

Part 2



Statistical Process Control

Control Chart Analysis



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Specialist Consulting Engineers for Plastics Processing, Plastics Building Products and PVC-U Windows.

COMPANY PROFILE

- Tangram Technology Ltd. was formed in 1996 as a technology based consultancy dealing with the needs of the plastics processing, plastics building products and PVC-U windows industries.
- Tangram provides high quality change management, technical writing, training, product design consultancy and field services for these diverse industries.
- Our client base consists of some of the largest plastics processing companies in the UK, window systems designers, window fabricators, specifiers, large contractors, hardware manufacturers and computer services companies. We carry out extensive work for the UK Government (DEFRA and DTI), the EC and the World Bank in a variety of fields.
- Tangram is technology based consultancy, not a management consultancy. We supply specialist technical knowledge needed by our client base.

TANGRAM TECHNOLOGY LTD. - Products and Services

Change Management

We develop and implement manufacturing strategies, quality systems and Health and Safety management systems to meet the requirements of the latest legislation. We can also provide project management services for similar large projects.

Manufacturing Strategy, Quality Management, Factory Layout, Health & Safety Management, Project Management.

Technical Writing

We develop technical literature to back-up or sell your products. These can be complex product manuals, specification guides or internal training information. All are designed to your needs and to a variety of formats from paper based to Help files or web pages.

Product Manuals & Technical Information, Specification Guides, Help Files & Expert Systems, Public Relations & Article Generation, Quality Documentation Services, Web Site Generation and Management.

Training Seminars

We provide standard courses and also develop special courses to your specifications.

Manufacturing Strategy, Quality Management, PVC-U Windows - Technical Aspects, How to specify PVC-U windows, Statistical Process Control, Potential Failure Mode Effects Analysis, Health & Safety, Project & Design Management.

Product Design

We help to design and produce new products. At the forefront of product developments for 20 years we can help to get your product to market.

Product Design & Management.

Field Service

We carry out a truly independent review and assessment of your needs for new machinery or systems.

Health Checks, Customer Set-up & Service, Information & Telephone Service.

Statistical Process Control

Part 2 Control Chart Analysis

**Dr Robin Kent
Tangram Technology Ltd**

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Printed in England by Tangram Technology Limited

Statistical Process Control

A practical workbook for industry

Control Chart Analysis

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The Workbook

Scope and Objectives

This Workbook is designed to allow trainers to carry out a structured training session of approximately 1 hour. The session covers the basics of Statistical Process Control for all levels of staff.

The Workbook provides internal or external trainers with all of the basic resources necessary to deliver a training session. The trainer should be either an internal trainer or an external professional trainer with a good knowledge of the sector.

This session covers the reasons for SPC and some of the basic steps to actually introduce SPC into a factory. The sessions and training only cover SPC for variables using average and range information. We have found this to be the best basis for introducing SPC into manufacturing. The use of SPC for attributes can always be introduced at a later stage when SPC variables is established and has proved it's worth.

In Part 1 of this Training Course we covered the basics of SPC. This can be regarded as a training course in teaching an alphabet and teaching you how to read.

In Part 2 of this Training Course we will cover SPC in more detail. This can be regarded as giving you a few good books to read and showing you how to tell the difference between the good guys and the bad guys (the bad guys always wear black and ride black horses so it isn't that hard).

Session timings

This training session is designed to take approximately 1 hour to run.

Changing the presentation

Trainers should feel free to modify the structure and content of the session to match the needs of the audience. Material that is not considered relevant may be deleted or additional material can be added to cover specific points that are felt to be particularly relevant.

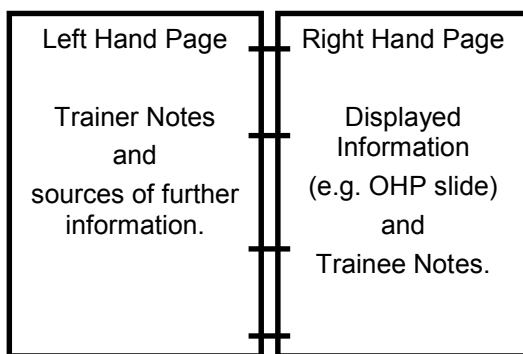
How to use the Workbook (Trainer's Page)

How to use this Workbook

This workbook is designed for use by internal trainers in the rubber industry to train employees of a company in the techniques of effective energy efficiency.

The workbook uses STOP format - this means 'Single Theme On Page'. This is designed to provide the trainer with all the information they need to carry out effective training.

Use the training book with the pages as shown below:



Left Hand Page - The trainer's page

The left hand page gives notes and discussion points for the trainer to cover whilst discussing this particular topic. It gives:

- A summary of the key points to be made.
- Some questions to ask of the delegates.
- Possible examples that will engage the delegates in the training.
- Sources of further information for the trainer - this is always in the box at the bottom of the page.

Right Hand Page - The delegate's page

The right hand page will show what is to be on the overhead projector (OHP), on the PowerPoint screen or in the delegate's copy of the Workbook (depending on the method of presentation chosen). The trainer can readily refer to this information and see exactly what the delegates are seeing.

Further Information

The Workbook series is designed to be self-sufficient and can be used with no other information other than internal company information where appropriate. Where trainers would like to have further information or explanation, this section of the trainer's page contains signposts to other sources of information.

As a general rule, it is recommended that the trainer obtains the complete set of further information as part of preparing the training session.

How to use the Workbook (Delegate's Page)

This right hand page contains all the required information for delegates.

The right hand pages do not have page numbers and the trainer can modify the order of the presentation to their own requirements.

Overhead projection slides

The right hand pages can be copied directly onto overhead projection slides to be shown to the delegates during the training session.

PowerPoint presentations

The information on this page is also contained in the Microsoft PowerPoint presentation that can be downloaded with the Workbook.

Delegate Workbooks

The right hand pages contain all the essential that the delegate needs to know. They can form a workbook for the delegate to retain and make notes. Print out only the odd numbered pages to quickly and easily create a Delegate Workbook.

The Normal Distribution (Review)

The Normal Distribution

Many measurements of natural things show a normal distribution e.g. height of people, weight of people, weight of products, dimensions of products etc.

An example of the normal distribution is show opposite.

The two important features of the normal distribution are:

- The location of the curve - this is described by the average.
- The spread of the curve - this is described by the standard deviation.

When we know these values then we can estimate the likelihood of being able to produce within tolerance.

The true calculation of the average and the standard deviation requires measuring lots of samples and is called a capability study.

The normal distribution also tells us the probability of finding a given value. For a normal distribution:

$\overline{X} \pm \sigma$ contains 68.26% of the population.

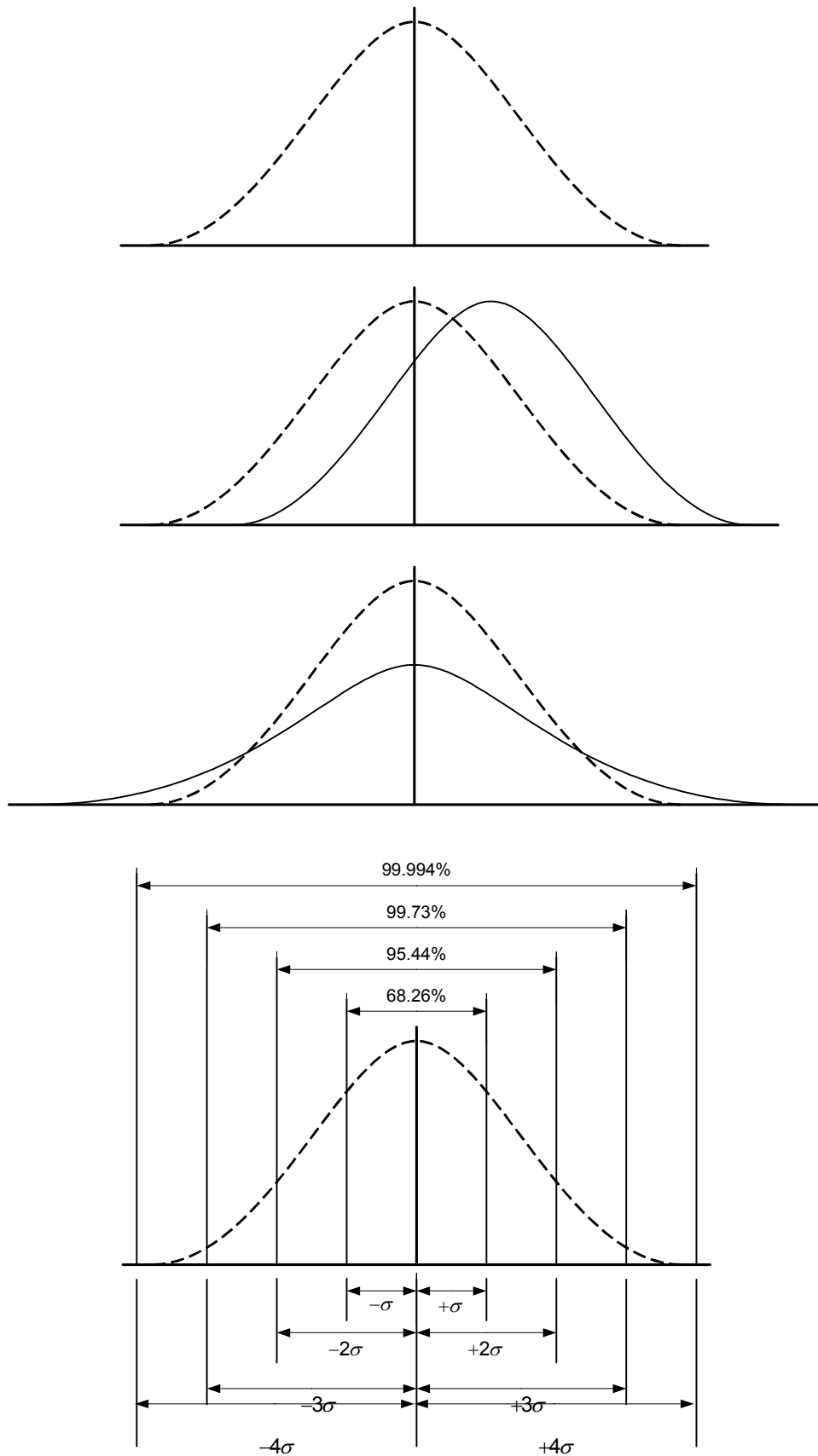
$\overline{X} \pm 2\sigma$ contains 95.44% of the population.

$\overline{X} \pm 3\sigma$ contains 99.73% of the population.

$\overline{X} \pm 4\sigma$ contains 99.99% of the population.

Further Information:

NORMAL DISTRIBUTION



The Control Chart (Review)

The Control Chart

Control charts can be regarded as 'snapshots' of the normal distribution at particular times.

The control chart uses 5 samples to rapidly estimate the location and spread of the normal distribution.

The control chart calculates:

- The average (\bar{X}) of 5 samples.
- The range (maximum value - minimum value) for 5 samples

Note: For a large number of samples the range can be related to the standard deviation σ by the formula:

$$\sigma = \bar{R} / 2.33$$

The Control Chart Rules

Check the Range Chart first

Look for the alarms:

- No points outside the control limits (upper or lower).
- No run of 7 consecutive points above or below the average line.
- No run of 7 consecutive points upward or downward.
- No pattern with 2/3 of the points in the middle 1/3 of the control limits.
- No pattern with 2/3 of the points in the outer 2/3 of the control limits.

If the range is in control then look at the average chart

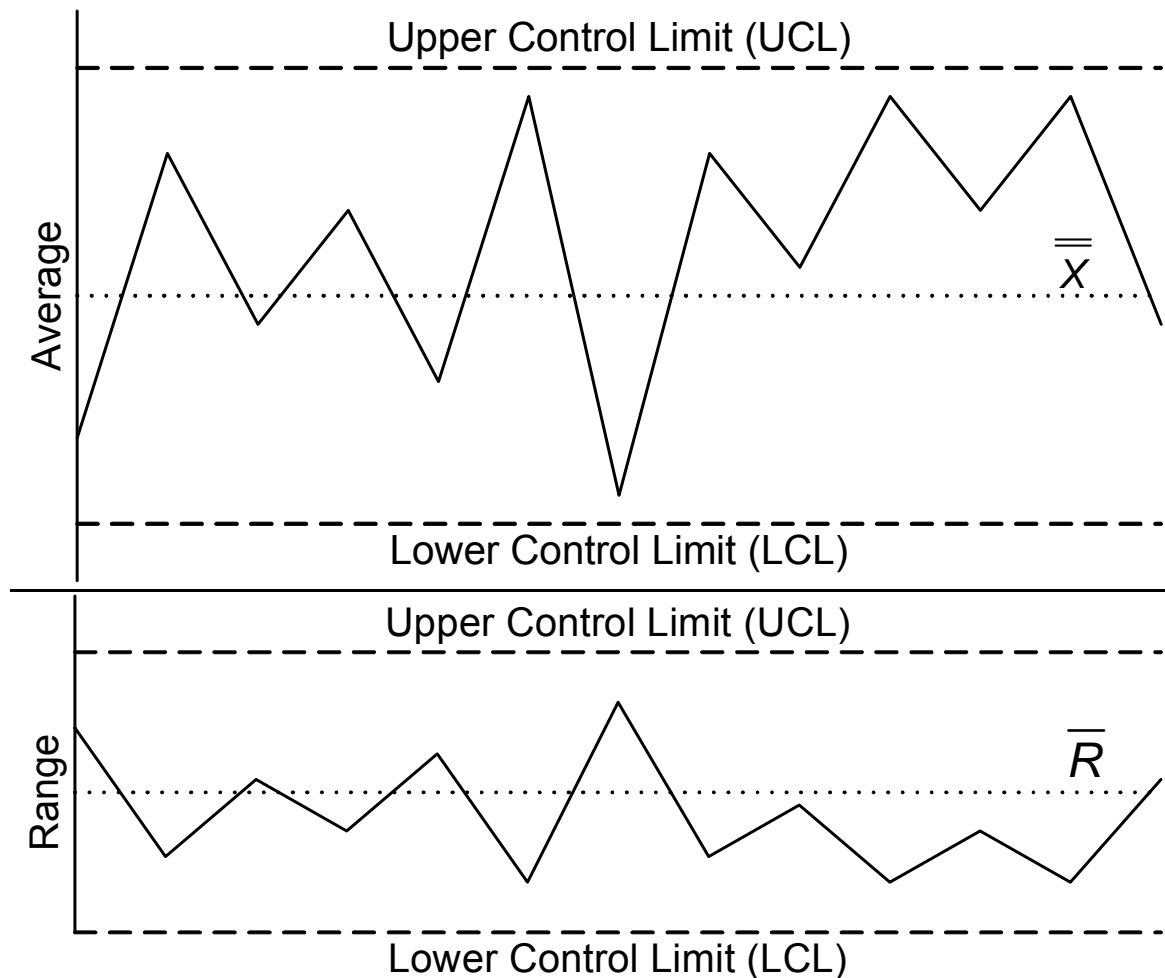
Look for the alarms:

- No points outside the control limits (upper or lower).
- No run of 7 consecutive points above or below the average line.
- No run of 7 consecutive points upward or downward.
- No pattern with 2/3 of the points in the middle 1/3 of the control limits.
- No pattern with 2/3 of the points in the outer 2/3 of the control limits.

If everything is OK then do nothing!

Further Information:

THE CONTROL CHART



- No points outside the control limits (upper or lower).
- No run of 7 points above or below the average line.
- No run of 7 upward or downward.
- No pattern with 2/3 of the points in the middle 1/3 of the control limits.
- No pattern with 2/3 of the points in the outer 2/3 of the control limits.

Range chart - Drift up or down

Description

During the period of the chart the range increase or decreases by about 3 times.

The range chart goes up or down during the period but there is an obvious overall trend.

There may be no out-of-control points on the chart.

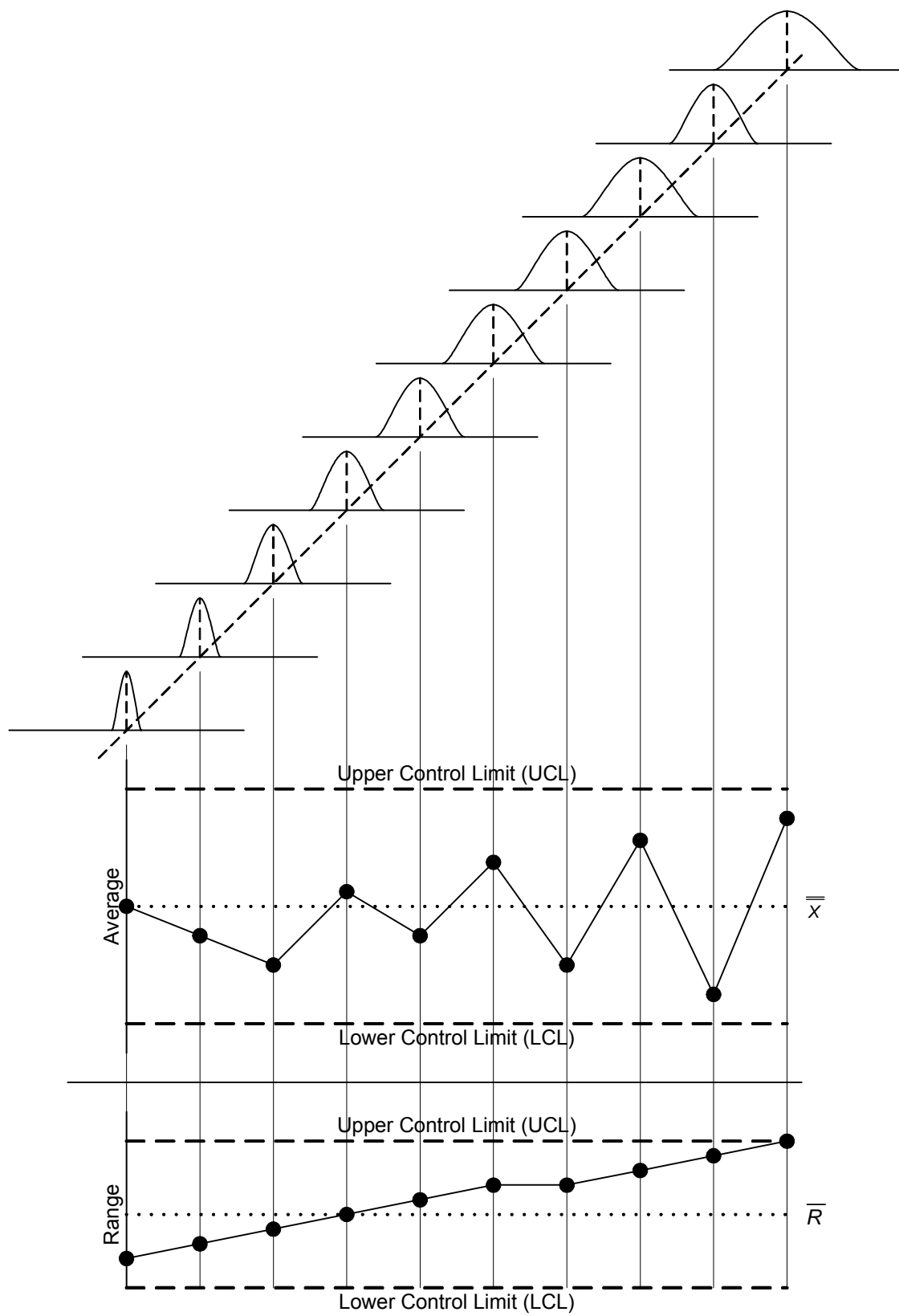
The average chart starts to show increasingly large swings but is still generally centred.

Possible causes

- Improvement or deterioration of operator skill.
- Going up - Poorly trained operator, worker fatigue.
- Going up - Tool wear, clogged machines, dirty machines.
- Going down - Good operator, gain in experience.
- Going down - Regular maintenance of machinery.
- Better or poorer control in previous areas giving gradual change in incoming material quality.

Trainer Tip: Do not look for the short term effects - a drift is a long term effect.

Further Information:



Drift in range chart

Range chart - Shift up or down

Description

During the period of the chart the range shifts up and down over reasonable periods and is relatively stable during these shifts.

There may be no out-of-control points on the chart.

The average chart starts to show large swings but is still generally centred.

Possible causes

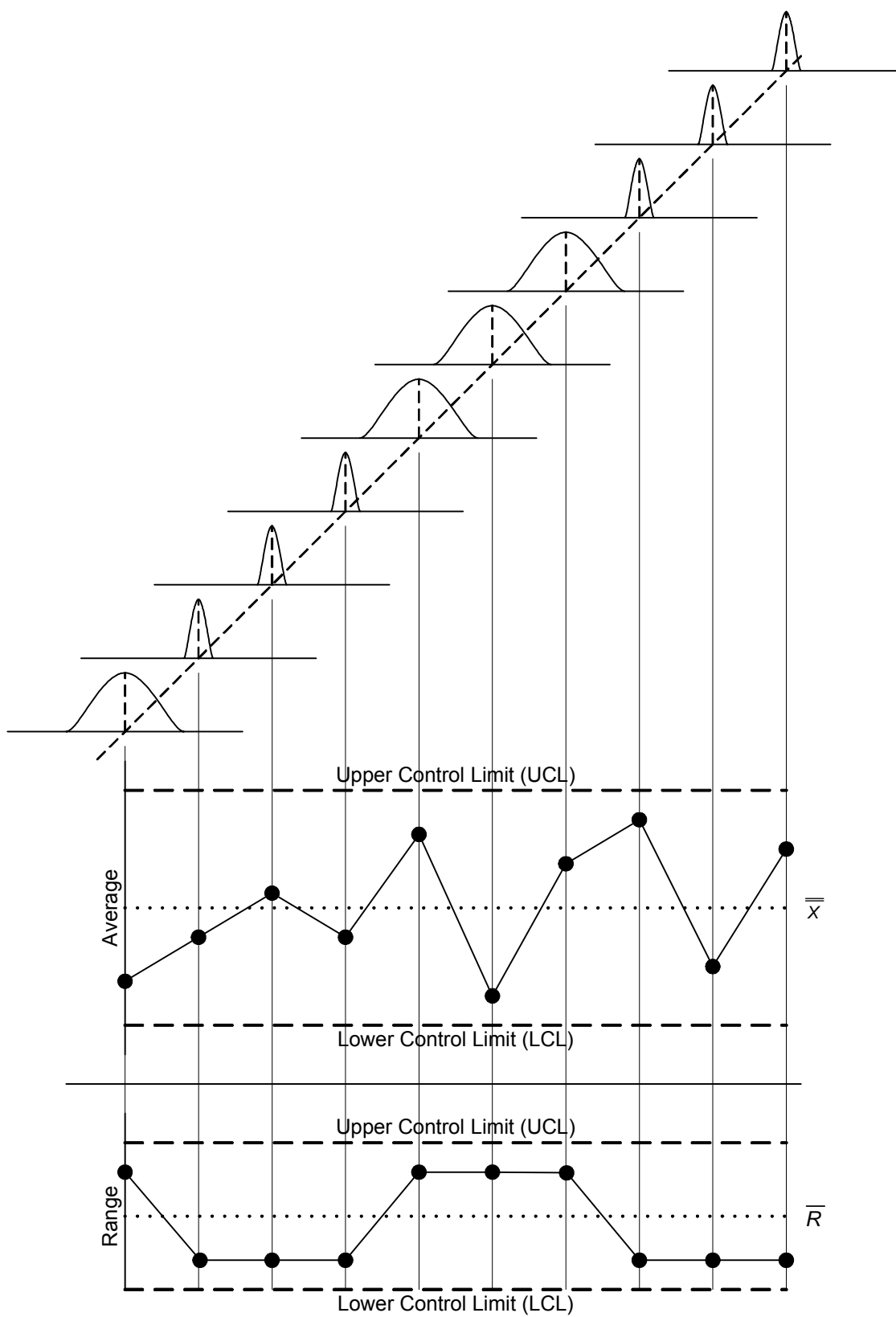
- Changes in method, e.g. regular tool maintenance.
- Changes in operator e.g. worker rotation.
- Changes in material.
- Changes in speed of machine operation.

Trainer Tip: The most common cause of shifts in the range is the operator - look there first.

Trainer Tip: Look for short term effects that match the timescale of the changes in the range chart.

Trainer Tip: This pattern in the range chart would also fail the 'No pattern with 2/3 of the points in the outer 2/3 of the control limits' rule.

Further Information:



Shifts in range chart

Range chart - Frequent changes

Description

Change in range is rapid, unpredictable and up or down.

This can be difficult to detect from the chart analysis.

There may be no out-of-control points on the chart.

The average chart starts to show large swings but is still generally centred.

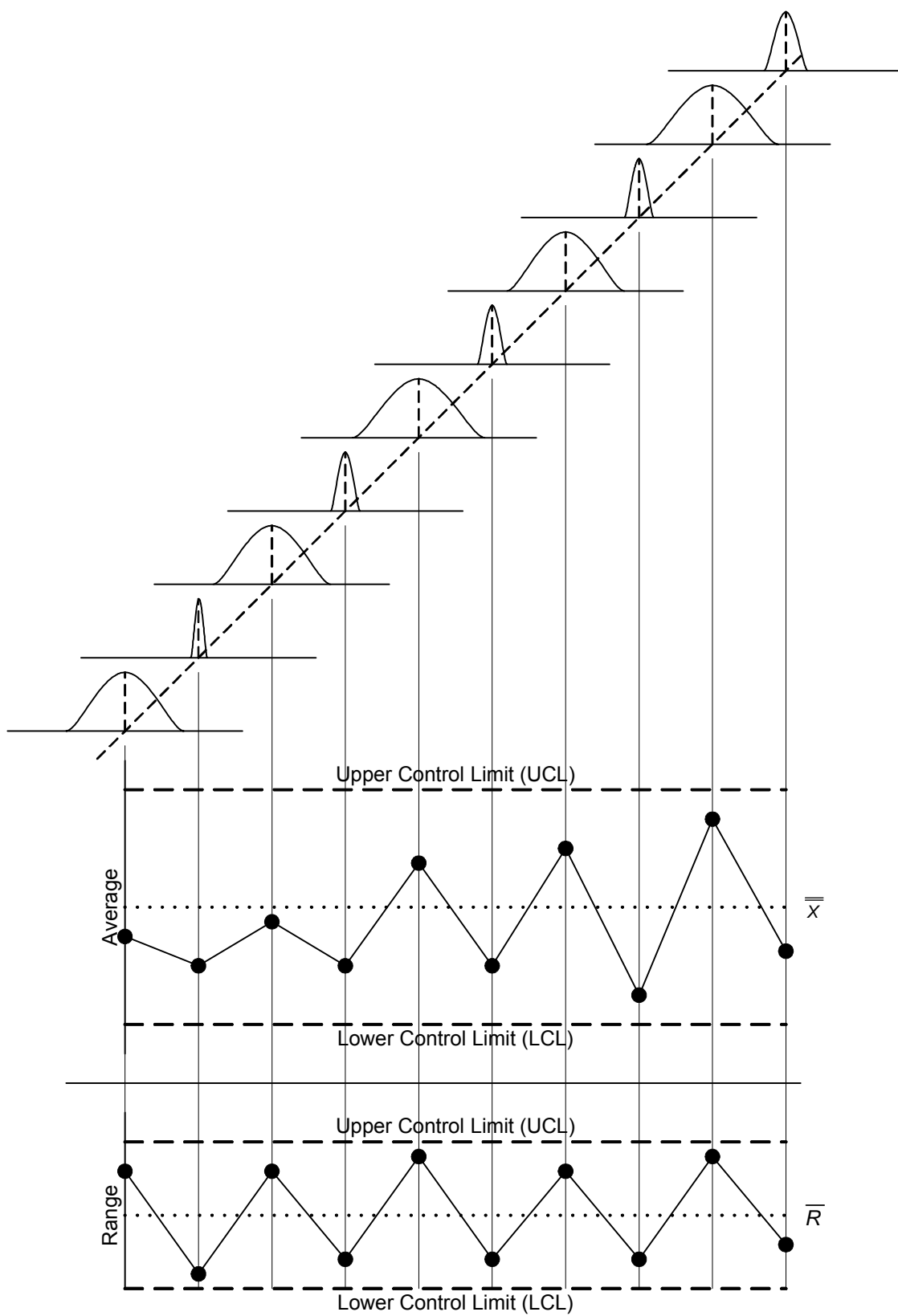
Possible causes

- Different worker using the same chart.
- Different processes under different conditions being recorded on the same chart e.g. two tools being used in parallel in process and being measured as one process.
- Mixture of materials of different quality.
- Limitations of process.

Trainer Tip: Look for variations that are obvious and are part of the process - there is probably a mixture here that you haven't spotted and are recording as a single process.

Trainer Tip: This pattern in the range chart would also fail the 'No pattern with 2/3 of the points in the outer 2/3 of the control limits' rule.

Further Information:



Frequent changes in range chart

Range chart - Points close to the centre

Description

During the period of the chart the range is very close to the centre of the chart at all times.

There may be no out-of-control points on the chart.

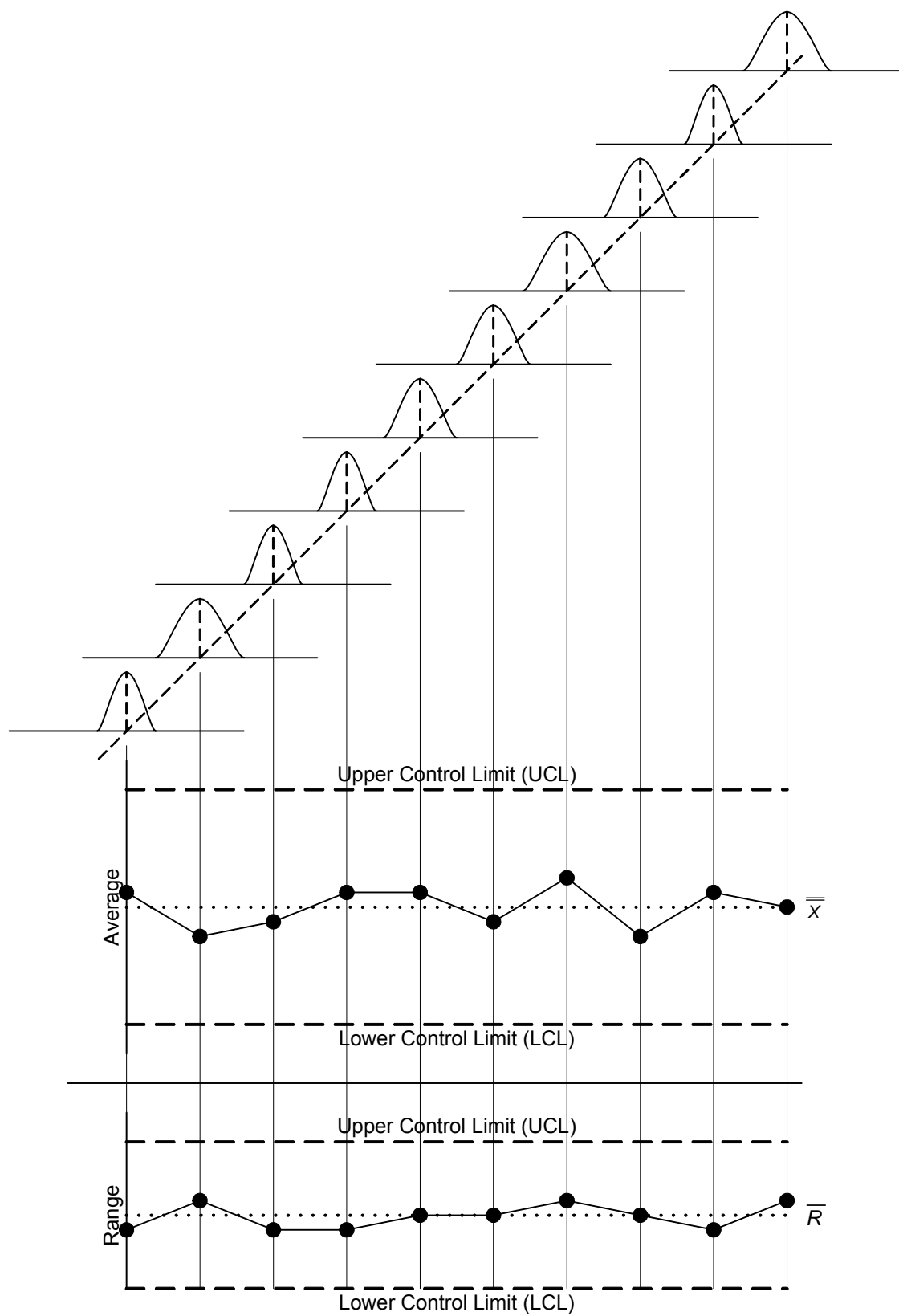
The average chart shows normal variations and is in control.

Possible causes

- Operators 'fudging' the results to show good numbers.
- Incorrect calculation of the range limits.
- Measuring instrument resolution is not sufficient to measure range correctly.
- Sampling is not accurate.

Trainer Tip: Look at the numbers and the methods of getting them - this may not be a process problem but a recording problem.

Further Information:



Points too close to centre in range chart

Average chart - Drift up or down

Description

During the period of the chart the average increase or decreases.

There is a drift upwards or downwards (the 7 intervals rule may or may not be broken).

The range chart is in control and the spread did not vary significantly.

Action should always be taken at the first alarm point ('7 up or down' or 'out-of-control' point).

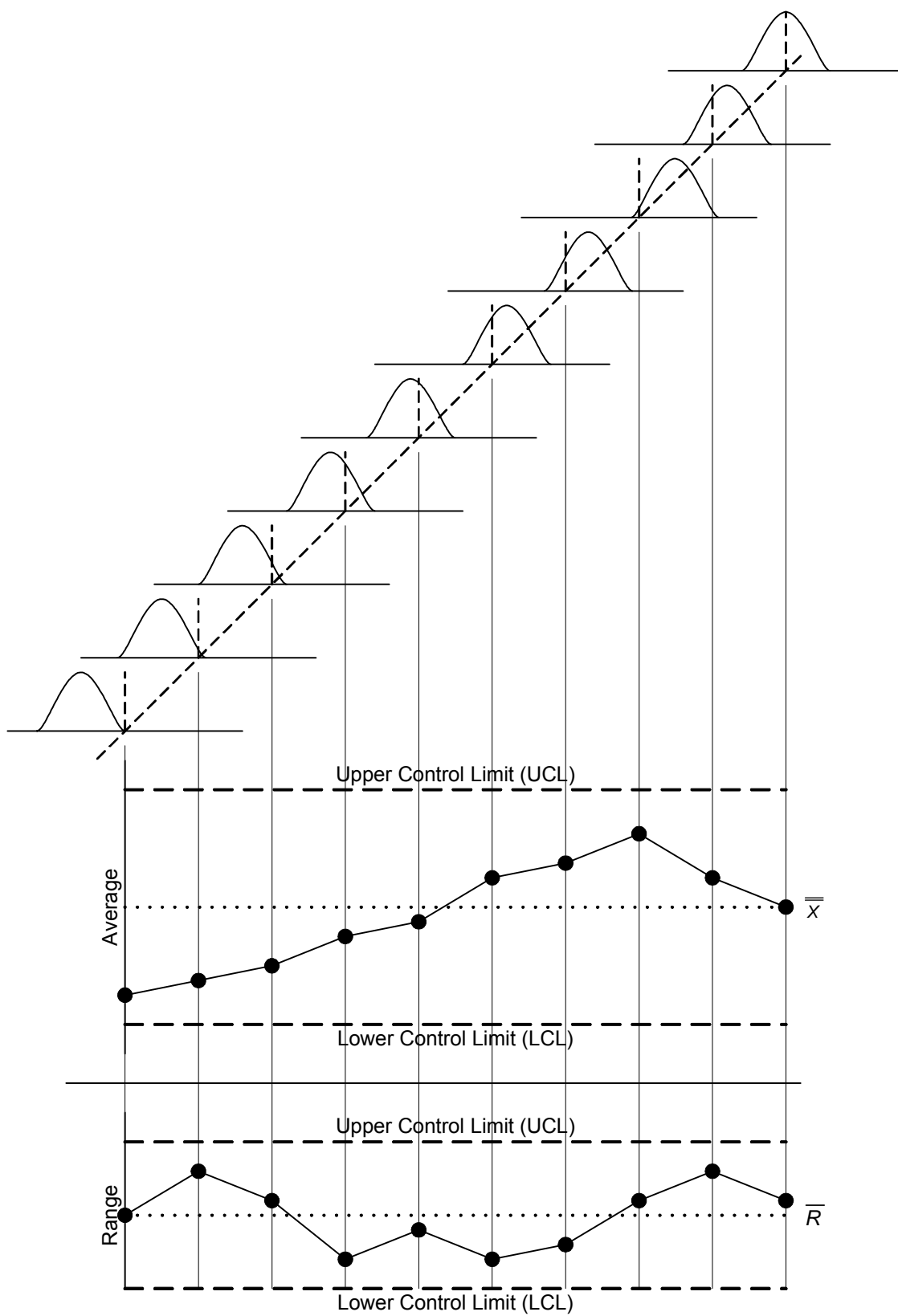
Possible causes

- Tooling wear or other gradual equipment deterioration which can affect all items.
- Worker fatigue.
- Accumulation of waste products e.g. clogged machines.
- Environmental condition changes e.g. temperature or humidity increase in the workplace as the factory warms up.

Trainer Tip: To spot trends it can also be worthwhile splitting data into sub-groups of 2 or 3 and to use an average of averages or a moving average chart to see underlying trends.

Trainer Tip: Do not look for the short term effects - a drift is a long term effect.

Further Information:



Drift in average chart

Average chart - Shift up or down

Description

During the period of the chart there was a large shift in the level of the average for no machine setting changes.

'7 above' rule was broken in this example but this is not necessarily so.

The range chart was 'in-control' and goes up or down during the period but there is no obvious overall trend.

Action should always be taken at the first alarm point ('7 up or down' or 'out-of-control' point).

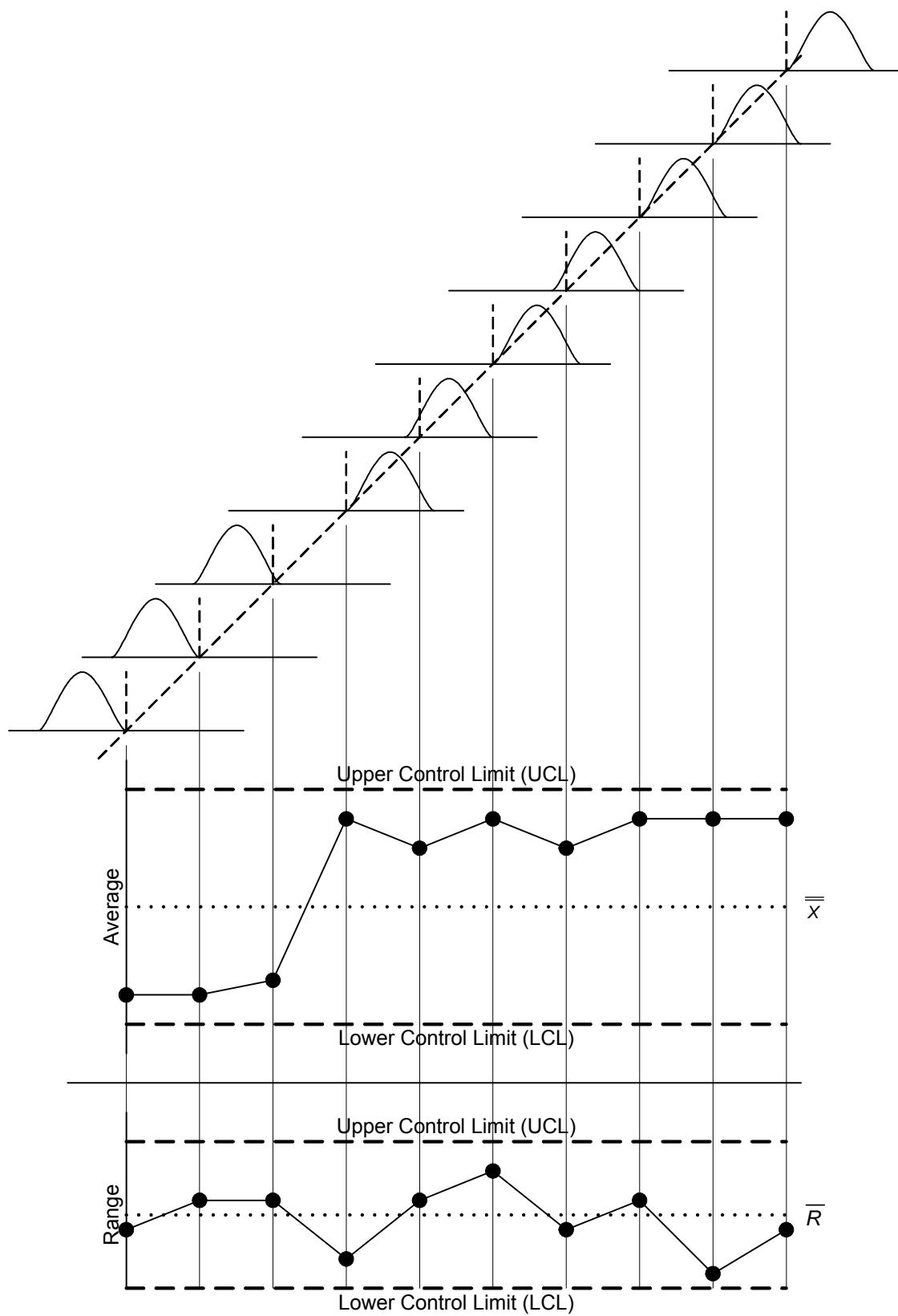
Possible causes

- Change in proportion of materials or sub-assemblies coming from different sources.
- New worker or new machine coming on line.
- Change in production method or process at an earlier process step.
- Change in inspection method or measurement machine.

Trainer Tip: Look for a change that matches the timescale of the change in the average chart.

Trainer Tip: This pattern in the range chart would also fail the 'No pattern with 2/3 of the points in the outer 2/3 of the control limits' rule.

Further Information:



Shifts in average chart

Average chart - Frequent changes

Description

Change is rapid, unpredictable and up or down.

The range chart goes up or down during the period but there is an obvious overall trend.

Points are often near the limits and rarely in the centre—there is a noticeable see-saw effect.

There may be no out-of-control points on the chart.

Action should always be taken at the first 'out-of-control' point.

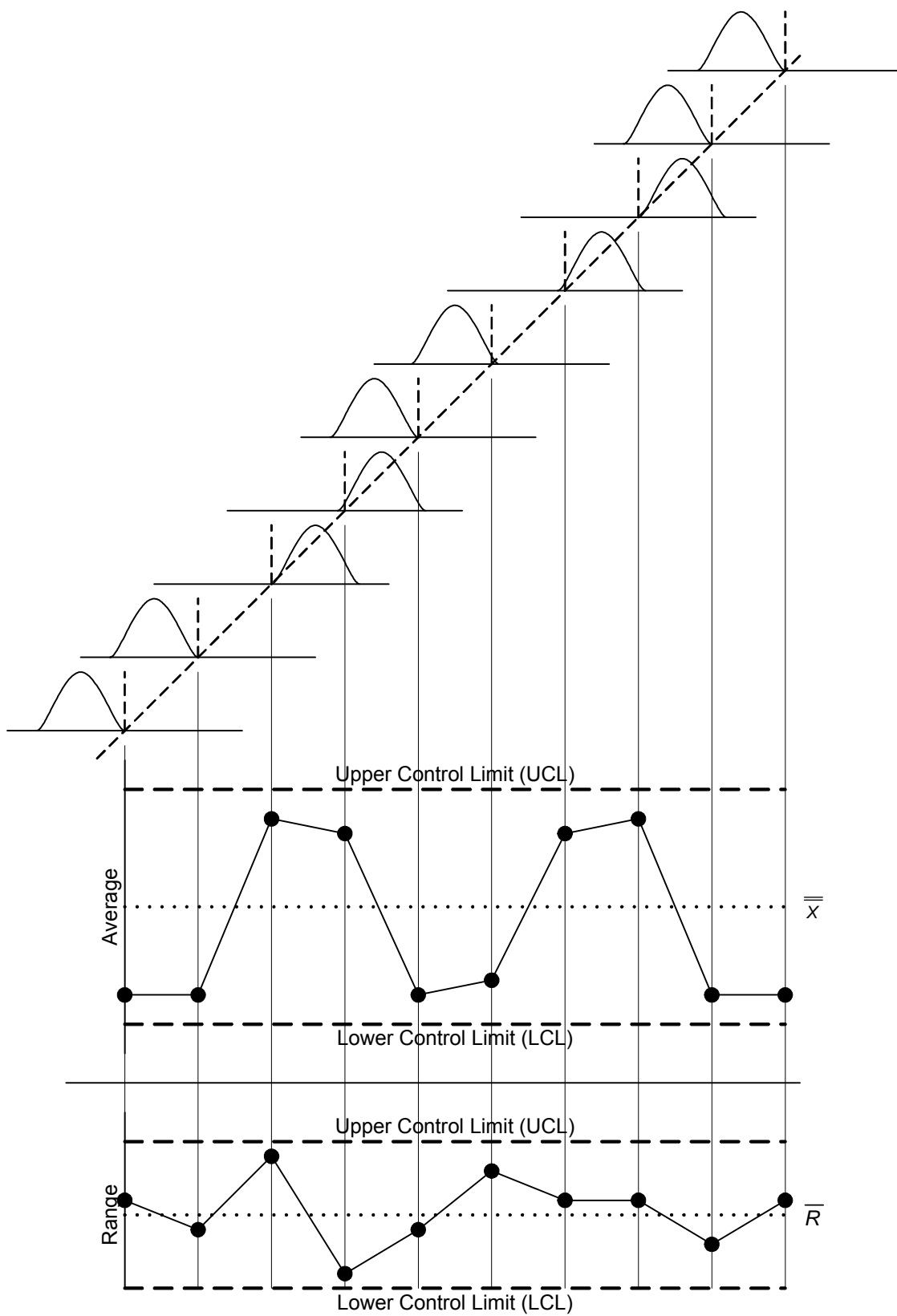
Possible causes

- Arithmetic errors.
- Large and systematic differences in material quality.
- Large systematic differences in test method or equipment.
- Possible equipment errors.
- Different processes under different conditions being recorded on the same chart e.g. two tools being used in parallel in process and being measured as one process.
- Rapid environment changes.
- Untrained operator.
- Over-adjustment of the machine when no 'out-of-control' points noted.

Trainer Tip: Erratic patterns normally mean that you are charting too far down the line. Go back up the process and look for variations there.

Trainer Tip: This pattern in the range chart would also fail the 'No pattern with 2/3 of the points in the outer 2/3 of the control limits' rule.

Further Information:



Frequent changes in average chart

Average chart - Points too close to the centre

Description

During the period of the chart the average is very close to the centre of the chart at all times. The points violate the 'No pattern with 2/3 of the points in the middle 1/3 of the control limits' rule.

There may be no out-of-control points on the chart.

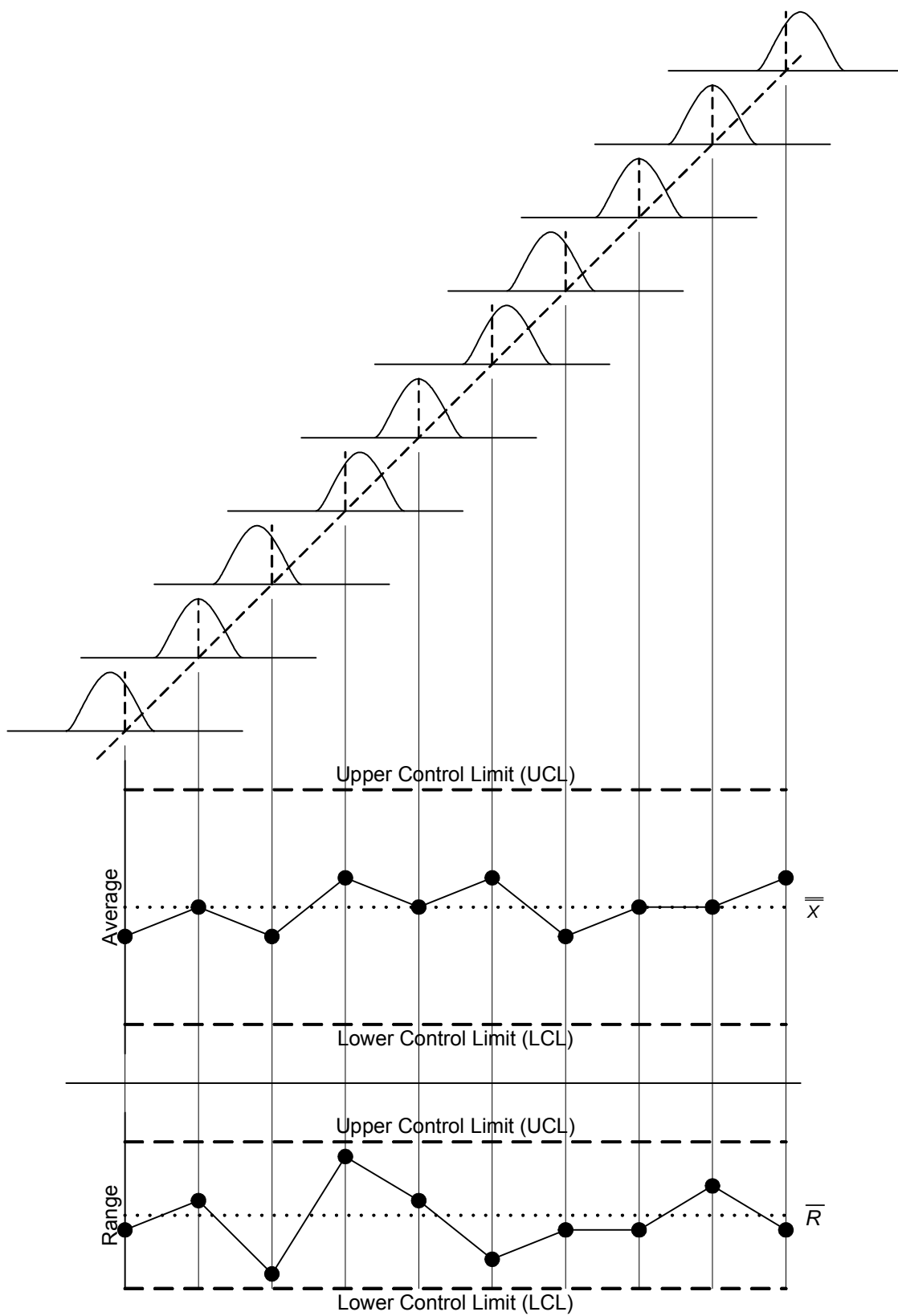
The range chart shows normal variations and is in control.

Possible causes

- Operators 'fudging' the results to show good numbers.
- Incorrect calculation of the range limits.
- Measuring instrument resolution is not sufficient to measure range correctly.
- Sampling is not accurate.

Trainer Tip: Look at the numbers and the methods of getting them - this may not be a process problem but a recording problem.

Further Information:



Points too close to centre for average chart

Common Causes

If the chart shows patterns that are not random the common causes will almost always be found by looking at the 'cause and effect chart'.

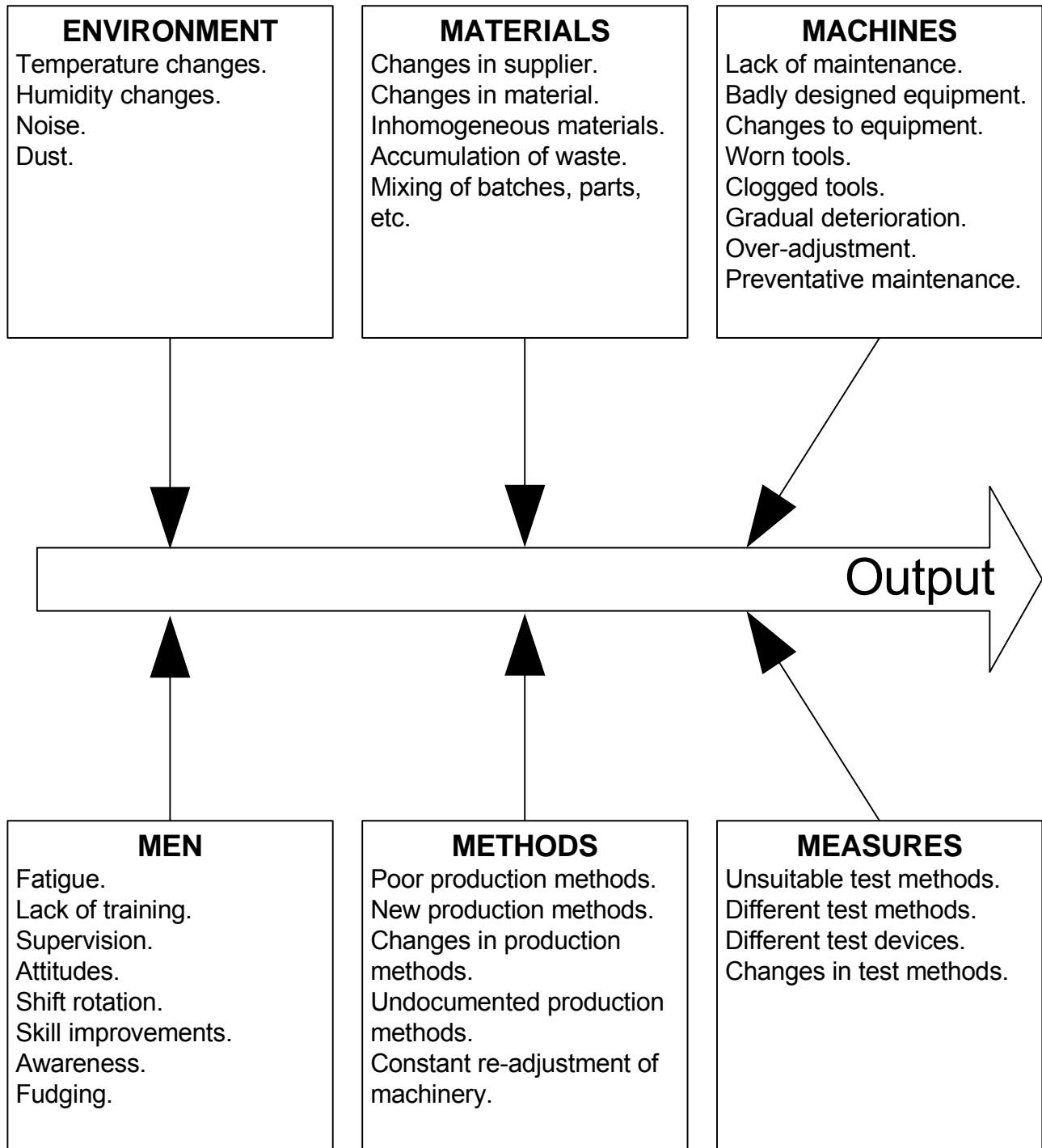
This looks at the most common causes and these are:

- Men - the things that people do will have a large effect on the product quality, e.g. are operators careful or are they slipshod, do they care about the job and the product?
- Methods - the ways that people do things will have a large effect on the product quality, e.g. people may think they all work to the same procedures but do they? Does every operator have different method of assessing the product?
- Machines - the reliability and consistency of the machines we use will have a large effect on the product quality, e.g. is the machine right for the job? Is it an old machines that breaks down often?
- Materials - the types and consistency of the materials we use will have a large effect on the product quality, e.g. is the material the right one? Did the buyer get a discount for 'off-specification material'?
- Environment - the environment will have a large effect on the product quality, e.g. is the factory temperature consistent? Does the water temperature vary with the outside temperature?

Further Information:

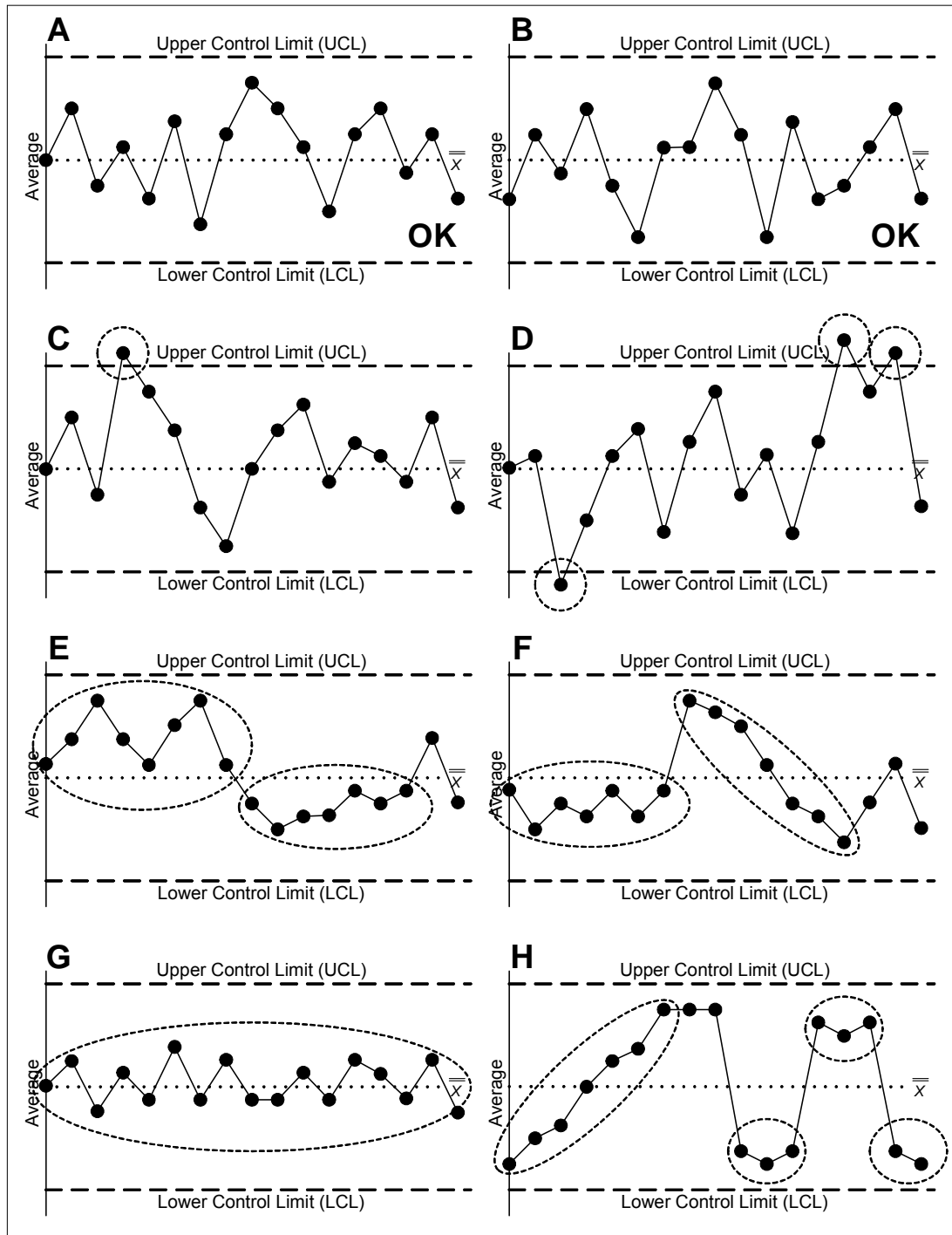
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THE COMMON CAUSES



The Alarms

Alarms test answers



Further Information:

THE ALARMS

