IE 312 – FALL 2018 **Due Date: 17.12.2018 13:00**
FACILITY DESIGN ASSIGNMENT

Castle Door Locks Co. Inc., which -as the name implies- produces door locks, is a medium sized company with approximately 250 employees, and a good market share in domestic markets in addition to exports. The company is planning to move its production facility to Istanbul where 70% of the total demand is realized in an effort to reduce its logistics costs. Management sees this as an opportunity to redesign the layout of the plant to reduce operating expenses and increase efficiency.

The product range of Castle Door Locks can be classified into five major groups according to the functionality, as follows:

- Cylinder mortise door locks
- Mortise door locks
- Safety mortise locks
- Mortise steel-door locks
- Rim locks

Currently the company produces a total of 55 different kinds of products in these product groups. 27 of those are miscellaneous cylinders, which are used as a crucial component for most door locks. Remaining 28 items are door locks, and 22 of these door locks need cylinders to function (see Figure 1).

Figure 1: Clockwise from above: a cylinder; a cylinder mortise lock; a mortise lock and a rim lock

Some analysis of the routings for the 28 door lock models reveals that some of the products can be regarded as slightly modified versions of a set of standard products. Variations in size, material and

some components provide the customers some options for different requirements and different price ranges. Thus, it turns out that it is possible to further simplify this problem by applying some group technology (GT) principles. This requires grouping of these products into product families. Then, for each family a standard routing representative of the whole family can be used in the flow analysis.

Part family formation is one of the main issues of GT. The methods offered for this purpose can be broadly categorized as: visual inspection; classification and coding; and production flow analysis. Although generally considered to be less accurate than the other methods, visual inspection is the least sophisticated and least expensive method; and it seems to be perfectly adequate for this specific case. Thus, the 28 models are classified into seven product families by some experienced staff from lock manufacturing through visual inspection based on similarities in design features and manufacturing requirements. The families and their members can be seen in Table 1. Also, in Figure 2 the members of the 6110 family are shown as an example.

Table 1: The list of door locks and their respective product families

6000	6040	6300	6110	6100	6400	6700
6000	6040	6300	6110	6100	6400	6700
6001B	6045	6305	6115	6105	6405	6701
6010B	6200-3	6310	6120		6410	6702
6020	6205-3	6315	6125			
6025	6210-3					
6030						
6035						

Target monthly sales volumes for the product families are given in **Table 2.** It may be observed from this table that product families 6000, 6110, 6100, and 6400 constitute more than 95% of the total production. Therefore, it is quite justifiable to base the whole flow analysis only on these four families.

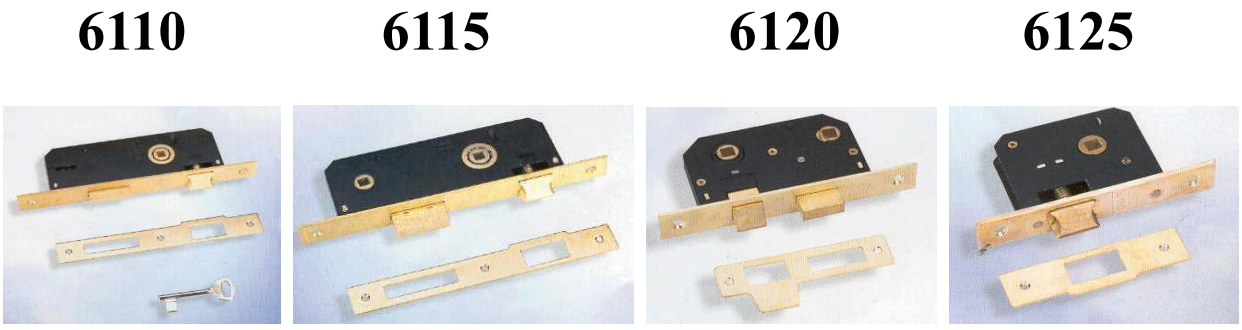

Figure 2: The members of the 6110 family

Process information:

The raw material and main processes required for cylinders and lock bodies differ by a great deal. Body and other components of the door locks are mostly made of metal sheet, zinc casting and springs; they have complex routings and require extensive material handling. Cylinders, on the other hand, are made of brass cut in circular shapes and need a totally different set of specialized machinery such that their processing departments and routings are separate.

Table 3 lists the components of product families that have substantial material flow between two or more machine shops or departments. Components that need single machine operations (ie. spring shop) or supplied directly from outsources in processed forms are considered to be unimportant.

Table 3: The list of components for product families

	6000		6100		6110		6400	
	Code	**Description**	**Code**	**Description**	**Code**	**Description**	**Code**	**Description**
1	3097	Body	3087	Body	3095	Body	3102	Body
2	3018	Faceplate	3018	Faceplate	3019	Faceplate 2	3263	U Cross
3	3030	Cylinder Cross	3266	Square Cross	3263	U Cross		
4	3263	U Cross	3048	Latch Cross	3269	Spring Cross		
5	3269	Spring Cross						

All the components listed in Table 3 are singular parts except for the faceplate. The faceplate is composed of the faceplate body and the two faceplate crosses assembled on both sides. It has a complex routing on its own. Note that each unit from 6000, 6100 and 6110 require a similar faceplate. Table 4 lists the components of the faceplate.

Table 4: The faceplate and its list of components

	3018		
	Code	**Description**	**Units**
1	3018	Faceplate	1
2	3022	Faceplate Cross	2

	3019		
	Code	**Description**	**Units**
1	3019	Faceplate	1
2	3022	Faceplate Cross	3

The faceplate is one of the important components of a door lock, not only because it has to have a non-rusting durable bright surface finish to ensure customer satisfaction, but also because it is one of the three components that is visible to people after the installation.

The faceplate is manufactured from the metal sheet that is cut to desired width and thickness. The silhouette of the faceplate is given by the suitable cutting mold installed on the press machine. It has two rectangular big holes, one for the latch and the other for the bolt. It also has two or sometimes three circular small holes on both sides for screws as seen in Figure 3. Note that a single faceplate may have two or three faceplate crosses depending on its type.

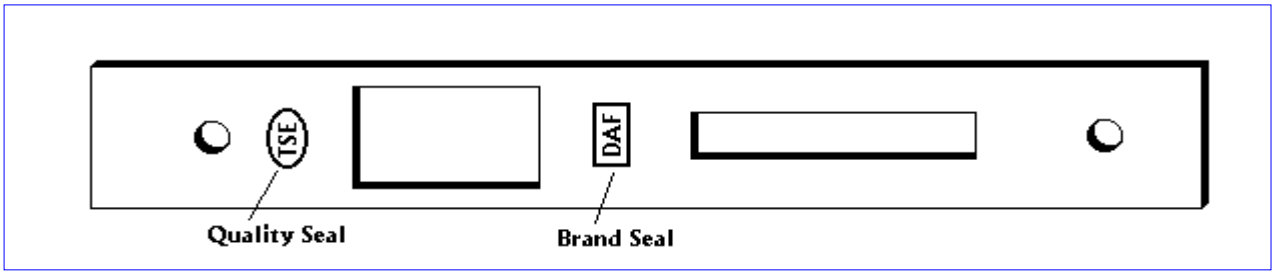

Figure 3: Drawing of a faceplate

An assembled door lock is depicted in Figure 4, and Figure 5 provides a sample operation process chart. A complete list of material flows for the components of each product family and the faceplate can be found in Appendix A.

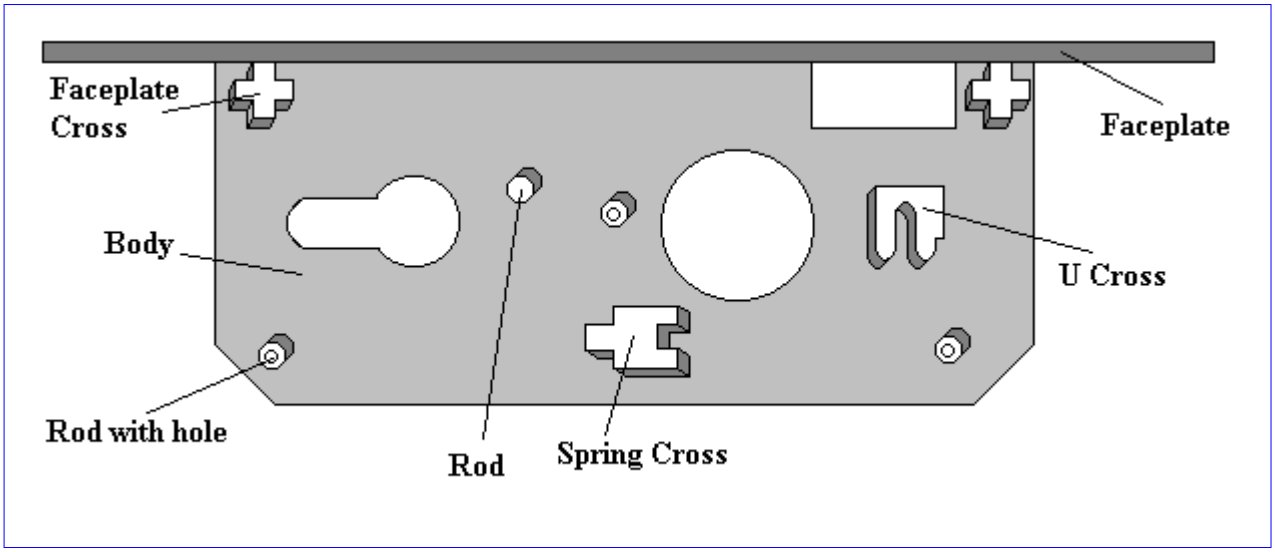

Figure 4: Door lock assembly

The flow data for cylinders is not given in Appendix A, but for each lock produced from families 6100 and 6400, a cylinder has to be produced. To produce the cylinders, the following path is followed:

Raw Material Storage -> Brass Cutting Shop -> Spring Shop -> Cylinder Shop -> Final Assembly

Material handling:

Material handling is carried out by two methods: forklift and handtruck. The usage of forklift is limited to the movement of heavy materials, namely to the transfer of metal coils from raw material storage to the cutting and complementary cutting shops. The movement of material other than this is done manually using handtrucks.

Cylinders are carried by handtrucks where transfer lot size is 500.

The cost of carrying one transfer lot for 1 meter is $ 0.025 for handtrucks and $ 0.08 for forklifts.

Raw materials from suppliers arrive to the raw material storage whereas shipments are carried out from finished goods storage.

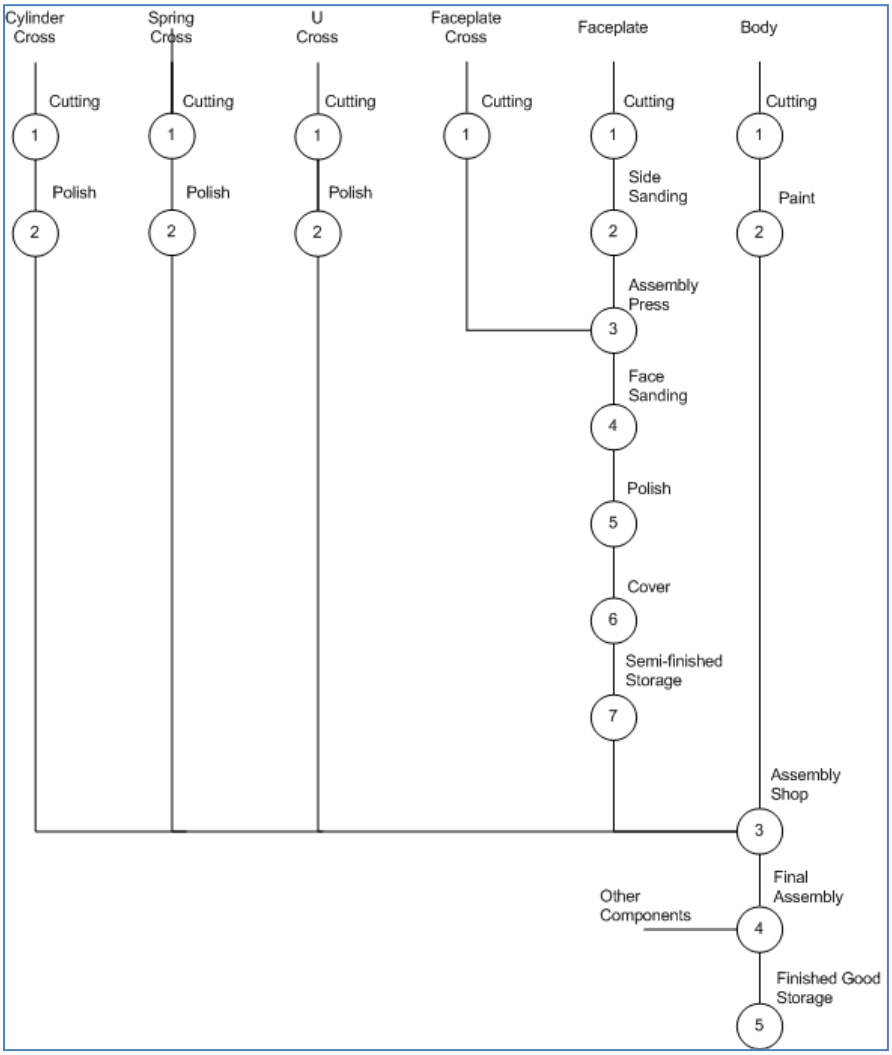

Figure 5: Operation process chart for product 6000

Area requirements:

Table 5 gives the current space requirements of departments and the machine shops. For departments such as paint shop, polish shop, etc. the total space requirements are given. For machines shops, area requirements per machine are given and the number of machines should be considered to find the total area requirement. The machine requirements are given in **Table 6.**

Table 6: Machine requirements for Part A

Department	No. of Machines
125 Ton Press	3
210 Ton Press	4
Assembly Press Shop	12
Coml. Cutting Shop	7
Cutting Shop	8
Side Sanding	3

TASKS:

Assume that you are a consultancy firm. You are asked to create a new facility layout to accommodate production using VIP-PLANOPT. In order to complete your assignment, Castle Inc. expects your group to address and/or perform the following tasks.

A. Using the flow volumes defined in the case develop a FROM-TO chart. Generate alternative layouts based on the *total flow cost*. Keep in mind that with the sole aim of minimizing the total flow cost, VIP-PLANOPT does not generate a block plan and there can be much unused space within the enclosed rectangular shape of the entire facility. To have an actually implementable layout, the shapes of the individual departments and the entire factory should be *reasonable(square-like)* and the unused space should be at most 20% of the total area. You should be creative and experiment with several features and capabilities of the software to use them in a way to serve your purpose. Among the layout alternatives you generate, select the one you think as the best and provide a rigorous analysis for the selected layout by calculating the pairwise distances and corresponding flow costs. Validate the objective of your best alternative using these values you calculated.

Note: Keep in mind that VIP-PLANOPT uses a heuristic solution procedure; therefore you should try several different seeds for the same parameter setting. While exploring the solution space use a systematic procedure and try meaningful parameter settings.

B. Instead of the process-based approach used in part A, another approach is a family based layout. For the Castle Lock case, it is not possible to compose an independent cell for each product family where all the processes for that family can be performed because there are common operations like polishing, painting and covering which cannot be duplicated. Instead, the machines that are currently pooled in the cutting shop and the assembly press shop can be grouped into separate shops for different product families.

In this case, the cutting press shop is divided into three cutting press shops and assembly press shop is divided into two assembly press shops. The first cutting press shop is assigned for the cutting operation of the products 6000, 6100 and 6110. The second cutting press shop is assigned only to cut the product, 6400. Correspondingly, the third cutting press shop is assigned for the cutting operation of the faceplates 3018 and 3019. In a similar fashion, the first assembly press shop is reserved for the processing of products; 6000, 6100, 6110, and 6400. The second one is reserved for the processing of the faceplates 3018 and 3019. The resulting departments and their required number of machines are given in **Table 7**. Apply the same analysis procedure you used in part A, to develop another layout with this rationale.

Table 7: Required number of machines for each family

Product Code	Department	No. of Machines
6000, 6100, 6110	Cutting Shop 1	4
6400	Cutting Shop 2	2
3018, 3019	Cutting Shop 3	4
6000, 6100, 6110, 6400	Assembly Press Shop 1	12
3018, 3019	Assembly Press Shop 2	3

C. Compute the required number of material handling devices of each type for the selected layouts of part A and B by using the data on **Table 8** and Egbelu's paper (Method 3 or 4) [1]. Comment on your results.

Table 8: Required number of machines for each family

	Handtruck	Forklift
Monthly Availability	20 days per month	20 days per month
Daily Availability	8 hours per day	8 hours per day
Efficiency	86%	90%
Speed	1 meter in 9 seconds	1 meter in 4 seconds
Pickup Time	1 minute	0.5 minutes
Delivery Time	1 minute	0.5 minutes

D. Compare the pros and cons of the two approaches that you used in part A and B. You are supposed to propose a layout to Castle Door Locks Co. Inc. Which layout would you recommend? Why? Explain thoroughly.

About teamwork:

While working on an assignment the students should consider themselves to be working as an engineering team to perform the design work defined by the case. Real projects do require a team effort wherein each member of the team brings complementary skills to be used in solving the problem. You should adopt a similar approach while working on these cases. Obviously for effective learning, each student is responsible to understand the complete case and know the solutions. The contribution of each member (in terms of percentage of work done) must be documented on the title page and signed by all members on the hard copy of project report.

DELIVERABLES:

A. Hard copy (delivered to the project T.A.)

B. Soft copy (e-mailed to the project T.A. including the files with the extension of *.VIP and *.OUT of the selected layouts of parts A and B.)

GRADING GUIDELINES:

A. The report (clarity, use of language, organization, charts, graphs, plots) (about 20%).

B. Content (about 80%).
   a. Completeness
   b. Correct use of VIP-PLANOPT
   c. Data organization, assumptions and definitions
   d. Results (alternatives, reasoning, discussions, selection and quality of final result).

REPORT FORMAT:

1. Title page
   Course name, project title, data set number, date,
   team members' names and percent contributions (with signatures) on the lower right-hand corner.

2. Table of Contents

3. Introduction
   A brief statement of the problem defined by the case and a brief review of the analysis technique used in its solution. A reader who does not have this case description sheet of your assignment should still understand what you are telling about.

4. Analysis and Solution
The main body of the report where the solution developed is discussed. The analysis procedure from which the design was derived should be logically developed both quantitatively and verbally so that the person reviewing your report will not have difficulty in interpreting various aspects of your design. Include charts, diagrams, drawings and tables whenever necessary. If there are extensive calculations or computer printouts, which are not directly required to follow your solution but provides supporting details, they may be included in an appendix.

This main body may be divided into subsections to bring an easy to follow hierarchy into your report. For example:

…
2.3. Alternative Layouts for Process based Approach
2.3.1. Alternative 1
…
2.3.k. Alternative k
2.3. k+1 Comparison and Decision
…….,etc.

or, a similar outline that suits you (but subsection titles should never be Task A, Task B as it does not mean anything)

5. Summary, conclusion and further remarks
A concise description of the actual solution proposed for implementation. A brief discussion about the robustness of this proposed design (i.e. relative to future and/or dynamic changes in the process plans or production volumes, or to your assumptions). A brief discussion of how well, in your opinion, the methodology, the concepts and the software utilized worked in solving the given problem.

6. Appendices (if any)
Should be properly listed, collated and numbered

Use a formal language in passive voice, and avoid colloquial style (avoid "we, you, what was going on," etc.). The text portion of the report (excluding figures, tables, and appendices) is limited to 15 pages type-written with Times New Roman, 12 font and 1.5 space. Charts, diagrams, drawings and tables should have proper captions, readable legends and should be referred in the text as shown in this document.

REFERENCES

[1] Egbelu, P.J. (1987). The use of non-simulation approaches in estimating vehicle requirements in an automated guided vehicle based transport system. Material Flow, 4, 17-32.

APPENDIX A

Table 9: List of material flows and their components, means of transportation, units per load, and lot size

Product Code	Comp. Code	Description	From	To	By Means Of	Transfer lot size
6000						
	3097	Body	Raw Material	Cutting Shop	Forklift	1000
	3097	Body	Cutting Shop	Paint Shop	Handtruck	100
	3097	Body	Paint Shop	Assembly Press Shop	Handtruck	100
	3030	Cyclinder Cross	Raw Material	Compl. Cutting Shop	Forklift	1000
	3030	Cyclinder Cross	Compl. Cutting Shop	Polish Shop	Handtruck	10000
	3030	Cyclinder Cross	Polish Shop	Assembly Press Shop	Handtruck	10000
	3263	U Cross	Raw Material	Compl. Cutting Shop	Forklift	1000
	3263	U Cross	Compl. Cutting Shop	Polish Shop	Handtruck	10000
	3263	U Cross	Polish Shop	Assembly Press Shop	Handtruck	10000
	3269	Spring Cross	Raw Material	Compl. Cutting Shop	Forklift	1000
	3269	Spring Cross	Compl. Cutting Shop	Polish Shop	Handtruck	10000
	3269	Spring Cross	Polish Shop	Assembly Press Shop	Handtruck	10000
	3018	Faceplate	Semi-Finished Inventory	Assembly Press Shop	Handtruck	500
	6000	Assembly Body	Assembly Press Shop	Semi-Finished Inventory	Handtruck	100
	6000	Assembly Body	Semi-Finished Inventory	Assembly Shop	Handtruck	100
	6000	Assembly Body	Assembly Shop	Final Assembly	Handtruck	100
	6000	Assembly Body	Final Assembly	Finished Goods Storage	Handtruck	100
6100						
	3087	Body	Raw Material	Cutting Shop	Forklift	1000
	3087	Body	Cutting Shop	Paint Shop	Handtruck	100
	3087	Body	Paint Shop	Assembly Press Shop	Handtruck	100
	3266	Square Cross	Raw Material	Compl. Cutting Shop	Forklift	1000
	3266	Square Cross	Compl. Cutting Shop	Polish Shop	Handtruck	10000
	3266	Square Cross	Polish Shop	Assembly Press Shop	Handtruck	10000
	3048	Latch Cross	Raw Material	Compl. Cutting Shop	Forklift	1000
	3048	Latch Cross	Compl. Cutting Shop	Polish Shop	Handtruck	10000
	3048	Latch Cross	Polish Shop	Assembly Press Shop	Handtruck	10000
	3018	Faceplate	Semi-Finished Inventory	Assembly Press Shop	Handtruck	500
	6100	Assembly Body	Assembly Press Shop	Semi-Finished Inventory	Handtruck	100
	6100	Assembly Body	Semi-Finished Inventory	Assembly Shop	Handtruck	100
	6100	Assembly Body	Assembly Shop	Final Assembly	Handtruck	100
	6100	Final Product	Final Assembly	Finished Goods Storage	Handtruck	100

Product Code	Comp. Code	Description	From	To	By Means Of	Transfer lot size
6110						
	3095	Body	Raw Material	Cutting Shop	Forklift	1000
	3095	Body	Cutting Shop	Paint Shop	Handtruck	100
	3095	Body	Paint Shop	Assembly Press Shop	Handtruck	100
	3263	U Cross	Raw Material	Compl. Cutting Shop	Forklift	1000
	3263	U Cross	Compl. Cutting Shop	Polish Shop	Handtruck	10000
	3263	U Cross	Polish Shop	Assembly Press Shop	Handtruck	10000
	3269	Spring Cross	Raw Material	Compl. Cutting Shop	Forklift	1000
	3269	Spring Cross	Compl. Cutting Shop	Polish Shop	Handtruck	10000
	3269	Spring Cross	Polish Shop	Assembly Press Shop	Handtruck	10000
	3019	Faceplate 2	Semi-Finished Inventory	Assembly Press Shop	Handtruck	500
	6110	Assembly Body	Assembly Press Shop	Semi-Finished Inventory	Handtruck	100
	6110	Assembly Body	Semi-Finished Inventory	Assembly Shop	Handtruck	100
	6110	Assembly Body	Assembly Shop	Final Assembly	Handtruck	100
	6110	Final Product	Final Assembly	Finished Goods Storage	Handtruck	100
6400						
	3102	Body	Raw Material	Cutting Shop	Forklift	1000
	3102	Body	Cutting Shop	125 Ton Press	Handtruck	100
	3102	Body	125 Ton Press	210 Ton Press	Handtruck	100
	3102	Body	210 Ton Press	125 Ton Press	Handtruck	100
	3102	Body	125 Ton Press	Cutting Shop	Handtruck	100
	3102	Body	Cutting Shop	Paint Shop	Handtruck	100
	3102	Body	Paint Shop	Assembly Press Shop	Handtruck	100
	3263	U Cross	Raw Material	Compl. Cutting Shop	Forklift	1000
	3263	U Cross	Compl. Cutting Shop	Polish Shop	Handtruck	10000
	3263	U Cross	Polish Shop	Assembly Press Shop	Handtruck	10000
	6400	Assembly Body	Assembly Press Shop	Semi-Finished Inventory	Handtruck	100
	6400	Assembly Body	Semi-Finished Inventory	Assembly Shop	Handtruck	100
	6400	Assembly Body	Assembly Shop	Final Assembly	Handtruck	100
	6400	Final Product	Final Assembly	Finished Goods Storage	Handtruck	100
3018						
	3018	Faceplate	Raw Material	Cutting Shop	Forklift	1000
	3018	Faceplate	Cutting Shop	Sidesanding	Handtruck	500
	3018	Faceplate	Sidesanding	Assembly Press Shop	Handtruck	500
	3018	Faceplate	Assembly Press Shop	Facesanding	Handtruck	500
	3018	Faceplate	Facesanding	Polish Shop	Handtruck	500
	3018	Faceplate	Polish Shop	Cover shop	Handtruck	500

	3022	Faceplate Cross	Raw Material	Cutting Shop	Forklift	1000
	3022	Faceplate Cross	Cutting Shop	Assembly Press Shop	Handtruck	10000
	3018	Faceplate	Cover Shop	Semi-Finished Inventory	Handtruck	500
3019						
	3019	Faceplate	Raw Material	Cutting Shop	Forklift	1000
	3019	Faceplate	Cutting Shop	Facesanding	Handtruck	500
	3019	Faceplate	Facesanding	Assembly Press Shop	Handtruck	500
	3019	Faceplate	Assembly Press Shop	Sidesanding	Handtruck	500
	3019	Faceplate	Sidesanding	Cover shop	Handtruck	500
	3019	Faceplate	Cover shop	Polish shop	Handtruck	500
	3022	Faceplate Cross	Raw Material	Cutting Shop	Forklift	1000
	3022	Faceplate Cross	Cutting Shop	Assembly Press Shop	Handtruck	10000
	3019	Faceplate	Polish Shop	Semi-Finished Inventory	Handtruck	500