10 Exercises on Reorder Point

Solved exercises to better understand the reorder point in the company's warehouses, based on the

Lean Thinking approach

2013

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Introduction

The "Lean Manufacturing" is one of the method to organize a factory. The "Lean Thinking" was born round 1960 and became famous round 1990.

This book is an exercises list to help the reader to practice what he studies on Lean Theory books. In every chapter there is a brief theoretical introduction with a summary of the useful formula to solve the following problems.

Theoretical Overview

The Model:

Supplier→Warehouse→Production Department

Buyer/Planner and Users

1) There is a department (or more than one) that use a material for production at a certain rate

2) The material flow is from the warehouse to the production department

3) There is a Buyer/Planner entitled to refill the warehouse buying from a supplier

4) The goal is to have the stock at a level that avoid stock-out and maintain a reasonable inventory level

The Ideal World:

A) The users take frow warehouse at constant rate (i.e. 1 kg / day, 10 lt / week, 1 Pack / h)

B) When the stock is "zero" the supplier instantly refill the stock when the planner give him the information

C) The diagram that show how the ideal world works is reported in Fig. 1

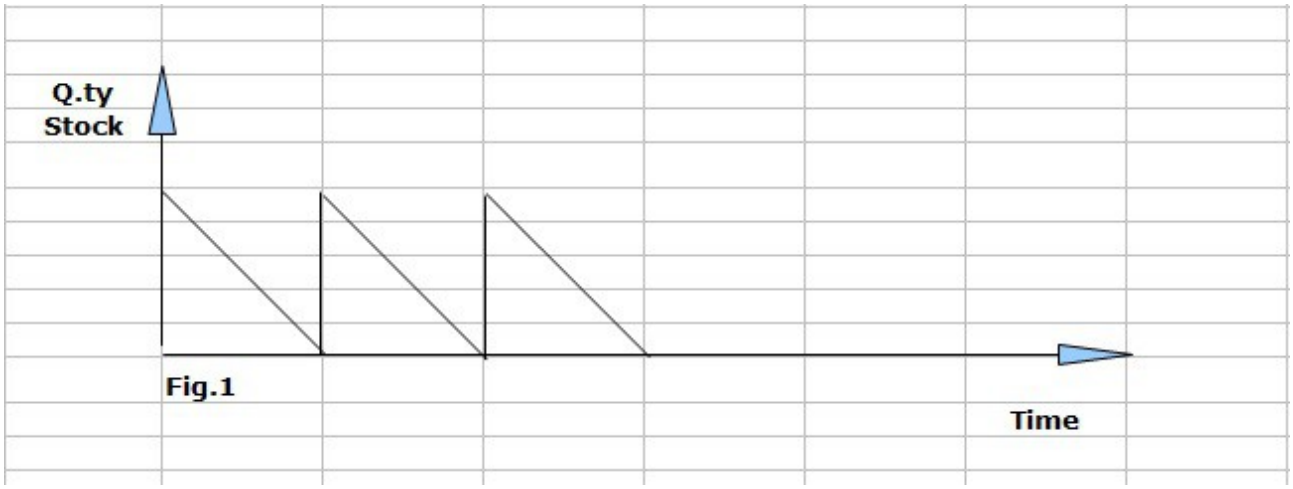

Fig.1

The Real World:

I) In the real world the user do not consume at constant rate

II) The supplier cannot refill the stock instantly and the planner cannot give the input immediately

III) A certain amount of stock has always be present in the company to avoid stock-out and production stopping

How to calculate the right amount of stock?

The Basic Approach

There is a "simple formula" that can be used

Reorder Point = Demand Rate * Lead Time

To use this formula, the Demand Rate and Lead Time has to be constant and expressed on the same time base.

Example 1:

A furniture company uses 100 kg of wood every day.

The Lead Time to obtain the wood is 7 days

Reorder Point = 100 kg / day * 7 days = **700 kg**

This means that when the stock level reach 700 kg an order to buy wood has to be placed

Example 2:

A tyres company uses 3000 air-cap a week.

The Lead Time to have the air-cap is 2 weeks.

Reorder Point = 3000 air-cap / week * 2 weeks = **6000 air-cap**

This means that when the stock level reach 6000 air-cap an order has to be placed

The Limit of the Basic Approach

To use the basic approach can be risky because in the real life some event can occur and stop the production (i.e. Supplier Delay, Buyer/Planner Sick, Delay in order emission, Extra Consumption, Defective material shipped).

In this case could be useful to have an extra stock of material normally named "Safety Stock". The point is how to size the Safety Stock.

One approach is percentage based (i.e. The safety stock is 15% of reorder point)

Another approach is time based (i.e. The safety stock is 5 days of material usage)

The reader can select the method he considers more reliable for the company.

Example 3:

The company of the Example 1 decided to have 3 days of safety stock.

Reorder Point = 100 kg / day * 7 days = 700 kg

Safety Stock = 100 kg / day * 3 days = 300 kg

New Reorder Point = 700 + 300 kg = 1000 kg

This means that when the stock level reach 1000 kg an order to buy wood has

to be placed

Example 4:

The company of the example 2 decided to have 20% of safety stock.

Reorder Point = 3000 air-cap / week * 2 weeks = 6000 air-cap

Safety Stock = 20% * 6000 = 1200 air-cap

New Reorder Point = 6000 + 1200 = 7200 air-cap

This means that when the stock level reach 7200 air-cap an order has to be placed

Reorder point with variable demand

In the real world the demand is very variable because of many reasons (i.e. Customer Demand Variation, Scraps, Multi Users, Machine breakdown etc.)

Based on this, the formula it is possible to find on Wikipedia is:

Reorder Point (ROP) = Average Lead Time * Average Demand + Z*SQRT(Avg. Lead Time * Standard Deviation of Demand^2 + Avg. Demand^2 * Standard Deviation of Lead Time^2)

where Z = NORMSINV(Service level), for example Z=1.64 for a 95% service level

What it is proposed here is a simplified model that is good balance between accuracy and time for calculation.

Two hypotheses:

1) The Lead Time is constant and expressed in week

2) The Z = 2 that means round 97% of service le

Hence, the formula becomes simpler (and more Lean!):

Reorder Point (ROP) = Lead Time (in Weeks) * Average Weekly Demand +

2 * SQRT (Lead Time * Standard Deviation of Demand^2)

and then

Reorder Point (ROP) = Lead Time (in Weeks) * Average Weekly Demand + 2 * Standard Deviation of Demand * SQRT (Lead Time)

This formula will be used in the following exercises.

To use this approach it is important to have reliable data of the demand.

The data has be collected close to the point of use, going in the warehouse, from the IT system (if it works well).

How much is the quantity to order?

The quantity to order should be evaluated with the calculation of the economic lot.

Our opinion is that to spend a lot of time and resources to evaluate this quantity could be a waste of time.

The costrains that normally you can find are:

1) The supplier has a minimum quantity that can ship because of the packaging

2) The cost of trasportation has to be taken in account

3) You should order at least the average quantity calculated before

Our suggestion is to order a little bit more of the average demand with a reasonable look at the shipping cost and avoiding the supplier not standard packaging.

Remeber that what you could spend for the more frequent transportation is probably less you could spend in 7 wastes by big shipping approach.

Minumum and Maximum Stock Level

It could be useful to have in mind a minumum and maximum level of stock to use as warning.

To determine the maximum level it is suggested to use this formula:

Maximum Quantity = Quantity ordered to the supplier + Material for 1 week work + Safety Stock

Looking at the example 4:

Maximum Quantity = 6000 air-cap + 3000 air-cap + 1200 air-cap = 10200 air-cap

This is a rule of thumb that can be refined. When the maximum quantity is reached, the planner have to revise the ordering model and ask to the users if there is something new in the consumption.

Note that the maximum quantity has to be evaluated in relation to the available space to stock the materials.

The "minimum quantity" is a warning level that should activate the people involved in the process to check if some corrective action is needed to replenish the stock.

Note: The minimum quantity has to be carefully chosen and it is not the reorder point.

Generally minimum quantity is less than reorder point

The rule of thumb proposed is: How long it takes to order and get the material from the supplier?

The minimum quantity is the equivalent in materials of the time the company need to get the material from the supplier.

Looking again at the example 4:

The company knows, based on its experience, that in case of urgency the time to get the air-cap is 1 week.

So they set the minimum quantity according to the weekly demand of 3000 air-cap.

Minimum Quantity = 3000 Air-Cap

It seems simple! Why in some company does not work?

Basically, the main reasons we found are:

1) The Planner do not know personally the user(s). This means that he has no reference and feedback about what to buy and when

2) The User do not know personally the Planner. This means that he cannot communicate any demand variation or any needs

3) There is not a very reliable system to evaluate material consumption

4) There is an "old style" relation with the supplier with the approach "here and now" without any respect of the supplier

5) The stock reduction is made too fast without any analysis. The best approach is: "First Control then Reduction"

6) There is no analysis of the available space to stock the material

7) Only the shipping cost is take in account and not the 7 waste reduction

8) There is a big production fluctuation because the production is not standardized.

So at the end of the day we proposed to increase communication among the people involved in the process.

First define clearly who is the Planner, the User, the Supplier and Warehouse Responsible

Then, increase the flow information about these people and promote the "Internal Supplier and Internal Customer approach"

Let's go to numerical exercises in order to better understand!

Exercise 1 – The Basic Approach

A knives company use 50 kg of metal sheets / day. They work 5 days a week. The production is quite standardized and the supplier is very relaiable.

The Supplier Lead Time is 2 weeks from the order.

Which is the Reorder Point?

Answer:

Using the "basic approach": **Reorder Point = Demand Rate * Lead Time**

Reorder Point = 50 kg / day * 10 days = **500 kg**

One possible question could be: "why 10 days and not 14 days in the formula"

Basically, you need an effort to have the same time base! We would like to suggest to base on weeks.

In this way: Demand = 250 kg / week – Supplier Lead Time = 2 Weeks

This lead to:

Reorder Point = 250 kg / week * 2 weeks = **500 kg**

The Reorder point is the same but with less risk of miscalculation.

Exercise 2 – The Basic Approach, the limit of using it

The knives company of the exercise 1 reach the reorder point of 500 kg of metal sheets on Monday 2nd September 2013. The planner order 500 kg to the supplier. It is expected to have the material on 16th of September 2013 (after 2 weeks).

How could any unplanned event affect the production?

Answer:

On 2nd September 2013 the warehouse has 500 kg of metal sheet.

During the week the production go smoothly, 250 kg of metal sheet are used.

On 9th September 2013 the warehouse has 250 kg of metal sheet.

During the week the production go smoothly, 250 kg of metal sheet are used.

On 16th September 2013 the warehouse has 0 kg of metal sheet and the supplier is exepected to "refill" the stock.

They expect and expect, but no supplier come.

The production is blocked! Everyone shouts and the boss is nervous. After a quick investigation it is discovered that the truck had an engine problem during the travel and is somewhere on the road to fix it.

The metal sheet will be delivered on 18th September 2013 with a 2 days of production lost.

No one is very responsible if the "basic approach" was chosen by the company.

Exercise 3 – The Basic Approach, the limit of using it – Another Story

The knives company of the exercise 1 reach the reorder point of 500 kg of metal sheets on Monday 2nd September 2013. The planner order 500 kg to the supplier. It is expected to have the material on 16th of September 2013 (after 2 weeks).

How could any unplanned event affect the production?

Answer:

On 2nd September 2013 the warehouse has 500 kg of metal sheet.

During the week the production go smoothly, 250 kg of metal sheet are used.

On 9th September 2013 the warehouse has 250 kg of metal sheet.

During the week the production **do not go smoothly beacuse of a defective machine work**, 100 kg of metal sheets were wasted.

So the shopfloor finished the raw material on 12nd September 2013.

Two days of production were lost.

The supplier delivered on 16th September 2013 as agreed.

Exercise 4 – The Basic Approach – Safety Stock

The knives company decided not to have stock problems any more. So they decided to have a "safety stock" time based. They decided to have 2 weeks of margin on the stock.

Which is the Reorder Point by considering the Safety Stock?

Answer:

The demand of metal sheet is 250 kg / week.

With the basic approach we already know that the Reorder Point was **500 kg.**

Safety Stock = 2 weeks, this means 250 kg / week for 2 = **500 kg.**

So the **Reorder Point is** = 500 + 500 = **1000 kg.**

It is important to underline that by having this higher reorder point means to have more money blocked in the inventory.

Exercise 5 – When the demand rate is variable

After 10 years the company grow up, more knives models are manufactured in 3 different buildings. The warehouse is one and serves 3 different lines with a variable demand during the week.

The knives lines use the same metal sheets to produce many different knives model.

The warehouse manager want to have a "right" amout of stock and start to analyze demand rate data of the last 6 months.

Regardless the production line served, the warehouse manager collect the data on "weekly demand" base.

Quantity [kg]:

Week 1 = 340

Week 2 = 200

Week 3 = 250

Week 4 = 320

Week 5 = 190

Week 6 = 230

Week 7 = 250

Week 8 = 150

Week 9 = 300

Week 10 = 320

Week 11 = 120

Week 12 = 350

Week 13 = 250

Week 14 = 140

Week 15 = 220

Week 16 = 100

Week 17 = 140

Week 18 = 350

Week 19 = 370

Week 20 = 200

Week 21 = 380

Week 22 = 400

Week 23 = 230

Week 24 = 250

The average Supplier Lead Time is 2 weeks.

Which is the Reorder Point? How much quantity is to order?

Answer:

The first step is to fix, clearly and strongly with the supplier, the Lead Time to have the material in house.

In the example, the warehouse manager strongly confirmed with the supplier the **Lead Time of 2 weeks.**

Then evaluate the "average" of the demand.

The final step is to evaluate the "standard deviation" that is a kind of "fluctuation of the demand".

VERY IMPORTANT NOTE!

Because the Supplier Lead Time is 2 weeks the data has to be grouped in 2 weeks data block and then calculate Average and Standard Deviation.

Quantity [kg]

Week 1-2 = 540

Week 3-4 = 570

Week 5-6 = 420

Week 7-8 = 400

Week 9-10 = 620

Week 11-12 = 470

Week 13-14 = 390

Week 15-16 = 320

Week 17-18 = 490

Week 19-20 = 570

Week 21-22 = 780

Week 23-24 = 480

In other words the demand has to be grouped in relation with the Supplier Lead Time.

Average Weekly Demand = 252,08 kg

Average Demand every 2 weeks = 504,17 kg (that is = 2 * 252,08 kg)

Standard Deviation 2 weeks based = 122,95 kg

Now the manager can calculate the reorder point with the "simplified formula" proposed here:

Reorder Point (ROP) = Lead Time (in Week) * Average Weekly Demand + 2 * Standard Deviation of Demand * SQRT (Lead Time)

ROP = 2 * 252,08 + 2 * 122,95 * SQRT (2) = 504,17 + 347,76 = **851,93 kg**

The quantity of **347,76 kg** is normally named **"safety stock"**.

it should be clear now, that when the metal sheets quantity fall under 851,93 kg , other metal sheets has to be ordered.

With this model, the safety stock should be enough to avoid any stock-out due to any reason.

How much quantity to order?

The model presented in this e-book is linked to logistic aspects and shipping rules. Anyway the average is a good starting point. In the example the quantity to order is round 500 kg.

A simulation of the stock level every 2 weeks is proposed in the following table:

Lead Time = 2 weeks

Demand Average = 504,17 kg

Standard Deviation = 122,95 kg

Quantity to Order = 500 kg

Stock Quantity in the period:

21/08/13 =851,93

02/09/13 = 429,70

04/09/13 = 929,70

16/09/13 = 335,39

18/09/13 = 835,39

30/09/13 = 447,40

02/10/13 = 947,40

14/10/13 = 573,27

16/10/13 = 1073,27

28/10/13 = 642,61

30/10/13 = 1142,61

11/11/13 = 719,96

Exercise 6 – Minimum and Maximum Quantity

In order to have a control on stock level, the warehouse manager would like to set a minimum and maximum level for warning.

How to set these levels?

Answer:

Looking at the model proposed:

Maximum Quantity = Quantity ordered to the supplier + Material for 1 week work + Safety Stock

In numbers: **Maximum Quantity =** 500 + 250 + 347,76 = **1097,76 kg**

When this value is passed, there is something to check.

Looking at the simulation, the level is passed only once.

Remember it is just a warning!

On the other hand, the minimum quantity is the equivalent in materials of the time the company need to get the material from the supplier.

In this example the Supplier Lead Time is equal to 2 weeks.

This means that:

Minimum Quantity Level is = 504,17 kg (Average Demand every 2 weeks)

This level is a warning and generally is lower than reorder point. In this exercise:

ROP = 851,93 kg > Min Level = 504,17 kg.

When the minimum level is reached a quick investigation has to be done to avoid stock-out and take corrective actions.

Exercise 7 – Standardizing Weekly Demand

The warehouse manager decided to speak with the shopfloor manager of the 3 knives lines in order to have a more standardized weekly demand.

They decided to force themselves to order a weekly quantity between 230 kg and 270 kg of metal sheets.

To obtain this they reduced the unofficial warehouse close the line and spend time to train people and asking for a more stable and clear production plan.

They were able to obtain this goal. Look at the following table:

Quantity [kg]

Week 1 = 230,00

Week 2= 250,00

Week 3 = 270,00

Week 4 = 260,00

Week 5 = 250,00

Week 6 = 270,00

Week 7 = 230,00

Week 8 = 230,00

Week 9 = 250,00

Week 10= 230,00

Week 11 = 240,00

Week 12 = 230,00

Week 13 = 250,00

Week 14 = 230,00

Week 15 = 270,00

Week 16 = 250,00

Week 17 = 270,00

Week 18 = 230,00

Week 19 = 260,00

Week 20 = 230,00

Week 21 = 250,00

Week 22 = 270,00

Week 23 = 230,00

Week 24 = 250,00

The Supplier Lead Time is still 2 weeks.

How the Reorder Point is affect by this choice.

Answer:

In the exmaple, the warehouse manager strongly confirmed with the supplier the **Lead Time of 2 weeks.**

Then evaluate the "average" of the demand.

The final is to evaluate the "standard deviation" that is a kind of "fluctuation of the demand".

In this new case:

Average weekly demand = 247,08 kg

Standard Deviation 2 weeks based =23,14 kg

By using the ROP formula:

ROP = 247,08 * 2 + 2 * 23,14 *SQRT(2) **= 559,63 kg**

By comparing this ROP with the situation of the exercise 5 it should be clear that the reorder point is lower now.

ROP exercise 5 (high demand variation) = **851,93 kg**

ROP exercise 7 (low demand variation) = **559,63 kg**

Round 300 kg less. What does it means in terms of savings?

If it is supposed an high grade metal sheet with the price of 70$ / kg, the fact to have a low reorder point means to have round **21.000 $** of inventory less than with an higher reorder point.

The savings is in terms of interests you could get and possibility to invest it in

any other fruitful way rather than staying stucked in materials on the shelf. You could get all this benefits without affecting the production and working smoothly.

Exercise 8 – Supplier more reliable and closer

After a market research the knives company found a more relaible supplier closer to the factory.

Based on this, the supplier lead time was reduced to 1 week.

How this affect the Reorder Point if the weekly demand is the quantity reported in the following table (the same of exercise number 7) ?

Quantity [kg]

Week 1 = 230

Week 2 = 250

Week 3 = 270

Week 4 = 260

Week 5 = 250

Week 6 = 270

Week 7 = 230

Week 8 = 230

Week 9 = 250

Week 10 = 230

Week 11 = 240

Week 12 = 230

Week 13 = 250

Week 14 = 230

Week 15 = 270

Week 16 = 250

Week 17 = 270

Week 18 = 230

Week 19 = 260

Week 20 = 230

Week 21 = 250

Week 22 = 270

Week 23 = 230

Week 24 = 250

Answer:

The approach is always the same.

Supplier Lead Time = 1 week

Average weekly demand = **247,08 kg**

Standard Deviation 1 Week = **15,74 kg**

Reorder Point (ROP) = Lead Time (in Week) * Average Weekly Demand + 2 * Standard Deviation of Demand * SQRT (Lead Time)

ROP = 1 * 247,08 kg + 2 * 15,74 * SQRT (1) = **278,56 kg**

Let us now compare the **ROP** of this exercise and the others:

ROP exercise 5 (high demand variation, 2 Wk Lead Time) = **851,93 kg**

ROP exercise 7 (low demand variation, 2 Wk Lead Time) **= 559,63 kg**

ROP exercise 8 (low demand variation, 1 Wk Lead Time) = **278,56 kg**

The difference between situation described in Exercise 5 and Exercise 8 is round 550 kg of stock.

This means, with the example of 70 $ / kg, **round 38.500 $** of money available for other scopes.

Exercise 9 – Solved exercises for 1,2,4 and 8 weeks Supplier Lead Time

Starting from the weekly demand reported in the table, calculate Reorder Point for different Supplier Lead Time (1 week, 2 weeks, 4 weeks and 8 weeks).

Quantity in kg.

	Quantity:
Week 1	340,00
Week 2	200,00
Week 3	100,00
Week 4	340,00
Week 5	230,00
Week 6	400,00
Week 7	230,00
Week 8	120,00
Week 9	150,00
Week 10	180,00
Week 11	200,00
Week 12	240,00
Week 13	100,00
Week 14	400,00
Week 15	450,00
Week 16	300,00
Week 17	230,00
Week 18	250,00
Week 19	400,00
Week 20	500,00
Week 21	350,00
Week 22	400,00
Week 23	200,00
Week 24	150,00

Answer:

Lead Time	**1 Week**	
Demand Average:	269,17	kg
Standard Deviation:	115,72	kg
Reorder Point:	**500,6**	**kg**
Safety Stock	*231,44*	kg
Min (1 Week Work)	269,17	kg
Max	769,77	kg

Lead Time	**2 Weeks**	
Demand Average:	538,33	kg
Standard Deviation:	182,75	kg
Reorder Point:	**1055,22**	**kg**
Safety Stock	*516,89*	kg
Min (2 Week Work)	538,33	kg
Max	1593,56	kg

Lead Time	**4 Weeks**	
Demand Average:	1076,67	kg
Standard Deviation:	216,95	kg
Reorder Point:	**1944,46**	**kg**
Safety Stock	*433,9*	kg
Min (4 Week Work)	1076,67	kg
Max	2587,23	kg

Lead Time	**8 Weeks**	
Demand Average:	2153,33	kg
Standard Deviation:	284,49	kg
Reorder Point:	**3762,64**	**kg**
Safety Stock	*568,98*	kg
Min (8 Week Work)	2153,33	kg
Max	4875,64	kg

Exercise 10 – Solved exercise for 1,2,4,8 weeks Supplier Lead Time

Starting from the weekly demand reported in the table, calculate Reorder Point for different Supplier Lead Time (1 week, 2 weeks, 4 weeks and 8 weeks).

Quantity in kg.

	Quantity:
Week 1	1000,00
Week 2	340,00
Week 3	500,00
Week 4	340,00
Week 5	1200,00
Week 6	450,00
Week 7	2000,00
Week 8	230,00
Week 9	700,00
Week 10	800,00
Week 11	870,00
Week 12	850,00
Week 13	500,00
Week 14	600,00
Week 15	700,00
Week 16	300,00
Week 17	600,00
Week 18	1000,00
Week 19	500,00
Week 20	750,00
Week 21	600,00
Week 22	800,00
Week 23	1000,00
Week 24	400,00

Answer:

Lead Time	**1 Week**	
Demand Average:	709,58	kg
Standard Deviation:	374,42	kg
Reorder Point:	**1458,41**	**kg**
Safety Stock	*748,83*	kg
Min (1 Week Work)	709,58	kg
Max	2168	kg

Lead Time	**2 Weeks**	
Demand Average:	1419,17	kg
Standard Deviation:	367,93	kg
Reorder Point:	**2459,83**	**kg**
Safety Stock	*1040,66*	kg
Min (2 Week Work)	1419,17	kg
Max	3878,99	kg

Lead Time	**4 Weeks**	
Demand Average:	2838,33	kg
Standard Deviation:	664,96	kg
Reorder Point:	**5498,19**	**kg**
Safety Stock	*1329,93*	kg
Min (4 Week Work)	2838,33	kg
Max	7006,59	kg

Lead Time	**8 Weeks**	
Demand Average:	5676,67	kg
Standard Deviation:	370,72	kg
Reorder Point:	**7773,78**	**kg**
Safety Stock	*741,44*	kg
Min (8 Week Work)	5676,67	kg