

Selecting Appropriate Calibration Intervals

Sources

- ▶ ILAC-G24, *Guidelines for the determination of calibration intervals of measuring instruments* (www.ilac.org)
- ▶ NCSL International RP-1, *Establishment and Adjustment of Calibration Intervals* (www.ncsli.org)
- ▶ Experiences

Why do we calibrate?

- ▶ To check the accuracy of a measuring instrument.
- ▶ To improve the accuracy of a measuring instrument.
- ▶ To have confidence in a measuring instrument's results.
- ▶ To test a new instrument.
- ▶ To test an instrument after it has been repaired or modified.
- ▶ To check the operation of an instrument which has had a shock, vibration, or exposure to adverse conditions.
- ▶ Because many instruments' results tend to drift over time.
- ▶ To ensure the best result prior to and after a critical measurement.
- ▶ Because measurements are important! Measurement and measurement-related operations have been estimated to account for between 3% and 6% of the GDP of industrial countries.¹

¹ *Calibration World, February 2009*

Risks of Not Calibrating

- ▶ Equipment downtime
- ▶ Production downtime
- ▶ Inaccurate results
- ▶ Need for rework
- ▶ Loss of money
- ▶ Safety concerns

So how often should/must we recalibrate?



Calibration intervals – What do the standards require?

- ▶ “Calibration programmes shall be established for key quantities or values of the instruments where these properties have a significant effect on the results.” *(ISO/IEC 17025, Section 5.5.2)*
- ▶ “Before being placed into service, equipment...shall be calibrated or checked to establish that it meets the laboratory’s specification requirements and complies with the relevant standard specifications.” *(ISO/IEC 17025, Section 5.5.2)*
- ▶ “...equipment...requiring calibration shall be labeled, coded, or otherwise identified to indicate the...date or expiration criteria when recalibration is due. *(ISO/IEC 17025, Section 5.5.8)*
- ▶ “When, for whatever reason, equipment goes outside the direct control of the laboratory, the laboratory shall ensure that the function and calibration status of the equipment are checked and shown to be satisfactory before the equipment is returned to service.” *(ISO/IEC 17025, Section 5.5.9)*
- ▶ “The laboratory shall have a programme and procedure for the calibration of its reference standards.” *(ISO/IEC 17025, Section 5.6.3.1)*

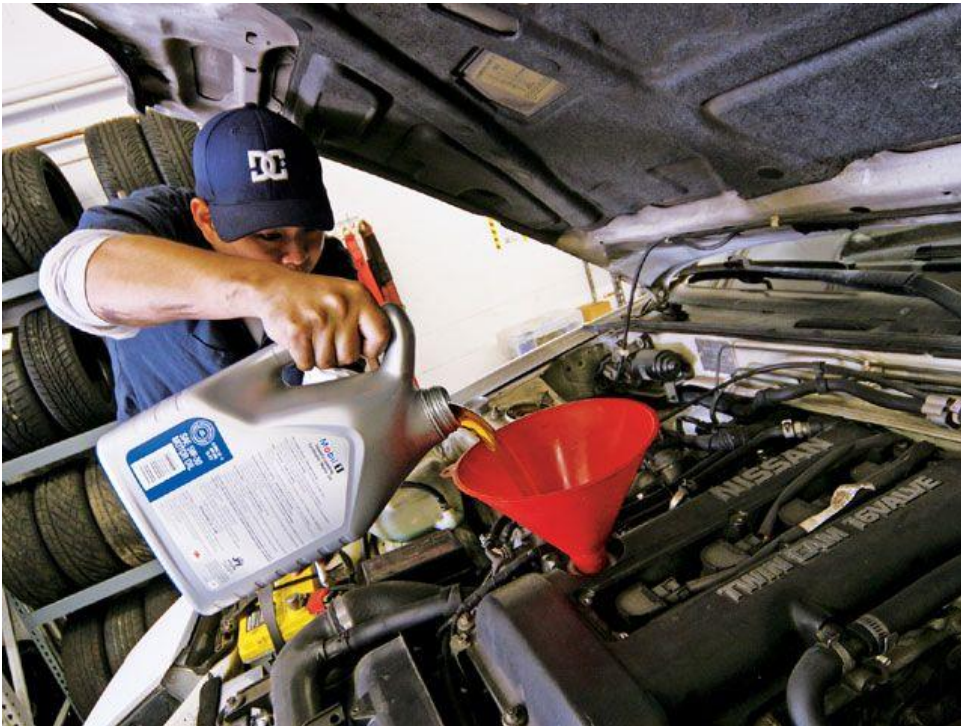
CAVEATS



- ▶ Your accreditation body may have specific requirements.
- ▶ Your industry may have specific requirements.
- ▶ Testing standards may have specific requirements.

Do any of these apply to you?

How often do you change your oil? Should everybody follow the same interval?



- ▶ Every 3,000 miles?
- ▶ Every 5,000 miles?
- ▶ Every 7,500 miles?
- ▶ Every 3 months?
- ▶ When the oil looks dirty?
- ▶ When the viscosity of the oil changes?
- ▶ When you remember?
- ▶ When you have time?

Factors to consider...

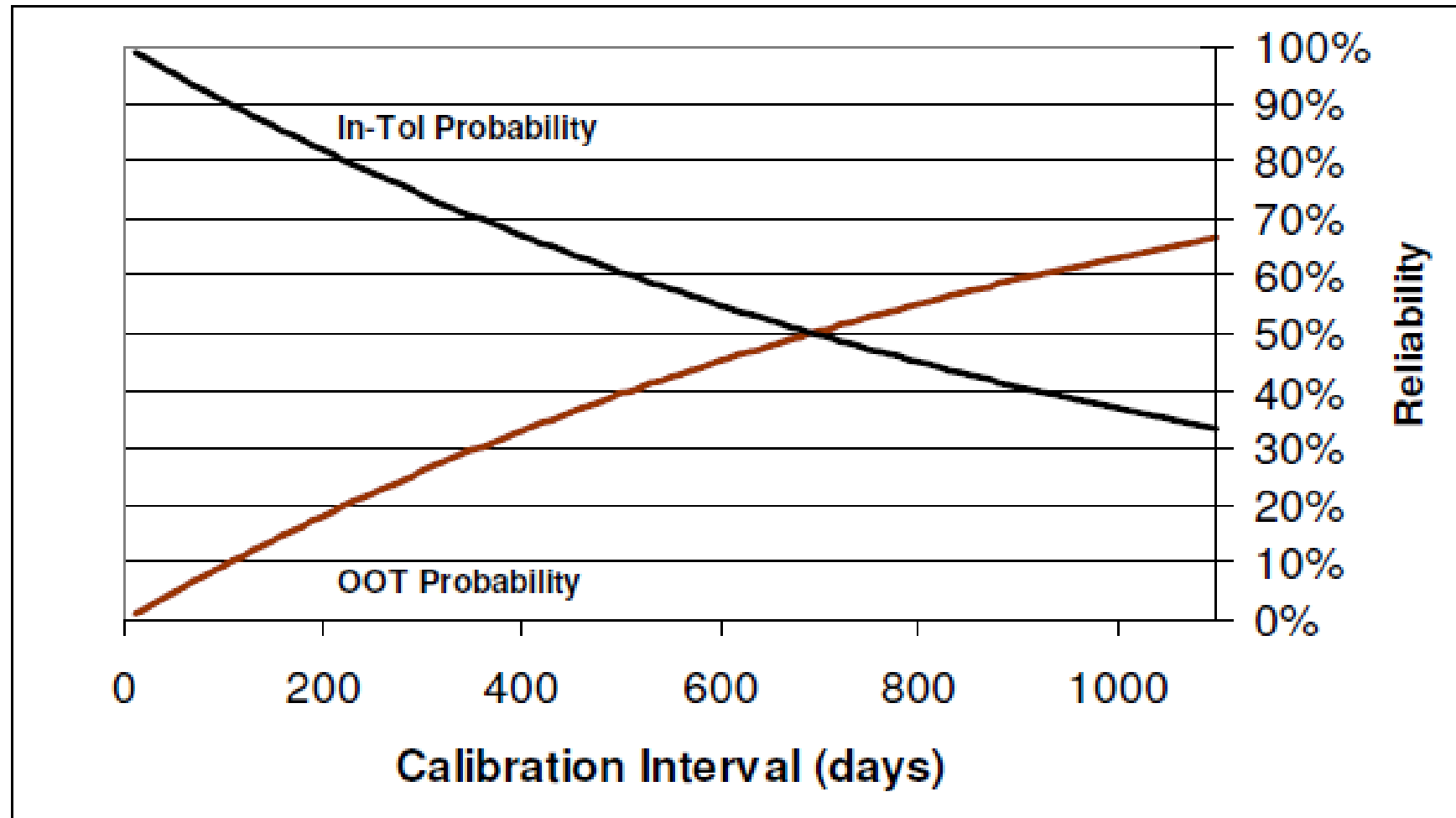
- ▶ What type of instrument is it?
- ▶ What interval does the manufacturer recommend?
- ▶ What is the extent and severity of use and what are the environmental conditions?
- ▶ Does it have a tendency to wear or drift?
- ▶ What is the measurement uncertainty required?
- ▶ What is the risk of an instrument exceeding the maximum permissible error?
- ▶ What is the cost of correction and recall measures when the instrument is found to be “out of calibration?”
- ▶ What does previous calibration data tell you?
- ▶ Are intermediate checks performed?
- ▶ Have the personnel been trained appropriately?

From ILAC-G24

For how long is a measurement uncertainty estimate valid?

- ▶ A calibration, and the corresponding measurement uncertainty, are just a snapshot in time.
- ▶ “Our knowledge of the values of the measurable attributes of a calibrated item begins to diminish from the time the item is calibrated. This loss of knowledge of the values of attributes over time is called **uncertainty growth**.”
(*NCSL International RP-1*)
- ▶ **When** does it exceed your out-of-tolerance condition?

Reliability vs. Time

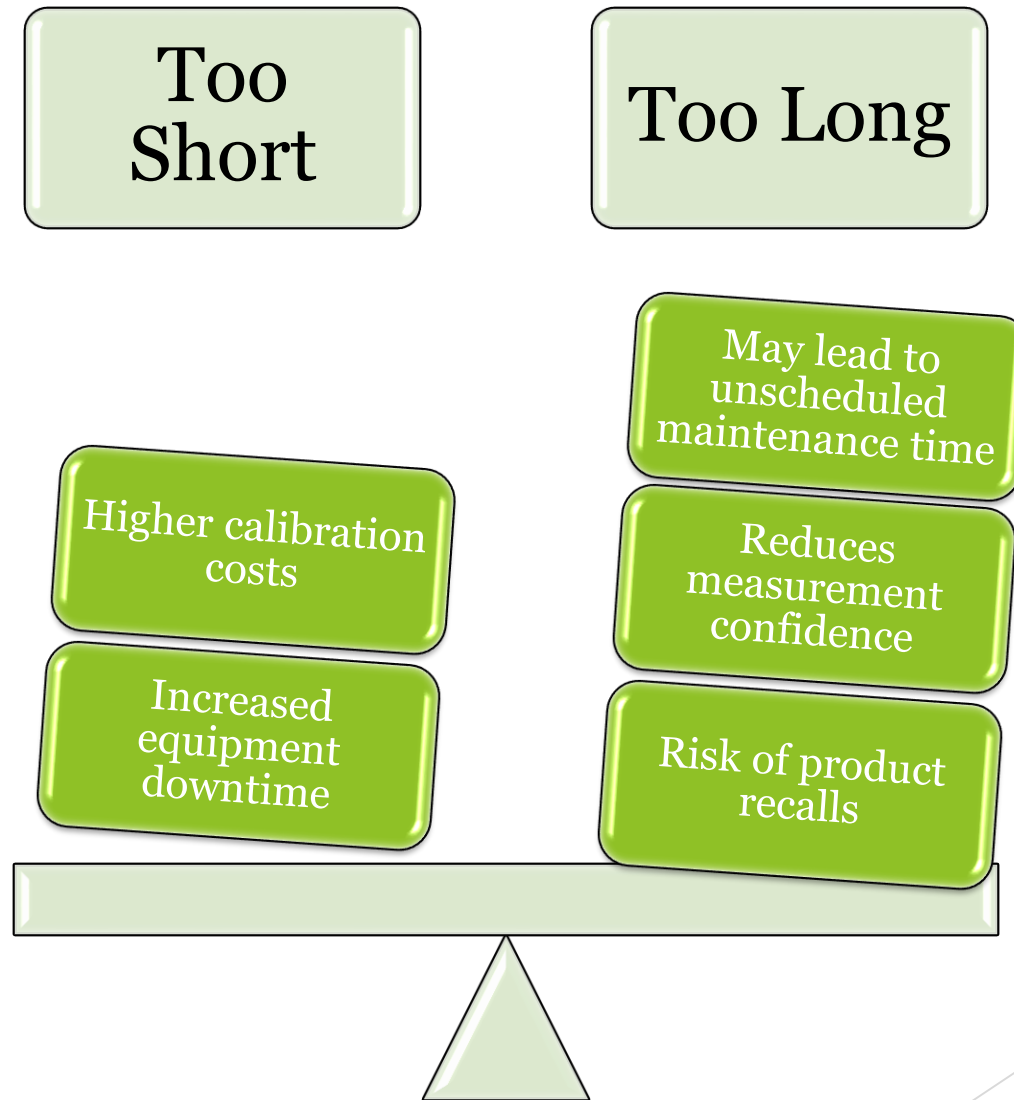


Interval Selection Methods

{ Interval } ...

... a definite length of time marked off by two instants

Establishing a Calibration Interval



Setting the Initial Interval

- ▶ Be conservative.
 - ▶ Because you don't know what to expect.
 - ▶ So you can collect more data initially.

No Periodic Calibration Required

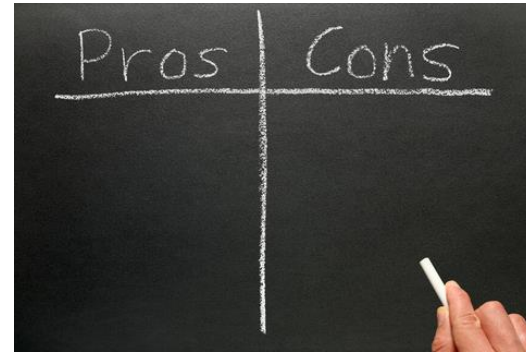
“No periodic calibration required” or “NPCR” status may be assigned to some items:

1. If the instrument does not make measurements.
2. If the instrument does not make critical measurements.
3. If the instrument makes measurements which only provide an indication of operational status but does not provide a numerical value.
4. If the operation of the instrument is unlikely to change.
5. Examples?
 - a) Ductility ruler

Calibration Interval Options



Fixed Intervals (every 6, 12 months...)



Pros

- ▶ Easy to implement
- ▶ Easy to remember
- ▶ Easy to schedule
- ▶ Easy record-keeping
- ▶ Requires little expertise for staff

Cons

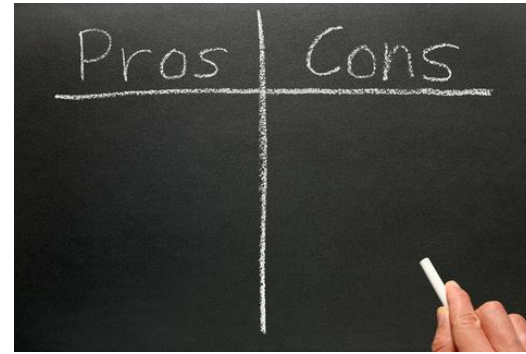
- ▶ “Out-of-calibration” equipment may be in use
- ▶ Test reports/products may need to be recalled
- ▶ Equipment may be calibrated too often = extra cost

How often?

		Probability That Time or Usage Will Affect the Instrument/Device		
		Low	Moderate	High
Measurement's Influence on the Test Result	High	Monitoring (Moderate Risk)	Frequent Monitoring (High Risk)	Frequent Monitoring (High Risk)
	Moderate	Infrequent Monitoring (Low Risk)	Moderate Monitoring (Moderate Risk)	Frequent Monitoring (High Risk)
	Low	Infrequent Monitoring (Low Risk)	Infrequent Monitoring (Low Risk)	Moderate Monitoring (Moderate Risk)

General Interval

(single interval for everything)



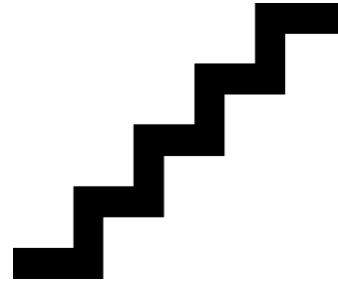
Pros

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Automatic Adjustment (aka Staircase)



Pros

- ▶ Intervals based on data
- ▶ Easy to implement
- ▶ Requires little expertise for staff

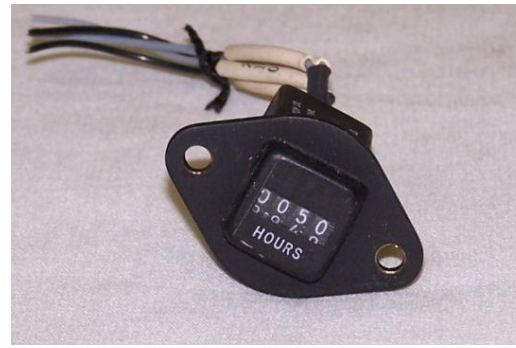
Cons

- ▶ Interval adjustments are responses to single calibration events.
- ▶ Unbalanced workload – difficult to track deadlines
- ▶ “Out-of-calibration” equipment may be in use
- ▶ Test reports/products may need to be recalled
- ▶ Equipment may be calibrated too often = extra cost

ILAC-G24: Each time an instrument is calibrated, the subsequent interval is extended if it is found to be within the maximum permissible error required for measurement, or reduced if found to be outside this maximum permissible error.

(Called “Simple Response Method” in NCSL International RP-1.)

In-Use Time



Pros

- ▶ Requires little expertise for staff
- ▶ Tracks equipment in-use time
- ▶ Number of calibrations varies directly with length of time in use.
- ▶ Some instruments drift over time.

Cons

- ▶ Cannot be used with all instruments
- ▶ Cost of timers can be high
- ▶ Unbalanced workload – difficult to track deadlines
- ▶ “Out-of-calibration” equipment may be in use
- ▶ Test reports/products may need to be recalled
- ▶ Equipment may be calibrated too often = extra cost

ILAC-G24: Calibration intervals are expressed in hours of use instead of calendar time.

Borrowed Intervals



Pros

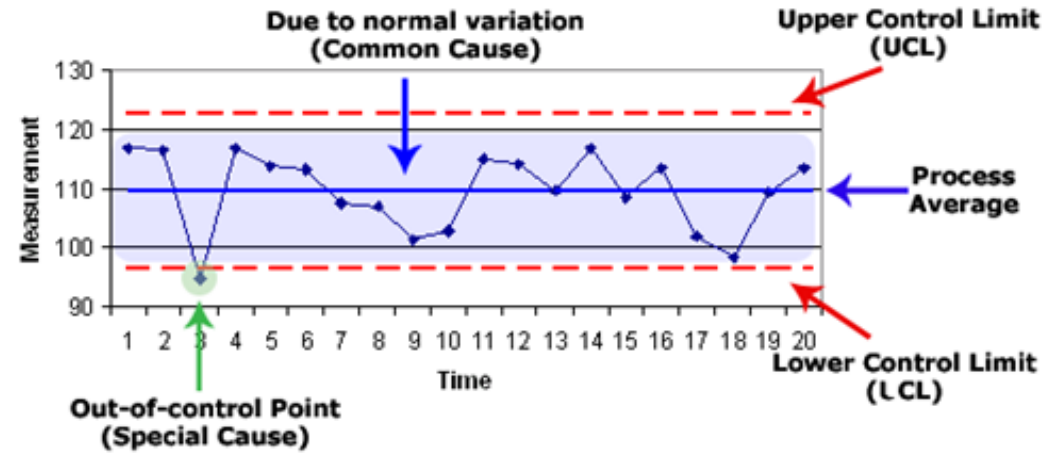
- ▶ Easy to implement
- ▶ Hard work is already done
- ▶ Possibly requires little expertise for staff

Cons

- ▶ Depends on which method you borrow
- ▶ How do you know when intervals change?
- ▶ Must have similar risk tolerance

Organizations must be similar with respect to calibration procedures, usage and handling of equipment, and environment.

Control Charts



Pros

- ▶ Calibration intervals are flexible
- ▶ Can help to predict out of control situations = time to recalibrate

Cons

- ▶ More work
- ▶ Unbalanced work load

Control Chart Example

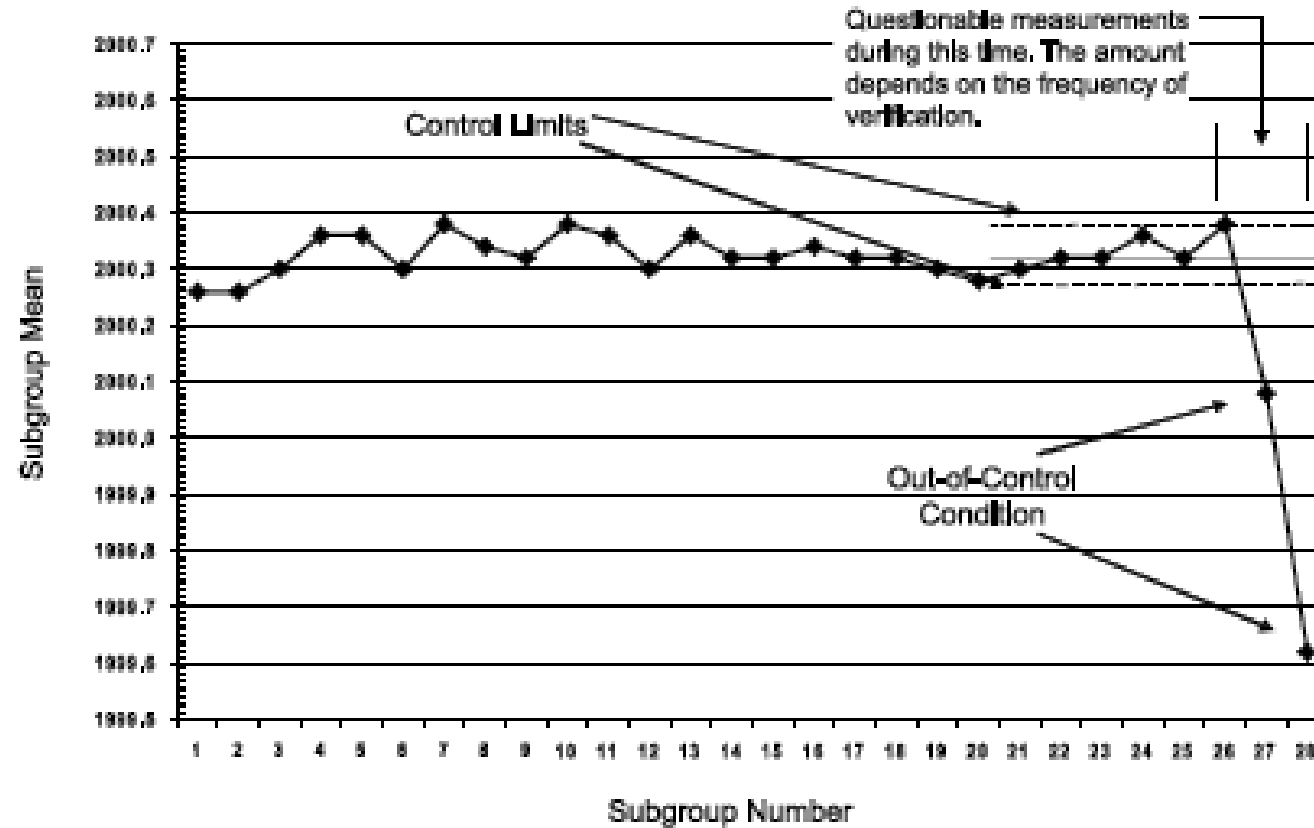
- ▶ Data—A laboratory places a nominal 2000-g mass on a balance each morning and takes five readings. The measurements are recorded and then collected in a spreadsheet.
- ▶ Each set of five readings is considered a subgroup. Subgroup averages and ranges are calculated. The average of the subgroup averages and the average of the subgroup ranges are calculated after approximately twenty subgroups.

Control Chart Data

Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Subgroup average	Max	Min	Subgroup range
2000.2	2000.4	2000.2	2000.2	2000.3	2000.3	2000.4	2000.2	0.2
2000.2	2000.2	2000.3	2000.3	2000.3	2000.3	2000.3	2000.2	0.1
2000.2	2000.4	2000.3	2000.3	2000.3	2000.3	2000.4	2000.2	0.2
2000.3	2000.5	2000.3	2000.3	2000.4	2000.4	2000.5	2000.3	0.2
2000.4	2000.4	2000.4	2000.3	2000.3	2000.4	2000.4	2000.3	0.1
2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	0.0
2000.4	2000.3	2000.4	2000.4	2000.4	2000.4	2000.4	2000.3	0.1
2000.3	2000.3	2000.3	2000.4	2000.4	2000.3	2000.4	2000.3	0.1
2000.4	2000.3	2000.3	2000.3	2000.3	2000.3	2000.4	2000.3	0.1
2000.4	2000.4	2000.4	2000.4	2000.3	2000.4	2000.4	2000.3	0.1
2000.3	2000.3	2000.4	2000.4	2000.4	2000.4	2000.4	2000.3	0.1
2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	0.0
2000.4	2000.3	2000.3	2000.4	2000.4	2000.4	2000.4	2000.3	0.1
2000.3	2000.3	2000.3	2000.3	2000.4	2000.3	2000.4	2000.3	0.1
2000.4	2000.3	2000.3	2000.3	2000.3	2000.3	2000.4	2000.3	0.1
2000.3	2000.4	2000.4	2000.3	2000.3	2000.3	2000.4	2000.3	0.1
2000.3	2000.4	2000.3	2000.3	2000.3	2000.3	2000.4	2000.3	0.1
2000.3	2000.4	2000.3	2000.3	2000.3	2000.3	2000.4	2000.3	0.1
2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	0.0
2000.3	2000.3	2000.2	2000.3	2000.3	2000.3	2000.3	2000.2	0.1
2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	2000.3	0.0
2000.3	2000.3	2000.3	2000.3	2000.4	2000.3	2000.4	2000.3	0.1
2000.4	2000.3	2000.3	2000.3	2000.3	2000.3	2000.4	2000.3	0.1
2000.4	2000.3	2000.5	2000.3	2000.3	2000.4	2000.5	2000.3	0.2
2000.3	2000.3	2000.3	2000.4	2000.3	2000.3	2000.4	2000.3	0.1
2000.3	2000.4	2000.4	2000.4	2000.4	2000.4	2000.4	2000.3	0.1
2000.1	2000.1	2000.1	2000.1	2000.0	2000.1	2000.1	2000.0	0.1
1999.7	1999.6	1999.7	1999.6	1999.5	1999.6	1999.7	1999.5	0.2
2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	0.0
2000.0	2000.1	2000.0	2000.1	2000.1	2000.1	2000.1	2000.0	0.1
2000.0	2000.0	2000.0	1999.9	2000.0	2000.0	2000.0	1999.9	0.1
1999.9	2000.1	2000.0	2000.1	2000.0	2000.0	2000.1	1999.9	0.2
1999.9	1999.9	2000.0	2000.0	1999.9	1999.9	2000.0	1999.9	0.1

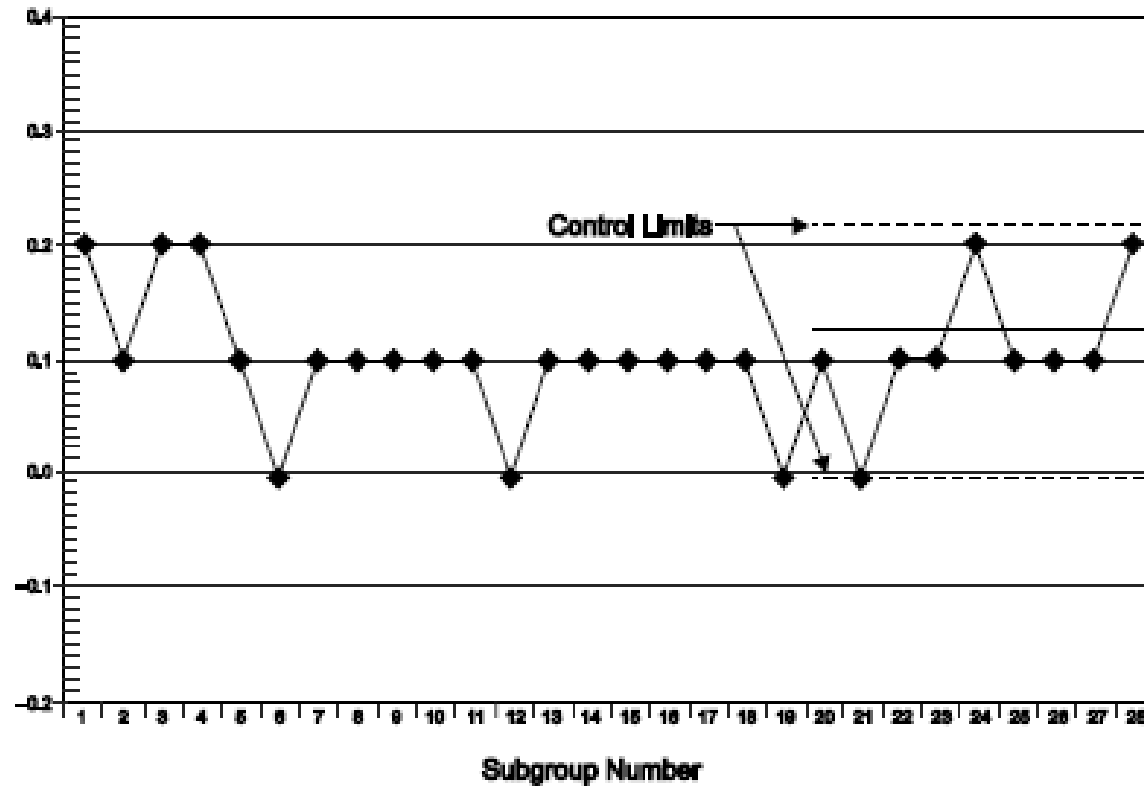
Average:

Graph the Data (Average (X-bar) Chart)



An out-of-control condition in the average (X) chart indicates a shift in the population average and could be due to the measuring equipment going out of calibration or some problem with the check standard itself.

Range (R) Chart



An out-of-control condition in the range (R) chart indicates an increase in the dispersion of the repeat observations, which could be attributed to inadequate control of the environment or incompetence of the operator involved in the measurements.

WECO Rules

- ▶ In Statistical Process Control, the Western Electric Rules are decision rules for detecting "out-of-control" or non-random conditions on control charts. Locations of the observations relative to the control chart control limits (typically at ± 3 standard deviations) and centerline indicate whether the process in question should be investigated for assignable causes. The Western Electric Rules were codified by a specially-appointed committee of the manufacturing division of the Western Electric Company and appeared in the first edition of its Statistical Quality Control Handbook in 1956. Their purpose was to ensure that line workers and engineers interpret control charts in a uniform way.

WECO Rules

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

===== CENTERLINE

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

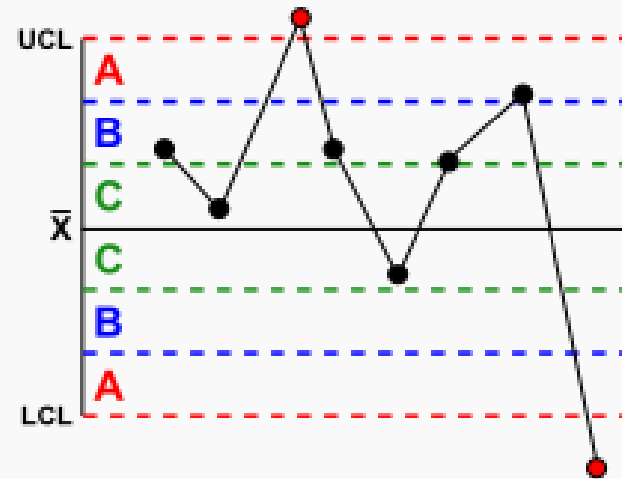
- ▶ Trend Rules: 6 in a row trending up or down, 14 in a row alternating up and down.

WECO Rules

Rule 1

Any single data point falls outside the 3σ limit from the centerline (i.e., any point that falls outside Zone A, beyond either the upper or lower control limit)

Rule 1: Any point beyond Zone A

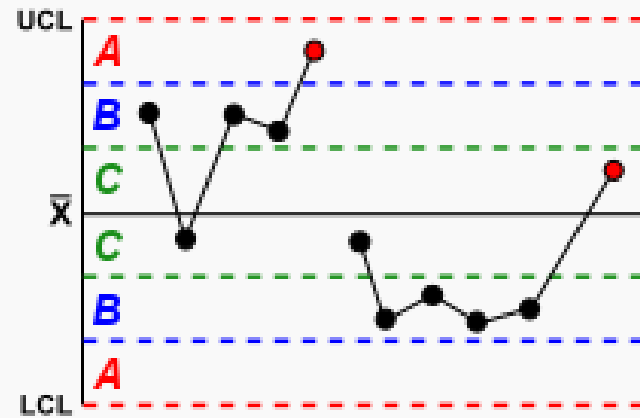


WECO Rules

Rule 3

Four out of five consecutive points fall beyond the 1σ limit (in zone B or beyond), on the same side of the centerline

Rule 3: Four out of five consecutive points fall Zone B or beyond

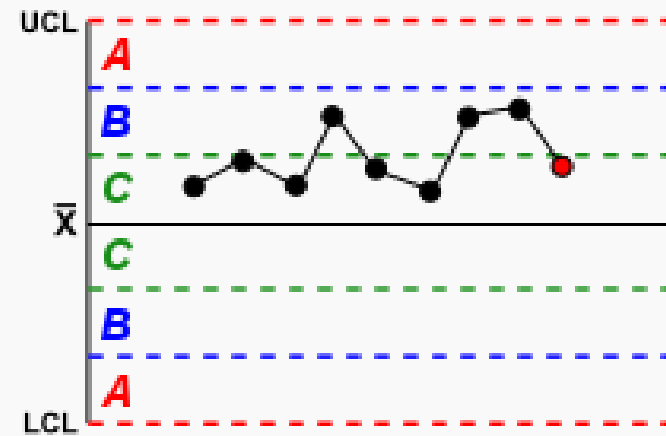


WECO Rules

Rule 4

Nine consecutive points fall on the same side of the centerline (in zone C or beyond)

Rule 4: Nine consecutive points on the same side of center line (mean)



Calibration Software



Pros

- ▶ ?

Cons

- ▶ Cost
- ▶ Requires some expertise
- ▶ Removes “thought process”

<http://www.capterra.com/calibration-management-software/>

Calibration Interval Methods

- ▶ Fixed intervals
- ▶ General interval
- ▶ Automatic adjustment (staircase)
- ▶ In-use time
- ▶ Similar items
- ▶ Borrowed
- ▶ Control charts
- ▶ Calibration software