Indira Gandhi
National Open University
School of Sciences

MSTE-001
INDUSTRIAL STATISTICS-I

Block

1

PROCESS CONTROL

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INDUSTRIAL STATISTICS-I: COURSE INTRODUCTION

In the core courses of this programme, namely, MST-001 to MST-005, you have studied the basic concepts of statistics and various applications of different statistical tools. You have also learnt about which statistical tool to apply in a given situation and how to interpret the results.

The course **Industrial Statistics-I** (MSTE-001) is the first elective course of the Industrial Statistics specialisation. The aim of this course is to enable you to apply statistical techniques and tools to data related to industries and business.

This course is divided into four blocks and each block comprises four units.

In **Block 1** entitled **Process Control**, we discuss the concepts of statistical quality control, process control and product control. We also discuss how we can control a **process** by using various control charts, such as the control charts for variables, namely, the $\bar{X}$- chart, R-chart and S-chart and control charts for attributes, namely, the p-chart, np-chart, c-chart and u-chart.

In **Block 2** entitled **Product Control**, we discuss the techniques of **product control** and describe acceptance sampling plan and rectifying sampling plan. We also describe single and double sampling plans for attributes in this block.

Block 3 entitled **Decision and Game Theory** discusses some decision making criteria generally used by decision makers to arrive at good decisions in a given situation using available data. But the selection of a decision criterion depends on the environment in which a decision is taken. We discuss four types of environments, namely, decision making under certainty, uncertainty, risk and conflict.

The aim of **Block 4** entitled **Reliability** is to familiarise you with methods of evaluating the reliability of industrial systems. All devices used by human beings have an inherent possibility of failure. As an industrial statistician, you must understand the failure behaviour of a component or a system. But a better way of studying the failure of a component is to study the **reliability** of the component. In this block, we explain what is meant by the reliability of a component and how it is connected with failure. We study some simple and complex systems having components that cannot be repaired. You will also learn how systems with less reliable components can be made more reliable at design level.

BLOCK 1: PROCESS CONTROL

The quality of a product/service is the most important consideration for all of us while using it. The meaning of the term quality has evolved over time and now it means how well a product/service satisfies customer needs or demands. In the ever-growing market competition, industries and businesses cannot hope to survive and succeed until and unless they deliver products/services of high quality. Therefore, the main purpose of the manufacturer or businessman today is to achieve quality assurance and ensure that their products/services meet the desired specifications and requirements. To do so, a system of monitoring and maintaining quality has to be put in place and this requires the use of statistical tools and methods. The method of monitoring and maintaining the quality of products and services using statistical tools is known as **Statistical Quality Control**. It was developed in 1920s by Walter Shewhart, a researcher of Bell Telephone Laboratories. W. Edwards Deming expanded Shewhart's theory and demonstrated how it can be used successfully in industry.

Statistical quality control techniques are broadly classified into two categories:

- Statistical process control or simply Process control, and
- Product control.

In this block, we discuss **process control** and in the next block we shall discuss **product control**.

This block comprises four units.

In **Unit 1**, we introduce the concept of **statistical quality control** (SQC) and describe the elements and techniques of SQC, its advantages and disadvantages. We explain the basic concepts of **process control** and **product control**. We also discuss the causes of variation in a product and finally introduce the concept of **control chart**, which is the main technique of process control.

In **Unit 2**, we present the general technique of constructing a control chart. When we deal with a variable (measurable quality characteristic), it is necessary to control the mean (average) as well as the variability of the quality characteristic. So we discuss different **control charts for variables** for controlling the mean $(\bar{X}\text{-chart})$ and variability (R-chart or S-chart) of the process.

For monitoring and controlling the quality characteristics that cannot be measured, we use **control charts for attributes**. The control charts for attributes are of two types: Control charts for defectives and control charts for defects. In **Unit 3**, we discuss the control charts for defectives and explain how to construct a control chart for fraction defective (p-chart) and control chart for number of defectives (np-chart).

Finally, in **Unit 4**, we discuss control charts for number of defects (c-chart) and control chart for number of defects per unit (u-chart). We also compare control charts for variables and attributes.

The following notations and symbols are used in this Block.

Notations and Symbols

Sec.	:	Section
Fig.	:	Figure
SQC	:	Statistical quality control
SPC	:	Statistical process control
CL	:	Centre line
UCL	:	Upper control limit
LCL	:	Lower control limit
USL & LSL	:	Upper and Lower specification limits
UNTL & LNTL	:	Upper and Lower natural tolerance limits
PC	:	Process capability
X	:	Random variable
E(X) and Var(X)	:	Mean and variance of a random variable X, respectively
SE(X)	:	Standard error of a random variable X
E(X) ± 3SE(X)	:	Control limits of a random variable X
$X_1, X_2, \ldots, X_n$	:	Measurements on a random sample of size n
n		Sample size
$\bar{n}$	:	Average sample size
k		Number of samples
$\bar{X}$	:	Sample Mean
$\bar{\bar{X}}$	:	Grand mean
R	:	Sample range
$\bar{R}$	:	Mean of sample ranges
S	:	Sample standard deviation
$\bar{S}$	:	Mean of sample standard deviations
P	:	Process fraction (proportion) defective
p	:	Sample fraction (proportion) defective
$\bar{p}$	:	Average fraction (proportion) defective
c	:	Number of defects
$\bar{c}$	:	Average number of defects
u	:	Number of defects per unit/item
$\bar{u}$	:	Average number of defects per unit/item
d	:	Number of discarded samples which are out-of-control
P[.]	:	Probability
$A, A_2, A_3, B_3, B_4, D_1, D_2, D_3, D_4, d_1, d_2, c_4$	:	Constants/factors that depend on the size of the sample
μ	:	Process mean
σ	:	Process standard deviation
$N(\mu, \sigma^2)$	:	Normal distribution with mean μ and variance σ^2
λ	:	Average number of defects in the process