ABB INC. MEDIUM-VOLTAGE PRODUCTS' SUPPLY CHAIN ANALYSIS, INCLUDING INVENTORY, SUPPLIER SCORECARD, AND RISK ASSESSMENTS

by

TAMBOURA E. GASKINS

B.S., Chemical Engineering (1994)
M.S., Chemical Engineering (1995)

Columbia University, School of Engineering and Applied Science

Submitted to the Sloan School of Management and the Department of Engineering Systems Division in Partial Fulfillment of the Requirements for the Degrees of

Master of Business Administration
and
Master of Science in Engineering Systems

In Conjunction with the Leaders for Manufacturing Program at the Massachusetts Institute of Technology

June 2006

© 2006 Tamboura E. Gaskins. All rights reserved.

The author hereby grants MIT permission to reproduce and to distribute publicly paper and electronic copies of this thesis document in whole or in part.

Signature of Author: 

Department of Engineering Systems Division

May 2, 2006

Certified by 

Jonathan L. Byrnes
Senior Lecturer, Center for Transportation & Logistics
Thesis Supervisor

Stephen C. Graves
Abraham Siegel Professor of Management
Thesis Supervisor

Debbie H. Berechman
Director of Master's Program
Sloan School of Management

Richard de Neufville
Chairman, Committee on Graduate Students
Department of Engineering Systems Division
ABB INC. MEDIUM-VOLTAGE PRODUCTS’ SUPPLY CHAIN ANALYSIS,
INCLUDING INVENTORY, SUPPLIER SCORECARD, AND RISK ASSESSMENTS

by

TAMBOURA E. GASKINS

Submitted to the Sloan School of Management and the Department of Engineering Systems Division on May 2, 2006 in Partial Fulfillment of the Requirements for the Degrees of Master of Business Administration and Master of Science in Engineering Systems

ABSTRACT

In conformance with ABB’s process excellence plan, this thesis study was undertaken to support improvements in on-time delivery of components, decreased order cycles, and reduced inventory levels for ADVAC (spring-mechanized)/AMVAC (magnetic-actuated) medium-voltage circuit breakers. With the goal of improving the efficiency of the ADVAC/AMVAC supply chain, the study involved analyzing circuit breaker inventory level and position, assessing a supplier scorecard, and assessing general supply chain risk methodologies. In an effort to assess supply chain risk, a value stream map was created to uncover where the project team should focus to best address supply chain risk and contingency planning.

The project team identified opportunities to improve order processing using an electronic ordering system. The team investigated the feasibility of eliminating or reducing air freight to improve transportation costs. Also, the team examined ADVAC/AMVAC inventory holdings at various stages in the supply chain and determined that it was more cost-effective to hold as much component inventory as possible instead of finished goods inventory, while standardizing delivery cycles, in order to move toward a just-in-time order-fulfillment process.

Thesis Supervisor: Stephen C. Graves
Title: Abraham Siegel Professor of Management

Thesis Supervisor: Jonathan L. Byrnes
Title: Senior Lecturer, Center for Transportation & Logistics
ACKNOWLEDGEMENT

The author wishes to acknowledge the Leaders for Manufacturing Program and ABB for its support of this work.
# Table of Contents

**Abstract** ................................................................................................................................. 3

**Acknowledgement** .................................................................................................................. 4

**Table of Contents** ..................................................................................................................... 5

**List of Figures** .......................................................................................................................... 7

## 1 Introduction

1.1 About ABB .................................................................................................................................. 9

1.2 Process Excellence in Power Technologies ................................................................................. 11

1.3 ADVAC/AMVAC Product Descriptions .................................................................................... 11

1.4 The NAMV Supply Chain ........................................................................................................... 13

1.5 Thesis Scope and Definition ........................................................................................................ 14

1.6 Thesis Framework ....................................................................................................................... 15

## 2 Managing Inventories ............................................................................................................ 17

2.1 The Value of a Lean Inventory Position ..................................................................................... 18

2.2 Circuit Breaker Strategic Inventory Management ......................................................................... 19

## 3 Using Supplier Scorecards .................................................................................................... 25

3.1 The Role of Incentives in a Vertically-Integrated Supply Chain ................................................ 25

3.2 The Ratingen Supplier Scorecard ............................................................................................... 26

3.3 Benchmarking Newell Rubbermaid’s Supplier Development Process ...................................... 27

3.4 Opportunity for Improving the Ratingen Scorecard .................................................................. 28

## 4 Understanding Supply Chain Risk .......................................................................................... 29

4.1 FMEA – A Tool for Assessing Risk ............................................................................................. 29

4.2 Performing an FMEA Assessment – What to Watch Out For ................................................ 30

4.3 The Importance of a Risk Assessment to NAMV ..................................................................... 31

## 5 Conclusion .................................................................................................................................. 33

5.1 Summary of Findings .................................................................................................................. 33

5.2 Recommendation

  Develop and Communicate an Operations Strategy and Structure .................................................. 33

5.3 Opportunity for Further Study ................................................................................................... 34

  A Postponement of Differentiation Strategy ................................................................................ 34

**Bibliography** .............................................................................................................................. 36

**Appendices** ................................................................................................................................ 38

**Appendix A – ABB Group 2004 Profitability Analysis** ................................................................. 39

  **Exhibit 1A** Return on Assets Analysis ...................................................................................... 39

  **Exhibit 2A** Asset Turnover Ratio Analysis ............................................................................... 40

  **Exhibit 3A** Consolidated Common-Size Income Statement ..................................................... 41

**Appendix B – The NAMV Supply Chain** ..................................................................................... 42

  **Exhibit 1B** A Multi-Value Chain ............................................................................................... 42

  **Exhibit 2B** A Vertically-Integrated Supply Chain ..................................................................... 43
LIST OF FIGURES

FIGURE 1: ADVAC CIRCUIT BREAKER ................................................................. 12
FIGURE 2: ADVAC/AMVAC PRODUCT DESCRIPTIONS ................................... 13
FIGURE 3: ADVAC/AMVAC SUPPLY CHAIN ..................................................... 14
FIGURE 5: SILVER, PYKE, AND PETERSON INVENTORY MODEL ......................... 21
FIGURE 7: AIR FREIGHT REDUCTION COST ANALYSIS .................................. 24
1 INTRODUCTION

The waves you create and the value you bring to the firm relies heavily on your ability to impact people and processes.¹

In an increasingly competitive global market, companies continually seek ways to stay cost competitive. They actively manage inventory levels with an eye on customer service. They seek to improve supplier relations and the transparency of information exchange, and they continuously evaluate supply chain risk and contingency plans—all in an effort to drive profitability and operational efficiency.

ABB’s strategic plan for 2005, as communicated by recently named CEO Fred Kindle, was to stabilize performance and improve margins—

“We will achieve this through greater operational excellence – better processes, better internal controls, a focus on more commonalities in an empowered, disciplined and decentralized organization.”

- Fred Kindle, CEO

In conformance with the overall ABB strategic plan for this year, the primary objective of this study was to impact the value-chain improvement initiative for ABB’s North America Medium Voltage (NAMV) business. Therefore, this study focused on the improvement of on-time delivery of components, the shortening of order cycles, and

the reduction and strategic placement of inventory within the NAMV supply chain.

1.1 About ABB

We are a leader in power and automation technologies that enable utility and industry customers to improve performance while lowering environmental impact.\(^2\)

Formed in 1998 by a merger of Asea AB of Sweden and BBC Brown Boveri of Switzerland, ABB Limited is an international supplier of power and automation technologies. Headquartered in Zurich, Switzerland, it employs approximately 100,000 employees in four regions: the Americas, Europe, Asia, and the Middle East and Africa. ABB is structured into two main divisions—Power Technologies and Automation Technologies, but also has other operations designated as Non-core Activities and Corporate/Other.\(^3\)

The Non-core Activities operating unit consists of the Oil, Gas and Petrochemicals, Building Systems, New Ventures, Equity Ventures and Structured Finance, Customer Service Workshops and the Logistic Systems business areas and generated in 2004 approximately $1.7 billion in revenues with an employee base of about 5000. The Corporate/Other unit employed approximately 1500 people, making up Corporate Headquarters, Research and Development, Real Estate, and Treasury operations.\(^4\)

\(^3\)ABB Financial Review 2004 2.
The Automation Technologies (AT) division is a supplier of automated systems, software, and services for industrial and commercial processes. There are several subdivisions of Automated Technologies, including Automation Products, Process Automation, and Manufacturing Automation. The combined activities of the AT subdivisions generated $11 billion in revenue in 2004, which was a 15% increase from 2003 revenue. The gross profit margin in 2004 remained steady at about 29 percent, while earnings before interest and taxes (EBIT) increased by 39 percent resulting in $1.027 billion EBIT in 2004.5

The Power Technologies (PT) division, while realizing revenue growth, was not as successful financially as the AT division in 2004. Although the PT division matched the AT division with revenue growth of about 15 percent—rising from $7.6 billion in 2003 to $8.8 billion in 2004, the PT division’s gross profit margin and EBIT margin declined 1.7% and 0.8%, respectively, during the same period, indicating a rise in cost of sales for the division. Fortunately, the PT division’s declining gross profit margin and EBIT were offset by an increase in both margins for the Non-core Activities group. The net results for ABB Limited were a 2% gross profit margin increase and a 3.5% EBIT increase from 2003 to 2004.6

---

5 ABB Financial Review 2004 3, 19, 21
In order to improve profitability, the Power Technologies division announced in 2004 that it would streamline its business activities.\(^7\)

### 1.2 Process Excellence in Power Technologies

The Power Technologies division with five business areas, including transformers, power systems, medium-voltage products, high-voltage products, and utility automation, has been focused on improving efficiency at its production sites in an effort to drive profitability and improve customer service. Toward this aim, the PT division has sought to standardize processes and decrease order cycles in all business areas, including medium-voltage products.\(^8\) In 2004, the medium-voltage products business (PTMV) made up 19 percent of the PT division’s revenue base\(^9\) by producing and selling a range of circuit breakers, switchgear, and distribution products.\(^10\)

In conformance with ABB’s process excellence plan, this thesis study was undertaken to support improvements in on-time delivery of components, decreased order cycles, and reduced inventory levels for the North American Medium Voltage (NAMV) supply chain.

### 1.3 ADVAC/AMVAC Product Descriptions

Circuit breakers in general are used to prevent damage to electrical equipment during power surges. When the current in an electrical system exceeds a set maximum, the circuit breaker breaks...
the electrical connection, thereby keeping the excessive electrical current from continuing through the circuit. The ADVAC (Figure 1) and AMVAC circuit breakers are ANSI-rated, medium-voltage vacuum breakers used in primary power distribution systems. (See Figure 2 for more product characteristics.) Medium-voltage circuit breakers, like ADVAC and AMVAC, are supplied to industrial customers like schools, hospitals, and manufacturing companies.

Figure 1: ADVAC Circuit Breaker
1.4 The NAMV Supply Chain

The NAMV supply chain is a complex entity with various customers and supply bases for a number of circuit breaker, switchgear, and energy distribution products (See Appendix 1B). Each factory in the supply chain operates as a profit center with unique performance targets and supply-demand challenges (See Appendix 2B).

The NAMV supply chain was the focus of this study. Specifically, component suppliers source parts to Ratingen, Germany for production of vacuum interrupters and circuit breaker modules. The Ratingen factory then sends the vacuum interrupters to various circuit breaker assembly plants around the world, including Italy (ITSCB), China (CNDMX), and the United States (USTRA). The assembly plants produce the finished circuit breakers for sale to external original
equipment manufacturers (OEMs) as well as internal switchgear manufacturing sites, like the one in Lake Mary, Fl.

The ADVAC/AMVAC CBMs are the precursor to the ADVAC/AMVAC circuit breaker and are produced in Ratingen specifically for distribution to the United States (See Figure 3 below). In Florence, South Carolina, ADVAC/AMVAC circuit breakers are the main operational component in medium-voltage switchgear and are assembled from Ratingen CBMs. The circuit breakers are distributed either to external OEMs, to an ABB after-market replacement parts group, or to the ABB switchgear facility in Lake Mary, Florida.

**Figure 3: ADVAC/AMVAC Supply Chain**

1.5 Thesis Scope and Definition

In order to play a significant part in meeting the 2005 ABB Group Financial Targets—i.e. compound average annual revenue growth of 5.3% in local currencies and 8% EBIT margins, NAMV sought to streamline its supply chain by reducing trans-Atlantic lead times for components, by reducing and strategically placing inventories, and by improving communication among supply chain

---

constituents. The internship project focused on supporting the NAMV process excellence plan to improve operating margins, which had a direct impact on both revenue growth and EBIT margin.

A focus on inventory reduction within the medium-voltage products supply chain is expected to impact positively the inventory turnover ratio, which is in line with the current strategy of the NAMV business unit to improve working capital by reducing inventory levels. The proposed operating target for inventory level was 5 – 10 percent of sales revenue. Also, a focus on inventory reduction will enable ABB to further its process excellence goals in the medium-voltage products business.

Ultimately, the internship project sought to identify and recommend ways to rectify areas of the NAMV supply chain that do not comply with ABB’s initiatives to stabilize performance and improve margins.

1.6 Thesis Framework

In keeping with the Leaders for Manufacturing Program charter, this thesis will combine technical and business assessments of the ABB NAMV circuit breaker/switchgear supply chain. Chapter 2 involves an assessment of circuit breaker inventory level and placement throughout the supply chain. Chapter 3 details an evaluation of the Ratingen, Germany supplier scorecard based on a benchmark of an established world-class supplier scorecard, and, lastly, Chapter 4 is a
survey of risk assessment methodologies and how they can be applied to mitigate risk in the NAMV supply chain.
2 MANAGING INVENTORIES

In a survey conducted by R. Michael Donovan & Co., Inc., 82 percent of the senior executives who responded said that excessive levels [of inventory] were a major concern for them. Some saw inventories as just a vehicle that absorbs massive amounts of cash while others understood that high inventories were also an indication of other serious problems.\(^{12}\)

In order to ensure profitability, a business must protect its sales; it must also aggressively manage the costs. A significant cost contributor is inventory holding cost. Therefore, profitable businesses usually seek to protect and grow sales while striving to reduce inventory. Inventories tend to grow excessively when replenishment lead times are long and/or forecasts are inaccurate. Long replenishment lead times result from long production cycles, long transportation times, or long order processing times. Shortening replenishment lead time is key to reducing inventory level and, therefore, the cost of holding inventory. The shorter the replenishment time, the further away from the customer inventory can be held; thus, minimizing inventory value and holding cost.

The current replenishment lead time for NAMV circuit breakers is 12-18 weeks. The goal for the project team has been to reduce this lead time to 5-6 weeks in order to realize substantial inventory holding

---

cost savings. If the cycle times for all the process steps are added, the cycle time to complete one item is typically less than one day. Therefore, since assembly is not the rate-limiting step, it is reasonable to believe that the lead time goal of 5-6 weeks can be achieved by instituting a standard order process consisting of a weekly order of a set quantity of components from Ratingen. The shortened lead time translates to lower cycle and safety stock levels and an overall leaner inventory position.

2.1 The Value of a Lean Inventory Position

Value includes short lead times, quality materials, on-time delivery, good customer service, and a fair price.\textsuperscript{13}

Proper inventory management enables an organization to realize the value of improved product quality and customer service. For this reason, NAMV has committed resources to improve its inventory position across all supply chains. Specifically for the medium-voltage circuit breaker supply chain, the focus has been on reducing inventory levels, on strategic placement of inventory, and on creating transparent and efficient communication channels. By reducing inventory levels, NAMV is looking to improve its cash flow position and decrease operating costs. By strategically placing inventory, the group seeks to manage order cycles and customer service levels while reducing inventory holding costs. Finally, by improving communication channels, i.e. implementing online ordering and databases of current

\textsuperscript{13} Donovan 6.
inventory levels at each stage of the supply chain, NAMV expects to be able to streamline its supply chain and increase order efficiency. Ultimately, NAMV will undertake all of these activities in an effort to add value by effective management of the supply chain and to improve business profitability.

2.2 Circuit Breaker Strategic Inventory Management

The first action in NAMV’s quest to reduce inventory was to understand the current inventory strategy and inventory levels for ADVAC/AMVAC circuit breakers. The Florence, SC circuit breaker assembly plant had been utilizing a variety of techniques to manage its mechanical parts inventory. Their strategy consisted of

- Executing a kanban from assembly to stores for circuit breaker modules (CBMs),
- Utilizing a two-bin or a single bin system for non-CBM parts, and
- Holding safety stock to manage demand and delivery uncertainty.

The actual quantities of various parts were indeterminate due to issues with inventory accuracy and bill-of-material accuracy. So, the first action for the project team was to get an accurate count of inventoried parts.

Next, the project team wanted to develop a strategy for its various inventories that supports the business unit’s plan to reduce and strategically place inventory to achieve a cost-effective, customer-focused supply chain. The inventory strategy would consist of a target cycle stock level, safety stock level, and re-order point as well as a
determination of an appropriate customer service target. Figure 5 illustrates the impact of the customer service target (CSL) on cycle stock, safety stock, and the re-order point. If the cycle stock is determined from the average demand between replenishments, then it is independent of the customer service level; however, safety stock and, therefore, re-order point—the combination of the cycle stock and safety stock values—are dependent on CSL. The higher the CSL, the more safety stock is recommended and, consequently, the more inventory is required.

---

**Assumptions—**

1. Demand rate and lead time are normally distributed, independent, random variables. Independence is a good assumption in this case as is randomness; however, the simulation assumes a level production rate, evenly distributed to meet a constant demand rate. So, the assumption of a normal distribution in the simulation should be confirmed with actual plant production and demand data before projected stock levels are determined. The monthly demand has been confirmed not to be normally distributed, based on data from "Breaker Module Inventory & Usage.xls." However, the stock levels have been approximated using a calculation based on a normal distribution assumption.

2. Std Dev of lead times was approximated as 25% of the expected lead time.

3. Std Dev of demand rate was approximated as half the typical batch size. A more rigorous approximation of the std dev of the demand rate would be to determine the number of full-sized batches required to meet the forecasted demand, and then to calculate the std dev using the formula below:

\[ \text{StdDev} = \sqrt{\frac{\sum (x - \mu)^2}{n-1}} \]

where \( x \) is the number of batches produced in a week times the batch size, \( \mu \) is the average weekly demand, \( n \) is the number of weeks of the forecast, and the summation is from week 1 to week \( n \).

---

A comparison of actual inventory for a six-month period in 2004 can be found in Appendix D. The SPP model recommends lower safety stock levels than what was actually held during the six-month period. The lower safety stock level corresponds to a decrease in the average replenishment purchase cost. Thus, combining the SPP model’s recommendation for safety stock holdings with management’s recommendation to decrease lead time would improve overall inventory carrying costs.

**Demand during Leadtime**

\[
\text{Total Demand in Replenishment Leadtime} = E(D) \times E(L)
\]

---

16 Silver 283.
In the project analysis, the order cycle was assumed to be monthly. The total demand during the replenishment leadtime is the expected demand, \( E(D) \), during the order cycle multiplied by the expected leadtime, \( E(L) \), for the same period. The shorter the order cycle, the less cycle stock is required. When determining the length of an order cycle, management must compare and balance the cost of ordering to the cost of holding cycle inventory.\(^{17}\)

In the case of the ADVAC/AMVAC circuit breakers, management decided that the new inventory strategy would be to increase order cycles to twice weekly deliveries of a fixed quantity of circuit breakers from the current practice of irregular shipments that are not coordinated with order cycles or quantities. With this change to regular, standard deliveries, the order cycle would be significantly reduced and the uncertainty in lead time would be eliminated. The result of the new strategy would be a lower cycle stock (and safety stock) requirement.

**Safety Stock**

\[
\text{Safety Stock} = k\sigma_x = k\sqrt{E(L)\text{var}(D) + [E(D)]^2 \text{var}(L)}
\]

When there is uncertainty in demand and lead time, safety stock is required to meet pre-determined customer service targets. When there is no uncertainty in lead time, \( \text{var}(L) \) equals zero, and the second term of the square root drops out, resulting in a reduction in

\(^{17}\) Silver 30.
the safety stock requirement. Thus, management’s strategy to set a standard order cycle and quantity would have the desired effect of reducing both cycle stock and safety stock levels and, therefore, reducing overall inventory costs.

**Ocean vs Air Freight**

Eliminating air freight was another strategy proposed by management to reduce supply chain/inventory costs. From June 2004 to February 2005, some NAMV orders were air-freighted from Ratingen, Germany to various sites in the United States in order to fill backorders. Figure 6 illustrates the number of breaker items (1B09608H01/1B09639H01) and re-closer items (GCE9017690R0111/GCE9017790R0111) that were air-freighted during this period.

![Figure 5: 2004 - 2005 Breaker/Re-closer Shipments](image)

18 Silver 283.
Figure 7 shows the potential shipping cost savings had all breakers and re-closers been shipped by ocean without any air-freighting. If air-freight had not been utilized for these items during this period, NAMV would have realized a 48% reduction in shipping costs (the per-unit costs are order of magnitude approximations of the actual costs).

**Figure 6: Air Freight Reduction Cost Analysis**

<table>
<thead>
<tr>
<th>Cost Analysis</th>
<th>Base</th>
<th>No Air Freight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Parts Delivered</td>
<td>5139</td>
<td>5139</td>
</tr>
<tr>
<td>Per Unit Ocean Freight Cost</td>
<td>$5</td>
<td>$5</td>
</tr>
<tr>
<td>Per Unit Air Freight Cost</td>
<td>$50</td>
<td>$50</td>
</tr>
<tr>
<td>Total Ocean Freight Cost</td>
<td>$23,050</td>
<td>$25,695</td>
</tr>
<tr>
<td>Total Air Freight Cost</td>
<td>$26,450</td>
<td>$0</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$49,500</td>
<td>$25,695</td>
</tr>
<tr>
<td>% Air Freight</td>
<td>53%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Therefore, the reduction or elimination of air freight is a good strategy for reducing supply chain costs for NAMV provided that demand forecasts and ocean shipments are reliable.

Standardizing the frequency of ocean shipments and order quantities would also facilitate the reduction or elimination of air freight. The current ordering process does not support the reduction of air freight, because the process is not as responsive to demand and leadtime variability or unexpected shortages as needed to discontinue expediting of certain shipments.
3 USING SUPPLIER SCORECARDS

3.1 The Role of Incentives in a Vertically-Integrated Supply Chain

The supplier scorecard assesses suppliers based on major performance benchmarks in several key areas. The supplier scorecard helps you know the score by distinguishing your superstars from the minor league suppliers.\(^9\)

In a vertically-integrated supply chain where there is no competition among suppliers for market share, such as with the ABB Global-Focused Feeder Factory (GFFF) model, the scorecard is less about distinguishing good suppliers from troublesome ones and more about improving communication between customer and supplier in order to achieve high performance for the entire supply chain. ABB’s GFFF concept is to have one central factory supply major components to ABB manufacturers of finished goods all over the world. There is no supplier competition, because there is only one GFFF for any particular finished goods facility. So, why should a GFFF care about a supplier scorecard assessment?

Each GFFF should care about its performance score because the supplier assessment is a way for the GFFF’s customers to communicate what they need in order to increase sales, decrease costs, improve morale, etc. That is, the supplier scorecard is a way for the customer to communicate to the supplier about how to improve ABB’s business. However, in order for a scorecard to be effective, there must be some

incentive for the supplier to improve its score. Without proper incentives, GFFFs will not be encouraged to change their behaviors in order to improve their scores. For a vertically-integrated supply chain, getting the supplier scorecard incentives right is important for the overall good of the company.

3.2 The Ratingen Supplier Scorecard

The Ratingen manufacturing facility is the vacuum interrupter GFFF of the NAMV circuit breaker and switchgear supply chain; Ratingen is the supplier of circuit breaker components to Florence, SC and Lake Mary, FL. Consequently, Lake Mary has created a scorecard for Ratingen, since Ratingen supplies Lake Mary directly for embedded pole and vacuum interrupter components. The scorecard is a multi-tabbed Excel workbook with several worksheets containing raw order data used to compute monthly metrics by which Ratingen is being assessed. Other worksheets contain the performance scores for the key rating areas.

The most relevant contents of the scorecard workbook are the performance metrics charts. The charts indicate the performance metrics by which Ratingen is being judged. The bar charts are excellent visual indicators of achievement, because they illustrate at-a-glance Ratingen’s actual performance versus targeted performance. Perhaps, the bar charts should be displayed more prominently within the scorecard workbook, since the charts communicate at-a-glance how Ratingen measures up to Lake Mary’s expectations.
The metrics that Lake Mary has identified as important to supplier performance are quality acceptance % and on-time delivery %. The quality acceptance % is the percent non-defective parts received from the supplier. The goal for the year for this metric is 98.0%. The on-time delivery % is the percent of “lots” of components that are received on time; the goals for this metric are 95% on time to due date and 98% on time to promise date. The due date is the date Lake Mary requests for order fulfillment, and the promise date is the date Ratingen promises to fulfill an order. Usually, the due date and the promise date are the same, but sometimes during high volume periods Ratingen needs to extend the due date to a later promise date.

3.3 Benchmarking Newell Rubbermaid’s Supplier Development Process

At Newell Rubbermaid (NR), they take the assessment of supplier performance very seriously—so seriously that they have developed a “5-Step Supplier Development Process” through which they assess performance and provide timely feedback to each NR supplier. The five steps of the NR supplier development process involve assessment, qualification, measurement, rating, and recognition. This development tool ensures that Newell Rubber has a reliable supply base capable of helping them maintain and grow market share in an increasingly competitive consumer products market.

---

Because Newell Rubbermaid has developed such a detailed methodology for assessing its suppliers and because its methodology was readily available via the internet for comparison purposes, it is the company that was chosen as the benchmark for the Ratingen supplier scorecard assessment. See Appendix E for more about the Newell-Rubbermaid supplier scorecard system.

3.4 Opportunity for Improving the Ratingen Scorecard

Currently, Lake Mary has a quality metric and a service level metric by which it assesses Ratingen’s performance in supplying circuit breaker modules. It communicates to Ratingen its performance to target by percentage on-time delivery (service level) and percentage quality acceptance (quality) charts. However, the current Ratingen scorecard lacks a direct measurement of productivity performance and how it impacts supply chain costs. Because Lake Mary and Ratingen operate as independent profit centers, there is little incentive to align performance targets. For this reason, there needs to be a performance metric that communicates the impact of supplier practices on global supply chain success. Perhaps, the Newell Rubbermaid productivity metric, i.e. total cost reduction divided by total purchase costs, could be a relevant NAMV productivity metric. The cost metric would give conformance to expectations meaning for Ratingen as it considers the impact of its performance scores.
4 UNDERSTANDING SUPPLY CHAIN RISK

Risk-taking, trust, and serendipity are key ingredients of joy.
Without risk, nothing new ever happens.
Without trust, fear creeps in.
Without serendipity, there are no surprises.\textsuperscript{21}

There are elements of risk associated with every part of a supply chain. There is supplier risk—can all the suppliers provide what you need, when you need it, in the quantity that’s needed? There is production risk, i.e. the risk that human, physical, and financial resources will be available when needed to meet demand requirements. And there is transportation or distribution risk that involves getting product to the customer in an orderly, timely, and cost efficient way. Assessing and mitigating the different types of risk will be a key component of the success of the NAMV supply chain methodology.

4.1 FMEA – A Tool for Assessing Risk

A failure modes and effects analysis (FMEA) spreadsheet is a tool commonly used to assess the risk involved in performing various tasks that comprise a business process. The FMEA enumerates each step of a given process, identifies potential failure modes, effects, and causes; and lists current process controls to recognize a failure and mitigate the effects. The individuals involved in creating the FMEA will assign a risk score to each failure mode, based on severity and likelihood of occurrence and detection, and decide if the potential risk is acceptable or if additional mitigations are necessary.

failure mode warrants corrective action to further mitigate the risk inherent to the process step. The result of an FMEA assessment is a ranking of potential failure modes based on risk scores.

To extend the FMEA assessment beyond the prioritization exercise, the template may also include columns for recommended actions, responsible persons, and a final risk score assigned after the corrective actions have been implemented. An example of an FMEA template may be found in Appendix C.

4.2 Performing an FMEA Assessment - What to Watch Out For

An FMEA assessment should be conducted by a multi-functional team of individuals who know the specific steps of the process. The team may also consist of suppliers and customers who each have a unique perspective on process/product failure modes. Ideally, the FMEA assessment should begin in the design stages of a particular process and should be conducted periodically throughout the life of the process.

The process team should endeavor to limit the scope of an FMEA exercise to sections of the process that will be more manageable by time and effort. If the process has many steps, the process team may inadvertently miss recording a failure mode due to time constraints or information overload during a brainstorming session. Breaking the

---

process down into manageable blocks will keep the FMEA exercise from being too time-consuming or too superficial.

Lastly, the FMEA tool should be combined with a poka-yoking, i.e. a mistake-proofing, exercise, because the FMEA exercise helps prioritize failure modes, not eliminate them. Once a step has been changed to incorporate a risk-mitigation or poka-yoke action, its risk score should be reassessed and re-prioritized. In the end, linking the FMEA to a detailed control plan that provides instruction about how to respond to failure modes will ensure that the FMEA remains up-to-date.

4.3 The Importance of a Risk Assessment to NAMV

The NAMV risk assessment should cover all relevant areas of supplier capability, distribution reliability, and the sustainability of the replenishment process. Should any one of these areas fail to deliver to expectations, it could have a devastating impact on the supply chain’s ability to function efficiently.

The evidence of this fact was discovered by the NAMV supply chain, when the supplier of the AMVAC circuit breaker control board was incapable of meeting the component’s quality specifications. Production of the AMVAC circuit breaker came to a halt until the supplier was able to resolve its quality issues. The supplier was the single source for the component, and the disruption caused significant delays and backorders of AMVAC new and replacement parts. A suitable contingency plan may have included options for multi-sourcing of key components or periodic supplier audits to assess sustainability.
If there had been options for multi-sourcing in place, the disruption in AMVAC production may have been avoided or, at least, minimized.
5 CONCLUSION

5.1 Summary of Findings

With the goal of improving the efficiency of the NAMV supply chain, the internship project involved analyzing circuit breaker inventory level and position, assessing the Ratingen supplier scorecard, and assessing general supply chain risk methodologies. The inventory analysis involved assessing current inventory levels, identifying an appropriate inventory model (e.g. two-bin system, continuous vs. periodic review, or fixed order quantity vs. order-up-to-level system) to meet customer demand and production requirements, and assessing appropriate safety stock levels to guard against variability in both supply and demand. The supplier scorecard assessment involved making recommendations for improving the usability of the scorecard to improve internal supplier-customer relations. In an effort to assess supply chain risk, current- and future-state value stream maps were created to illustrate the importance of knowing where the supply chain is now and where it should be directed to best address supply chain risk and contingency planning.

5.2 Recommendation

Develop and Communicate an Operations Strategy and Structure

It is recommended that NAMV continue its development of an operations strategy and structure and that the strategy be communicated and well-understood across the entire global supply chain. As the corporate strategy for operations is to focus on
improving efficiency at production sites in an effort to drive profitability and improve customer service, the operations strategy should be aligned in such a way. An appropriate operations strategy would involve standardization of process, streamlining order cycles, and decreasing the cost of inventory. Using available data to drive supply chain decisions would greatly enhance the effectiveness of the operations strategy.

The project team identified opportunities to improve order processing using an electronic ordering system. The team investigated the feasibility of eliminating or reducing air freight to improve transportation costs. Also, the team examined ADVAC/AMVAC inventory holdings at various sites along the supply chain and determined that it was more cost-effective to hold as much component inventory as possible, as opposed to finished goods inventory, while standardizing delivery cycles, in order to move toward a just-in-time order-fulfillment process. It is recommended that these initiatives continue to be explored and an execution plan and timeline be created in order to realize the expected cost savings and efficiency improvement.

5.3 Opportunity for Further Study

A Postponement of Differentiation Strategy

There is an opportunity to explore make-to-order and postponement of differentiation strategies in the NAMV circuit breaker supply chain in order to increase profitability and improve customer
service. It will become clearer, as the order leadtimes are reduced from 12-18 weeks to 5-6 weeks, where make-to-order and postponement strategies will add the most value for the NAMV division.
BIBLIOGRAPHY


Vick, Bill. “PTMV Value Chain Optimization.” *ABB Group Presentation.*
### APPENDIX A – ABB Group 2004 Profitability Analysis

**EXHIBIT 1A  Return on Assets Analysis**

\[
\text{ROA} = \frac{\text{Earnings Before Interest and Taxes}}{\text{Average Total Assets}}
\]

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Total Assets</td>
<td>$27,539</td>
<td>$29,967</td>
</tr>
<tr>
<td>Rate of Return on Assets</td>
<td>3.9%</td>
<td>1.2%</td>
</tr>
</tbody>
</table>

*From Consolidated Financial Statements (2004 Annual Report)*

**Year Ended December 31,**

(in millions $)

#### Income Statement

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2003</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</td>
<td>$20,721</td>
<td>$20,427</td>
<td>$19,472</td>
</tr>
<tr>
<td>Cost of Sales</td>
<td>(15,757)</td>
<td>(15,928)</td>
<td>(15,098)</td>
</tr>
<tr>
<td>Gross Profit</td>
<td>4,964</td>
<td>4,499</td>
<td>4,374</td>
</tr>
<tr>
<td>Selling, General, and Administrative Expenses</td>
<td>(3,786)</td>
<td>(3,917)</td>
<td>(4,050)</td>
</tr>
<tr>
<td>Amortization Expenses</td>
<td>(45)</td>
<td>(31)</td>
<td>(45)</td>
</tr>
<tr>
<td>Other Income (Expense), net</td>
<td>(49)</td>
<td>(194)</td>
<td>(80)</td>
</tr>
<tr>
<td><strong>Earnings Before Interest and Taxes</strong></td>
<td>$1,084</td>
<td>$357</td>
<td>$199</td>
</tr>
</tbody>
</table>

#### Balance Sheet*

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2003</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash and Equivalents</td>
<td>$3,676</td>
<td>$4,783</td>
<td>$2,336</td>
</tr>
<tr>
<td>Marketable Securities and Short-term Investments</td>
<td>524</td>
<td>473</td>
<td>589</td>
</tr>
<tr>
<td>Receivables, net</td>
<td>6,330</td>
<td>6,049</td>
<td>5,134</td>
</tr>
<tr>
<td>Inventories, net</td>
<td>2,977</td>
<td>2,671</td>
<td>2,261</td>
</tr>
<tr>
<td>Prepaid Expenses and Other</td>
<td>1,688</td>
<td>1,794</td>
<td>2,628</td>
</tr>
<tr>
<td>Assets Held for Sale and in Discontinued Operations</td>
<td>155</td>
<td>4,981</td>
<td>7,499</td>
</tr>
<tr>
<td><strong>Total Current Assets</strong></td>
<td>$15,350</td>
<td>$20,751</td>
<td>$20,447</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2003</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financing Receivables, non-current</td>
<td>1,233</td>
<td>1,372</td>
<td>1,605</td>
</tr>
<tr>
<td>Property, Plant and Equipment, net</td>
<td>2,981</td>
<td>2,858</td>
<td>2,701</td>
</tr>
<tr>
<td>Goodwill</td>
<td>2,602</td>
<td>2,528</td>
<td>2,221</td>
</tr>
<tr>
<td>Other Intangible Assets, net</td>
<td>493</td>
<td>601</td>
<td>587</td>
</tr>
<tr>
<td>Prepaid Pension and Other Employee Benefits</td>
<td>549</td>
<td>564</td>
<td>537</td>
</tr>
<tr>
<td>Investments and Other</td>
<td>1,469</td>
<td>1,727</td>
<td>1,435</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td>$24,677</td>
<td>$30,401</td>
<td>$29,533</td>
</tr>
</tbody>
</table>

*2002 Balance Sheet numbers are from 2003 Annual Report - Consolidated Financial Statements*
EXHIBIT 2A  Asset Turnover Ratio Analysis

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Assets Turnover Ratio</strong></td>
<td>0.75</td>
<td>0.68</td>
</tr>
<tr>
<td><strong>Accounts Receivable Turnover</strong></td>
<td>3.35</td>
<td>3.65</td>
</tr>
<tr>
<td><strong>Days A/R Are Outstanding</strong></td>
<td>109</td>
<td>100</td>
</tr>
<tr>
<td><strong>Inventory Turnover</strong></td>
<td>5.58</td>
<td>6.46</td>
</tr>
<tr>
<td><strong>Fixed Asset Turnover</strong></td>
<td>7.10</td>
<td>7.35</td>
</tr>
</tbody>
</table>
### EXHIBIT 3A  Consolidated Common-Size Income Statement

**ABB Group - Consolidated Common-Size Income Statement**

<table>
<thead>
<tr>
<th>Year Ended December 31,</th>
<th>2004</th>
<th>2003</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(in millions $)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Income Statement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenues</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Cost of Sales</td>
<td>-76%</td>
<td>-78%</td>
<td>-78%</td>
</tr>
<tr>
<td><strong>Gross Profit</strong></td>
<td>24%</td>
<td>22%</td>
<td>22%</td>
</tr>
<tr>
<td>Selling, General, and Administrative Expenses</td>
<td>-18%</td>
<td>-19%</td>
<td>-21%</td>
</tr>
<tr>
<td>Amortization Expenses</td>
<td>-0.22%</td>
<td>-0.15%</td>
<td>-0.23%</td>
</tr>
<tr>
<td>Other Income/Expense, net</td>
<td>-0.24%</td>
<td>-1%</td>
<td>-0.41%</td>
</tr>
<tr>
<td><strong>Earnings Before Interest and Taxes</strong></td>
<td>5%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Interest and Dividend Income</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Interest and Other Finance Expense</td>
<td>-2%</td>
<td>-3%</td>
<td>-2%</td>
</tr>
<tr>
<td><strong>Income/Loss from Continuing Ops. Before Taxes</strong></td>
<td>4%</td>
<td>-0.29%</td>
<td>0.34%</td>
</tr>
<tr>
<td>and Minority Interest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provision for Taxes</td>
<td>-2%</td>
<td>-1%</td>
<td>-0.42%</td>
</tr>
<tr>
<td>Minority Interest</td>
<td>-0.49%</td>
<td>-0.32%</td>
<td>-1%</td>
</tr>
<tr>
<td><strong>Income/Loss from Continuing Operations</strong></td>
<td>2%</td>
<td>-2%</td>
<td>-1%</td>
</tr>
<tr>
<td>Loss from Discontinued Operations, net of tax</td>
<td>-2%</td>
<td>-2%</td>
<td>-4%</td>
</tr>
<tr>
<td><strong>Net Income/Loss</strong></td>
<td>-0.17%</td>
<td>-4%</td>
<td>-4%</td>
</tr>
</tbody>
</table>
APPENDIX B – The NAMV Supply Chain

EXHIBIT 1B  A Multi-Value Chain

EXHIBIT 2B  A Vertically-Integrated Supply Chain

PTMV
Supplier  Vacuum Interrupter  Circuit Breaker  Switchgear  Customer

Ceramics  CuCr contacts  DECMS  Metal bellows  Deep draw material

OEM  CZEJF  ITSCB  DECMS  INABB  AUTIL

ITSCB  DECMS  INABB  USTRA  NODIS  OEM

EGARC  OCE  EGARC  OEM  CNDMX

CN

24 Kontas 44.
## APPENDIX C – FMEA Template

<table>
<thead>
<tr>
<th>Process Step</th>
<th>Potential Failure Mode</th>
<th>Potential Failure Effects</th>
<th>Severity</th>
<th>Potential Causes</th>
<th>Occurrence</th>
<th>Current Controls</th>
<th>Detection</th>
<th>Risk Score</th>
<th>Recommended Actions</th>
<th>Resp. Person</th>
<th>Actions Taken</th>
<th>Occurrence</th>
<th>Severity</th>
<th>Detection</th>
<th>Risk Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

44
APPENDIX D – SPP Model versus Actual Inventory Levels

EXHIBIT 1D – Silver, Pike, and Peterson (SPP) Inventory Model*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Demand</strong></td>
<td>1428 Units</td>
</tr>
<tr>
<td><strong>Average Monthly Demand</strong></td>
<td>238 Units</td>
</tr>
<tr>
<td><strong>StdDev of Monthly Dem.</strong></td>
<td>86.64179</td>
</tr>
<tr>
<td><strong>Average LeadTime</strong></td>
<td>2.69 Months</td>
</tr>
<tr>
<td><strong>StdDev of Monthly LT</strong></td>
<td>0.8645</td>
</tr>
<tr>
<td><strong>Expected LT Deman</strong></td>
<td>639.9556</td>
</tr>
<tr>
<td><strong>StdDev of Exp LT Demand</strong></td>
<td>250.0323</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inventory Positions</th>
<th>CSL=95%</th>
<th>90%</th>
<th>85%</th>
<th>80%</th>
<th>75%</th>
<th>70%</th>
<th>60%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>k</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycle Stock</td>
<td>CS</td>
<td>640</td>
<td>640</td>
<td>640</td>
<td>640</td>
<td>640</td>
<td>640</td>
</tr>
<tr>
<td>Safety Stock</td>
<td>SS</td>
<td>410</td>
<td>320</td>
<td>260</td>
<td>210</td>
<td>168</td>
<td>130</td>
</tr>
<tr>
<td>Re-order Point</td>
<td>s</td>
<td>1050</td>
<td>960</td>
<td>900</td>
<td>850</td>
<td>807</td>
<td>770</td>
</tr>
</tbody>
</table>

* Leadtimes are based on the quantity received (not the quantity ordered). So, for the quantity received, the leadtime was determined from the order date and the due date (projected) or receipt date (actual). The data in this example is for descriptive purposes only and do not represent actual ABB demand data.
EXHIBIT 2D - Actual End of Period Inventory Levels*

| Item | Cost | Jan | Feb | Mar | Apr | May | Jun | Avg | CSL | Avg Dam/LT | Safety Stock Value | Carrying Cost |
|------|------|-----|-----|-----|-----|-----|-----|-----|-----|------|-------------|-----------------|--------------|
| A    | $650.00 | 525 | 423 | 285 | 68  | 317 | 155 | 206 | 60% | 924 | $102,400     | $29,565.18     |
| B    | $975.00 | 199 | 368 | 366 | 400 | 417 | 447 | 371 | 99% | 320 | $361,725     | $31,062.85     |
| C    | $340.00 | 346 | 276 | 270 | 194 | 71  | 307 | 244 | 66% | 603 | $822,930     | $11,124.80     |
| D    | $427.00 | 55  | 52  | 65  | 70  | 43  | 79  | 60  | 70% | 100 | $25,620      | $2,815.00      |
| **Totals** |      |     |     |     |     |     |     |     |     |     | **$662,705** | **$74,558**    |

EXHIBIT 3D - SPP Inventory Model Cost Estimations*

Carrying Cost = Avg Inv * Unit Cost * 6% Carrying Charge

EXHIBIT 4D - Comparison of Costs*

<table>
<thead>
<tr>
<th>Costs</th>
<th>Six Month Inventory Holdings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005 Actual</td>
</tr>
<tr>
<td>Safety Stock</td>
<td>$662,705.00</td>
</tr>
<tr>
<td>Carrying</td>
<td>$74,557.82</td>
</tr>
</tbody>
</table>

* See Exhibit 5E for an explanation of the calculations. The data in this example is for descriptive purposes only and do not represent actual ABB demand data.
EXHIBIT 5D - Inventory Calculations Legend

$L = \text{Length of the lead time, in a number of unit time periods (dimensionless)}$

$D = \text{Demand in a unit time period, in units}$

$x = \text{Total demand in a replenishment lead time, in units}$

$E[y] = \text{Mean of } y, \text{ or the expected value of } y \text{ (where } y \text{ is any random variable)}$

$\text{var}[y] = \text{variance of } y, \text{ (where } y \text{ is any random variable)}$

$\text{Cycle Stock} = \left[ \frac{\text{Weekly Demand}}{\left(\# \text{ Deliveries per Week} \times 2\right)} \right] \text{ (e.g. avg inventory during an order cycle} \times \# \text{ order cycles)}$

$\text{Cycle Stock} = E[x] = E[L] \times E[D] = \text{Exp. demand during the exp. lead time}$

$\text{var}[x] = E[L] \times \text{var}[D] + \{E[D]\}^2 \times \text{var}[L]$

$\sigma_x = \sqrt{\text{var}[x]} = \sqrt{E[L] \times \text{var}[D] + \{E[D]\}^2 \times \text{var}[L]$

$\text{Safety Stock} = k \times \sigma_x$

$\text{Inventory} = \text{Cycle Stock} + \text{Safety Stock}$

$\text{Inventory} = E[x] + k \times \sqrt{E[L] \times \text{var}[D] + \{E[D]\}^2 \times \text{var}[L]}$

$\text{WIP} = \text{Weekly Demand} \times \text{Production Throughput Time}$
APPENDIX E – Newell-Rubbermaid Supplier Scorecard

There are four specific criteria the NR uses to measure supplier performance. These criteria are quality, service level, productivity, and responsiveness. Each criterion is weighted 25% of the total performance score. The quality criterion or metric is defined as adherence to defined specifications and is measured as the number of defective parts per million. The service level metric is defined as on-time shipment within a window of zero days late and no more than two days early; and service level is measured as the percentage of orders arriving on-time. The productivity metric is the yearly total cost reduction, calculated by the total cost reduction divided by total purchase costs; and, finally, responsiveness is determined subjectively by the purchasing personnel and may be based on any number of factors, including, but not limited to, lead time reduction, implementation of corrective actions, and responsiveness to emergency orders. The points attainable are shown in the table below.

Newell Rubbermaid’s Scorecard Point System

<table>
<thead>
<tr>
<th>Rating</th>
<th>Quality</th>
<th>Service Level</th>
<th>Productivity</th>
<th>Responsiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reported DPPM</td>
<td>Shipment %</td>
<td>Cost Reduction %</td>
<td>Subjective Value</td>
</tr>
<tr>
<td>5</td>
<td>0 – 3,600</td>
<td>100</td>
<td>&gt; 10</td>
<td>Extremely Cooperative</td>
</tr>
<tr>
<td>4</td>
<td>3,601 – 5,000</td>
<td>99 – 99.9</td>
<td>&gt; 5.1 - 10</td>
<td>Very Cooperative</td>
</tr>
<tr>
<td>3</td>
<td>5,001 – 7,000</td>
<td>98 – 98.9</td>
<td>&gt; 4.1 - 5</td>
<td>Acceptable Conduct</td>
</tr>
<tr>
<td>2</td>
<td>7,001 – 10,000</td>
<td>97 – 97.9</td>
<td>&gt; 3.1 - 4</td>
<td>Marginally Acceptable</td>
</tr>
<tr>
<td>1</td>
<td>10,001 – 20,000</td>
<td>95 – 96.9</td>
<td>&gt; 0.0 - 3</td>
<td>Poor Conduct</td>
</tr>
<tr>
<td>0</td>
<td>&gt; 20,000</td>
<td>&lt; 95</td>
<td>&lt; 0.0</td>
<td>Unacceptable Conduct</td>
</tr>
</tbody>
</table>