UNIVERSITÀ DEGLI STUDI DI TRIESTE

Prof. Ing. Raffaele Campanella

E-mail: raffaele.campanella@yahoo.it

335 211609

INDUSTRIAL PLANTS II

Chapter one ï part 8:

Lean manufacturing

SEVEN TOOLS OF QUALITY

DOUBLE DEGREE MASTER IN

ñPRODUCTION ENGINEERING AND MANAGEMENTò

CAMPUS OF PORDENONE

UNIVERSITY OF TRIESTE

						DATA COLLECTION SHEETS	
						STRATIFICATION	
						CORRELATION	
					7 TOOLS	PARETO'S DIAGRAM	
						HISTOGRAMS	
						CONTROL CHARTS	
						ISHIKAWA DIAGRAM	
					ONE POINT LESSON		
					A3	5 WHYS	
TECHNIQUES AND TOOLS					KEY PERFORMANCE INDICATORS		
					5 S		
				YAMAZUMI	ANDON		FLASH MEETINGS
				TAKT TIME	VISUAL MANAGEMENT		GROUP WORK
			ERGONOMY	KANBAN	STANDARDIZATION		EMPOWERMENT
			TPM	KAIKAKU	PDCA		INVOLVEMENT
			SMED	JIT	POKAYOKE		AGREEMENT
		SPAGHETTI CHART	OEE	HEIJUNKA	KAIZEN		INFORMATION
	WASTES	LABOUR TIMES STUDY	ONE PIECE FLOW	FROM PUSH TO PULL	SIX SIGMA		COMMUNICATION
	HOSHIN KANRI	CURRENT VMS	FUTURE VSM	PULL	JIDOKA		MOTIVATION RESEARCH
PRINCIPLES	DEFINE THE VALUE	IDENTIFY THE VALUE FLOW	SET UP FLOW ACTIVITIES	MANUFACTURE PULLING THE PRODUCTION	RESEARCH PERFECTION		ATTENTION TO PEOPLE
FOCUS	CUSTOMER				QUALITY		EMPLOYEES

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PROBLEM SOLVING TECHNIQUES

THE SEVEN TOOLS

- DATA COLLECTION
- DATA STRATIFICATION
- HISTOGRAMS
- PARETO DIAGRAM
- CAUSE-EFFECT DIAGRAM (Ishikawa)
- CONTROL CHARTS
- CORRELATION DIAGRAMS

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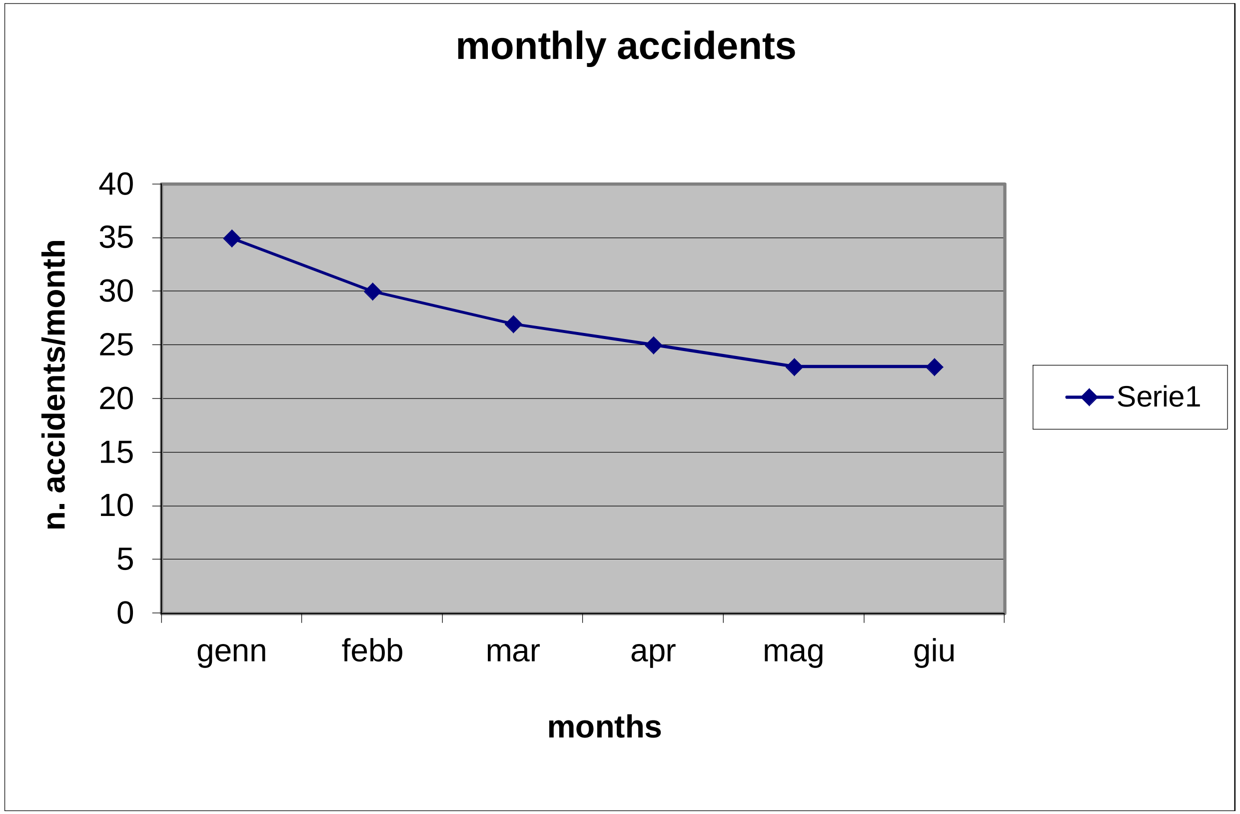
DATA COLLECTION

DATA COLLECTION SHEET

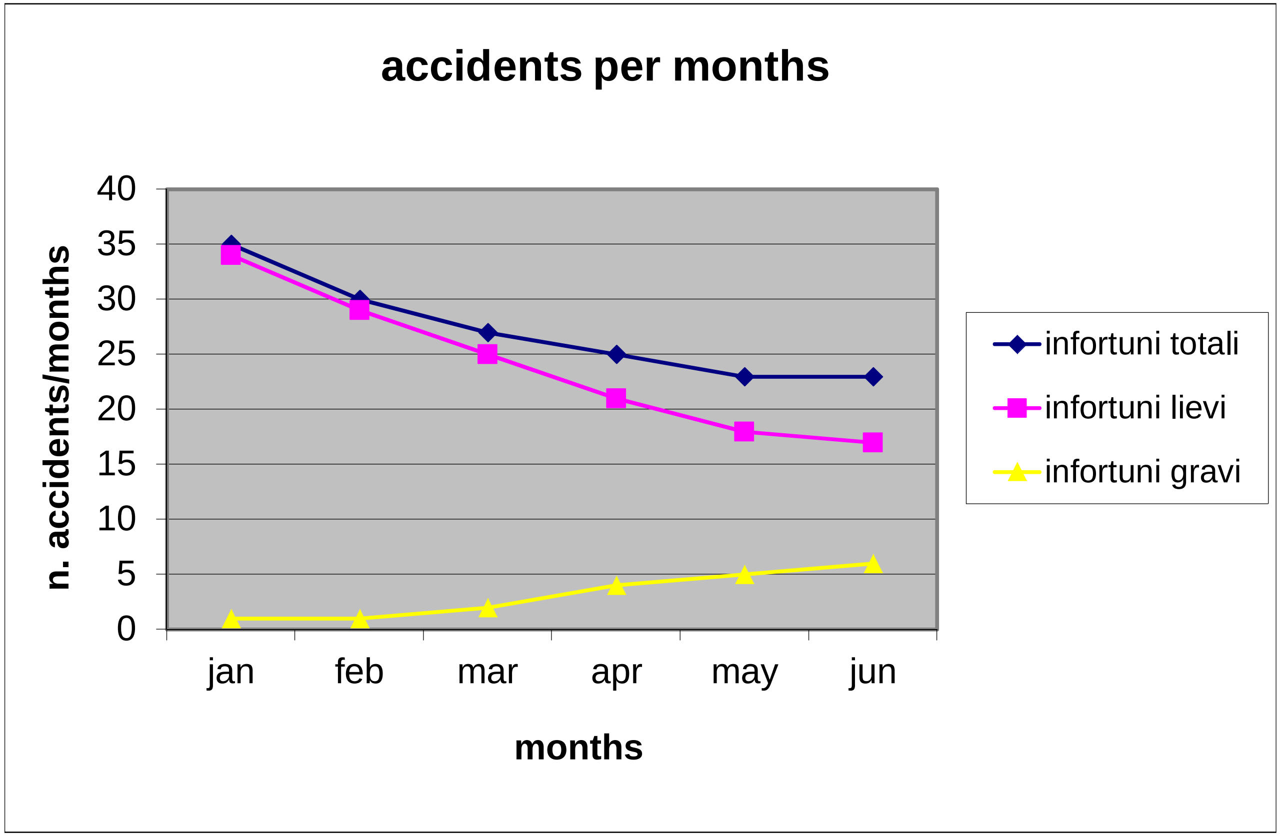
COMPANYé é é é é é ..			
PRODUCTS:é é é é é é		AREA:é é é é é é é é	
PRODUCTION PHASE:é		WORKSHOP:é é é é é é é é	
N. prod.INSPECTIONé é	3211	OPERATOR:é é é é é é é	
NOTEé é é é é é é é		BATCHé é é é é é é é é é é .	40277

TYPE	**DEFECTS FOUND**			total
Scratches	IIII/	IIII/	III	13
Bump	IIII/	IIII/		10
Deformation	IIII/	IIII/	I	11
Breaks	IIII/	II		7
Other	III			3
			Total defects	44
			percentage defects	1,40%

DATA STRATIFICATION



DATA STRATIFICATION



HISTOGRAMS

9,9	9,9	9,7	10,1	9,8	10,3	10
10,1	10,1	10,1	9,6	9,6	9,6	10,1
9,9	9,8	9,9	10	10,2	10,1	9,9
9,9	9,8	9,8	9,8	9,8	9,9	9,5
9,9	9,8	9,8	9,8	9,9	9,9	9,9
9,8	9,6	9,6	9,9	9,7	9,7	9,4
9,8	9,7	9,7	10	10	10	
9,9	9,9	9,9	9,8	9,7	9,7	
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9,9	10,2	10,1	10,1	9,7	9,5	
9,9	9,9	9,9	10	9,6	9,6	
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9,8	9,9	9,9	9,9	9,8	9,9	
9,7	9,5	9,5	9,6	9,8	9,9	
9,7	10,1	10,3	10,2	9,8	9,9	
9,6	9,7	9,5	9,5	9,9	9,9	
9,6	9,7	9,6	9,6	10,2	10,1	
9,5	9,6	9,6	9,3	9,5	9,4	
9,4	9,4	10	10	9,5	9,4	
9,4	9,3	9,3	9,4	9,5	9,4	
9,3	9,4	10	10	9,3	9,3	

HISTOGRAMS

a) **First Step**: Calculation of the number of collected data (in our example n = 150);

b) **Second Step**: Determination of the range of considered values , got as the difference between the maximum and minimum value (in our example R = 10.3 - 9.3 = 1;

c) **Third Step**: Division of the interval into a certain number of classes (K), using a value close to what results from K = $\sqrt{n}$. From the graph below we see that we have chosen K = 10;

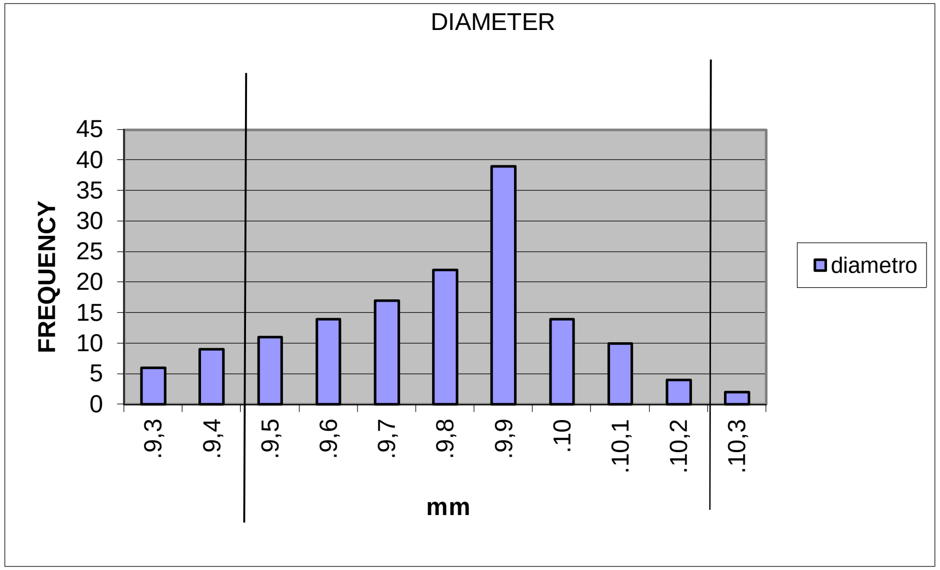
d) **Fourth step**: Determination of the Class amplitude (H): **H = R / K = 0.1**

e) **Fifth step**: Determination of the classes limits, that are the extreme points; In our case: 9.30 + 0.10 = 9.40 This figure will correspond to the lower limit of the upper class.

f) **Sixth step:** Construction of a frequency table, based on the calculations just made:

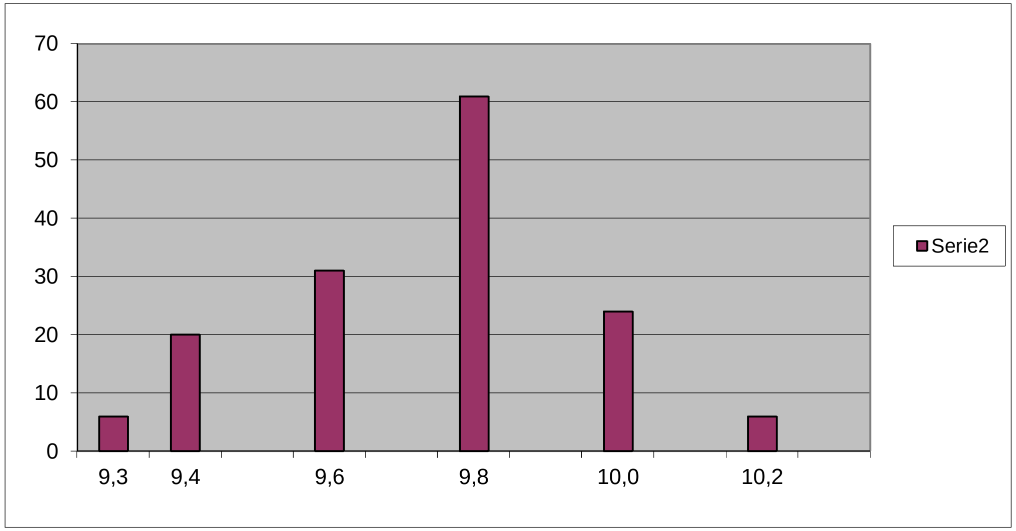
HISTOGRAMS

9,3	6
9,4	9
9,5	11
9,6	14
9,7	17
9,8	22
9,9	39
10,0	14
10,1	10
10,2	4
10,3	2



HISTOGRAMS

9,3	6
9,4	20
9,6	31
9,8	61
10,0	24
10,2	6



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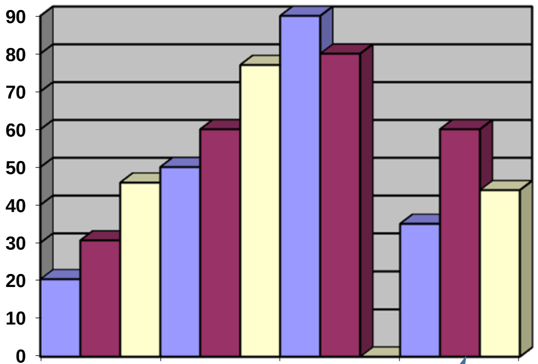
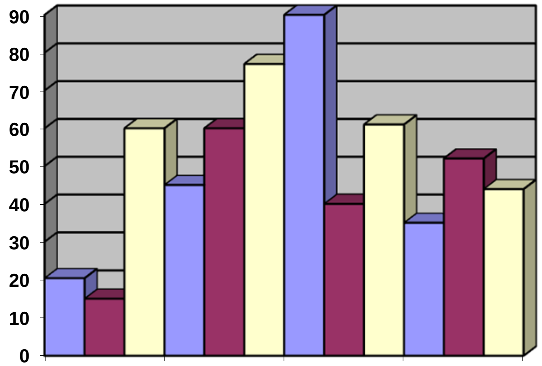
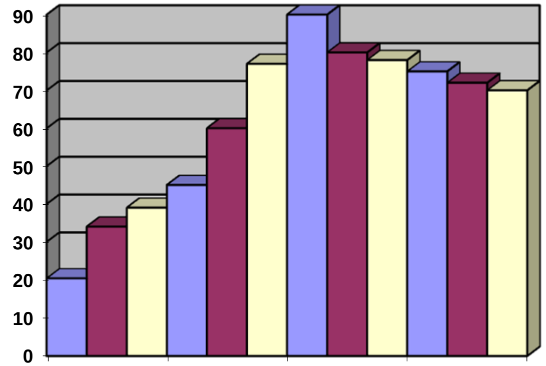
HISTOGRAMS



if there is an isolated part, the related data must be analyzed using the data layering technique

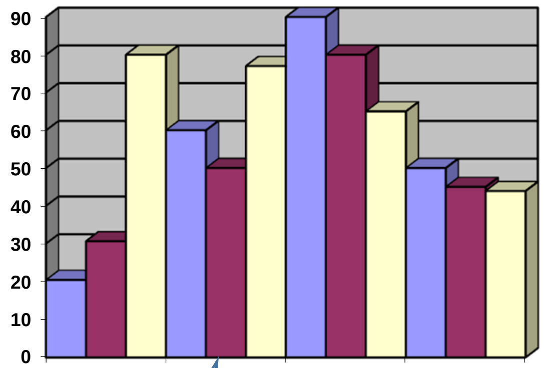


if the histogram is "comb-toothed" it is likely that there are too many classes with respect to the number of data, or an improper rounding of the measures

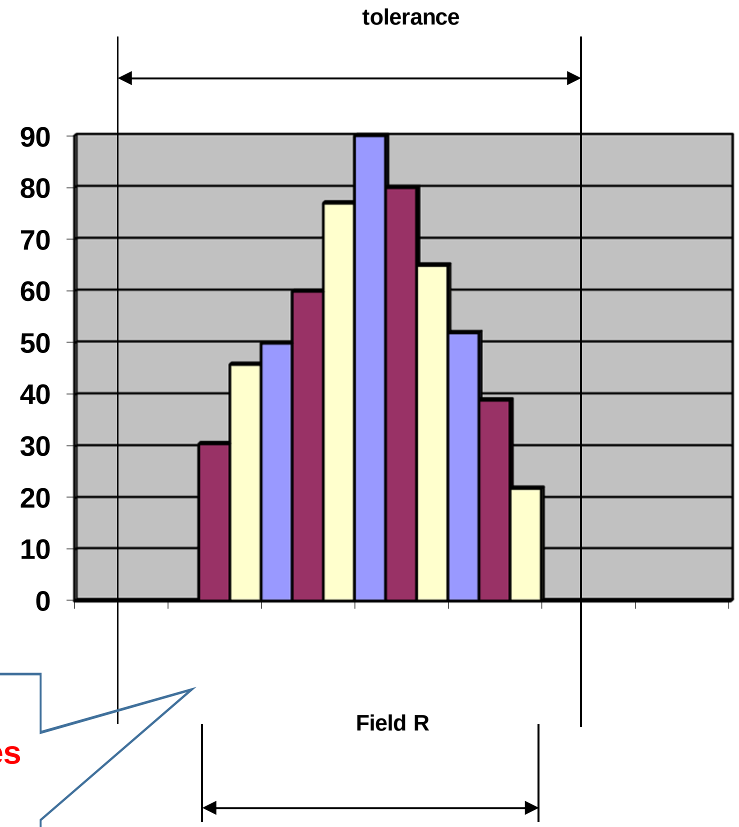


if the histogram is asymmetrical it is likely that there are sampling or measurement errors or overlapping of non-homogeneous data

HISTOGRAMS



if the histogram has two peaks, there is probably a mixing of the data deriving from two distinct manufacturing processes. In this case it is better to make two different histograms



Field R of the detected values is contained within the tolerance. The risk of rejection for small variations is minimal.

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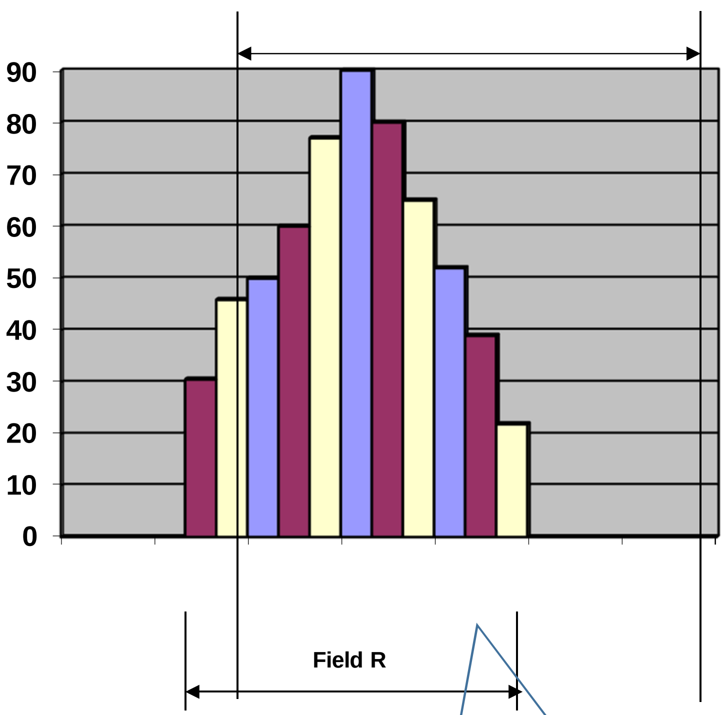
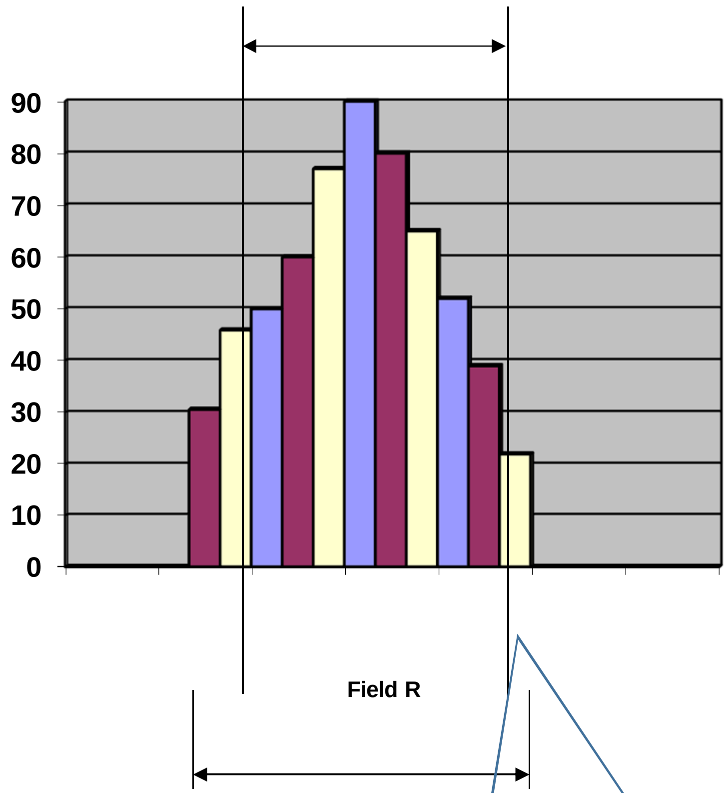
HISTOGRAMS



Field R coincides in whole or in part with the tolerance. The risk of having non-compliant pieces due to a slight variation of the process is sensitive.



Field R is completely or partially outside the tolerance limits. It is clear that action must be taken on the process to bring it back within the tolerance limits

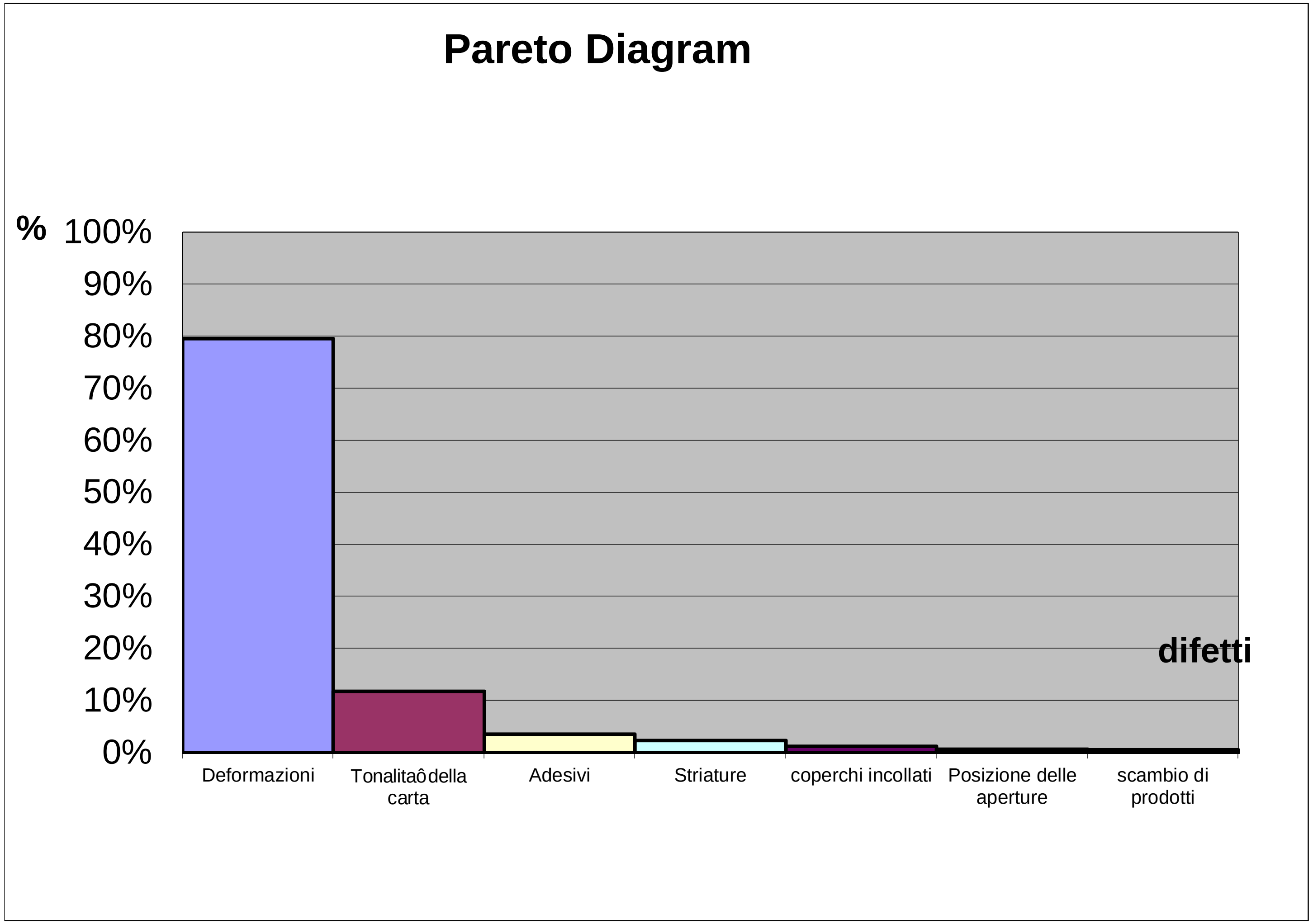
PARETO DIAGRAM

Defect	frequency	Euro	Tot. Euro
Strips	4	25, 85, 46, 20	176
Paper colour tone	2	371, 500	871
Adhesives	11	6, 23, 7, 41, 16,	
		90, 16, 4, 5, 10, 51	269
Deformations	11	51, 2011, 201, 70,	
		523, 460, 411, 921,	
		300, 718. 199	5865
Glued caps	3	31, 9, 54	94
Opening position	1	55	55
Products exchange	1	40	40

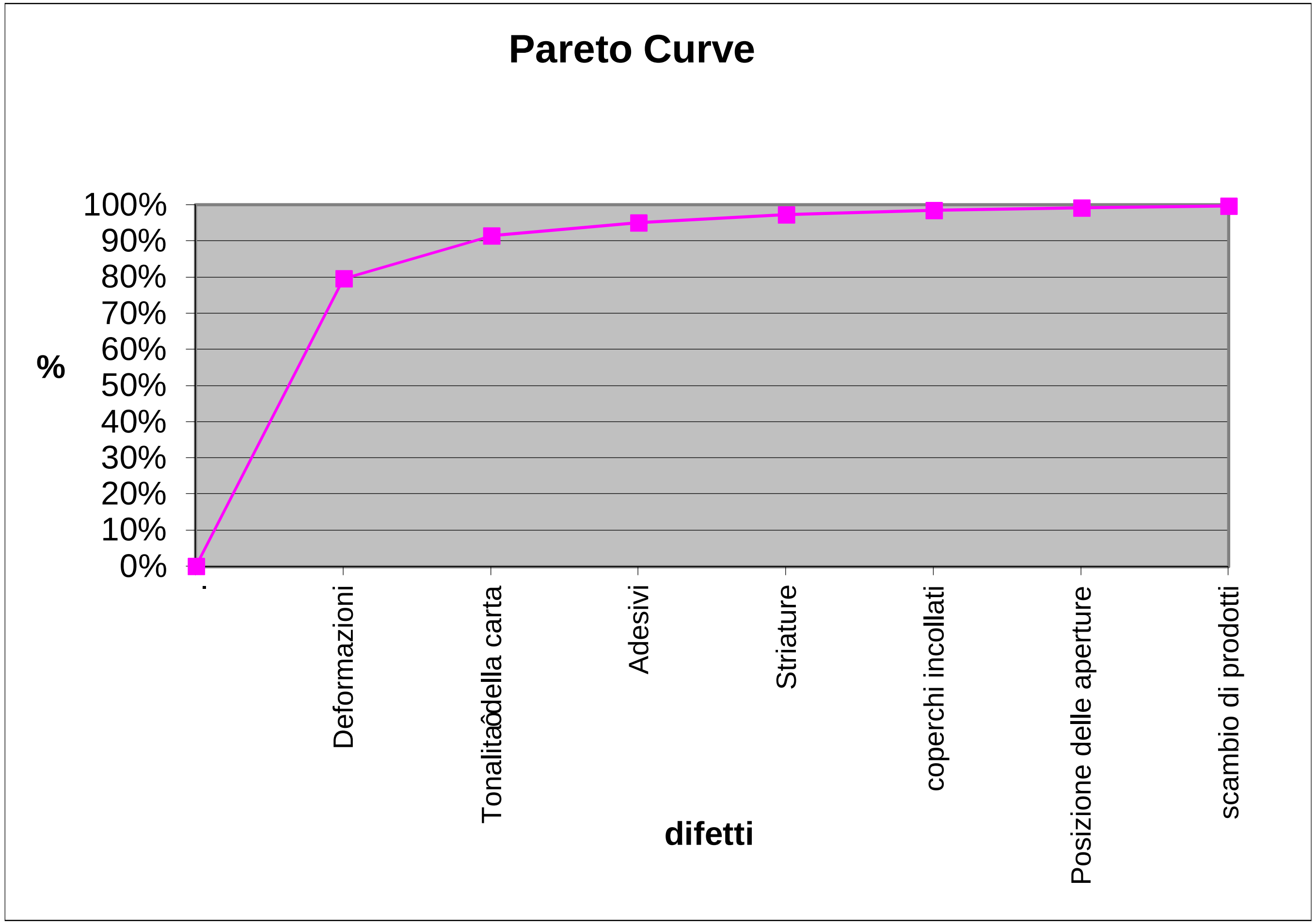
PARETO DIAGRAM

Difect		frequency			Tot. Euro		
Deformation		11	33,30%		5865		79,60%
Paper colour tone		2	6,06%		871		11,80%
Adhesives		11	33,30%		269		3,60%
Strips		4	12,10%		176		2,30%
Glued caps		3	9,09%		94		1,20%
Openng position		1	3,03%		55		0,70%
Exchange of products		1	3,03%		40		0,50%
Total		33			7370		

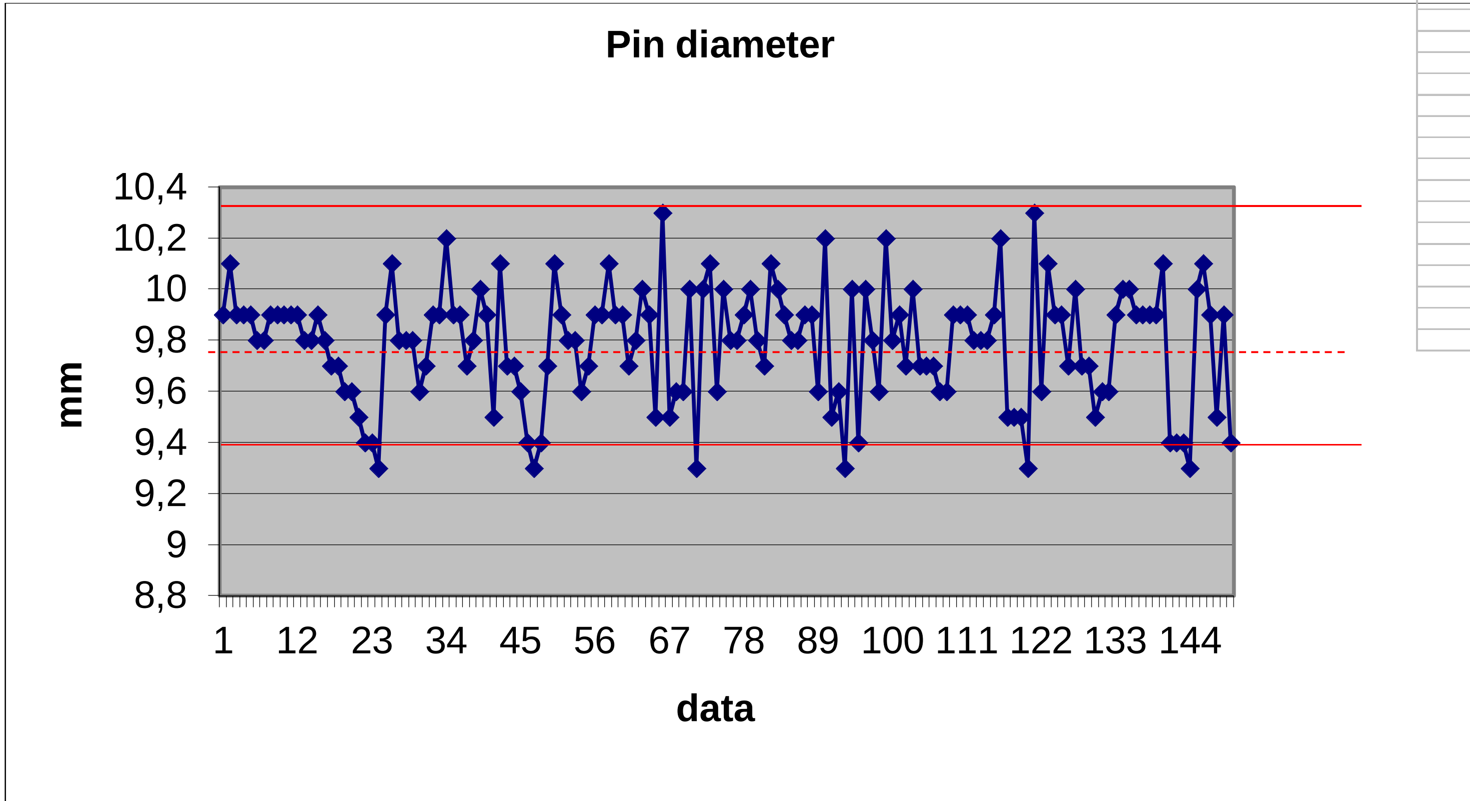
PARETO DIAGRAM



PARETO CURVE



CONTROL CHARTS



9,9	9,9	9,7	10,1	9,8	10,3	10
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9,9	9,8	9,8	9,8	9,8	9,9	9,5
9,9	9,8	9,8	9,8	9,9	9,9	9,9
9,8	9,6	9,6	9,9	9,7	9,7	9,4
9,8	9,7	9,7	10	10	10	
9,9	9,9	9,9	9,8	9,7	9,7	
9,9	9,9	9,9	9,7	9,7	9,7	
9,9	10,2	10,1	10,1	9,7	9,5	
9,9	9,9	9,9	10	9,6	9,6	
9,9	9,9	9,9	9,9	9,6	9,6	
9,8	9,7	9,7	9,8	9,9	9,9	
9,8	9,8	9,8	9,8	9,9	10	
9,9	10	10	9,9	9,9	10	
9,8	9,9	9,9	9,9	9,8	9,9	
9,7	9,5	9,5	9,6	9,8	9,9	
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9,6	9,7	9,5	9,5	9,9	9,9	
9,6	9,7	9,6	9,6	10,2	10,1	
9,5	9,6	9,6	9,3	9,5	9,4	
9,4	9,4	10	10	9,5	9,4	
9,4	9,3	9,3	9,4	9,5	9,4	
9,3	9,4	10	10	9,3	9,3	

HOW CAN WE SAY THAT OUR PROCESS IS IN CONTROL?

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CONTROL CHARTS

Control charts are used to routinely monitor quality.

Depending on the number of process characteristics to be monitored, there are two basic types of control charts.

UNIVARIATE CONTROL CHART

a graphical display (chart) of one quality characteristic.

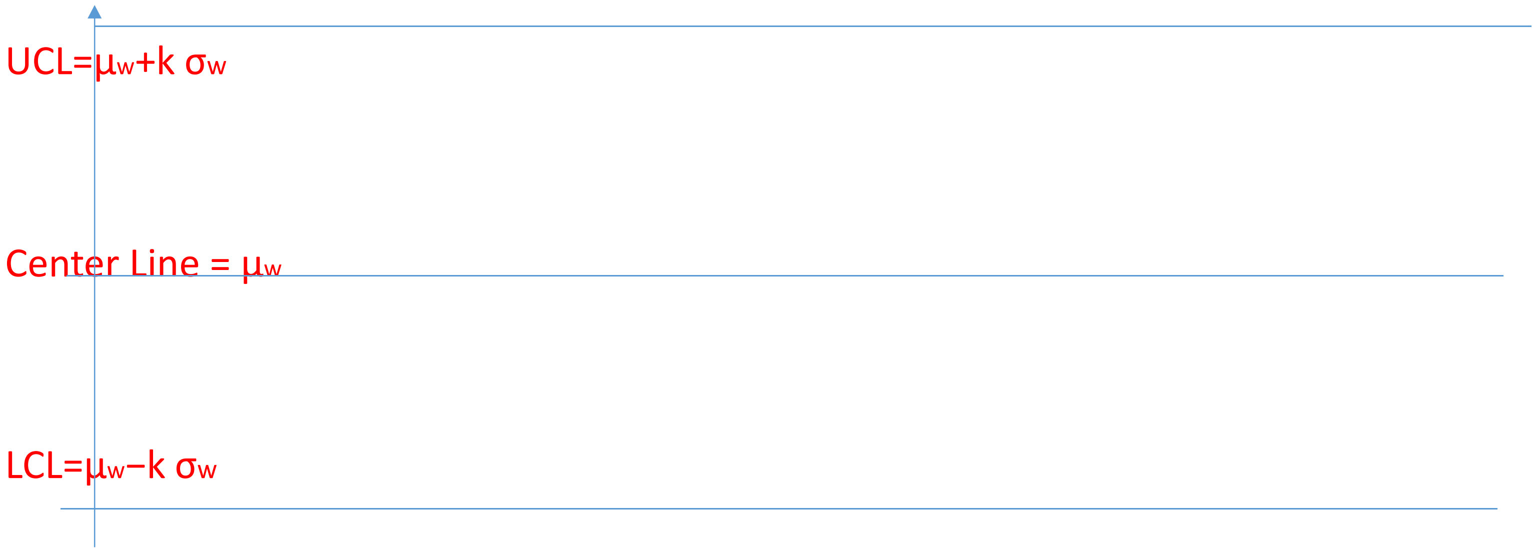
MULTIVARIATE CONTROL CHART

a graphical display ofa statistic that represents more than one quality characteristic.

CONTROL CHARTS

During the 1920's, Dr. Walter A. Shewhart proposed a general model for control charts as follows:

Shewhart Control Charts for variables Let w be a sample statistic that measures some continuously varying quality characteristic of interest (e.g., thickness), and suppose that the mean of w is μ_w, with a standard deviation of σ_w



. Then the center line, the UCL, and the LCL are where k is the distance of the control limits from the center line, expressed in terms of standard deviation units. When k is set to 3, we speak of 3-sigma control charts.
Historically, k=3 has become an accepted standard in industry.

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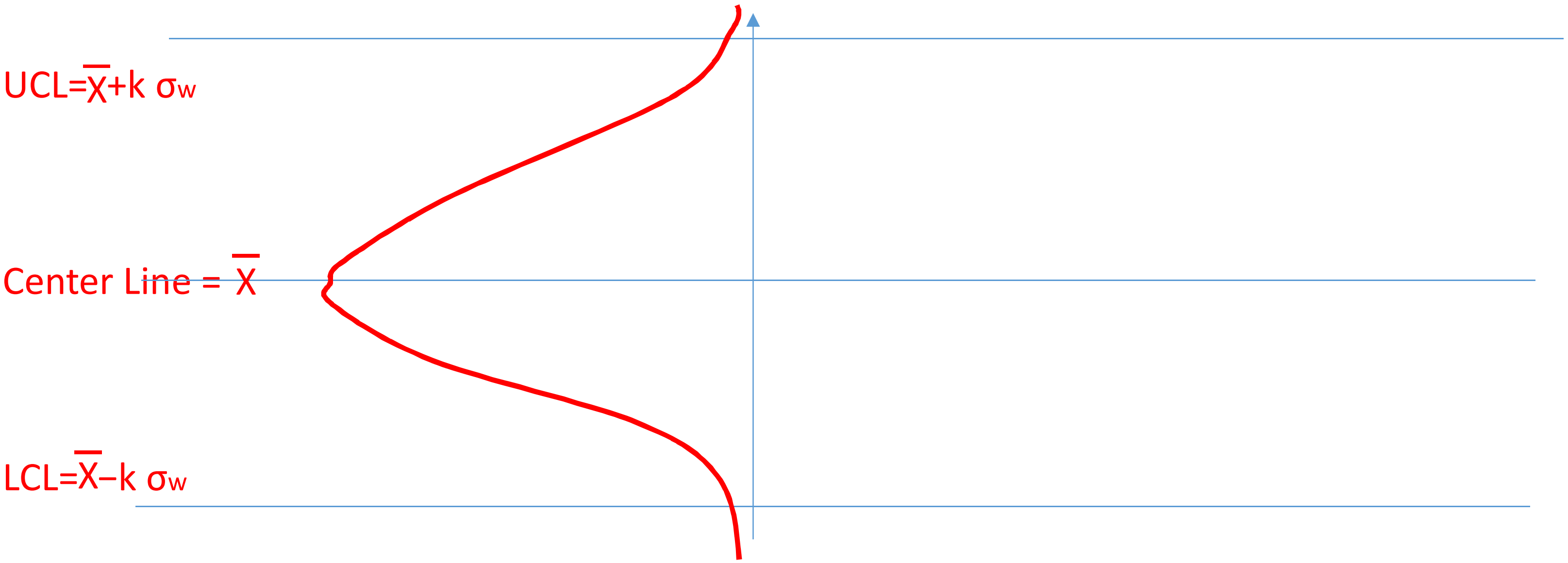
CONTROL CHARTS



$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \bar{x})^2}{N-1}}$$

The centerline is the **process mean**, which in general is unknown. We replace it with a target or the average of all the data. The quantity that we plot is the sample average, $\bar{X}$. The chart is called the $\bar{X}$ chart.

We also have to deal with the fact that σ is, in general, unknown. Here we replace σ_w with a given standard value, or we estimate it by a function of the average standard deviation. This is obtained by averaging the individual standard deviations that we calculated from each of m present samples, each of size n.

It is equally important to examine the standard deviations in ascertaining whether the process is in control.

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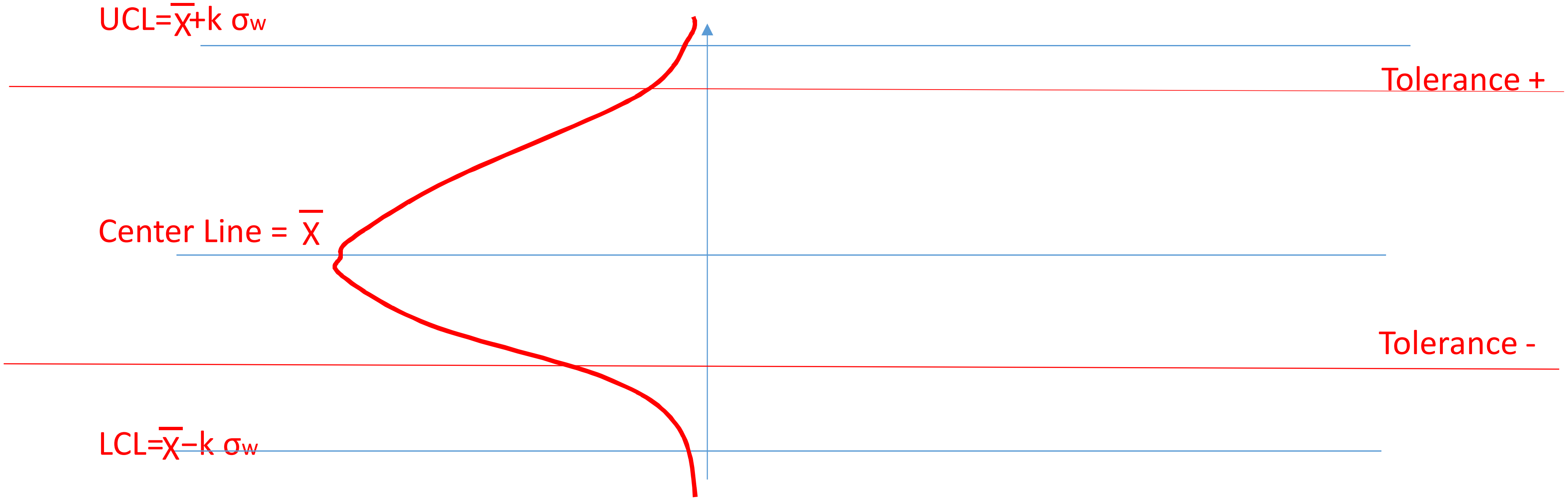
CONTROL CHARTS



$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(x_i-\bar{x})^2}{N-1}}$$

The control limits as pictured in the graph might be 0.001 *probability* limits. If so, and if chance causes alone were present, the probability of a point falling above the upper limit would be one out of a thousand, and similarly, a point falling below the lower limit would be one out of a thousand. We would be searching for an assignable cause if a point would fall outside these limits. Where we put these limits will determine the risk of undertaking such a search when in reality there is no assignable cause for variation.

CONTROL CHARTS

Systematic causes:

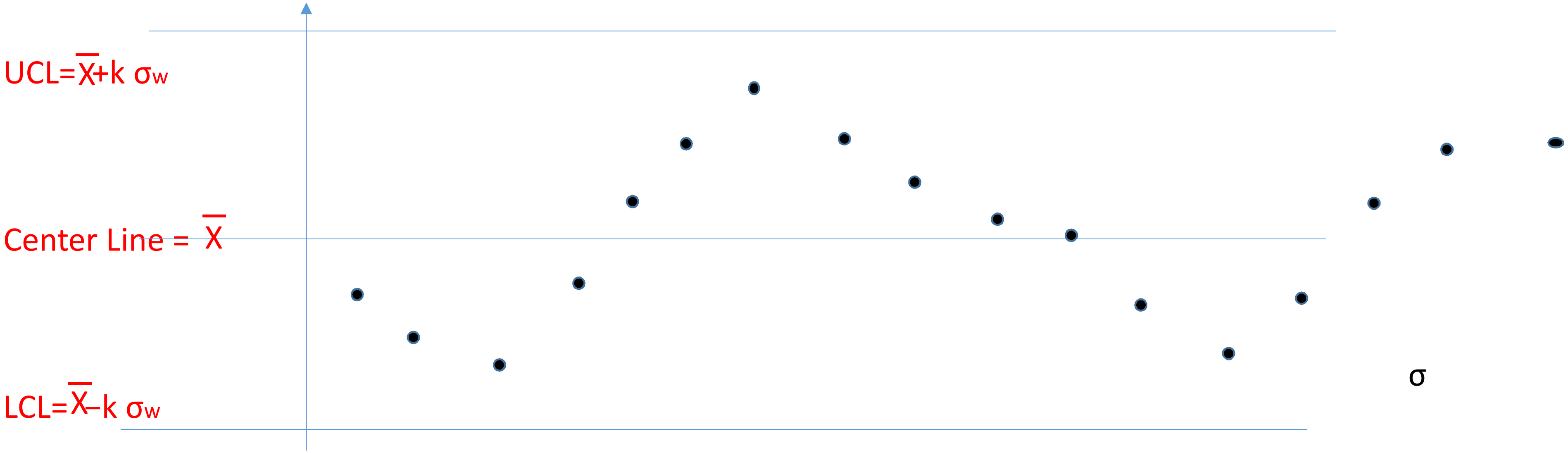
If particular trends of the process are evident, this is the signal that they are due to specific causes.

The assessment is based on the fact that the probability of occurrence of these trends is too high to consider them random.

It then means that external elements are active to disturb and distort the production process.

CONTROL CHARTS

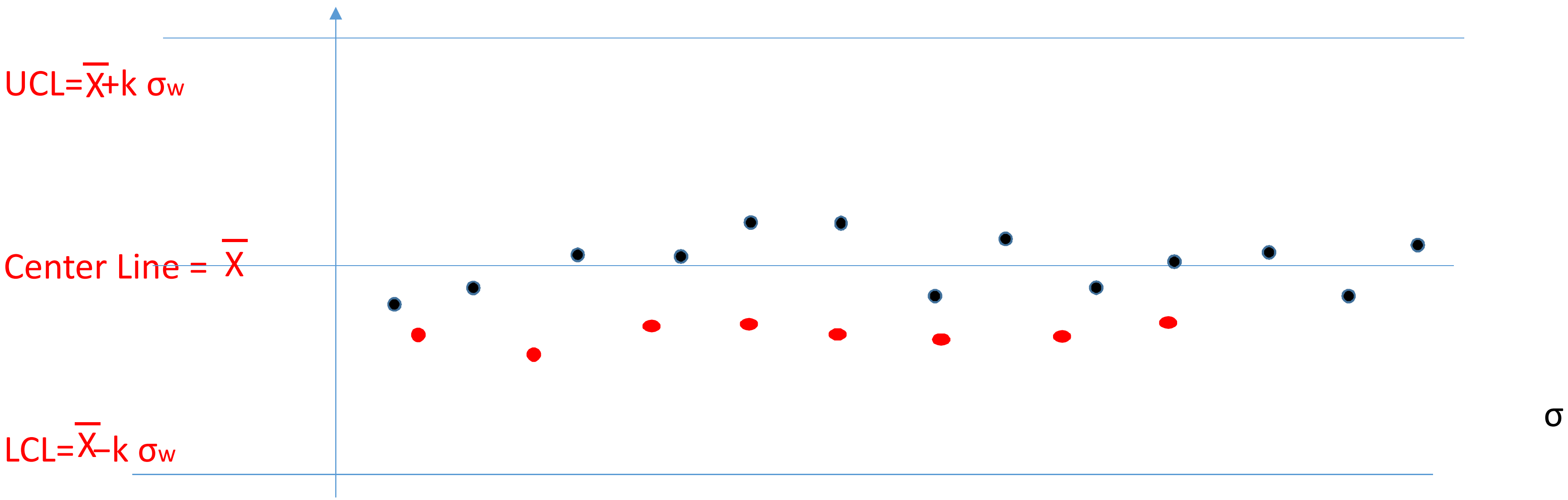
TRENDS



The Cycles show trends of the points on the chart which are repeated with a certain frequency. Their distribution can be compared to the trend of the sine or cosine function. The causes that lead to this can be traced back to the operation of the machines, to the shifts, to systematic changes in production.

CONTROL CHARTS

TRENDS



Stratification occurs when the points tend to concentrate around the central line of the paper (at the average), thus eliminating the variability of the process. This mainly happens due to errors in the creation of the control charts.

The Series is when the points are arranged only on one side of the central line, usually denoting an error in the tooling of the machine.

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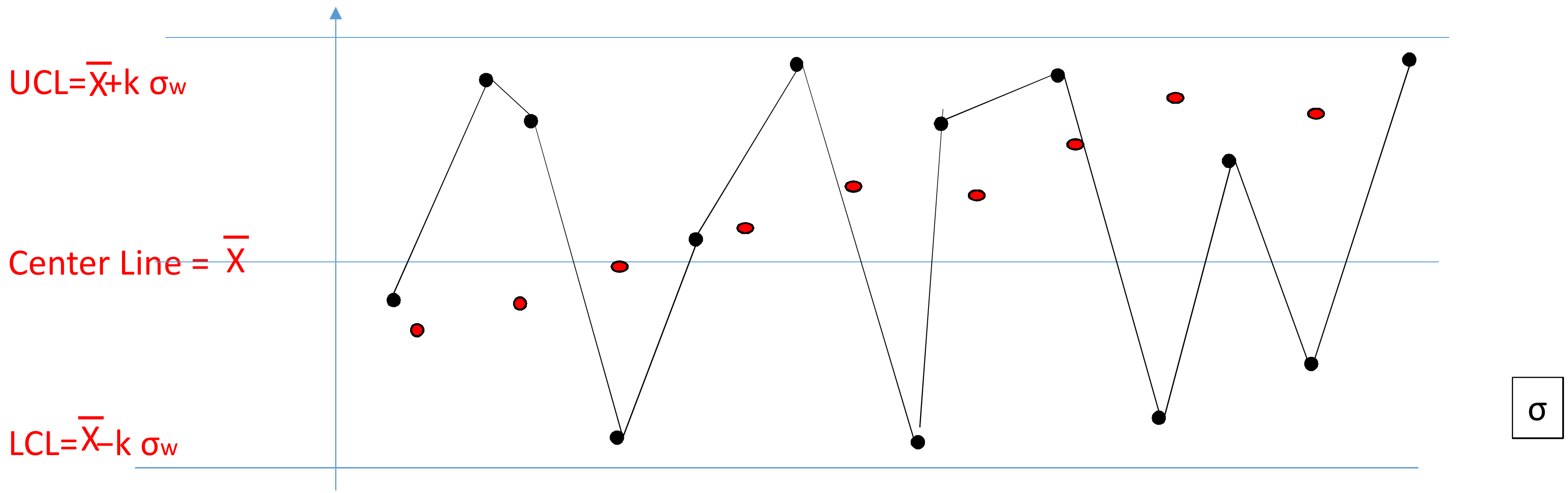
CONTROL CHARTS

TRENDS



A **Mixture** instead represents the opposite case to the previous one, that is when the points oscillate strongly between the upper and lower limits. This happens if the type and quality of raw materials vary very clearly, or if operators make excessive adjustments to the machinery.

Finally, a **Trend** occurs when the observations systematically take a certain direction.

TEST DELLE SERIE

Per ultimo, sempre legato agli andamenti delle osservazioni, esiste il *Test delle serie o sequenze*. Esso avviene in questo modo:

- Se su 11 punti consecutivi, 10 si trovano tutti dalla stessa parte della linea centrale, allora il processo è fuori controllo;
- Se su 14 punti consecutivi, 12 si trovano tutti dalla stessa parte della linea centrale, allora il processo è fuori controllo;
- Se su 17 punti consecutivi, 14 si trovano tutti dalla stessa parte della linea centrale, allora il processo è fuori controllo;
- Se su 20 punti consecutivi, 16 si trovano tutti dalla stessa parte della linea centrale, allora il processo è fuori controllo.

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CONTROL CHARTS

WESTINGHOUSE COMPANY RULES

General rules for detecting out of control or non-random:

Any Point Above +3 Sigma

--- +3 σ LIMIT

2 Out of the Last 3 Points Above +2 Sigma

--- +2 σ LIMIT

4 Out of the Last 5 Points Above +1 Sigma

--- +1 σ LIMIT

8 Consecutive Points on This Side of Control Line

=================================== CENTER LINE

8 Consecutive Points on This Side of Control Line

--- -1 σ LIMIT

4 Out of the Last 5 Points Below - 1 Sigma

-- -2 σ LIMIT

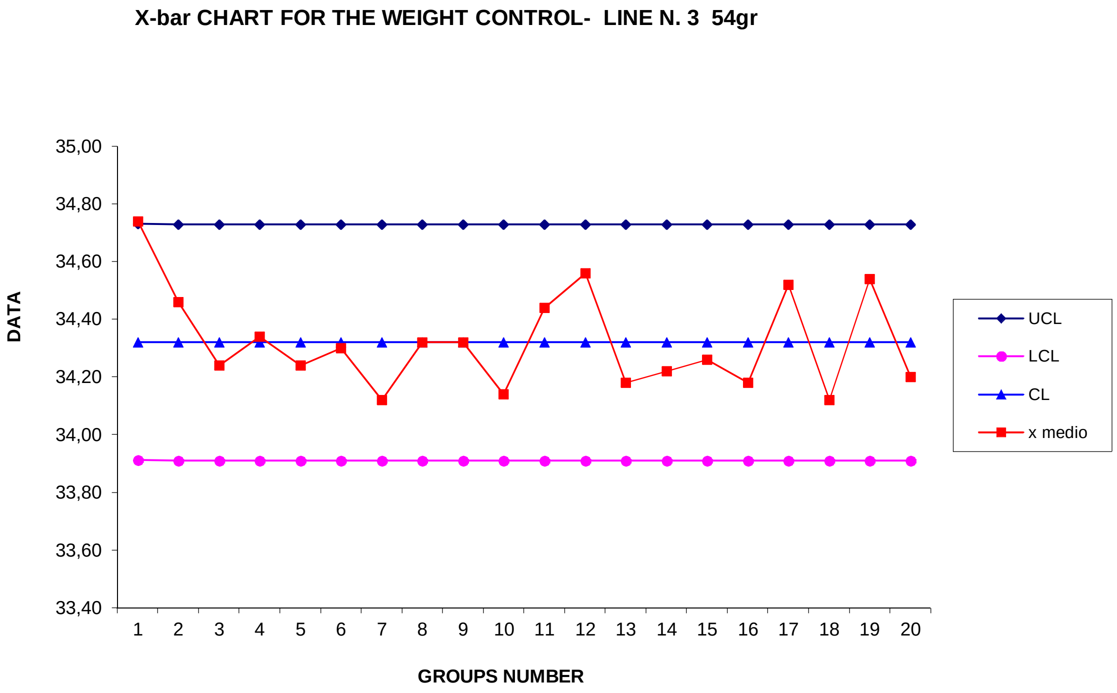
2 Out of the Last 3 Points Below -2 Sigma

--- -3 σ LIMIT

Any Point Below -3 Sigma

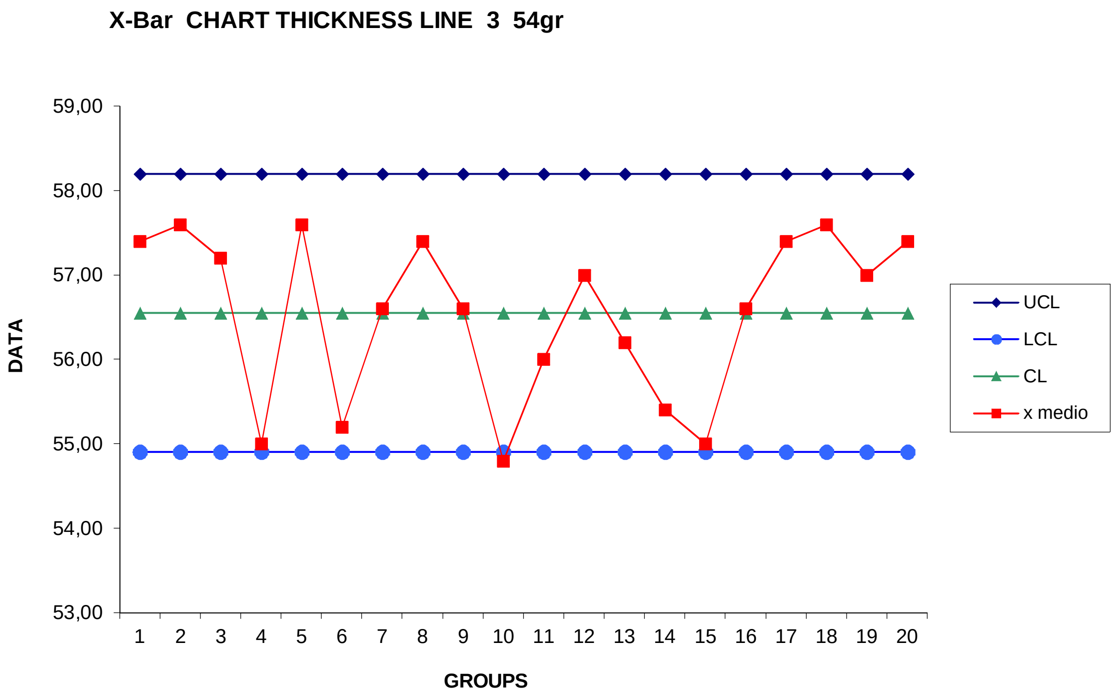
CONTROL CHARTS

Paper Mill – Duino Plant



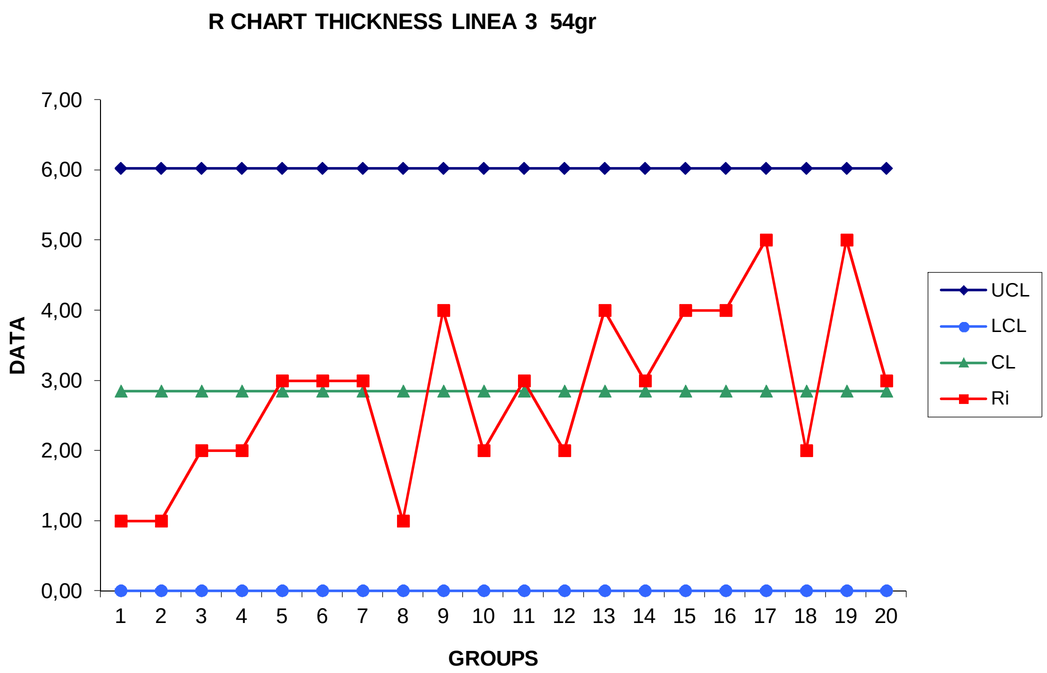
CONTROL CHARTS

Paper Mill – Duino Plant



CONTROL CHARTS

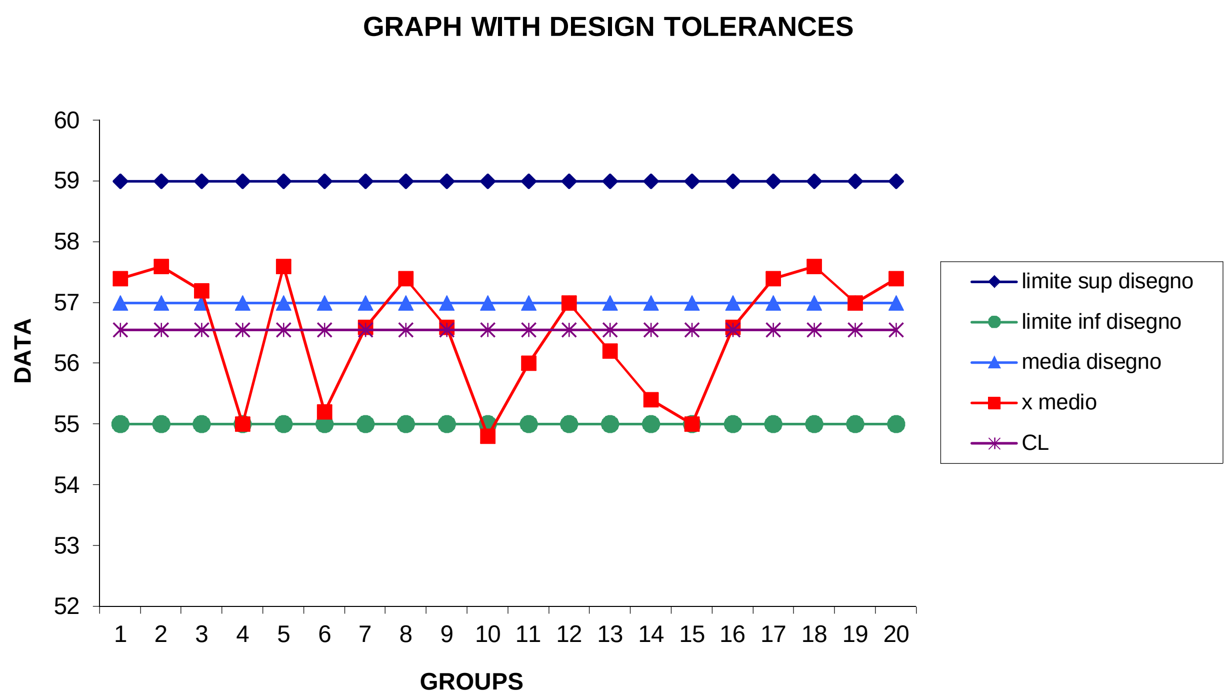
Paper Mill – Duino Plant



CONTROL CHARTS

Paper Mill – Duino Plant

DESIGN SPECS

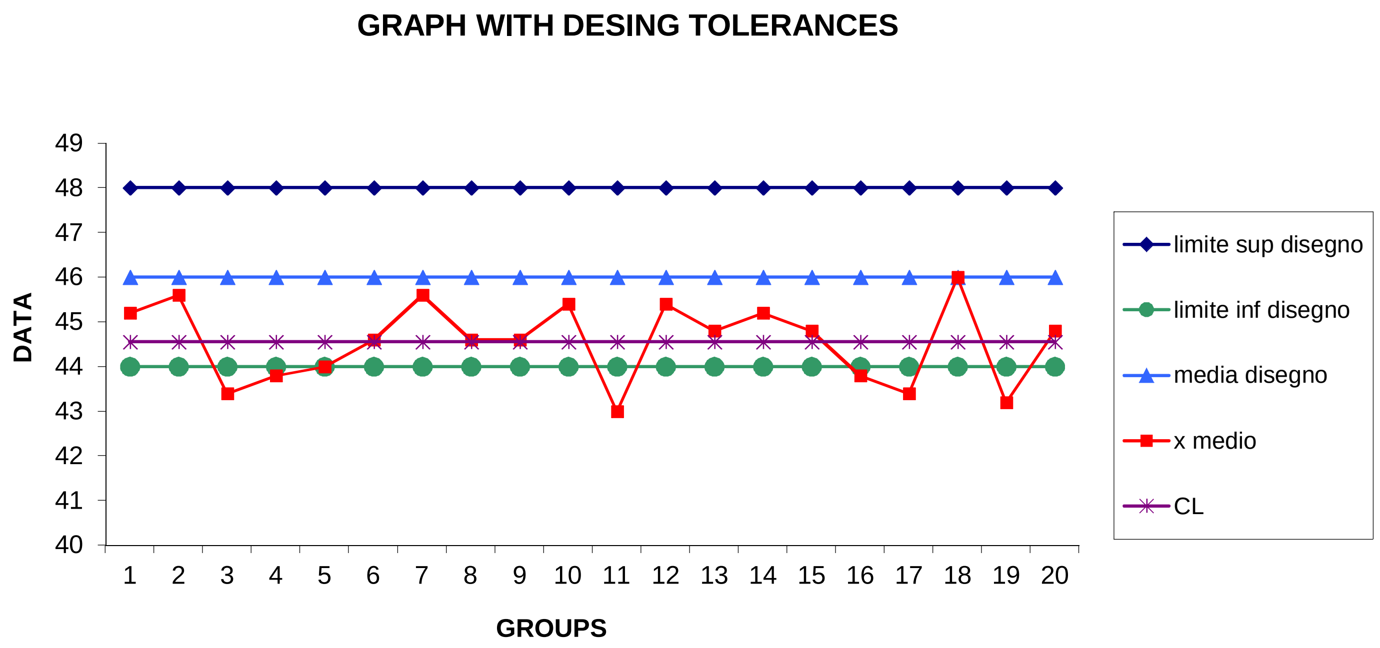


Materiale riservato
Raffaele Campanella

CONTROL CHARTS

Paper Mill – Duino Plant

DESIGN SPECS



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CORRELATION

A correlation is a statistical measure of the relationship between two variables.
The measure is best used in variables that demonstrate a linear relationship between each other.
The fit of the data can be visually represented in a scatterplot.
Using a scatterplot, we can generally assess the relationship between the variables and determine whether they are correlated or not.

CORRELATION

The correlation coefficient is a value that indicates the strength of the relationship between variables. The coefficient can take any values from -1 to 1. The interpretations of the values are:

-1: Perfect negative correlation. The variables tend to move in opposite directions (i.e., when one variable increases, the other variable decreases).

0: No correlation. The variables do not have a relationship with each other.

1: Perfect positive correlation. The variables tend to move in the same direction (i.e., when one variable increases, the other variable also increases).

CORRELATION

Correlation and Causation

Correlation must not be confused with causality. The famous expression ñcorrelation does not mean causationò is crucial to the understanding of the two statistical concepts.

If two variables are correlated, it does not imply that one variable causes the changes in another variable. Correlation only assesses relationships between variables, and there may be different factors that lead to the relationships.

Causation may be a reason for the correlation, but it is not the only possible explanation.

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CORRELATION

The correlation coefficient that indicates the strength of the relationship between two variables can be found using the following formula:

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Where:

År_{xy} ï the correlation coefficient of the linear relationship between the variables x and y

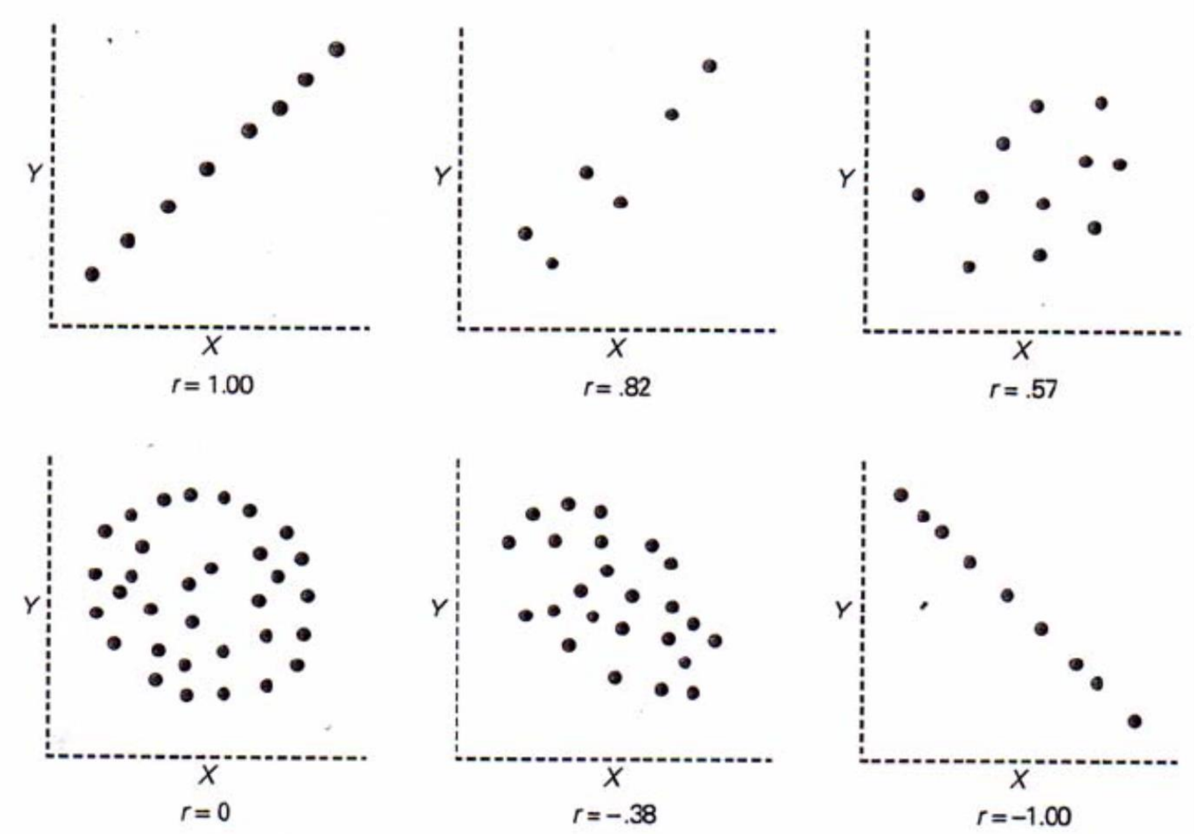
Åx_i ï the values of the x-variable in a sample

Å$\bar{x}$ ï the mean of the values of the x-variable

Åy_i ï the values of the y-variable in a sample

Åö ï the mean of the values of the y-variable

CORRELATION



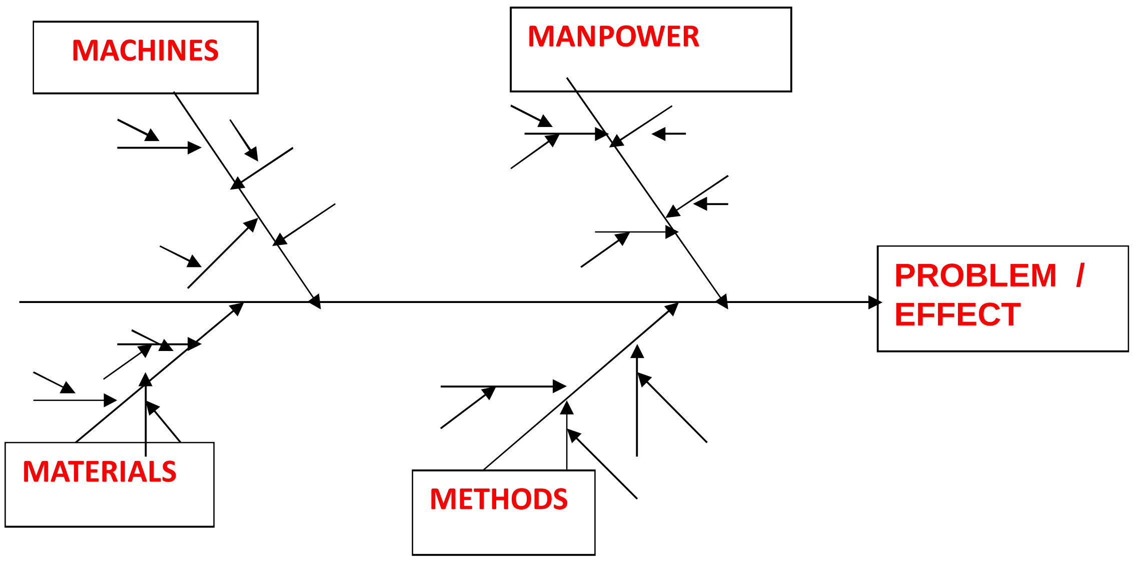
CONTROL CHARTS

FREQUENT QUESTIONS

- Are you always measuring yourself with the same tools?
- Is their accuracy always the same?
- Are there any differences between the methods used by the different operators?
- Is the process influenced by the environment (temperature, humidity ...)?
- Is the process affected by the wear of the tools? Is the training of operators homogeneous?
- Has the supplier of raw materials changed?
- Is the process affected by operator fatigue?
- Has there been a change in maintenance procedures?
- Has the machine been recently tuned? Do the samples come from different shifts / operators?
- Are operators afraid of "pointing out problems"?
- ....

UNIVERSITÀ DEGLI STUDI DI TRIESTE

CAUSE-EFFECT DIAGRAM (ISHIKAWA)



PHASE 1: IDENTIFY THE PROBLEM TO BE STUDIED

PHASE 2: LIST THE MACRO-CAUSES

PHASE 3: LIST THE MICRO-CAUSES

PHASE 4: MICRO-CAUSES ANALYSIS

PHASE 5: FIND THE PERTINENT ACTIONS

PHASE 6: ASSIGN THE RIGHT PRIORITY TO THE ACTIONS

PHASE 7: DO THE ACTIONS

PRIORITY MATRIX

ELEMENTS TO BE MATCHED	A	B	C	D	E	F	G	H	I	L	M	N	Lines column
A		+3	0	-3	0	+3	0	+3	0	+3	0	0	12
B			-3	+3	0	-3	0	-3	0	-3	+3	+3	9
C				0	+3	+3	-3	+3	-3	+3	-3	-3	12
D					0	+3	0	+3	0	+3	-3	-3	9
E						-3	+3	0	+3	0	-3	0	6
F							-3	+3	+3	0	-3	0	3
G								+3	-3	+3	-3	+3	9
H									+3	0	+3	-3	6
I										0	+3	-3	3
L											+3	-3	3
M												+3	3
N													0
Column TOTAL	0	0	3	3	0	6	6	3	6	3	15	15	
GENERAL TOTAL (lines+column)	12	9	15	12	6	9	15	9	9	6	18	15	

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4. RELATIVE IMPORTANCE OF THE NEEDS

The attribute is undesirable. Do not consider a product with this attribute:	**1**
The attribute is not important, but I would not mind if there is:	**2**
It would be nice to have this attribute even if not necessary:	**3**
The attribute is very desirable, but I would consider a product without it as well:	**4**
The attribute is critical. I would not take into account a product without this attribute	**5**

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WEIGHTED CHOICE

	5	4	3	2	1
Grace	**C**	**E**	**J**	**L**	**M**
William	**A**	**F**	**G**	**B**	**H**
Angela	**I**	**A**	**M**	**K**	**H**
Robert	**A**	**D**	**E**	**I**	**M**
Silvya	**C**	**B**	**A**	**F**	**I**
Andrew	**L**	**A**	**B**	**C**	**F**
Cecily	**A**	**C**	**F**	**K**	**J**
Mary	**D**	**G**	**C**	**A**	**B**

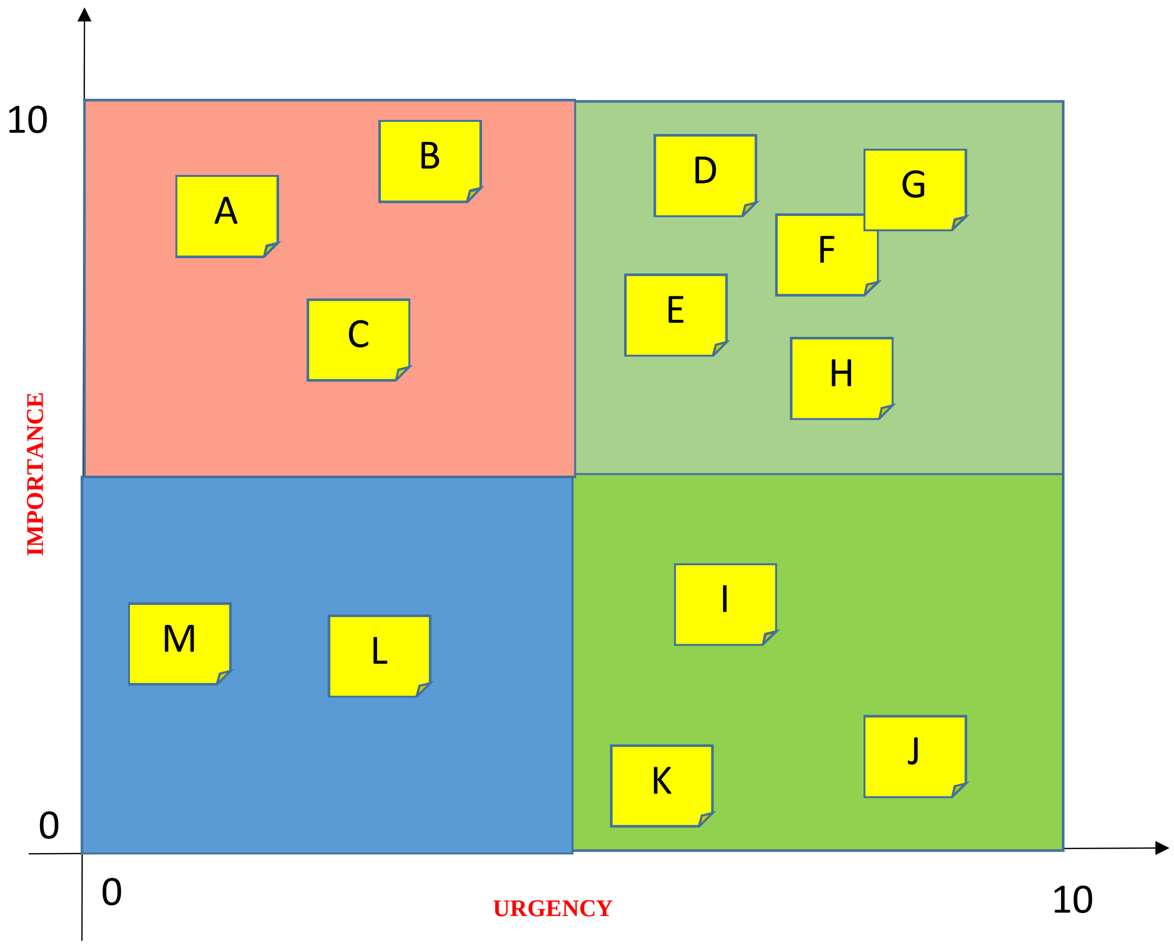
PRIORITY AMONF 13 ELEMENTS: A,B,C,Dé .M

WEIGHTED CHOICE

	Grace	William	Angela	Robert	Silvya	Andrew	Cecily	Mary	TOTAL
A	0	5	4	5	3	4	5	2	28
B	0	2	0	0	4	3	0	1	10
C	5	0	0	0	5	2	4	3	19
D	0	0	0	4	0	0	0	5	9
E	4	0	0	3	0	0	0	0	7
F	0	4	0	0	2	1	3	0	10
G	0	3	0	0	0	0	0	4	7
H	0	1	1	0	0	0	0	0	2
I	0	0	5	2	1	0	0	0	8
J	3	0	0	0	0	0	1	0	4
K	0	0	2	0	0	0	2	0	4
L	2	0	0	0	0	5	0	0	7
M	1	0	3	1	0	0	0	0	5

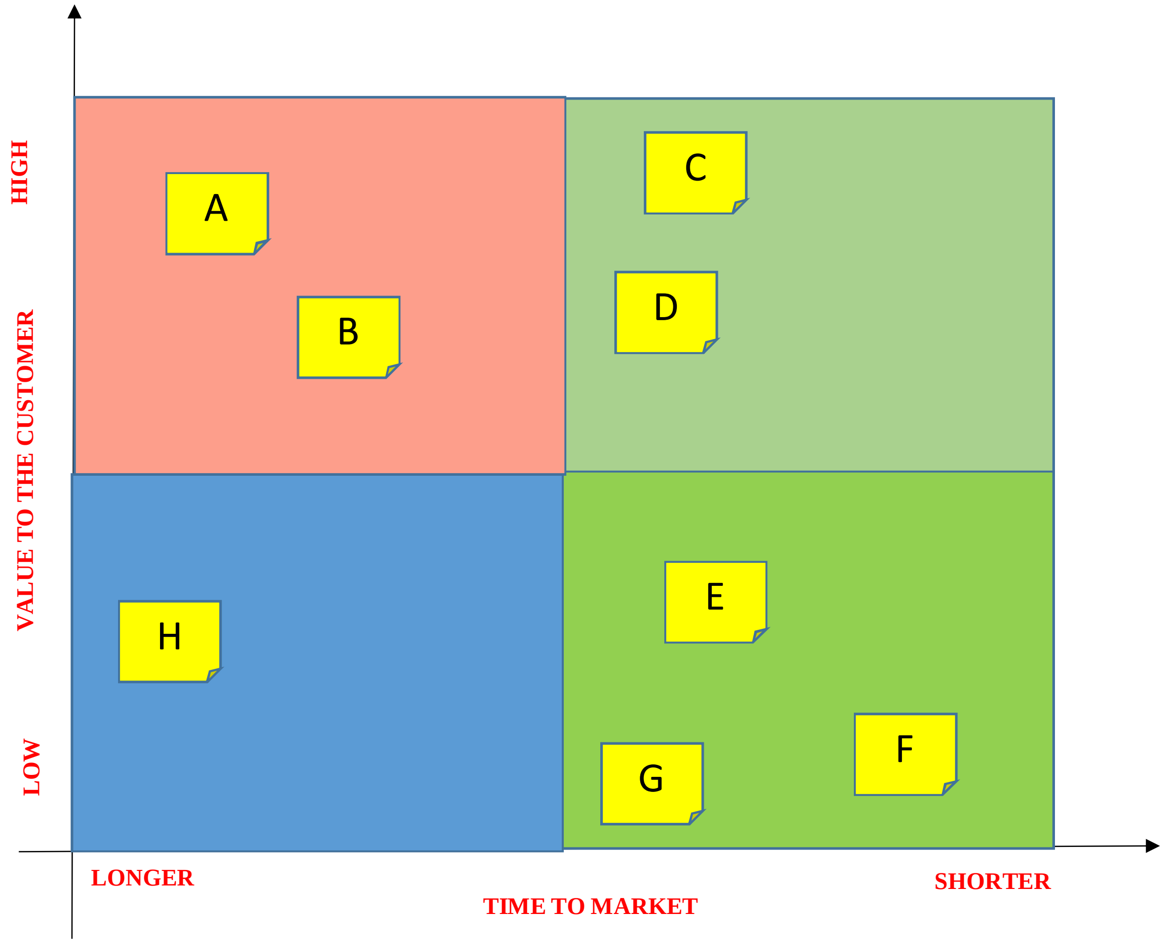
PRIORITY AMONG 13 ELEMENTS: A,B,C,Dé .M

2 VARIABLES MATRIX



Materiale riservato
Raffaele Campanella

2 VARIABLES MATRIX



2 VARIABLES MATRIX