Bill of Material Testing for Enterprise Resource Planning (ERP) Implementation

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ABSTRACT

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Implementing enterprise resource planning (ERP) is a very difficult process that has risks associated with it. It is important for a company to eliminate as many implementation risks as possible before attempting to go live with the system.

The purpose of this project is to outline the testing process used for an Oracle enterprise resource planning (ERP) implementation at a garage door company in the United States. Bill of material (BOM), manufacturing exchange system (MES), and system performance related to geneating BOMs and shop floor order data are to be thoroughly tested to ensure the system is ready with regards to product structure and manufacturing data before swithching to the new system. The need for this testing, as well as the process used to perform the testing, will be explained. Testing issues will be

covered to show the different problems found. Specific factors that hinder and limit testing will be discussed as well as an overview for final testing plans.

This company is a manufacturer of commercial and residential garage doors. The company consists of four manufacturing plants and a corporate office. Each plant produces different models of garage doors. These different models are shipped to the sister plants to fulfill their customers' orders so that the same product is not manufactured at multiple locations. The plant in this study will be the first plant to process orders and build product out of the Oracle-based enterprise resource planning (ERP) system. Oracle will be the primary information system for this plant by March of 2005. The enterprise resource planning (ERP) system will process customer orders into BOMs and schedule them for production. This system will be responsible for providing the shop floor control system with all of the production data. Once orders have shipped, the system will bill customers and order materials to replenish inventory. In order to calculate product and material costs, provide work instructions for production, and control inventories, BOMs must be set up in Oracle to include each size, option, and model that is built at the plant. For enterprise resource planning (ERP) to be successful, it is critical for all of the BOMs to be accurate. Any inaccuracy with the bills can lead to costing issues, product outages, inventory overages, late shipments, and wrong product being shipped to the customer. It is critical to have a good process for testing and correcting BOM issues to prevent this from happening.

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Chapter I: Introduction

Implementing enterprise resource planning (ERP) is a very difficult process that has risks associated with it. It is important for a company to eliminate as many implementation risks as possible before attempting to go live with the system. The company studied in this project is a garage door manufacturer located in the United States. The actual name of the company will remain confidential.

This company is a manufacturer of commercial and residential garage doors. The company consists of four manufacturing plants and a corporate office. Each plant produces different models of garage doors. These different models are shipped to the sister plants and distribution centers to fulfill customer orders so that the same product is not manufactured at multiple locations. Currently, the manufacturing plants, corporate office and distribution centers all have independent legacy systems. Maximizing business efficiency and customer service is difficult to accomplish when all locations and departments are not functioning on a single shared system. The company has decided to implement an Oracle-based ERP system at all plants, offices, and warehouses in order to help the company run more efficiently.

The plant referred to in this study will be the first plant to process orders and build products out of the Oracle-based ERP system. Oracle will be the primary information system for this plant by March of 2005. The ERP system will process customer orders into BOMs (bills of material) and schedule them for production. This system will be responsible for providing the shop floor control system with all of the production data. Once orders have shipped, the system will bill customers and order materials to replenish inventory. In order to calculate product and material costs, provide work instructions for production, and control inventories, BOMs must be set up in Oracle to include each size, option, and model that is built at the plant. For proper production and material planning, it is critical for BOMs to be complete and accurate (Correl, 1995). Accurate BOMs will help prevent product outages, inventory overages, late shipments, and wrong products being shipped to customers (Pachura, 1998). BOM and data accuracy is critical through all aspects of manufacturing. This would include the shop floor control and MES systems. It is important to make sure bills of material and other manafacturing data is accurate to ensure orders are processed correctly.

Statement of the Problem

The purpose of this project is to outline the testing process used for an ERP implementation with regards to product structure and manufacturing data before switching over to the new ERP system. Bill of material and manufacturing data accuracy are critical in supporting manufacturing processes (Pachura, 1998). System performance and validation testing is equally important for a successful implementation (Schwartz. 1998). It is essential that the BOMs, MES, and system performance are thoroughly tested to ensure the system is ready prior to implementation. The need for this testing, as well as the process used to perform the testing, will be explained. A variety of issues that sufaced during testing will be discussed. Specific factors that hinder and limit testing will be discussed as well as an overview for final testing plans.

Project Objectives

The following objectives have been created to help ensure that all product data and performance requirements are met prior to switching to the new ERP system. These objectives are to:

1) Provide a systematic approach to bills of material testing that enables most BOM errors to be detected and corrected prior to going live with the system
2) Identify the open issues remaining before switching to the new ERP system so alternative-processing methods may be adopted to handle the issues until fully resolved
3) Ensure that the MES provides proper and accurate data to the shop floor control systems
4) Ensure system performance is adequate to handle the daily business loads

Assumptions of the Study

It is assumed that the testing processes established in this study will be used through implementation completion in the initial plant. It is also assumed that the findings and recommendations from this study will be used for the future implementations at the other plants and that the configurator team member make-up will remain relatively constant until the end of the project.

Definition of Terms

BOM: Bill of material is a listing of all the materials, components and quantities used to manufacture an item (Kremzar, 2001).

ERP: Enterprise resource planning is a combination of the different legacy systems in an organization into one system (Ferrando, 2001). ERP is a shared business system that provides real time data for all aspects of the business in every area of the organization.

Load verification: Load verification is a shop floor control system used to track the status of a complete shipping load with regards to its individual orders.

MES: Manufacturing execution system is a link that bridges the gap between ERP and shop floor systems. It provides real time data to manufacturing equipment and employees, provides feedback to ERP on manufacturing measurable data such as inventories, order status inventory and more (Davis, 2003).

MRP: Material requirement planning uses BOMs, inventory data, and the master schedule to plan material ordering and replenishment (Kremzar, 2001).

OID record: Order identification records are records that identify all of the options and unique manufacturing information associated with orders and items.

Pick-list: A pick list is a piece of shop paperwork listing the items that need to be selected and packaged for shipping a particular order.

Shop floor control: Shop floor control is a system for handling order information, tracking work in progress, and inputting control data at the manufacturing or material handling point of operation (Kremzar, 2001).

Limitations of the Study

1. This study was conducted during the first plant's implementation of ERP and does not include any data from the other plants' implementations.
2. Due to the product structure in the garage door industry, the main testing emphasized in this project covers BOM-related testing including MES and system performance testing as related to BOM processing. It does not focus on the many other areas of important ERP implementation testing necessary for a successful ERP implementation.

3. The implementation testing at this facility is about 70% complete at this point and only provides a good snapshot of progress made in the project as well as future plans to complete the implementation testing.

Chapter II: Literature Review

This chapter will give an overview of what enterprise resource planning is and what the benefits are to having an ERP system. It will also describe a manufacturing execution system and discuss the benefits of the system. Finally, the need for testing BOMs, MES, and overall performance will be established.

> ERP is: An enterprise-wide set of management tools that balances demand and supply, containing the ability to link customers and suppliers into a complete supply chain, employing proven business practices for decision-making, and providing high degrees of cross-functional integration among sales, marketing, manufacturing, operations, logistics, purchasing, finance, new product development, and human resources, thereby enabling people to run their business with high levels of customer service and productivity, and simultaneously lower costs and inventories; and providing the foundation for effective commerce. (Kremzar & Wallace, 2001).

ERP combines the different legacy systems in an organization into one system (Ferrando, 2001). Basically, ERP is a shared business system among all areas of an organization. Common centralized information is used to make business decisions.

A key function missing in many manufacturing facilities is a link between ERP and manufacturing (Davis, 2003). Manufacturing execution system (MES) links ERP to the shop floor (Bartholomew, 2003). MES is responsible for taking ERP information and applying it to shop floor functions such as shop floor control and load verification. MES will then feed back information such as order status to ERP so customer service can have instant access to information that will help them service customers better. MES can boost

7. Monitoring and evaluating performance
8. Project champion
9. Project management
10. Software development, testing, and troubleshooting
11. Top management support

Everything done in an ERP system affects the success of the entire company (Gale, 2002). If the system set up is done correctly and all of the items in ERP are correct, there is a greater chance of success than if the system set up and items in ERP are not correct. Ronald Pachura states the importance of BOM accuracy in an MRP system (Pachura, 1998). ERP would certainly have the same if not greater requirement for BOM accuracy since it will be the basis of the entire business system; in fact, 98% minimum BOM accuracy is necessary for MRP to begin functioning properly (Kremzar, 2001). Purchasing, billing, costing, scheduling, shipping, customer service, and engineering are all parts of the ERP system that may affected by inaccurate BOMs. Implementing a successful ERP system requires transition and migration testing (Al-Mashari, 2003). An article by Matthew Schwartz states how most companies could not assess system performance until they went live and applied a load to the system (Schwartz, 1998). Testing helps to reduce costs and shorten implementation by surfacing issues before going live. Crane, a pipe manufacturer, faced delays in implementation, which cost roughly $20 million in overruns (Songini, 2004). A thorough testing plan can help eliminate large cost overruns and potential project failure.

efficiencies, cut scheduling times, and improve turnaround by eliminating time-consuming manual entries and having access to real time data downloaded from the ERP system (Davis, 2003).

ERP combined with MES can be a very powerful tool to run a business. However, there are risks associated with an ERP implementation. CIO Magazine states how Hershey Foods had a flawed implementation that led to distribution problems (Wheatley, 2001). They tried to do too much at one time (Carr, 2002). Delays in Hershey's implementation caused them to convert to ERP during their busy season without thoroughly testing the system before implementation. The entire system was turned on without phasing in portions to ensure success. Thorough testing had proven to be successful in past legacy system development and was not followed in the ERP implementation. The issues occurred during the peak Halloween and pre-Christmas selling season. Hershey's shares plummeted 27% that year due to late and missed shipments (Wheatley, 2001). Fox Meyer Drug also had a failed ERP implementation, which caused the company to go bankrupt.

Fui-Hoon Nah identified 11 factors that contribute to a successful ERP implementation (Nah, 2003).

1. Appropriate business and IT legacy systems
2. Business plan and vision
3. Business process re-engineering
4. Change management program and culture
5. Communication
6. ERP Teamwork and composition

Summary

This chapter briefly defined ERP and MES and outlined the advantages of using the integrated systems in an organization. It also established the need for testing an ERP and MES system prior to implementation to ensure success. The literature reviewed in this chapter indicated the importance to thoroughly test an ERP system before going live. This testing should not only include ERP but also any other related or linked system such as MES. Testing should be performed on every function of the system, from order information, BOMs, routings, costing, billing, customer service, purchasing, reporting, and all other functions of the ERP and MES systems used. Care must be taken during the implementation process so there are no interruptions in regards to shipping complete and on-time orders. Any issues affecting product shipments and customer service can have a devastating impact on business. To prevent this from happening, it is important to thoroughly test the ERP system to validate BOM accuracy and performance prior to its implementation.

Chapter III: Methodology

The purpose of this project is to outline the testing process used for an ERP implementation with regards to product structure and manufacturing data before switching over to the new ERP system. The most significant issue surrounding testing in the company studied is the large number of models and options available to the customer. Initially, there were 172 models in the commercial product line and 77 models in the residential product line. Residential doors are used on homes and sheds where as commercial doors are more complex and are typically used on large buildings and factories. Each of the residential or commercial models have a width, height, color, lock, spring, track, window, insulation, and strut options. The possibility for unique configurations is almost endless. Due to the number of models and options, it is not feasable to manually create a BOM for every possible product configuration. To allow for automatic BOM configuration, Oracle has a module called the configurator. The Oracle configurator is "The part of an application that provides custom configuration capabilities" (Brand, Damiani, Leach, Sawtelle, & Shanzer, 2003). The configurator allows for BOMs to be generated as needed by selecting from an extensive list of model options. The system then generates a BOM for the item once the option selections are complete. This allows for BOMs to be generated when a particular door configuration is ordered and eliminates the need to pre-configure a large number of BOMs.

Rules must be written for each model and put into the Oracle configurator to allow for this function. Configurator rules are sets of logic that pick and apply items to the BOM based on defined criteria (Brand, 2003). There are thousands of different configurator rules for a given product group. The rules must then be tested to ensure accurate BOMs are generated. The configurator team is responsible for this task. This team is made up of two team leaders, five rule writers, two bills of material testers, and one consultant who develops custom processes. To help organize work efforts, the residential and commercial models were both divided into like product groups. One rule writer was assigned to write rules for a given group of models. The two BOM testers enter different product configurations and generate BOMs for each model, and then they validate the data.

Generating bills of material in Oracle is a lengthy process that takes from 10-15 minutes per BOM. To generate a BOM an order must first be generated. To do this, information such as customer name, purchase order, and other order information must be entered in the Sales Order form (Robinson, 2004). Once that information is entered, the Ordered Item and Quantity fields must be filled in. The configurator can then be launched and all of the options are entered for the order. From there, the order is booked and finally progressed. Booking the order attaches the items to the sales order. Progressing the order creates the BOM, routings, cost roll-up and then finalizes the order. The next step is to return to the order line and explode out the order details for that line on the order. There will be a unique part number identified in the exploded line details. That number is used to generate a bill of material report that can be printed and verified for accuracy. The short procedure is shown in Figure 1 (Robinson, 2004).

Create Sales Order ➔ Print BOM

1 Use the following menu path(s) to begin this task: Select Orders, Returns - Sales Orders.

2 Start the task using the menu path

3 Double-click + **Orders, Returns**

4 Double-click

5 Enter the customer name or number into the **Customer** field

6 Enter the customer PO in the **PO** field

7 Enter the order type in the Order Field (Normally CSR-Order)

8 Click the Line Items tab

9 Enter the model of the item to configure / order in the **Items** field

10 Enter the order quantity in the **Quantity** field

11 Select the **Configurator** button

12 Make required selections

13 Click the **Done Button**

14 Click the Book Order button

15 Once booked click the **OK** button

16 Select the **Line Items** tab

17 Select **Actions** then **Progress Order**

18 Once the order is progressed select the **OK** button

19 Select the **Line Items** tab

20 Select the **View** drop down menu and click the **Show Line Details** box

21 Query for the new item numbers by the **F11** key and typing **%*%** in the items field followed by pressing the **Ctrl & F11** key simultaneously.

22 Write down or copy all of the new items numbers designated with a * to word pad

23 Exit the **Sales Order** form by clicking on the **X** in the upper left corner

24 Change to the **Product Engineering** responsibility by selecting the **Top Hat Icon** at the top of the screen ad select **Product Engineering**

25 Navigate to **Bills, Reports ➔ Bills**

26 Select **Single Request**

27 Select **Bill of Material Structure Report GUI**

28 Enter the first new item number into the **Item** field and select **OK**

29 Select **Submit** to generate the report

30 The system will ask if you want to submit another request, if you have more new items to run select **Yes** and repeat the submission, if not select **No**

31 Select the **View** drop down menu and select **View Requests**

32 Once the report says **Complete,** click on the Options drop down menu and select **Reprint**

Figure 1. Create Sales Order Procedure.

The process to enter the order and generate a printed BOM takes 10-15 minutes. The BOMs are from a pre-determined list and include many variable configuration options including, height, width, track type, track lift, spring type, locks, windows, and other possible options. The options that are entered are taken from a model configuration sheet and include different model levels; the complete door, track only, hardware only, hardware box only, and sections only assemblies. It is necessary to test the levels separately from each other as well as together as a complete door since the assemblies can be purchased individually. Below is a partial configuration sheet for the complete door level of a model. A full sample of the entire configuration sheet for the same model can be seen in Appendix A through F, which will include all levels of the model.

XXX Series - Complete Door

Color	Sand	Brown	Sand	Alm
Width Ft and Width In	18ft	9ft 10 in	9ft	10ft
Door Height	7' 0"	6' 9"	7' 0"	8' 0"
Insulation	**Yes**	**Yes**	**Yes**	**Yes**
Springs	Ext	Ez-set	Ext	Ez-set
Lift	Low Headroom	15" SR	Low Headroom	Low Front
Track	2" Standard	2" Heavy	2" Standard	2" Heavy
Lock	Snap	Snap	Keyed Side	Cremone
Struts	Solid	4 Xtra Struts	2 Xtra Struts	STD
Lites	STD	Sec 4 DSB	Solid	Sgl Sec 4 Pnl 2
Additional Options	10 Ball Roller	High Cycle Springs	Operator Bracket	None
Packaging	Unipack	Unipack	Unipack	Unipack
Order #	*	*	*	*

Figure 2. Model Configuration Sheet.

The bill is then reviewed for accuracy against the product specification releases. This review can take anywhere from 30 minutes to two hours per bill depending on the complexity of the model and the options selected. The BOM review consists of checking the different component bundles of the door. These component bundles are the track, spring, hardware box, strut, and sections. The track bundle consists of about 10-15 components and is mounted to the door jambs in the garage. The spring bundle includes from one to six springs and the necessary shaft components needed to counter balance the door. The hardware box contains all of the hinges, fasteners and other small parts necessary to install the door. There are typically 30 to 70 items in the hardware box. The strut bundle is the simplest portion of the bill. There are typically one to 14 struts in the strut bundle but it is usually made up of only one or two different parts. Last is the section bundle, which may contain up to 15 sections that can be as wide as 32' 2". There are normally 20–30 different components in the section bundle. In the complete door bill, there are easily over 100 items that need to be checked for accuracy. To do this, the BOM is compared with the product specification releases.

The product specification releases contain all of the pertinent information and rules for a model. They specify what options are available for the model and what sizes the particular door can be made. Steel and insulation sizes and types are outlined as well as any manufacturing information required to build the door. The documents also outline what type and grade of hardware should be used for the door as well as door weights so that it can be accurately sprung. There are about 120 pages of reference materials used to check a single model. This process is detail orientated and is time-consuming work that can only be performed by people familiar with the product lines and BOM structure.

Initially, approximately 12 BOMs will be generated and reviewed for a given model. Any issues that are discovered are entered into either the residential or commercial BOM issue logs which are shared among the configuration team. Once a logged issue is thought to be resolved, it is marked " Ready To Test" on the log and will be re-tested by the BOM testers. Once all of the initially posted issues are resolved, the model will go into final BOM testing. In final testing, all of the configurations will be generated and tested from the model configuration sheets for all levels of the model. If all BOMs are correct, then the model is approved for production. There is a sign-off sheet located in a shared configurator team folder that includes all of the levels of the model.

MES testing is done using two different order sources. The first source uses the orders that were entered for BOM testing. The second source is to randomly select orders from the existing legacy system. These orders are then simulated in the ERP and MES system. These orders are transferred from ERP to the MES and then reviewed for accuracy. The first part of this testing is to review the order identification records (OID). The OID record is a record that identifies all of the options and unique manufacturing information associated with an order. These records are reviewed to make sure they match what was entered into ERP and that all of the proper BOM components necessary for manufacturing have been passed to the MES. The review also helps verify that the model data mapping is correct. Once the OID data is validated the records will be processed through the shop floor system; however, the orders will not be produced. Testing will include verifying that pick-lists are accurate and provide enough information to complete the order. A pick list is a piece of shop paperwork listing the items that need to be selected and packaged for shipping a particular order. They are verified against the

BOMs for the items on the order. The manufacturing data displayed on the shop floor monitors is reviewed as well. This information also tells the department how to complete the order and is displayed in several work cells along the production line. All generated product labels and shipping documents are reviewed to make sure they are accurate. The product labels will be scanned into the load verification system so the product load can be marked complete. The shipping information is then transferred back into ERP from MES and accounting reviews the information to ensure the billing transactions are processed correctly.

Acceptance Testing

Phase one acceptance testing includes BOM, MES, and performance testing. Acceptance testing is the last phase of testing before going live with ERP. Initially, 20 orders will be processed through each department, simulating about three hours of run time. The orders will be entered into ERP and transferred to the shop floor system through MES. Before manufacturing, at least 25% of the BOMs and OID records will be reviewed for accuracy to ensure there are no customer shortages or wrong products produced. Then the orders are to be manufactured and shipped using the new ERP system. This testing helps identify any BOM, MES, or severe performance issues since the orders are entered and processed immediately.

Phase two acceptance testing follows the same process as phase one except that a full day of production is completed for each department through the new system. Each department's test is done at separate times so more focus can be put towards answering questions and verifying that the systems are functioning correctly. A predetermined amount of BOMs will be reviewed during and after the test. Shipping, manufacturing, inventory, customer service, and accounting information will be reviewed for any issues. At this testing stage, customer billings out of ERP will not be sent to the customers, rather they will be reviewed for accuracy by accounting. Processing times will be monitored during this stage as a performance indicator for what to expect when the system is fully implemented.

Phase three acceptance testing will be spread out over approximately two and a half days. One full day of orders will be entered into the ERP system for production. The orders will be processed and reviewed the first day, and then sent to the shop floor system. The orders will be produced by production utilizing the shop floor system. When production is complete, shipping will load all of the orders, mark the load complete, and ship the finished product to the customer using the ERP and MES system. Accounting will process all necessary billing through ERP and send it to the customer. The entire order, manufacturing and billing cycle will be tested from start to finish through the new system. Special attention will be paid to BOM accuracy, any remaining issues, and overall performance. At that point, if there are no critical issues the system switch over will be scheduled within one week of the final acceptance test. This delay will be necessary so that an inventory can be performed prior to fully switching to the new ERP system.

Limitations

The limitation of this research and testing process is that the main focus of the study is on testing BOMs and the MES system, as well as the performance associated with processing the BOMs and transferring them to production. Although testing was and will be performed in other areas of the implementation, the researcher has not and will not focus any effort on other areas of testing other than those defined in the problem statement.

Summary

This chapter outlined the process that has been used and will continue to be used for BOM, MES, and performance testing in this ERP implementation. BOM testing and model sign off is the first series of testing followed by the MES/shop floor testing, and then the final acceptance and performance testing.

Chapter IV: Results

The purpose of this project is to outline the testing process used for an Oracle ERP implementation with regards to product structure and manufacturing data before switching to the new ERP system. Product structure development and BOM testing has been in process for the past 16 months. This chapter will outline what issues were found during testing and some solutions to the problems.

Up to this point, testing has been moving along simultaneously with system development for about 20 months. The initial system configuration had been BOM and MES tested through near completion in April 2004. During final acceptance testing, the system had performance problems related to processing the product structure and orders. Instead of trying to implement ERP and struggling through the busy season (May through December), the company decided to delay implementation to ensure there would be no interruptions to customer service. During this time, the model structure was redesigned to make system maintenance easier and to provide performance enhancements. The system is now scheduled for implementation in February of 2005.

The following chapter will outline the testing process, results, and decisions made up to the first acceptance test. The system redesign and new testing efforts will be discussed, as well as the progress made towards implementation. A brief summary of the testing that remains prior to implementation will follow.

Testing Prior to Redesign - BOM Testing

Bills of material testing includes verifying all levels of the BOM are accurate. The BOM is reviewed for accuracy against the product specification releases. This review can take anywhere from 30 minutes to two hours per bill depending on the complexity of the model and the options selected. The commercial models typically take longer to review because they are more complex and have more components. The BOM review involves checking the different component bundles of the door. These component bundles are the track, spring, hardware box, strut, and sections. There were several BOM issues found in the component bundles.

Many items were identified when the track bundles were checked. In some cases, the wrong vertical and horizontal track length was configured. Although these parts would work correctly for the given door, they were not parts stocked at that location. Wrong jamb brackets and splice plates were also a common error in the configurator rules. This was because the specification didn't cover that part of the track assembly well. Some rules were developed by modeling another plant's track specification and not according to how the consolidated track specification had intended. Some of the track covered under the consolidated track specification was new to the implementing plant as well as the other locations. Due to the lesser familiarity with the new track system, it was a little harder to develop rules and check the configured bills. In some cases, the track was missing several major components all together. This was usually because a bracket was missing from the written rule, thus preventing the rule from working.

The spring bundle is a time-consuming item to test. The spring system provides the necessary torque and power needed to allow the door to be lifted with minimal force by a person or electric opener. If springing is incorrect, the door will not function properly and it will have a very negative impact on customer satisfaction. To test the spring system, the door springing weight must be determined for the door. The springing weight is a combination of the weight of the sections, the struts and all of the hardware placed on the door. Once the weight is determined, the springs then need to be manually calculated for the door weight, width, height, and lift type. The calculated springs are then compared to the ones calculated by the Oracle configurator system. For example, a 12-foot by 10-foot door would have a different weight than a 13-foot by 10-foot door; therefore it would get different springs. There are thousands of different spring combinations that a door could have. Having the door sprung correctly is critical to customer service as well as the safety of the door. If the springs do not match then the manually calculated springing weights are compared to the system-generated weights to try and isolate the problem. During this testing, both springing weight issues and spring calculation issues arose in some models. Once the springs are confirmed, shafts, fasteners, cable drums, cables and brackets are verified against the release to assure accuracy. Since there are many different spring assembly configurations, this testing is complex and time-consuming taking up about 30% of the time necessary to review the whole BOM.

The hardware box contains all of the smaller parts necessary for the door's operation; these include fasteners, rollers, hinges, brackets, and other miscellaneous parts. There were several issues with the hinging on the doors that occurred in about 25% of the models. In this issue, there were incorrect hinges on the BOM and in a few instances they were missing all together. Clarifying the specification and revising some rules solved this problem. Cable configurations had one major issue. The order quantity was dividing the cable required into a fraction of what was needed. This would have resulted in inventory and cost problems, and would have caused confusion on the production floor. Fasteners are difficult to test. There can be anywhere from 51 to 500 fasteners required for assembling a door. This quantity varies by the door size and strut requirements. The type of door and selected options also has an impact on the combination and quantity of different fasteners used. The required quantity is manually calculated and compared to the quantity generated in the ERP system. Bottom bracket usage and low headroom parts were the only other common issues in the hardware box. These issues were resolved by editing the configurator rules.

The strut components are simple to review and take only a couple of minutes per configuration. Each model configuration is compared to the strut charts in the product specifications. The quantity and type of struts is dependent on the size, model, and width of the door. There were three types of problems that arose during the testing involving the struts. The first issue involved missing or wrong struts used in the BOM. The second issue involved two different strut widths that were required for the door. These bills showed the correct raw strut parts in the bill but did not show that one of the struts had to be cut one foot shorter than the remaining struts. The final and most critical error found regarding the strut bundle was a quantity issue. If an order was placed for multiple doors, the rule would multiply the struts times the quantity ordered. The result was that there would be several times the correct quantity of struts on the bill. This caused spring weights to be off by as much as 100 pounds and would have created issues with costing and inventory control. The cut size of the strut was corrected by adding a total to the configurator. This total is no more than a value that is stored and sent to the shop floor system indicating to production to cut one strut down to the desired length. The other two issues were resolved by editing rules in the configurator.

The last component assembly is the section bundle. The section bundle contains all of the steel, stiles, foam, glue, windows, bottom retainer, and packaging necessary to manufacture the sections. There were many issues uncovered during testing in this area. In some cases section steel weights were incorrect due to the number of doors ordered. Window lites were incorrect for some models and required several rule corrections. Stile insulation tape was used in all models but was only required for non-insulated ribbed doors. Bottom astragal was incorrect due to a wrong part being used for some models. The issue that had the most impact on the section BOMs was bundling and packaging rules. While this may seem minor compared to door construction, it would have had a heavy impact on running the product on the shop floor system. If the shop floor control system does not have complete and correct section bundling and packaging information, the product cannot flow through the line. An example of one issue included incorrect door bundling with two sections per package instead of four. This caused twice as many section packages to be created and it did not create the proper shipping labels for the door. In cases like these, manual steps would need to be taken to force the door through the system. This would, in turn, cause confusion in production and delays on the line. If this product were to be shipped to other plants, the bundling and labeling would not match their system and would cause problems there as well.

MES Testing

In addition to checking the BOM and OID records, pick list records were also verified against the BOMs and engineering specifications. OID, which stands for order identification data, is information that is generated by ERP to be sent to the MES/shop floor control system. Some of these records may include section heights, material cut lengths, or drilling instructions. The OID records are not material-related but rather instructional data on how to complete a part or function. The pick list records provide a list of components that need to be packaged into the hardware box for final door assembly at the customer's location. The pick list is passed from Oracle through shop floor control. Phantom bill items and low-level assembly components are dropped from the BOM to form a simple parts list. This list will include the order number, part number, bin location of the part, and quantity. This testing helps ensure that production can complete an order once it is configured and scheduled by Oracle.

Issue Reporting

All issues found within the testing parameters were placed on either the residential BOM log or the commercial BOM log until they were corrected. A sample issue can be seen in Figure 3 as it would be listed in either of the BOM issue logs. The rule writer responsible for initial rules for that product group is also responsible for any rule editing that may be necessary. Due to the complexity of the rules, sometimes the same issue had to be retested several times before it was corrected. Once issues were corrected, the person fixing the rule would mark the item ready for testing in the issue log. The item would then be reconfigured and tested as soon as possible. When retesting the BOM, the exact same configuration for the door is entered, but only the items previously identified as incorrect were usually checked. This was to reduce redundancy and to speed up testing. If the issue was retested and found to be resolved, it was removed from the current issue log and placed into the resolved issue log. This helped to prevent anyone from working on a problem that had already been resolved. A record of the issues was also kept for future reference.

#	DATE IDENTIFIED	INSTANCE	ITEM	ITEM DESCRIPTION	PROBLEM/ISSUE	STATUS	RES DATE	Assigned	Priority
527	11/17/2004	PTEST	XXX	All residential models	FACE HARDWARE BOLT BAGS NOT TO CURRENT SPECIFICATION			GLS	1
528	11/17/2004	PTEST	XXX	XXX.HB.8.0.6.0.FM.SOL.WH.9.GS.2.B.LHRF.D.CROLL;1XST	WILL NOT ALLOW USER TO SELECT UNIPACK WHICH IS NECESSARY TO PICK THE PROPER BOLT BAGS FOR A UNITIZED TRACK ASSEMBLY. THE CUSTOMER WILL BE MISSING THE 1001078 BAG IF UNITIZED CANNOT BE SELECTED	Ready to Test	22-Nov-04	GLS	1
529	11/17/2004	PTEST	XXX	XXX.HB.8.0.6.0.FM.SOL.WH.9.GS.2.B.LHRF.D.CROLL;1XST	MISSING 1001188 TK BOLT BAG - BOLT BAG TRACK TSS BRKTS LOOSE			GLS	1

Figure 3. Sample Model Issue/Issue Log

At the beginning of April 2004, 808 commercial and 514 residential issues had been identified. Of these issues, 30 were remaining on the residential BOM log, with six of them being priority one items. Of the 25 items that remained on the commercial BOM log at that time, nine of them were priority one items. Priority one issues are problems that would affect customer service. By mid-April, up to 96% of the BOM issues found were resolved as final rule changes were put into effect. There have been instances when fixing one configurator rule affects items that were previously correct on a different part of the BOM. Some rules are interdependent of each other and changing either one can have an unforeseen effect on other portions of the bill. It is critical that new bills are generated after issues are resolved to determine if more issues have surfaced.

Issues Affecting Testing

Software and hardware issues have slowed down the testing and debugging process. System performance issues have also slowed the process down considerably. During the first half of testing, it was common to wait half an hour or more for an order to book that should have only taken one to two minutes. Frequent system errors were common and would cause a considerable amount of delay, thus slowing down the overall progress of testing. These performance issues had begun to improve prior to the acceptance testing. There was a need for additional improvement in system speed but it was manageable for the time being, at least for testing. Some engineering specifications were inadequate and did not provide enough detail to allow the rules to be written from them. This slowed down the process of completing, debugging, and testing some rule sets.

Final Acceptance Testing - Phase I Testing

The first department to begin the final testing was the steel pan department. Approximately 20 orders were processed in this test. The main issue found in that department was some confusion over the information regarding locks. The shop floor system was showing the operators of the machines a lock code instead of the full written name of the lock. In some cases, too much information was given to them. The steel pan department only needs specific information pertinent to making the door sections. In some cases they were shown some lock codes that were only related to the hardware configuration of the door. This was a fairly simply fix in which the shop floor system mapping was changed to exclude unnecessary information. The other issue was that some of the bundling and packaging codes were not optimized for the line. This was more of a specification issue than an implementation issue, so the decision was made to deal with it at a later date. There were no major BOM issues found during this testing.

The hardware department testing had uncovered issues with labels. They were printing labels through the new shop floor system instead of the legacy system. There was some missing information on the labels that was needed to match up product bundles. In addition, changes in print size were requested so they could pick the correct parts faster without needing to closely read the entire pick slips. There were no major BOM issues found in this testing.

The expanded poly-steel department, which manufactures the premium insulated product, did not run production off the ERP system because of the way the line is run. The department starts a product run in which they produce all colors and sizes needed for the next day's shipments. This cycle takes 16–18 hours. There was not a good way to process only part of the run out of the ERP system. So a simulated run was done in EPS instead. Data was downloaded to the shop floor system and labels were generated and printed. The labels were then walked down the line and scanned at each work cell to simulate the production. The only issues found involved packaging and bundling, which were resolved shortly thereafter.

The shipping function was tested during each of the other department runs since the data was available from every department. No product was actually shipped using the new labels and paperwork. Instead, it was simulated thoroughly through completion of the loads.

Phase II Testing

The one-day production test was conducted in the steel pan and hardware departments. The main issues were training related, including some confusion by the employees who had not been involved in previous testing. One factor was the amount of time it took the system to process the orders. Once the orders were entered, the system took several hours to process them before they could be sent to the MES system for production. In addition to this issue, when orders were being processed, or if imports were going on, the system would freeze users' sessions so they could not complete their daily tasks. The proposed solution to this issue was to use two of the test servers in combination with the production server to help take some of the load off of processing the orders. This project was scheduled to be performed within one week. The final acceptance test would follow.

Phase III Testing

In the final stage of testing, one full day of orders was entered into the ERP system. The following day they were to be built and shipped. Initial results indicated that the server additions were helpful. As the day progressed, the served became bogged down and orders were not processing in an acceptable amount of time. Customer service started entering the orders at 7:00 AM and finished the day's orders around 2:00 PM. By 5:00 PM, only about half of the orders had completed processing through the system and were ready to schedule for production. It is critical for order processing to be complete before 5:00 PM each day so springs can be ordered and the production schedule can be set up for the following day. If the order processing isn't completed by that time, production will run out of work and shipments would be delivered to customers late. At the end of the day, it was decided to abort the final phase three testing and to look into what performance enhancements could be made to the system. After review by senior management, it was decided that the ERP implementation would be delayed until February 2005, in order to ensure being able to keep up with customer service during the upcoming busy season.

System Redesign - System Issues

The main obstacle to implementation was the poor performance in processing orders. The long delays before orders were available for production and material planning needs to be resolved so as not to effect their lead times with customer shipments. In the garage door business, customer service is critical to success. The two main concerns their customers have are quality and on time shipments. With only three days to process the order, manufacture and ship product, there is little room for delays. After reviewing the order processing performance issue, several factors that had contributed to poor performance were noted.

1. Processing time for the 1800–2000 daily new BOMs was a major load on the system
2. Two hundred forty-nine different models requires a lot of system resources for configuration rules and data
3. BOM structure has too many configurator rules slowing the system down
4. Redundant BOM rules among different model levels
5. Phantom items in BOM for pricing and descriptions are not necessary

These issues were the major focus involved in redesigning the model structure to gain system performance. Without resolving these issues, the company could not go forward with the implementation without jeopardizing customer service and on-time delivery. The five contributing factors were the focus of an effort to reduce processing time.

BOM Quantity/System Performance

Although the large number of BOMs that are to be generated daily cannot be reduced while still offering a broad product line, the amount of processing for each BOM needed can be minimized. With processing over 1800 BOMs daily, if the time for each BOM is substantially reduced, the total processing time for daily orders could be cut to an acceptable level. The focus was then placed on substantially reducing the amount of time each BOM took to process. This was done by reevaluating the way the BOMs were modeled in the system and by consolidating models.

Model Reduction

With 249 different product models offered and modeled in configurator, there was a good opportunity for model reduction. Like models were compared and combined into one configurator model when the difference between them could be made into an option verses an entire new model. Previously, insulated doors had their own separate model number from the exact same door without insulation. The insulation was made an option in the base model and the old model number was made obsolete. This is one example of the model reduction efforts. This reduction reduced the total number of models in configurator to 52. The model reduction reduced the amount of configurator by 429,000. It also freed up system memory and table space in the server. Model configuration maintenance was also increased by the consolidations. Product specification changes would now require rules to be modified in just a few models instead of possibly ten or twelve as was the case before.

BOM Rules

The next focus was to reduce the total number of BOM rules a model had in configurator. This was handled by creating item kits or assemblies. Previously, all items needed in a configuration had BOM rules selecting every item individually to create the whole BOM. The assembly kits consist of related items that go into nearly every door. Section bundles all get the same safety labels. There are four different standard labels used on the doors. Instead of these labels being picked by four different BOM rules, they can be picked from BOM attribute rules without having any rules in configurator. This reduced four rules per model, multiplied by current 52 models, thus reducing the total number of configurator rules by 208. The same type of kit assemblies were set up for residential top and bottom brackets, spring anchor brackets, and spring drums. Unlike the standard label kits, these assembly kits did require a minimal number of configurator rules to properly place the kits into the correct BOMs; however, they still eliminated another 1872 configurator rules for a total reduction of 2080 rules. This reduction in rules contributed to a slight improvement in performance. More importantly it will simplify BOM testing and system maintenance by grouping common items into assemblies.

Redundant Rules

Redundant rules are rules that appear in more than one level of the same model. A complete door model is made up of the track, hardware only, hardware carton, struts and spring assembly levels. A customer can order a complete door or any of the lower level assemblies of the door. In the original model structure, the complete door would incorporate all of the lower assembly level rules. These related rules appeared in both the lower level and the complete door to satisfy orders for either the complete door or the lower level alone. This would mean that these rules were duplicated several times in each model. To eliminate most of this redundancy, the lower level rules were not incorporated into the complete door models. The completed door model would select the appropriate lower levels as a child BOM. By doing this, all of the necessary components would be included in the BOM, and many unnecessary redundant rules were then eliminated. In the case of the track assembly models, the old system was set up so each different product model would have its own track assembly model. In the redesign, there is only one residential track model and one commercial track model. Although these two track models contain more rules to satisfy all track requirements of the different models, having only two models dramatically reduced many configurator rules. The efforts in eliminating redundant rules produced a further reduction of 60,560 rules. This helped improve performance and also aided in model maintenance by eliminating repetitive rule entries. New models can be set up quicker with less chance for error due to fewer rule entries. This will contribute to more accurate BOMs and lower model implementation costs in the future.

Pricing Rules

The last model improvement item was to reduce or eliminate the many phantom items and option classes used for pricing and descriptions. In the original model configuration, pricing was handled by configurator rules that pick phantom items and option class items to define the list pricing for the items as configured by the system. The item description was also generated in the same manner. A door description would include the model, size, width, insulation, glazing, color, locking, spring type, track type, track mount, track radius, and packaging. To eliminate the need for these phantom items and option classes, a functional companion was added to the bill generating process. Through the use of the functional companion, many configurator rules and unnecessary items were eliminated from the models. This resulted in the reduction of 110 additional BOM rules per model for a total reduction of 5,720 rules.

System Redesign Summary

The system redesign eliminated thousands of unnecessary configurator rules as well as model reductions from 249 to 52 models contained in configurator. This allowed approximately 429,000 rules to be eliminated from the configurator. Item kits reduced the total number of configurator rules by 2,080. The need for phantoms and option class items was eliminated further by reducing 110 rules per model for a total of 5,720 rules. Most of the redundant rules in the configurator were also eliminated resulting in a further reduction of 60,560 rules across the 52 models. The system redesign efforts reduced BOM configurator rules by approximately 497,000 rules. Due to the complexity of the configurator model structure, the models could not be tested for performance until the pilot model was completed.

System Redesign Testing

The redesign testing was performed in two stages. The first stage involved pilot model testing. The second consisted of residential BOM testing for the redesigned configurator models. The pilot model was set up to include all of the performance changes to the model structure as outlined above. The configurator model was then tested to validate the design and to test performance as compared to the previous model structure. Once the pilot model was validated and proven, the testing progressed to the other residential models.

With the pilot model, the first notable result was an improvement in the model's performance, reducing overall processing time from 581 second to 153 seconds for a residential model. The initial configurator screen loaded faster, option selection was faster, and closing the configurator to save the configuration was noticeably quicker. When the generated item was booked and progressed, the overall process seemed noticeably faster as well. This will allow orders to process and be available for production scheduling within minutes of being entered. As shown in the chart below, order processing times are more than three times faster than the original model structure.

	Old Configuration Model Seconds	**Pilot Configuration Model Seconds**
Open Configurator	25	15
Select Options	83	40
Close Configurator	140	29
Book Order	78	14
Progress Lines	255	55
Total Time S.	**581 Seconds**	**153 Seconds**

Table 1. BOM Generation Comparison Times

The BOM review on the model went well with only a handful of issues surfacing. Of these issues, only one issue involving packaging has remained. It is a minor problem that will be resolved before the system goes live.

Currently, the company is in the process of testing 15 more residential models that should be complete and approved by the end of December 2004. Some of the issues that were found on these models are: packaging, vertical track lengths, missing bolt bags, insulation parts, steel quantity, and window frames. Most of these problems are simple rule debugging issues where there is a syntax error in the rules or a missing total. In the case of the packaging issues, they were caused by confusion in the way the specification was written. These issues are being worked on and are close to being resolved.

Chapter V: Conclusion

The purpose of this project was to outline the testing process used for an ERP implementation with regards to product structure and manufacturing data before switching to the new system. Approximately 4,000 man hours of testing has been conducted on BOMs, MES, and system performance up to this point. During the first round of final implementation testing, the project had been delayed due mainly to system performance.

Due to the performance issue, the configurator modeling system was redesigned to improve performance by reducing the time needed to process each item BOM. This was done by:

1. Reducing the total number of models in configurator from 249 to 52
2. Reducing the total number of BOM rules in configurator by over 240,000
3. Eliminating most of the redundant BOM rules among different model levels which resulted in 25,000 rule reduction
4. Replacing phantom and option class items in BOM for pricing and descriptions with functional companion reducing 5,700 rules

Order and BOM processing times have been cut down to less than one-third the time that it took for original model structure to process. With these improvements, all indications show that system performance will be adequate with the new system. Orders will complete processing within minutes of being entered allowing necessary materials to be ordered and production to be scheduled before the end of the day.

While only one-third of the configurator models have been tested since the redesign, it is anticipated that the improvements that were seen in the first 16 models tested will be representative of the remaining models since their model structure is nearly identical to those tested. As shown below in Figure 5, processing times have been greatly improved by over three times that of the previous models.

Time Period	5/24/04	5/25/04	5/26/04	11/10/04	11/11/04	11/12/04	**New Model Average**	**Old Model Average**
Total Orders	236	236	236	236	236	236	236	236
Total System Cycle Time Hours	1.00	1.21	1.20	4.11	3.89	4.32	**1.14**	**4.10**
Total System Cycle Time Minutes	60.21	72.5	72	246.36	233.4	258.9	68.24	246.22
BPCS to Oracle Int Minutes	3.5	3.5	4.5	15.3	14.2	16.4	3.83	15.30
Oracle Int to Oracle OE Minutes	1.91	1.25	1	5.6	4.6	6.1	1.39	5.43
Configure and Book Minutes	28.5	28	27.00	91.26	86.00	95.20	27.83	90.82
Autocreate Config Items Minutes	26.3	39.75	39.5	134.2	128.6	141.2	35.18	134.67
Configure and Book Orders / Minute	8.28	8.43	8.74	2.59	2.74	2.48	**8.48**	**2.60**
Autocreate Config Items Orders / Minute	8.97	5.94	5.97	1.76	1.84	1.67	**6.96**	**1.76**

Table 2. Order Processing Times

The increase in system performance due to the model redesign, order processing should be completed well before the 5:00 PM deadline. It is customary for all orders to be entered by 3:00 PM. If it is assumed that there could be up to 100 entered at that time, it should take approximately 30 minutes to complete the processing. This processing would be expected to complete by 3:30 P.M. or shortly after. This would satisfy the company's requirements and would not delay customer shipments.

Due to the success of this test process, the configurator team has agreed to use the current process for the remainder of the implementation project testing. The test plan and process will be modified if necessary during the implementation process at the other locations.

Recommendations

After completing this testing process at the first plant, several recommendations can be made to help aid in testing and implementation at the other locations. These recommendations will assist in designing a successful product configuration testing process. They should be helpful in any implementation involving a large quantity of BOMs, whether or not MES will be utilized.

1. Consolidate as many configurator models prior to starting model construction
2. Plan how to minimize the total number of BOM rules while retaining a high level of system model maintainability.
3. Prevent using redundant rules in multiple levels of the configuration model
4. Consider using simple functional companions when one or two companions can replace hundreds or thousands of configurator rules
5. Have a well thought-out model roll-out plan so testing can progress with development. That way any issues seen in one model can be avoided with the next model
6. Use one or more pilot models to prove model validity, BOM accuracy, and initial performance assessment
7. Create a testing plan that includes BOM, performance, and MES testing, if applicable

8. Make sure rule writers and developers are responsible for initial model and BOM testing before releasing for formal testing
9. Create issue logs to track what issues have been found, if they have been fixed, and when they are ready to be retested
10. Include people from outside the configuration team for testing whenever possible, this will help with future training and change management

Using a well thought-out testing plan can help ensure a successful ERP implementation. Most BOM issues can be corrected prior to switching to the new system. Any remaining issues will be known so alternative processing methods can be utilized until resolved. The MES and any shop floor control systems used will be thoroughly tested to ensure no manufacturing issues will occur. System performance will have been tested to ensure the system can handle daily order loads without having an impact on production or customer shipments.

By having a complete testing plan, a quicker less expensive implementation can result at the future locations. Model structure performance can be maximized by using the minimum amount of rules as incorporated in this plant's model redesign. By following the processes established here, the other locations can save development and testing time by following the established modeling and testing process. Complete testing at the other locations can help prevent running into performance or BOM accuracy issues during their implementation. Improving customer service is the main focus throughout the company. By avoiding implementation issues throughout the entire company, they can work to minimize negative customer service while implementing ERP.

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Appendix A

Model Configuration Sheet – Complete Door

XXX Series - Complete Door				
Color	White	Brown	Sand	Alm
Width	5ft 7in	7ft 10 in	9ft	10ft
Door Height	6' 6"	6' 9"	7' 0"	8' 0"
Insulation	No	Yes	Yes	No
Springs	Ext	Ez-set	Std Tor	Std Tor
Lift	12" SR	15" SR	Low Front	Low Rear
Track	2J	2J Heavy	2	2 Heavy
Lock	NONE	Snap	Keyed Side	Cremone
Struts	1 top strut	4 Xtra Struts	2 Xtra Struts	STD
Lites	Sgl S3 Shrwd 306	Sec 4 INS	Solid	Sgl Sec 4 Pnls 2&3
Additional Options	Hvy Hdw	High Cycle Springs	Operator Bracket	None
Packaging	Dist	Dist	Unipack	Dist
Order # ____	____*____	____*____	____*____	____*____
Color	White	Brown	Sand	Alm
Width	11ft	15ft 6 in	16ft	18ft
Door Height	6' 6"	6' 9"	7' 0"	8' 0"
Insulation	Yes	No	Yes	No
Springs	Std Tor	Ez-set	Ez-Set	Ext
Lift	12" SR	15" SR	Low Front	Low Headroom
Track	2J	2J Heavy	2	2 Heavy
Lock	NONE	Snap	Keyed Side	Cremone
Lites	Sec 4 Single	Sec 3 & 4 Sgl	S4 Sunset / Wlmsbrg	Sec 3 & 4 OBS
Struts	1 top strut	Std	1 Xtra Struts	STD
Additional Options	10 Ball Rollers	Hvy Hdw	Hvy Hdw	Hvy Hdw
Packaging	Dist	Dist	Dist	Unipack
Order # ____	____*____	____*____	____*____	____*____
Color	White	Brown	Sand	Alm
Width	8ft	13ft 6in	17ft 6in	17ft 8in
Door Height	6' 6"	6' 9"	7' 0"	8' 0"
Insulation	Yes	No	Yes	No
Springs	Std Tor	Ext	Ez-Set	Std Tor
Lift	Low Front	15" SR	15" SR	Low Rear
Track	2J	2 Heavy	2	2 Heavy
Lock	NONE	Snap	Keyed Side	Cremone
Lites	INS S3 Sunrise 305	S4 Ruston/Cathedral	Solid	Sec 3 Sgl
Struts	1 top strut	Std	2 Xtra Struts	STD
Additional Options	10 Ball Rollers	Tri-Wall	Operator Bracket	High Cycle Springs
Packaging	Dist	Unipack	Dist	Dist
Order # ____	____*____	____*____	____*____	____*____
Color	White	Brown	Sand	Alm
Width	16ft 8in	4ft	18ft	16ft
Door Height	7' 0"	8' 0"	7' 0"	6' 6"
Insulation	Yes	No	Yes	No
Springs	Ext	Ext	Ez-Set	Std Tor
Lift	12" SR	15" SR	Low Front	15 SR
Track	Less 2" Track	2J	Less 2" Track	2 Heavy
Lock	Silde	Slide	Snap	None
Lites	Sec3 Ins	S4 Stocktn / Colonial	Solid	Sec 3 OB
Struts	1 top strut	STD	STD	STD
Additional Options	10 Ball Rollers	Tri-Wall	10 Ball Roller	Hvy Hdw
Packaging	Unipack	Dist	Dist	Dist

Appendix B

Model Configuration Sheet – Sections Only

XXX Series - Sections Only				
Color	White	Brown	Sand	Alm
Width	5ft 4in	7ft 6 in	8ft	9ft
Door Height	6' 6"	6' 9"	7' 0"	8' 0"
Insulation	No	Yes	Yes	No
Lock	None	Snap	Keyed Side	Cremone
Lites	Sgl S3 Shrwd 306	Sec 4 INS	Solid	Sgl Sec 4 Pnl 3
Additional Options	None	None	None	None
Packaging	Dist	Dist	Dist	Dist -Tri-wall
Order # ____	____*____	____*____	____*____	____*____
Color	White	Brown	Sand	Alm
Width	10ft	15ft 0 in	18ft	16ft
Door Height	6' 6"	6' 9"	7' 0"	8' 0"
Insulation	Yes	No	Yes	No
Lock	NONE	Snap	Keyed Side	Cremone
Lites	Sec 4 Single	Sec 3 & 4 SGL	S4 Stockton	Sec 3 & 4 OBS
Additional Options				
Packaging	Dist	Dist -Tri-wall	Dist	Dist -Tri-wall
Order # ____	____*____	____*____	____*____	____*____

Appendix C

Model Configuration Sheet – Hardware Only

XXX Series - Hardware Only				
Color	White	Brown	Sand	Alm
Width	12ft	16ft 0in	14ft	18ft
Door Height	6' 6"	6' 9"	8' 0"	7' 0"
Insulation	Yes	No	Yes	No
Springs	Std Tor	Ez-set	Ez-Set	Ext
Lift	12" SR	15" SR	Low Front	Low Headroom
Track	2J	2J Heavy	2	2 Heavy
Lock	NONE	Snap	Keyed Side	Cremone
Struts	Sec 4 Single	Sec 3 & 4 SSB	Sec 4 Sunset / Wlmsbrg	Sec 3 & 4 OBS
Lites	1 top strut	Std	1 Xtra Struts	STD
Additional Options	10 Ball Rollers	Hvy Hdw	Hvy Hdw	10 Ball Comm Rollers
Packaging	Dist	Dist	Dist	Unipack
Order # ____	____*____	____*____	____*____	____*____
Color	White	Brown	Sand	Alm
Width	9ft	12ft 6in	17ft 0in	16ft 0in
Door Height	6' 6"	6' 9"	7' 0"	8' 0"
Insulation	Yes	No	Yes	No
Springs	Std Tor	Ext	Ez-Set	Std Tor
Lift	Low Front	15" SR	15" SR	Low Rear
Track	2J	2J Heavy	2	2 Heavy
Lock	NONE	Snap	Keyed Side	Cremone
Lites	Solid	Sec 4 Cathedral	Solid	Sec 3 OBS
Struts	1 top strut	Std	1 Xtra Struts	STD
Additional Options	10 Ball Rollers		Operator Bracket	High Cycle Springs
Packaging	Dist	Unipack	Dist	Dist
Order # ____	____*____	____*____	____*____	____*____

Appendix D

Model Configuration Sheet – Track Assembly

XXX Series - Track Assembly				
Width	5ft 7in	7ft 10 in	9ft	10ft
Door Height	6' 6"	6' 9"	7' 0"	8' 0"
Insulation	No	Yes	Yes	No
Springs	Ext	Ez-set	Std Tor	Std Tor
Lift	12" SR	15" SR	Low Front	Low Rear
Track	2J	2J Heavy	2	2 Heavy
Packaging	Dist	Dist	Dist	Dist
Order # ____	___*___	___*___	___*___	___*___
Width	11ft	8ft	17ft 6in	18ft
Door Height	6' 6"	6' 6"	7' 0"	7' 0"
Insulation	Yes	Yes	Yes	Yes
Springs	Std Tor	Std Tor	Ez-Set	Ez-Set
Lift	12" SR	Low Front	15" SR	Low Front
Track	2J	2J	2	Less 2" Track
Packaging	Dist	Dist	Dist	Dist
Order # ____	___*___	___*___	___*___	___*___

Appendix E

Model Configuration Sheet – Hardware Box

XXX Series - Hardware Box				
Color	White	Sand	Alm	Alm
Width	5ft 7in	18ft	16ft	10ft
Door Height	6' 6"	7' 0"	6' 6"	8' 0"
Insulation	No	Yes	No	No
Springs	Ext	Ez-Set	Std Tor	Std Tor
Lift	12" SR	Low Front	15 SR	Low Rear
Track	2J	Less 2" Track	2 Heavy	2 Heavy
Lock	NONE	Snap	None	Cremone
Struts	1 top strut	Solid	Sec 3 SGL	STD
Lites	Solid	STD	STD	Sgl Sec 4 Pnl 3
Additional Options	Hvy Hdw	10 Ball Roller	Hvy Hdw	None
Packaging	Dist	Dist	Dist	Dist
Order # ____	*	*	*	*
Color	White	Brown	Sand	Brown
Width	8ft	15ft 6 in	16ft	13ft 6in
Door Height	6' 6"	6' 9"	7' 0"	6' 9"
Insulation	Yes	No	Yes	No
Springs	Std Tor	Ez-set	Ez-Set	Ext
Lift	Low Front	15" SR	Low Front	15" SR
Track	2J	2J Heavy	2	2J Heavy
Lock	NONE	Snap	Keyed Side	Inside Slide
Lites	Solid	Sec 3 & 4 SGL	Sec 4 Sunset / Wlmsbrg	Sec 4 Cathedral
Struts	1 top strut	Std	1 Xtra Struts	Std
Additional Options	10 Ball Rollers	Hvy Hdw	Hvy Hdw	Tri-Wall
Packaging	Dist	Dist	Dist	Unipack
Order # ____	*	*	*	*

Appendix F

Model Configuration Sheet – Repair Sections

XXX Series - Repair Sections				
Color	White	Brown	Sand	Alm
Width	6ft 0in	8ft 0in	9ft	10ft
Section Height	21	19.375	19.375	21
Insulation	No	Yes	No	Yes
Section Type	INT	TOP	BTM	INT
Lock	NONE	NONE	NONE	NONE
Lites	Solid	Sec 4 INS	Solid	Sgl Pnl 3
Additional Options	Tri-wall	None	None	None
Packaging	Dist	Dist	Dist	Dist
Order # ____	*	*	*	*
Color	White	Brown	Sand	Alm
Width	11ft	15ft 6 in	16ft	18ft
Door Height	21	19.375	21	21
Insulation	Yes	No	Yes	No
Section Type	Lock	TOP	Lock	INT
Lock	Snap 1 Side	NONE	Lock Bar RSLO	NONE
Lites	Solid	OBS Stockton	Solid	Solid
Additional Options	Tri-wall	None	None	None
Packaging	Dist	Dist	Dist	Dist
Order # ____	*	*	*	*