

# World Class Layouts

A study of packaging plants for liquid food

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*This article is based upon the master thesis with the same name, written autumn 2008 – spring 2009. The purpose of the study was to determine what a world class layout is, how it is developed, and how it can be measured. It focuses on line production plants.*

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A large part of the goods we use and buy is nowadays more or less mass produced. This does not mean that goods are in any way of poorer quality but only that the product is manufactured in a large scale. In this kind of large-scale production, it is not unusual for the manufacturing equipment, machinery, placed interconnected with conveyers in a so-called production line, which often can work fully automated so that the need of production staff is relatively small.

What should these lines look like? In other words; how should the machines in the factory be located? What are the factors that determine how the machines should be placed? And is there any metrics that can be helpful in measuring one or more production lines? These are the questions that will be answered in this text with focus on the filling and packaging industry.

## ***From mass- to lean production***

Early in the 20<sup>th</sup> century the world changed, in the lead was the car manufacturer Henry Ford who with the help of the so called assembly line lowered the production costs to manufacture a car, model T, a great deal. This caused the cars no longer were granted for the upper-class only for even the working middle class could afford to have a car. The principle of production in an assembly line is that a lot

of resources are invested to improve and specialize the production as much as possible but then have a very low production cost per unit. Ford's mass production was considered the superior production system for about fifty years but after Japan's defeat in World War II Japanese industry recovered very quickly, especially the car manufacturer Toyota excels. The reason is, according to Taiichi Ohno, that:

*All we are doing is looking at the timeline from the moment the customer gives us an order to the point when we collect the cash. And we are reducing that time line by reducing the non-value-added waste.*

The main principle is to focus on the customer and what he is willing to pay for. All activities which the customer is not willing to pay for is a waste that should be minimized.

1986 Richard Schonberger conducted a large study of American companies that had succeeded in implementing Japanese production and management philosophy. Schonberger identified among other things the ability to continuously improve, involve employees, and base decisions on facts. The study enveloped in a book called: *World Class Manufacturing – the lessons of simplicity applied* and is the first time the phrase world-class manufacturing was used.

According to Schoonberger production lines ought to be *lean and simple* and he has identified many examples in almost every industry; but the filling and packaging industry which is the subject of this study. Other industries have been shortening conveyers, reducing buffers, and closing gaps between processes but the canners, brewers, bottlers, and packagers have not. As protection from unreliable equipment packaging industries, did what they always had done, inserted long conveyers between workstations and stuffed them with buffer stocks. The reason is that increasing line speeds and complex equipment make failures likely so to avoid full line stoppages for minor failures accumulation is used. Still, major problems do stop the line why lines in this business are down 30-50% of the time. The industries respond to the poor line performance is to make the lines run even faster, which cause even more jam-ups.<sup>1</sup>

When building a factory there is a common used method called systematic layout planning which first was formed by Richard Muther 1964. This method still is the benchmark for how these developments is done and consists of eight steps:

1. Product-, quantity-, process- and production analysis.
2. Function deployment and function requirements.
3. Relationship analysis.
4. Relationship chart.
5. Block layout.
6. Principal layout.
7. Evaluation.
8. Specific layout.

The different steps in this method won't be explained in this article but the interested reader is advised to learn more about SLP on the web or by reading the book: Systematic

Layout Planning from 1973 by R. Muther.

During the study three companies; The Absolute Company, Carlsberg Breweries, and Tetra Pak Packaging Solutions, have been visited in order to see how a company in the packaging industry works with these issues on a daily basis.

### ***The Absolute Company***

The Absolute Companies first consideration is to achieve an optimal flow at the complete plant. To have an overall perspective of the plant is good as sub-optimization can be devastating. If trucks can't load and unload it does not matter how many products the factory can produce per hour.

The absolute company has built the operations around the operators, so that they can help each other and seldom have to cross the production flow and access the machines easily. This layout contributes with a good visual overview and the opportunity for the operators to solve problems together. All crossing flows are aimed to be minimized both production and operator flows. The production is vertically separated, which includes moving the products vertically and that is, by Toyota, identified as waste. However it can sometimes be worth to utilize conveyer transportation to improve operator accessibility.

Conveyers are somewhat long and buffers or accumulation capacity is kept between every operation. As mentioned in the background of the thesis this is common for the packaging industry yet the aim must be to reduce accumulation and conveyer length as much as possible, to drive operation improvement.

To automatically inspect every product after each production step and take away all defect products is good. This way no time, and money, will be spent on products that cannot be sold anyway. The operations with the worst quality problems will also

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<sup>1</sup> Schoonberger, Richard J. World Class Manufacturing.: The next decade (1996) pg. 156.

be visualized if the defect products are taken away after each operation. Thus it will be obvious which operations are in need of improvement. To re-distill defect product and sell it is a way to shrink costs of poor quality, however defects is a cost and the aim is to eliminate them.

The Absolute Company have prepared well for future expansion. As Absolute can double their capacity in the existing building, as half of the building is empty, the initial investment is also unnecessary large. The Absolute Company has also bought land to be able to build an, to the existing, identical house. The empty space is waste at the same time as a world class manufacturer has to have a long time-horizon in all investments and look to its long term return. To build a factory that is too small and have to be moved out of after just a couple of years is not a good investment either.

### ***Carlsberg Breweries A/S***

Carlsberg Breweries base is the planned capacity need in the factory. This is according to the first step of SLP and one have to think it is safe to assume that the production analysis is done as well, but perhaps not as explicit as in SLP.

Carlsberg share the overall goal, to minimize the number of crossing flows at the complete site, with Absolute. Carlsberg also have a plan for future expansion but always tries to keep the investments in future expansion as low as possible. Buying land is however seen as a minimum.

Capital expenditures and operational expenditures are good metrics to compare different layouts with each other. How much it cost to build and how much it cost to run. These metrics are among the most interesting design criteria for the layout and will also be used in my further analysis.

For Carlsberg it is important to have effective cleaning equipment. As the production rates are very high bottles breaks. This is

once again related to the issues that are common for packaging lines, a production speed so high that quality suffers. The aim must of course be not to have any breaking bottles in the production process, as it makes the surrounding wet and dirty. To avoid these problems Carlsberg have drains around all machines and automatically splashes them with water if necessary. The idea of surrounding the machines with drains is however a good idea yet broken bottles should be avoided.

To plan the complete plant in order to place the brew house so it looks good for people passing outside the factory does not make sense for a engineer. The other design parameters are more or less aligned with the other companies and the overall goal to avoid crossing flows at the complete plant.

Utilization factor of about 50% is again a sign that the packaging industry focuses more on top speed of the machines than the actual approved bottles or packages. This is perhaps because filling equipment is sold pretty much only based on production-rate.

### ***Tetra Pak***

Tetra Pak have a clear process to develop the layout and, pretty much, uses SLP. The documented, and established, process is very good to be able to make sure the work is done properly, and in the same way, every time.

Tetra Pak differs some from the other companies as a new layout is developed for every sale. Carlsberg Breweries is the parent company of the Carlsberg market companies around the globe and also develops new layouts somewhat often. The Absolute Company is a rather small company and does not develop new layouts that often. As Tetra Pak repeats this process with every sale they have four principle macro layouts which are used to fit different customer archetypes. This has the benefit of not doing the same thing over and over

again but to do it right one time. Parts of SLP should not be skipped but knowledge from earlier work must be utilized.

The layout is evaluated in the same way as in SLP which Tetra Pak is alone of the companies to do. The criteria to evaluate the layout can be discussed as well as the number of criteria used. Many criteria give a fuller picture but have the downside that it means more work. Later in this chapter a suggestion of parameters will be presented.

After installation and hand-over of a production line a survey for customer feedback is handed out. To collect information from the customer is essential to be able to improve the next layout. Feedback from many customers also shows issues that many customers experience and is more urgent to do something about. The other companies do not have the same possibility to gather feedback from customers. The Absolute Company has no possibility but Carlsberg can do it from the market companies. It is important that the one filling in the survey understands the production completely and have hands on experience from it to be able to see all pros and cons with the layout and how well it fits the customer.

### ***World Class Production Layout***

It is difficult to determine what a world-class layout looks like in the general case, it does depend on the customer preferences and need. It is however possible to say that if the layout is developed through SLP, with focus on customer requirements and needs, all decisions and evaluations are based on facts, and the layout is continuously followed-up and feedback is gathered from the operators working at the floor a world class layout will be obtained.

The overall goal is to minimize the waste in the production process. Waste is identified as everything the customer is not willing to pay for such as; unnecessary ma-

chine stops, defect products, operator and material transportation.

By listening to the customer, and operator, and continuously improve the layout according to their feedback will ultimately generate a world class layout and ensure that World-Class layouts will be delivered in the future.

The packaging industry traditionally has a high focus on the production speed. By using the SMED methodology production time can be freed up and time can be utilized more efficiently. This is a great area of improvement for the complete industry.

### ***Design Parameters Governing the Layout***

The design parameters identified to govern or affect the layout are:

#### **Capital expenditures**

- **Investment**
- **Space utilization**

#### **Operational expenditures**

- **Material handling**
- **Operator accessibility**
- **Crossing material flows**

#### **Functionality**

- **Expandability**
- **Line Flexibility**

#### **Work environment**

- **Work environment**
- **Visual overview**

#### **Hygiene:**

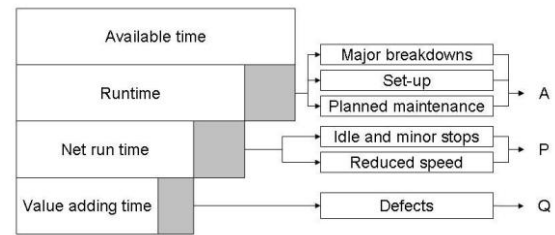
- **Easy to clean**
- **Surrounded by drains**
- **Possibility to separate the different operations**

### ***Measuring the Layout***

The different design parameters can be measured as presented in Table 1.

**Table 1. Metric per parameter**

Parameter	Metric
<b>CapEx</b>	
Equipment investment	Total cost or differing equipment cost per line
Space utilization	Floor space per line
<b>OpEx</b>	
Material Handling	Pallet meters per hour
Operator Accessibility	Operator traveling time (or distance) per hour
<b>Function</b>	
Expandability	Prepared lines
Line flexibility	Product types per line
Crossing material flows	Number of crossing flows per line
<b>Work environment</b>	
Visual overview	Operator supervision points per line
<b>Hygiene</b>	
Separation of operations	Availability to separate operations



**Figure 1. OEE**

No exact metrics could be found for the more subjective parameters work-environment and easy to clean. The parameter surrounded by drains is parameter affecting the hygiene in the plant but it is not directly dependent of the macro perspective of the layout.

To measure the performance of the complete plant or lines Overall Equipment Efficiency (see Figure 1) is suggested to be used as it shows both improvement potential in the areas of availability, performance and quality as well as it focuses on the number of approved products rather than produced products.