Applications - LEAN

SMED Exercise:

Which are the tasks that could be converted in External tasks ?

Car arrives

-

Lift up the car with a jack

Search for the toolbox

Search for tools in the toolbox

Unscrew the wheel

Sort the old wheel

Replace and screw a new wheel

Inflate new wheel to right pressure

Un-lift the car with the jack

-

Car goes away

SMED Exercise:

Which are the tasks that could be converted in External tasks ?

Solution

Car arrives (car is moving)

- Car stops

Lift up the car with a jack => Could be done only when car is stopped

Searching for the toolbox => Could be done before car stop

Searching for tools in the toolbox => Could be done before car stop

Unscrew the wheel => Could be done only when car is stopped

Sort the old wheel => Could be done only when car is stopped

Replace and screw new wheel => Could be done only when car is stopped

Inflate the new wheel to right pressure => Could be done before car stop

Un-lift the car with the jack => Could be done only when car is stopped

- Car starts / Car goes away (car is moving)

Have a look at the wheel replacement of a formula one: all possible convertible tasks are converted.

SMED Exercise:

Which tasks should be optimized FIRST ?

Car arrives

-

Lift up the car with a jack

Search for the toolbox

Search for tools in the toolbox

Unscrew the wheel

Sort the old wheel

Replace and screw a new wheel Inflate new wheel to right pressure

Un-lift the car with the jack

-

Car goes away

SMED Exercise:

Which tasks should be optimized FIRST ?

Solution

Car arrives

-

Lift up the car with a jack => Use a Jack that can be placed easily and as quickly as possible

Search for the toolbox

Search for tools in the toolbox

Unscrew the wheel => Use a faster device to unscrew / fit the car with a one bolt only system

Sort the old wheel

Replace and screw a new wheel => Use a faster device to unscrew / fit the car with a one bolt only system

Inflate new wheel to right pressure

Un-lift the car with the jack => Could be done only when car is stopped

-

Car goes away

Have a look at the wheel replacement of a formula one : maximum optimization

Associate all statements to the right flow

"Make to Order" => PUSH or PULL ?

"Make to stock" => PUSH or PULL ?

Large stock => PUSH or PULL ?

Better flexibility => PUSH or PULL ?

Anticipation => PUSH or PULL ?

Solution

Associate all statements to the right flow

"Make to Order" => PULL

"Make to stock" => PUSH

Large stock => PUSH

Better flexibility => PULL

Anticipation => PUSH

You are working in a company selling syrups. Identify in the Supply Chain process, the Added Value steps of the process (for the customer).

VA : Transforming the product for the customer, it's OK
BR : Business Required => should be reduced / minimized
NVA : Pure Waste => eliminate (if not possible reduce)

Assessment of forecast	**?**
Replacement of a broken pump	**?**
Construction of the planning	**?**
Supply of long lead-time components	**?**
Rework of a batch produced with a wrong label	**?**
Training of staff	**?**
Writing of a user's guide	**?**
Cleaning of production vessels	**?**
Loading of raw materials (liquid sugar, fruits, ...)	**?**
In-process control	**?**
Filling of 75cl bottles	**?**
Shipment of finished products	**?**
Invoicing	**?**

Solution

You are working in a company selling syrups. Identify in the Supply Chain process, the Added Value steps of the process (for the customer).

VA : Transforming the product for the customer, it's OK
BR : Business Required => should be reduced / minimized
NVA : Pure Waste => eliminate (if not possible reduce)

Assessment of forecast	**BR => produce right quantity**
Replacement of a broken pump	**NVA => improve equipment reliability (maintainability)**
Construction of the planning	**BR => produce right quantity**
Supply of long lead-time components	**BR => enable production**
Rework of a batch produced with a wrong label	**NVA => improve process reliability: avoid mistakes (early detection reduces impact)**
Training of staff	**BR BR => produce right quality**
Writing of a user's guide	**BR=> produce right quality & avoid time losses**
Cleaning of production vessels	**BR => produce right quantity**
Loading of raw materials (liquid sugar, fruits, ...)	**VA**
In-process control	**BR => produce right quantity by detecting mistakes as early as possible in the process**
Filling of 75cl bottles	**VA**
Shipment of finished products	**VA**
Invoicing	**BR => make the money in**

You plan to launch a new product whose demand is expected to be 1000 units/day.

The product will be produced in a plant working in 2 shifts (16h/day) and 7 days per week.

You are expecting a loss factor (raw operating time / schedule time) of 78% and no issue with quality.

What is the minimum throughput of the equipment to be used in the plant (in units/hour) ?

Solution

The loss factor is RoT / ST = 0.78

To get 1000 for the day you need to go for a higher quantity every day => 1000/0.78 = 1282,05

To produce 1282 within 16 hours you need to have a throughput => 1282/16 = 80.13 => **80**

You may also calculate this way

You want to have an actual production 1000 when working (ST) during 16 hours. => 1000/16 = 62.5 units/hour
But you have a loss factor of 0.78 => you must have a nominal speed higher => 62.5 / 0.78 = 80.13 => **80**

A production unit is running 24h/day and 7 days/week.

32h are lost in average every week.

The speed of the line is 85% of the specification of the equipment.

The quality rate is 92%.

Calculate how much is the OEE ?

Solution

OEE is ET / ST but can also be calculated as the combination of 3 ratio :
Let's have a look at the External Resource (for the name of these ratio):
Operational Equipment Effectiveness (OEE)
OEE = Availability x Performance x Quality

When looking at the diagrams in the course (S2)
OEE = RoT/ ST x NoT / RoT x ET / Not = ET / ST

ST : 24*7 = 168h as we have a total of stops: 32h
=> RoT is 168-32 =136 h => RoT/ST = 0.8095 (80.95%)

Speed loss (Performance) is given : 0.85 and Quality ratio is given : 0.92

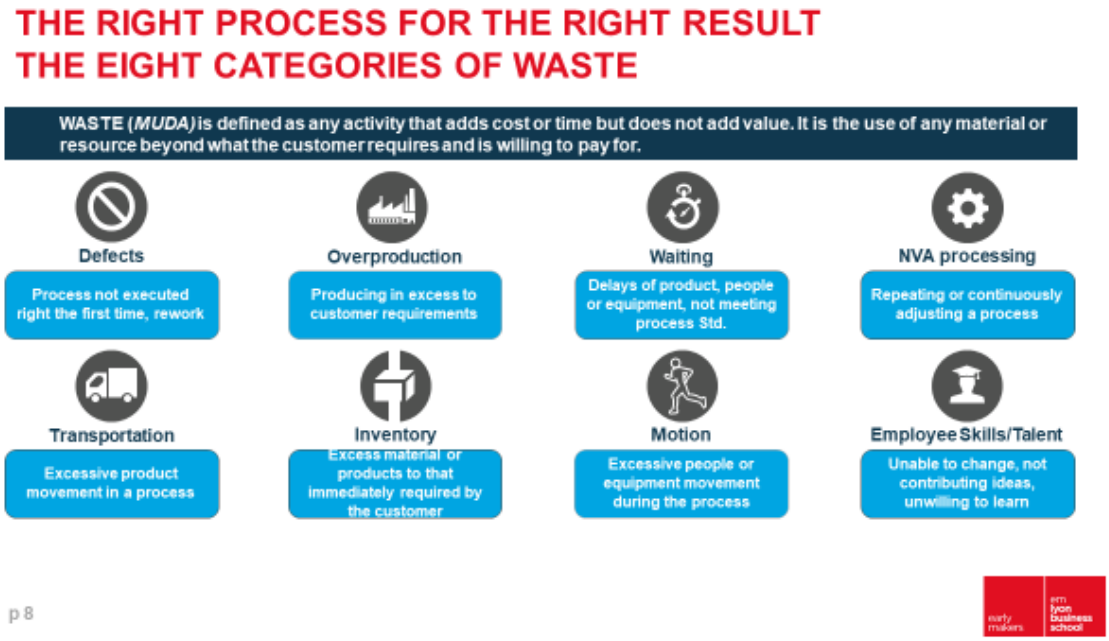
OEE = 0.8095 x 0.85 x 0.92 = 0.6330 ⇔ **63.30%**

You may also calculate successively ST => Rot => NoT => ET
ST = 7*24 = 168 ; Rot = St –Stops => 168-32=136 ; NoT = Rot * speed loss => 136*0.85 = 115.6 ; ET = Not * Quality ratio => 115.6*0.92 = 106.352 => OEE = ET / ST = 106.352/168 = 63.30 ⇔ 63.30%

QUIZ: Classify the examples of waste into their different categories

Multiple approvals
Rework
Purchasing items before they are needed
System response time
Limited employee responsibility
Redundant data
Bringing samples to the Quality Control Lab
Extra copies

Reminder : 8 Categories of Waste (In slides Course 2)



Solution

Multiple approvals	Transportation
Rework	Defects
Purchasing items before they are needed	Overproduction
System response time	Waiting
Limited employee responsibility	Neglected human talent
Redundant data	Inventory excess
Bringing samples to the Quality Control Lab	Motion
Extra copies	Excess processing

Remarks: alternative answers

- Purchasing items before they are needed => Inventory excess
- Redundant data => Excess processing
- Multiple approvals => Overproduction
- Extra copies => Overproduction

Control cards:

Using the data of the last month, you are able to calculate the average value of one key parameter of your process and its standard deviation (mean = 50 and std dev = 3,5).

Assuming customer specifications of +/-25%,
what should be the minimum and maximum limits of your control cards (LCL and UCL) ?

A	**LCL = 39,5 - UCL = 60,5**
B	**LCL = 37,5 - UCL = 62,5**
C	**LCL = 46,5 - UCL = 53,5**

Solution

A	**LCL = 39,5 - UCL = 60,5**
B	**LCL = 37,5 - UCL = 62,5**
C	**LCL = 46,5 - UCL = 53,5**

LCL = mean – 3* stdV = 50 - 3*3.5 = 39.5

UCL = mean + 3* stdV = 50 + 3*3.5 = 60.5

Remarks:

LCL : Lower Control Limit

UCL : Upper Control Limit

What is the global yield (in %) of a process made of 20 steps, each step having a yield of 95% ?

Solution

P = p * p * p ….

$P = p^n$

$0.95^{20} = 0.358 => 36\%$

0.95 * 0.95 * 0.95 …

-

What is the main objective of a 6-Sigma project ?

A - Reducing variations

B - Removing all variations

C - Negotiating less restricting specifications with suppliers

D - Quantifying interactions with the largest number of process variables

Solution

A

The time needed to go from home to the bus station (A) = 5 min +/-3 min

The time needed to go from the bus station to school (B) = 10 min +/- 4 min

What is the expectation about the deviation to go from home to school (A+B) ? --> 15 min +/- ?

Solution

There is simple linear additivity for the mean (or mathematical expectancy) => 5+10=15

For the +/- it' standard deviation (square root of variance) !

And you add the variances

home to the bus station: standard deviation is 5 min (+/-5)
bus station to school: standard deviation is 4 min (+/-4)

So the variance for the total time is $5^2 + 4^2 = 25$
So standard deviation for the total time is $\sqrt{25} = 5$
standard deviation is square root of variance

For the total time it's : 15 +/**5** => (10 ; 20) **5 is the answer**

Somme explanations about variances additivity
(sorry I found it only in french language)

https://www.youtube.com/watch?v=ddOj_ryk8xM

Capability calculation: the formulas

CAPABILITY CALCULATION

- **Specifications:**
  - LSL: Lower Specification Limit
  - USL: Upper Specification Limit
- **Process: (ST: measure on 50 points)**
  - LCL: Lower Calculation Limit
  - UCL: Upper Calculation Limit
- **LCL and UCL calculation:**
  - LCL = Mean - 3 x Standard Dev.
  - UCL = Mean + 3 x Standard Dev.
- **Cp and Cpk calculation:**
- Cp = (USL – LSL)/(UCL – LCL)
- Cpk1 = (USL – Mean)/(UCL – Mean)
- Cpk2 = (Mean – LSL)/(Mean – LCL)
- Cpk = Min (Cpk1, Cpk2)

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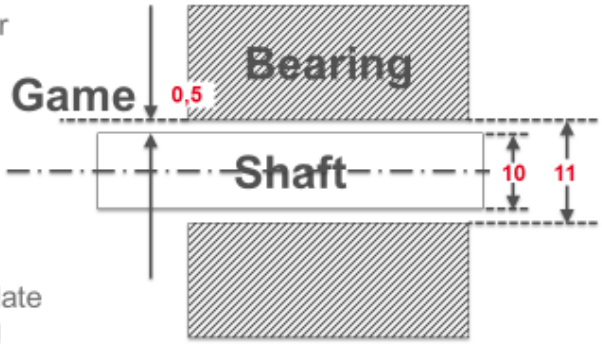
*Remark: for Cpk denominator UCL-Mean = Mean+3*SD- Mean = 3*SD and the same for Mean-LCL = 3*SD*
You may found this version in many formulas in documents or websites

Capability calculation: the example and question asked

CAPABILITY: EXAMPLE

- Piece made of a **shaft** and a **bearing**
- The **game** in between is the customer specification

Specifications	Target	+/-
Shaft	10	0,2
Bearing	11	0,2
Game	0,5	0,1



- Using the data in the Excel file, calculate the Cp, Cpk, DPMO for shaft, bearing and game

- *DPMO: Defects Per Million Opportunities*

p 12

Beware: here the "game" is <u>half</u> of the difference between bearing and shaft. It's not the standard way of presenting a game in mechanics (we would rather consider game is 11-10 = 1)

Solution

Let's make the detailed calculation for the series of values of the shaft.
(same type of calculation for bearing and for the game)

VOC is turned into technical specifications =>

Specifications for the Shaft: USL = 10+0.2 = 10.2
LSL = 10- 0.2 = 9.8

The usual name for the width USL-LSL is Tolerance Interval (TI)

VOP is determined by result of the production process
(200 values for measured shaft diameter) =>

Result of process for the Shaft: Mean = 10.0558
Standard Deviation SD = 0.0398

Therefore, Control limits are (Mean +/- 3.SD) UCL = 10.0558 + 3* 0.0398 = 10.1752
LCL = 10.0558 - 3* 0.0398 = 9.9364

Now we can calculate different versions of the capability, first **Cp**

Cp = TI/6*SD = (USL-LSL)/(UCL-LCL)
Cp = (10.2-9.8)/(10.18-9.94) = 0.4/0.24 = 1.67 **Cp = 1.67**
(1.68 with excel exact calculation) (for Cp or Cpk you keep x,xx)
or TI/(6*SD) = 0.4/(6*0.0398) = 1.67

Then we mays also calculate **Cpk**

Cpk is the lowest value of Cpk_1 and Cpk_2

Cpk_1=(USL-Mean)/(UCL-Mean) = (10.2-10.0558)/(10.1752-10.0558)=
0.1442/0.1194 = 1.21
Cpk_2=(Mean-LSL)/(Mean-LCL) = (10.0558-9.8)/(10.0558-9.9364)= 2.14
Cpk is the lowest value, MIN(Cpk_1;Cpk_2) => **Cpk = 1.21**

Cp is quite correct but ideal Cp for si-sigma should be 2 or more
Cpk should be 1.67 or more

Repeat same calculation for Bearing and Game

Bearing Cp=1.45 Cpk=1.43 (you can remark result is centered)
Game Cp=1.15 Cpk=0.82 The final result is really bad

See Excel solution for detailed results

FURTHER INFORMATION ABOUT INDIVIDUAL EVALUATION QUIZ

The quiz will roughly (not strictly) be built according to following principles

- Around 20 questions of equivalent value. 1 point each. You may have some questions with higher value (2 points) for questions we consider as more difficult

- Most questions are multiple choice questions

- For those questions we ask you to choose 1 from a list (3 to 5 proposal)

- For some questions we ask you to choose 2 or 3 from a list (5 proposal)

- The topics are listed in the document "BBA Operational Excellence - Summary of Key points"

- A few questions (2 to 4) are about calculation. You should be able to treat these question if you understood the example listed before in the document.

- In the quiz questions are more basic than examples treated during the course (you are provided with only useful data) During the course we work often on calculations quite close to the real situations inside a business (with excess data, multiple questions, …)

- You are allowed to use all data gathered during the course (slides, your written notes, downloaded documents, …

We wish you to succeed the quiz !