the KODs, the gas is separated from liquid and other impurities before send it to the Process Trains. In the Process Trains, feed gas is treated at several stages before liquified in the temperature of -156 deg C. PT Badak NGL activity is limited on the liquifaction process only, the supply of raw materials (Feed gas) is depend on the gas producers, and both the marketing and sales of LNG is also depend on other party. In order to process the feed gas into LNG and LPG, PT Badak NGL shall manage the manpower and run & maintain the plant & support facilities (PT Badak NGL official website, 2018), therefore the term of inventory in this paper is limited on the MRO materials not the raw materials As a non profit company, PT Badak NGL's operational cost is based on the cost center. Every year PT Badak NGL proposes the budget for 1 year operation both for Operating Expenditure (OPEX) and Capital Expenditure (CAPEX) to the gas producers with the cash call mechanism. The OPEX is included the plan to purchase the inventory materials.

ISBN: 978-623-92201-0-5

Maintenance Department is one of 12 Department in PT Badak NGL, and has responsibility to maintain & repair the plant facilities and invenrory to ensure that the avilability and relaibility of the plant always in good condition. Warehouse & Supply Chain (WHSC) is part of Maintenance

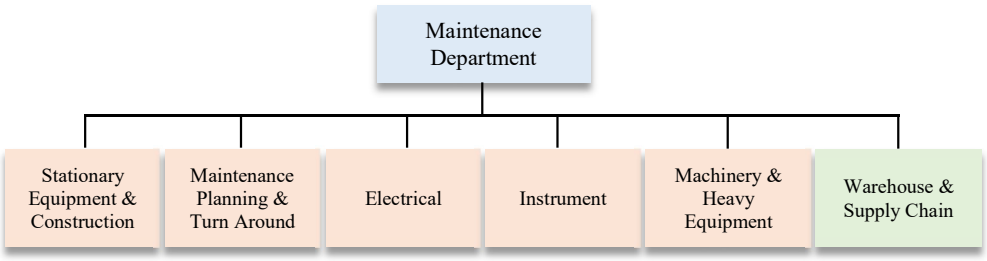

Figure 4. Organization of Maintenance PT Badak NGL

Department and has the main responsibility to ensure that stock of MRO material is always available when needed to support the plant availability and responsibility.
There are three Key Performance Indicators (KPI) for Warehouse in PT Badak NGL to measure the perfomance and effectiveness work related to the inventory to support the plant availability and reliability, the parameters are as follow:

a. Inventory Value & Level : Number and Value of inventory in the warehouse at the end of certain period, usually at the end of the year
b. Turn Over Ratio : Ratio between inventory issued value and inventory purchased value (in percentage) at certain period, usually in one year.
c. Service Level : Ratio between material issued and material request (in percentage) at certain period,

Eventhough PT Badak NGL is an at cost company, the spending expenses shall be reported to and audited by the gas producers, including the inventory expenses. The higher inventory value and remaining items/materials that can not be utilized, the worse inventory performance.

Until 2018, majority of material in the warehouse is Potential Dead Stock Material (approx US$ 25K in value) which means that those materials are never been issued/used more than 5 years after they are purchased.
This condition leads to the inefficiency of operating expense because:

- Company spend millions of dollars (around US$ 25 Millions) to purchase materials that have not been utilized for long time, or probably will never been used.
- Company must maintain those materials for long time and spend the handling cost that should not be necessary, if each item required 45 cents handling cost per year, therefore the company shall spend approximately US$ 15,500 / year to handle the PDS Materials.

Therefore it is clearly mention that the business problem in this case is “Inefficient Inventory due to large PDS Materials over the years.

Inventory Policy & Performance of PT Badak NGL

In PT Badak NGL, inventory materials turnover are classified into 4 (four) categories (PT Badak NGL Warehouse Operating Procedure, 2015):

a. Fast Moving Materials (Category A); materials that are being issued/used less than 1 year after purchasing.
b. Slow Moving Materials (Category B); materials that are being issued/used 1-2 years after purchasing
c. Non Moving Materials (Category C); materials that are being issued/used 2-5 years after purchasing
d. Potential Dead Stock Materials/PDS (Category D); that are being issued/used or never been used after 5 years purchasing

Inventory material replenishment in PT Badak NGL use the Economic Order Quantity (EOQ) with Reorder Poin (ROP) policy based on the MIN-MAX level, once the inventory reach the MIN level, Warehouse then creates order to purchase.
To determine the MIN and MAX level, several factors are considered such as:

- Average usage within last 12 month (MU)
- Lead Time procurement (LT)
- Safety Stock (SS), depend on the CEC, CEC 1&2 =2 months, CEC 3&4 = 1 month. No SS for CEC 5.
- Constanta Factor (CF), depend on the CEC; CEC 1&2 = 2, CEC 3,4&5 = 1.5

ISBN: 978-623-92201-0-5

Formula to determine MIN & MAX are below:

MIN = (MU x LT) + SS

MAX = (MU x LT) x CF + SS

(PT Badak NGL Warehouse Operating Procedure No.OP/SP/BP29/99-003 dated 4 Nov 2015)

Turn Over Ratio in PT Badak NGL is the ratio of issued material (out) and replenished material (in) within certain period. This parameter indicates how effective the prediction of purchased material to be utilized.
In the last 5 years, the TOR performance of PT Badak NGL is shown below

Table1. Turnover Ratio 2014-2018

	2014	2015	2016	2017	2018
TOR	0,70	0,74	0,72	0,71	0,82

Those tabel informs that from all purchased inventory materials, only (average) 72% was used every years, or in other word; 28% materials are remain in warehouse and not utilized. This condition will impact to the increasing inventory volume and value from time to time, if the material is not used within 5 years, then it is categorized as the Potential Dead Stock (PDS) material. Service Level in PT Badak NGL is the percentage of issued material to requested materials. This parameter indicate the ability to fulfil user's request
In the last 5 years, the SL performance of PT Badak NGL is shown below

Table 2. Service Level 2014-2018

	2014	2015	2016	2017	2018
SL (%)	99,75%	99,52%	97,81%	99,58%	99,01%

The Service Level data indicates that more than 99% request from user can be fulfilled by inventory, which is quite good. It means that actually all material needed by plant can be provided by warehouse, even though with 72% TOR. Therefore the 28% unutilized materials are actually not needed to be used within one year.

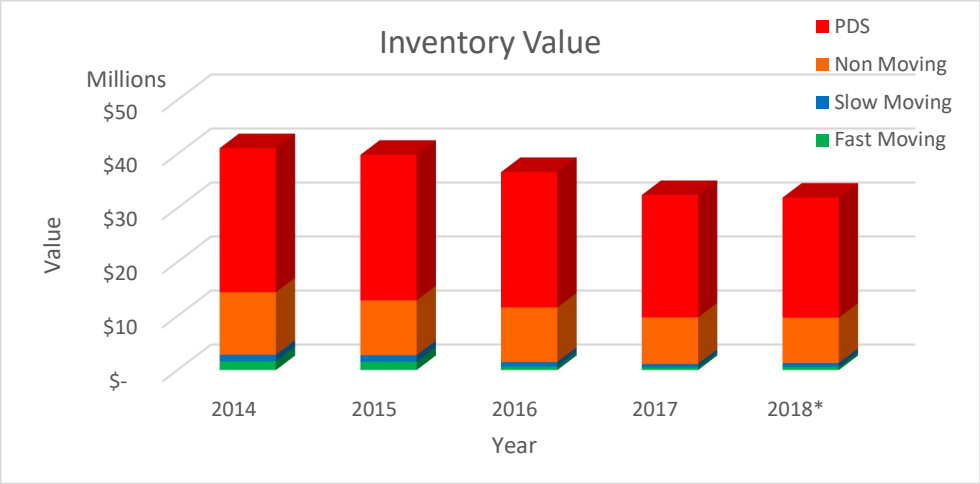

Figure 5. Inventory Value and Clssification Material Inventory of PT Badak NGL 2014-2018

Because the TOR is always around 72% for years, many materials are stay in warehouse for quite long and become Potential Dead Stock (PDS) as shown in the above figure, the value of PDS is also very high, more that 70% of total inventory. Action taken shall be conducted as soon as possible to reduce the PDS irem and value.

Root Cause Analysis

To find out and list the possible factors that contribute to the inventory problem in PT Badak NGL, the Cause and Effect Analysis is used using Ishikawa/Fishbone Diagram (*Mind Tools Content Team, 2016*).
Forum Group Discussion (FGD) is formed to develop the Ishikawa Diagram, the FGD members contains the competent and key persons related with the inventory control, inventory system and have the power to make decision related with the inventory.

ISBN: 978-623-92201-0-5

The members of FGD are:

1. Senior Manager Maintenance (myself as the superior of Warehouse and Supply Chain)
2. Manager Warehouse and Supply Chain (the one who responsible to manage the Warehouse Activity)
3. Coordinator, Inventory (the one who responsible to control the inventory, he leads several inventory analysts)
4. Material Engineer (the ones who develop the inventory system and inventory regulation)

The FGD revealed the Ishikawa/Fishbone Diagram as follow:

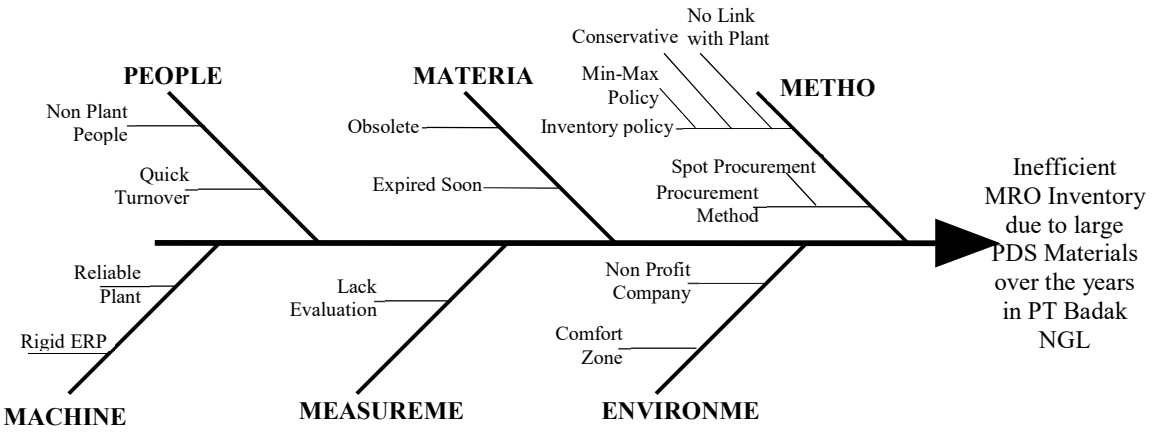

Figure 6. Ishikawa Diagram

METHOD

The current inventory policy is believed as one of many factors contributes in the problem, especially several policies below:

1. Pure Min-Max Policy
   The implementation of Pure Min-Max policy is suitable for the routin consumable materials, but not for non-routin and unpredicted required materials like MRO. Using pure reorder point method using min-max policy, the stocks are always be replenished to the maximum point, no matter they will be utilized soon or later, when the material is not utilized soon, stay more than 5 years in inventory, then they become Non Movement and Potential Dead Stock (PDS) material. Modification and adjustment to the min-max policy shall be made to avoid those long stay material in inventory.
2. Conservative
   Inventory policy in PT Badak NGL was created based on conservative approached to ensure there is no interruption in production, therefore any possibility that may cause production interruption shall be eliminated including lack of inventory. Another conservative thing is on the accounting system when there is no revaluation or depreciation method and procedure for the aged materials that have been stay quite long, called impairment.
3. No Link with the Plant Program
   Currenty, the inventory system and plant program is not connected each other, the replenishment of inventory is based on the routin activites. There is no linked system between the plant reliability condition with inventory approach. Integrated system between plant activities and inventory shall be established to forecast the need of materials based on the plant condition and plant program, because MRO inventory is about the prediction of what materials needs in the future
4. Spot Procurement
   Currently 90% of procurement activities in PT Badak NGL for stock item uses spot procurement, one of the disadvantage of spot procurement is we must follow the bidding process which takes time and once we purchase the materials, we should keep it in our inventory. Currently with several mode of purchasing like consignment and long term agreement, there is possibility to minimize the inventory in our own warehouse. Consignment, Price List agreement are more preferable method for MRO inventories, because most of the inventory materials are the OEM sparepart that exclusively available at certain agent or authorized distributors. By having longterm agreement or consignment method it will minimize stock

MATERIAL:

One of the reasons why there are many stock materials stay quite long in inventory and eventually unused is because of **obsolete and expiration** issue arrive before they are utilized. Most of the obsolete issue are mostly came from instrument and electrical materials as the technology growth very fast on both sectors, meanwhile for chemical and mechanical means that contain sensitive material usually face the expiration issue such as physically and chemically changed, broken, brittle and fragile. Iventory startegy for “shortlife” materials (fast obsolete) and sophisticated materials shall be different from the traditional and common materials. Keeping them in the stock brings high risk when the obsolesence issue is coming.

ISBN: 978-623-92201-0-5

PEOPLE:
Contribution from people came from two aspect:

1. Inventory People are not from Plant People
   Most of inventory people (76%) are not from plant people such as Maintenance, Technical or Operation, therefore their sense of belonging of how important and level of urgency of spare parts is not as good as plant people, this will impact to the decision whether we should stock this or not, or stock quantity we have to keep in our inventory.
2. Quick TurnOver
   In the last 10 years the employee turnover in Maintenance and Technical Department is so quick, data from HRD Dept shows that in average, maintenance employee only stay 2.1 years in their position before they move (rotation or promotion) to other position, this condition make not enough time to establish the program by himself to review and manage the inventory, meanwhile the new people need time to learn first.

ENVIRONMENT:
There are two factors PT Badak NGL's environment that cause the problem of PDS

1. Nonprofit Company
   As a result of nonprofit company, PT Badak NGL shall expense the budget that already proposed previously, too much under or over budget will have negative appraisal, therefore PT Badak NGL is pushed to utilize the budget as much as optimum condition, including spending on materials, eventough at several case is not urgently needed.
2. Comfort Zone
   More than 40 years of experience operating the LNG Plant without any significant problem has formed the behaviour of employee to work in the comfort zone, it is quire difficult to move from the existing procedure and environment if there is no problem so far. This condition leads to minimum creativity and innovation, in the other hand they already comfort with the current condition.

MEASUREMENT:
The main factor in measurement is lack of evaluation of inventory performance, regular monthly reports only contain reporting the inventory performance without any evaluation and analysis therefore there is no improvement needed.

MACHINE:
There are two items in Machine Category that contributed in to the problem:

1. Rigid ERP
   Currently PT Badak NGL uses Oracle as the ERP system for all transactions, including the inventory, the current ERP package was designed with standard design and small customization to adapt the current system, for changing to different and difficult to be modified (rigid).
2. Reliable Machine/Plant
   Because of high reliability of plant condition, less breakdown occurs than prediction, this lead to the unutilized the spare parts that have been purchased to anticipate if there is any breakdown.

From those six factors (Method, Material, People, Environment, Measure and Machine), FGD has decided the most influence factor. The most influence factor will become the focus and most priority on the problem solving. To decide which the most influenced factor is, FGD use comparative method. Each factor is compared each other, the more influence factor will have score 2, while the other is 1 and so on.
For example:

- Method vs Material; Method is more influence than Materials, therefore Method has score 2 while Materials has score 1
- Material vs People; Material is less influence than People, thus Material has score 1 and People has 2.

After all factors have been compared, their scores then accumulated to have the total score.

Table 3. Comparison Matrix

	Method	Material	People	Enviro	Measure	Machine	Total SCORE
Method		2	2	2	2	2	10
Material	1		1	2	2	1	7
People	1	2		2	1	2	8
Environment	1	1	1		2	2	7
Measure	1	1	2	1		1	6
Machine	1	2	1	1	2		7

ISBN: 978-623-92201-0-5

From the comparative matrix above, it is concluded that the METHOD factors such as Min-Max Policy, Conservative Policy, No link to the Plant Condition, and Procurement Method are the most influence and contributed to the problem, therefore in the solution(s) will focus to solve this factor.

Problem Solution

According four contributor factors and act as the root causes of the problem, we deploy several alternative solutions that focus on those factors and shown in the following table.

Alternative Solutions

Those alternative solutions are developed during Focus Group Discussion with the same members, each item has been discussed in accordance to the members' experiences in handling inventory and conducting the plant maintenance activities.

Table 4. Alternative Solutions

No	Root Cause	Alternative Solutions
1	Pure Min-Max Policy	1. Revise the policy of Min-Max Inventory with consideration of reliability aspect.
2	Conservative Approach	2. Sell or Auction the excessive/potential dead stock inventory to third party 3. Sharing inventory with other similar industry 4. Using impairment method
3	No Link inventory and Plant Program	5. Establish link system between inventory Plant Operating and Maintenance Program 6. Recategorize the spare part inventory
4	Spot/Traditional Procurement	7. Consignment contract 8. Increase blanket contract

Decision Analysis

From all alternative solutions above, the next step to be conducted is to sort them based on the ability to conduct, priority & importance, and also action taken from any consequences coming from those solution. To conduct and fulfill those criteria we use the Kepner-Tregoe Decision Analysis.

Kepner Tregoe decision making is a structured methodology for gathering information and prioritizing and evaluating it. It was developed by Charles H. Kepner and Benjamin B. Tregoe in the 1960s.

(Dr.David McDermott in his writing at https://www.decision-making-confidence.com/kepner-tregoe-decision-making.html)

Kepner Tregoe method is described into the following steps to approach decision analysis:

1. Establish a decision statement
2. Establish strategic requirements (Musts), and operational objectives (Wants)
3. Assign relative weight for each objective
4. List alternatives solutions
5. Assign a relative score for each alternative solution on an objective-by-objective basis
6. Calculate weighted score for each alternative and identify the top solution(s).
7. List adverse consequences for each top solutions.

The reason why using The Kepner-Tregoe method in this analysis is because we want to make priority which solution(s) need to be conducted immediately, and also to determine any risks arise from those solution, provide anticipation/preventive action and prepare the contingency plans.

Establish a decision statement

Decision Statement in this case is: provide solution to reduce the value of existing potential dead stock inventory and to avoid excessive inventory and existence of potential dead stock in the future.

Establish Strategic Requirement (MUST) , and Operational Objectives (WANT)

The strategic (MUST) requirements and operational objective (WANTS) requirments for decision statement are discussed among the FGD members and conclude the following requirements as shown in the following table

ISBN: 978-623-92201-0-5

Table 5. MUST Requirements

No	Objective
1	Legal; comply with legal aspect, company regulation and government regulation
2	Under control; decision can be made by company control, not depend on other institution.

Table 6. WANT Requirements

No	Objective
1	Reduce Inventory; implementation can reduce inventory
2	Reduce PDS; implementation will reduce PDS item
3	Low Cost; implementation will need additional cost as minimum as possible
4	Infrastructure: implementation will impact to the minimum change of infrastructure such as ERP, Organization, Business Process.
5	Standardize; the implementation can be standardize in the system
6	Time completion; solution can be completed as quick as possible

Assign Relative Weight for Each Objectives

The next step is to give the relative weight for each objectives for WANTS requirements. The weight for each requirement is decided during FGD as shown in the following table. The objective of reducing inventory and PDS are put into high weight as both of them are the main objective of this all about.

Table 7. Relative Weight of Objectives (WANT requirement)

No	Objective	Weight
1	Reduce Inventory	9
2	Reduce PDS	9
3	Low Cost	8
4	Minimum Change Infrastructure	7
5	Standardize	7
6	Time Completion	8

List All Alternative Solutions

According to Table 4 above there are 8 (eight) of Alternative Solutions to be analyzed and the explanation of each alternative solutions is shown below:

1) **Revise Pure Min-Max Policy**
   This solution is to revise the pure min-max policy by considering the probability of failure and reliabilty factor, therefore eventhough the sparepart item has reach the minimum level, it is not automatically ordered, or if it should be ordered, it is not order to maximum quantity. Time to order and order quantity shall consider the probability of failure, and reliability factor such as MTBF (Mean Time Berween Failure) of the equipment. It is hoped by using the New Min-Max Policy, the order quantity will be reduced, and the inventory item and value also decrease in the future.
2) **Sell or Auction the excessive & PDS inventory**
   This solution is to sell or auction the excessive inventory material, especially the potential dead stock items to third party or other company/institution who need it. The purpose is to eliminate unecessary and excessive inventory and company will gain the revenue from it. By selling them of course will reduce the PDS inventory in the system.
3) **Sharing Inventory with other company**
   This idea is to make cooperation and share the inventory items with other companies, especially with similar industry. This make all companies will minimize our stock, we will not stock all items needed, because some items are stock in other companies. This solution will also reduced the inventory item and value
4) **Using Impairment Method**
   Impairment method is the accounting tools to condact revaluation of the inventory. This tools is usually used to revaluate again the asset or capital that is no longer used when its value is below its book value. By impairing the inventory, the inventory value will be decrease,
5) **Establish Link between Inventory & Plant Condition**
   This solution is to build procedures and system that automatically link the inventory level with Plant condition requirement, by establishing this system, inventory will be filled only when the plant needed based on the plant program (ie: overhaul, turn around and upcoming project). This system will make the inventory item more effective, because the item needed will be

ISBN: 978-623-92201-0-5

replenished near the execution.

6) Recategorize the spare part inventory
   This solution is to recategorized and remapping again all items into normal inventory items or insurance items. Many PDS items actually are still needed, they haven't utilized yet because the equipment is not broken yet, once the equipment is broken those materials must be available. For this kind of materials we should put them into the insurance item category. By recategorizing and remapping the items, it will reduce the PDS item in the inventory level and move them itu Insurance item.
7) Consignment
   Establishing the consigment method will reduce our inventory, eventhough the materials are stored in the warehouse, they are not counted as our inventory, they are the vendor inventory, the transaction is counted after the materials is used.
8) Blanket Contract
   This is the long term contract of purchasing material, the intent is to reduce the lead time of material, compare with spot purchasing method. By this method, the materials will not stay longer in the warehouse. We will order when needed to avoid hold stock in the warehouse

Setup the Relative Score of Each Alternative Solution into the Objective WANTS Requirement.

Before setting up the score of each alternative solution against the objectives, the clear parameter and its rating shall be defined first. FGD has agreed to give the rating (from 9 to 6) on each objectives based on the criteria as shown in the Appendix 1; Parameter of the Rating for Each Alternative Solutions.

Using the parameter in Appendix 1, the table below shows the rating of each 8 alternative solutions on each objectives.

Table 8. Rating of Each Alternative Solution

	Alternative No.	1	2	3	4
No	**Objective**	**Revise Min-Max Policy**	**Sell/Auction the excess Mat'l**	**Share inventory with others**	**Impairment Method**
1	Reduce Inventory	6	7	7	8
2	Reduce PDS	6	7	7	9
3	Low Cost	9	9	8	9
4	Minimum Change Infrastructure	9	9	7	9
5	Standardize	8	6	6	8
6	Time Completion	8	7	6	9

	Alternative No.	5	6	7	8
No	**Objective**	**Link Inventory & Plant**	**Recategorize inventory**	**Consign-ment**	**Blanket Contract**
1	Reduce Inventory	8	7	7	7
2	Reduce PDS	8	9	8	8
3	Low Cost	6	9	7	7
4	Minimum Change Infrastructure	6	8	7	8
5	Standardize	8	8	6	6
6	Time Completion	6	8	7	7

Put The Score and Calculate.

Put each alternative into the objectives of MUST to find out the passed mandatory, and calculate the weight of objective from Table 7 and and rating of each alternative against the objective of WANTS in the Table 8 to find out the total score for each alternative. The complete data is shown in the Appendix 2; Score of Each Alternative Solutions. From 8 (eight) solution alternative, two alternative (Alternative No. 2; Selling/Auction the excessive inventory and Alternative No.3; Sharing Inventory with others) do not pass the MUST critera on Legal Aspect, because until now PT Badak NGL is not permitted to sell the inventories as the inventories is belong to government assets. The one that can sell the inventories is the government istelf.

ISBN: 978-623-92201-0-5

Therefore only 6 alternatives that can be further evaluated and the total score is shown in the following figure:

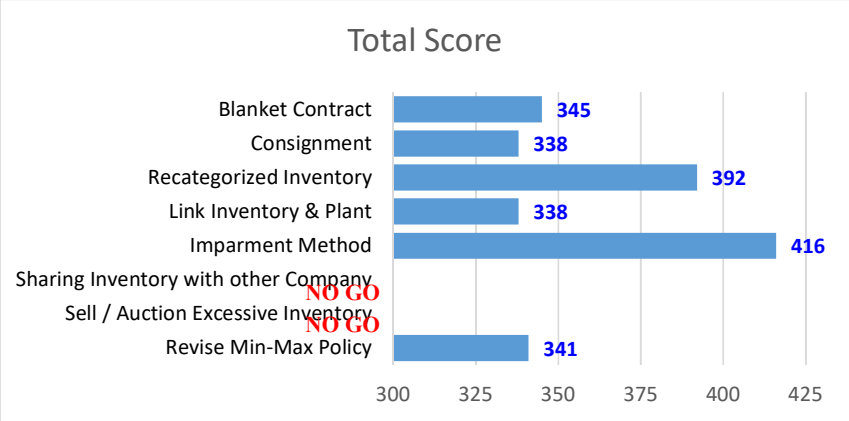

Figure 8. Total Score of each Alternative Solutions

According to the total score from those alternative solutions, there are two solutions that have significant score compare to others, which are:

1. Impairment Method (score 416)
2. Recategorize Inventory (score 392)

Both solutions are then chosen as most priority solution that need to be implemented as soon as possible, while the other can be implemented later as the second priority.

Potential Problem Analysis

After we decided two solution that need to be implemented soon, we shall consider the potential problem(s) of those decision in order to anticipate if something goes wrong during implementation. To analyze the potential problem, the Kepner-Tregoe Potential Problem Analysis is used. Using the procedure of K-T PPA (*published No. 710-35-P456112D E/PDA40-HD105bΩ 18 July 2013*), the following table is made for each solution.

Table 9. Potential Problem Analysis for Impairment

Potential Problem	Possible Cause	Preventive Action	Contingency Plan
Slow Progress	Less Manpower	Set minimum 3 person for each dicipline	Establish Contract manpower
		Inform to all managers to release his subordinate	Establish Contract manpower
	Lack of Impairment Knowledge	Choose personnels who understand the impairment method	Contract to other institution
		Socialize clear SOP of impairment method	Contract to other institution
		Conduct workshop of impairment to all taskforce members	Contract to other institution
	Not focus	Setup dedicated taskforce	Contract to other institution
		Isolate from daily activities	Conduct activities outside Bontang
Incorect Calculation	Lack of Impairment Knowledge	Choose personnels who understand the impairment method	Contract to other institution
		Socialize clear SOP of impairment method	Contract to other institution
		Conduct workshop of impairment to all members	Contract to other institution
	Different Understanding or Persception	Conduct workshop of impairment to all taskforce members	Contract to other institution

ISBN: 978-623-92201-0-5

Table 10. Potential Problem Analysis for Recategorize

Potential Problem	Possible Cause	Preventive Action	Contingency Plan
Takes time to finished	Too many items (thousands) need to be reviewed	Classify first all items into their categosry before discussion	Setup several groups based on each dicipline
	Less Manpower	Appoint minimum 3 experience person for each dicipline	Manager shall be part of the team member
		Inform to all managers to release his subordinate	Ask Senior Manager to setup the taskforce
Put into Wrong category	There is items at grey area	Set clear define the grey area items.	Managers (has the right) to decide it
	Lack of knowledge	Assign personnel that has experience more than 10 years	Manager shall be part of the team member
	No clear guidance or parameter	Provide SOP	Asking Subject Matter Expert

Refer to the potential problem analysis above, if the problem occurred, preventive action for each problem has been developed to avoid it. But if the preventive action can not stop the occurred problem, the contigency plan is prepared, consequently this contigency plan will impact to the score of the solution. The table on Appendix 3; Score if The Problem Occurred will show the impact of each solutions if the problem happend and we have to do the contingency plan.

1. Impairment

   The contingency plan for impairment is we contract the work to the other institution (expert) and will impact to additional cost and the score for Low Cost change from 9 to 6 (it will ada cost more than $1000)

   The score for impairment solution if the problem happend is reduce from 416 to 392. The score of 392 is still the highest from other solutions.

2. Recategorize Materials

   The contingency plan for Recategorize Material is involving Management into part of the team. This will impact to the additional time to finish the work, because the original team cannot finish on time. Therefore the score of criteria for Time Completion will change from 8 (3-6 month completion) to become 7 (6-12 month completion)

According the the problem analysis and their impact to the change of the score above, it is conclude that eventhough the problem will reduce the score for “impairment” and “categorize”, the new score is still high and they are still become the prioritized solutions.

Implementation Plan

Success Indicator

The success indicator for those solution shall be clearly setup to evaluate the successful criteria of the solutions. Following are the example of success indicator that can be implemented

a) Impairment of Inventory
   - The taskforce team is established
   - The rule and procedure have been issued
   - The inventory value can be reduced at least 25% at first year
   - The program can be finished no later than the target

b) Recategorization of material
   - The taskforce team is established
   - The new category (insurance) has been established
   - The rule and procedure have been issued
   - The inventory value can be reduced at least 25% at first year
   - The program can be finished no later than the target

Completion Target

For those two solutions (Impairment and Recategorize) and considering the action shall be conducted immediately and the result will be affected at the end of the year 2019, the completion target is set to six months (June 2019). This is to give any opportunity for improvement in the midyear to evaluate the result before end of the year.

ISBN: 978-623-92201-0-5

Time Table of Implementation

Time table is very important, not only as the guidance and to monitor the progress of the work but also to organize the resources needed. The simplified time table for all solutions are shown in the following page.

No	Step	January				February				March				April				May			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Impairment																					
1	Setup Taskforce Impairment																				
2	Create Procedure																				
3	Workshop taskforce member																				
4	Impairment Work																				
5	Present in front Management																				
6	Provide Final Report																				
Recategorize																					
1	Setup Taskforce Recategorize																				
2	Create Procedure																				
3	Workshop taskforce member																				
4	Recategorize Work																				
5	Present in front Management																				
6	Provide Final Report																				

Resource Needed

To support and make the solution happened, any source related to the work shall be well prepared.

Table 11. Resource Needed

No	Solution	Manpower	Budget	Material
1	Impairment	5 person (dedicated Taskforce)	US$ 100	Stationary
2	Recategorize	10 person (dedicated Taskforce)	US$ 100	Stationary

For “impairment, we only need 5 person as combination from existing F&A and Inventory personnel, the budget is needed for puchase the stationary needs only. They work in daily basis as part of their job description.

For “recategorize”, we need around 10 person, combination from existing inventory, mechanical, rotating, electrical, instrument and reliability people who understand their materials. The budget is needed for purchase the stationary needs only. They work in daily basis as part of their job description.

CONCLUSIONS

PT Badak NGL faces the problem on their inventory because the number of Potential Dead Stock (PDS) is quite large with approximately 70% of the inventory value. It occurs quite long from time to time and leads to inefficient of handling inventory and impact to the cost and company performance.

Analysis using fishbone diagram and conducting Focus Group Discussion (FGD) has been conducted to find out the most influential cause(s) of the problem and revealed that

the problem of inefficient MRO inventory due to PDS materials over the years in PT Badak NGL is caused by several factors as follow:

1) Min-Max Policy,

ISBN: 978-623-92201-0-5

2) Conservative Policy,
3) No link to the Plant Condition, and
4) Procurement Method

To reduce the current large PDS value and to avoid a similar problem in the future, several solutions are developed and using the Kepner-Tregoe Analysis and FGD, two main solutions shall be implemented immediately:

1. Conducting Impairment Method to reevaluate inventory
   Impairment method is the accounting tools to conduct a revaluation of the inventory. This tool is usually used to revaluate again the asset or capital that is no longer used when its value is below its book value. By impairing the inventory, the inventory value will be decreased.
2. Perform recategorize of inventory materials
   This solution is to recategorized and remapping again all items into normal inventory items or insurance items. Many PDS items actually are still needed, they haven't utilized yet because the equipment is not broken yet, once the equipment is broken those materials must be available. For this kind of materials, we should put them into the insurance item category. By recategorizing and remapping the items, it will reduce the PDS item in the inventory level and move them into Insurance item

Recommendation

To reduce the PDS value in PT Badak NGL's inventory, two solutions below shall be implemented as soon as possible with the target of 6 months:

1. Impairment
2. Recategorize

Meanwhile, other 4 solutions below can be implemented after that, with the target completion between 1-1.5 years

1. Revise the policy of Min-Max inventory
2. Provide System that linked between inventory & maintenance program
3. Create consignment method
4. Increase Blanket Contract

In this chapter, we only focus on the first two solutions only, and to make the first two solutions (short term) happen, several actions below shall be followed up:

1. Setup the Taskforce for Impairment Inventory
   Task force members for Recategorized shall consist of at least the following discipline:
   - Inventory people
   - Accounting people

   The main job of this task force is to list all inventory material and revaluate the material value using the impairment method. The output of this task force is the new value of inventory.
2. Setup the Taskforce for Recategorized Materials
   Task force members for Recategorized shall consist of at least the following discipline:
   - Inventory people
   - Mechanical expert
   - Instrument expert
   - Electrical expert
   - Rotating & Machinery expert
   - Reliability expert

   The main job of this task force is to remapping again all materials and recategorized which are materials for the normal inventory and which ones as the insurance items. The insurance item will keep in limited quantity and will not be categorized as the Potential Dead Stock. The output is the new list of material based on their categorized, including the insurance items. Currently, the insurance items in inventory PT Badak NGL is 1,117 items from total 31,000 items (or 3.6%), we believe this value is too small, we predict at least 8-10% of the inventory consists of insurance item. That is why we have to conduct re-categorize again the inventory to get more valid composition of inventory.
3. Setup the success indicator, completion target, time schedule and resources needed as well.

REFERENCES

Erns & Young, 2010, Impairment *accounting – the basic of IAS 36 Impairment of Assets, 2010, 1-10*
International Gas Union, 2018, *2018 World LNG Report*, 27th World Gas Conference Edition, 7-8
Kepner Tregoe Inc, 2013, *Potential Problem Analysis,* published No. 710-35-P456112D E/PDA40-HD105bΩ 18 July 2013, 1-2

ISBN: 978-623-92201-0-5

Logistik, 2012, EOQ – Economic Order Quantity Model still alive, June 5, View at 5 December 2018 at http://logisitik.blogspot.com/2012/06/eoq-economic-order-quantity-model-still.html

McDermott, David*,2011, Kepner Tregoe Decision Making, The Steps, The Pros and The Cons,*Decision Making Confidence, View at 6 December 2018 at https://www.decision-making-confidence.com/kepner-tregoe-decision-making.html

Mind Tools Content Team, 2016, Cause and Effect Analysis, Nov 2016, View at 15 November 2018 at https://www.mindtools.com/pages/article/newTMC_03.htm

MMH Staff, 2013, The Case for Managing MRO Inventory, Supply Chain Management Review, View 23 August 2018 at http://www.scmr.com/article/the_case_for_managing_mro_inventory

Ordu, Promise A, 2014, *EOQ in a Just in Time (JIT) World*: *An Empirical Analysis of the Impact of EOQ Variables on Operating Profit: The Case of Nigerian Bottling Company Plc*. European Journal of Business and Management, 130

Phillip Townsend Associates, 2017, *Operational Performance BADAK LNG-2016,* Phillip Townsed Associates Inc, 127

PT Badak NGL, 2018, About PT Badak NGL - Company Profile - History, View 16 Augustus 2018 at http://portal.badaklng.co.id/internet/tentang-perusahaan/profil-perusahaan/sejarah-perusahaan.html

PT Badak NGL, 2015, *Warehouse Operating Procedure OP/SP/BP29/99-03, 1-23*

PT Badak NGL, 2015, *Policy/Procedure Guide, Category of Stock Material*, 1-14

Radasanu, Alin Constantin, 2016, *Inventory Management, Service Level and Safety Stock,* Journal of Public Administration, Finance and Law, 147

Rao, C. Madhusudhana and Rao, K. Prahlada, 2009, *Inventory Turnover Ratio As a Supply Chain Performance Measure,*Serbian Journal of Management, 4 (1) (2009), 41-50

Stevenson, William J., 1996, *Production/Operation Management,* 5th Edition, 526-588

Vrat, Prem, *2014*, Basic Concepts in Inventory Management, In *Material Management An Integrated Systems Approach,* XXIII, 21-22