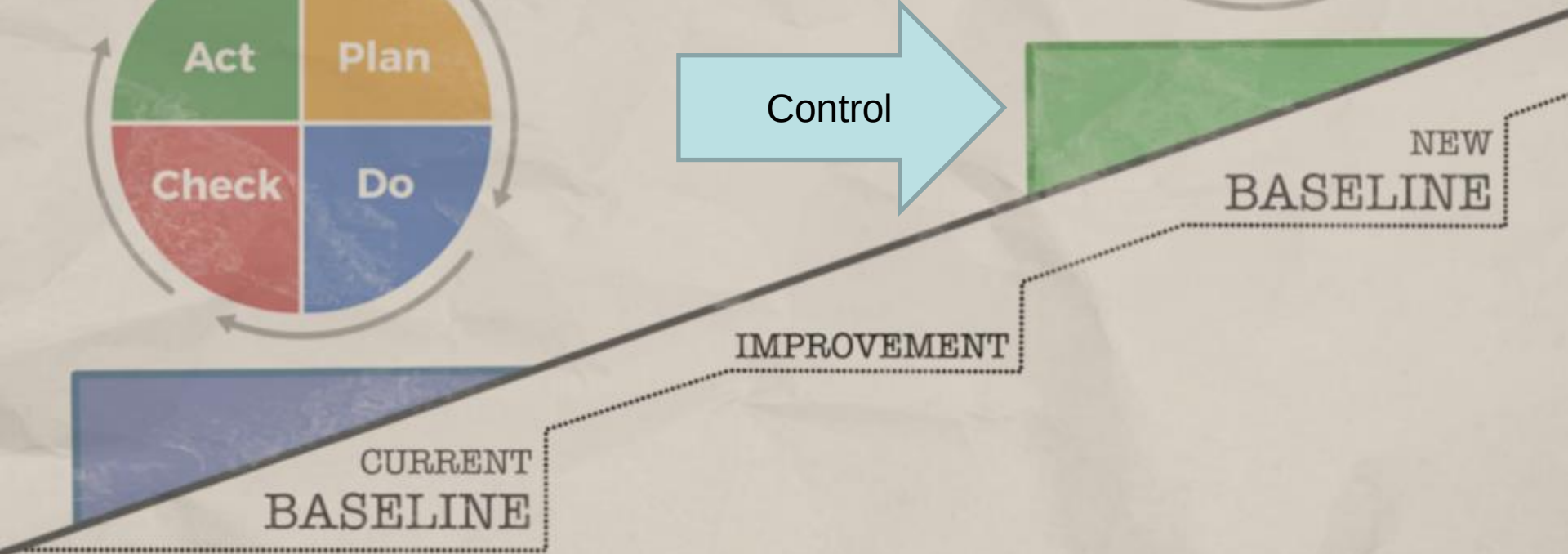
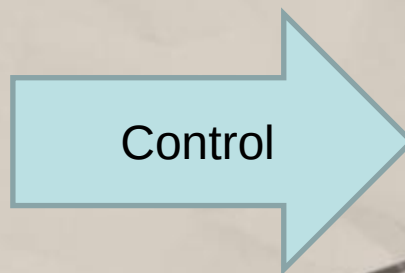




Level 5 – Continuous Improvement with Industry 4.0

Control 2 – Control Charts and Case Studies





- Process Risks
- RPN's



- How to check
- Frequency
- Non-conformance?



- Safety
- Training
- Shopfloor



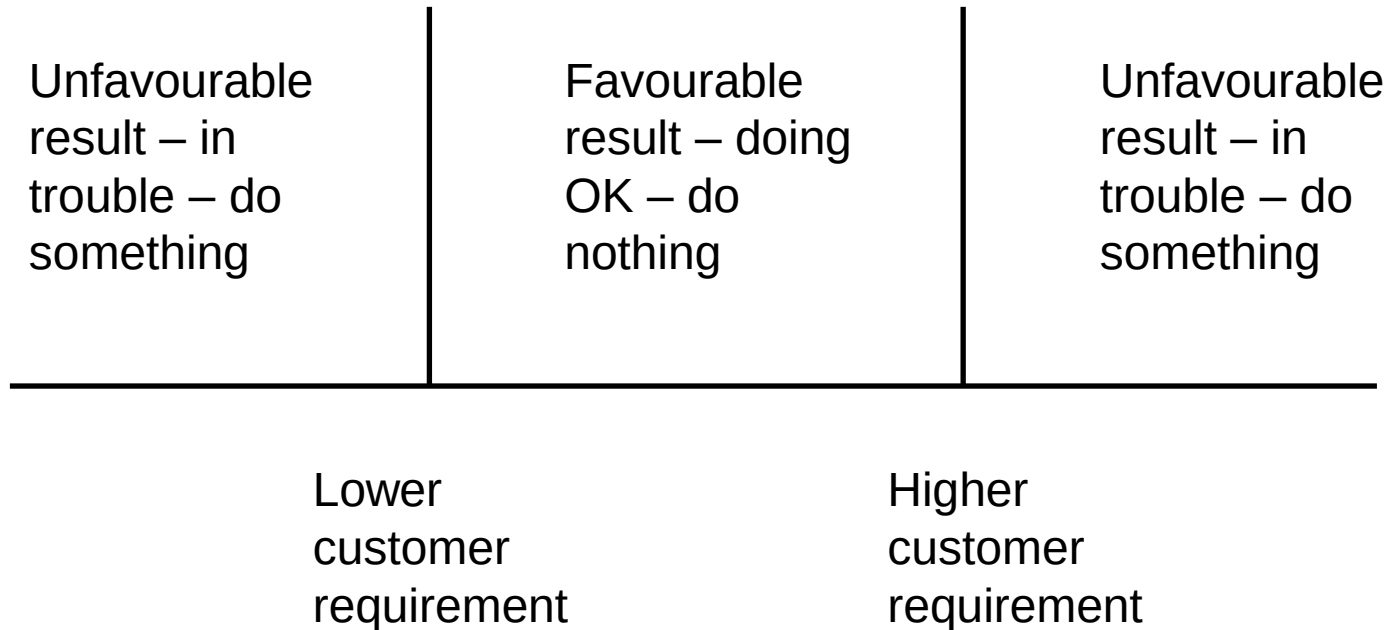
There are two methods for interpreting data within a manufacturing environment:-

The Specification Value approach (VoC)

Shewharts Control Chart approach (Voice of the Process)



The Specification Value approach (VoC)



Measure - Standard Deviation

Consider a sample of 5 data points; 6.5, 7.5, 8.0, 7.2, 6.8

The **Range** is the highest minus the lowest; $8.0 - 6.5 = 1.5$

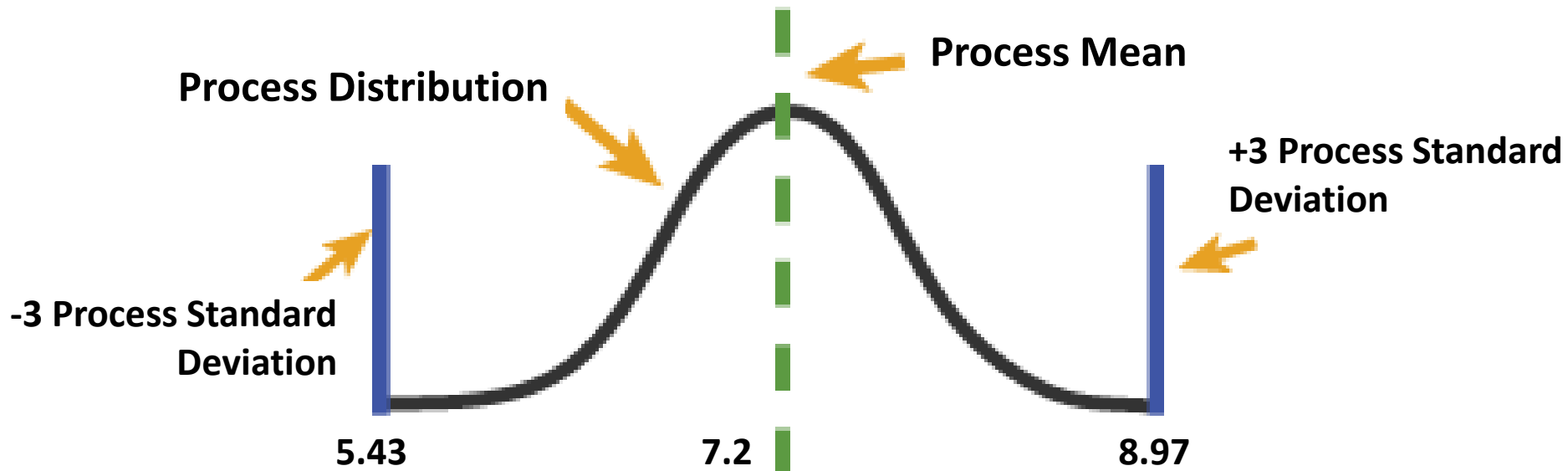
The **Mean** (X-bar) is 7.2

The Standard Deviation is

$$stdev = \sqrt{\frac{(6.5 - 7.2)^2 + (7.5 - 7.2)^2 + (8.0 - 7.2)^2 + (7.2 - 7.2)^2 + (6.8 - 7.2)^2}{5 - 1}}$$

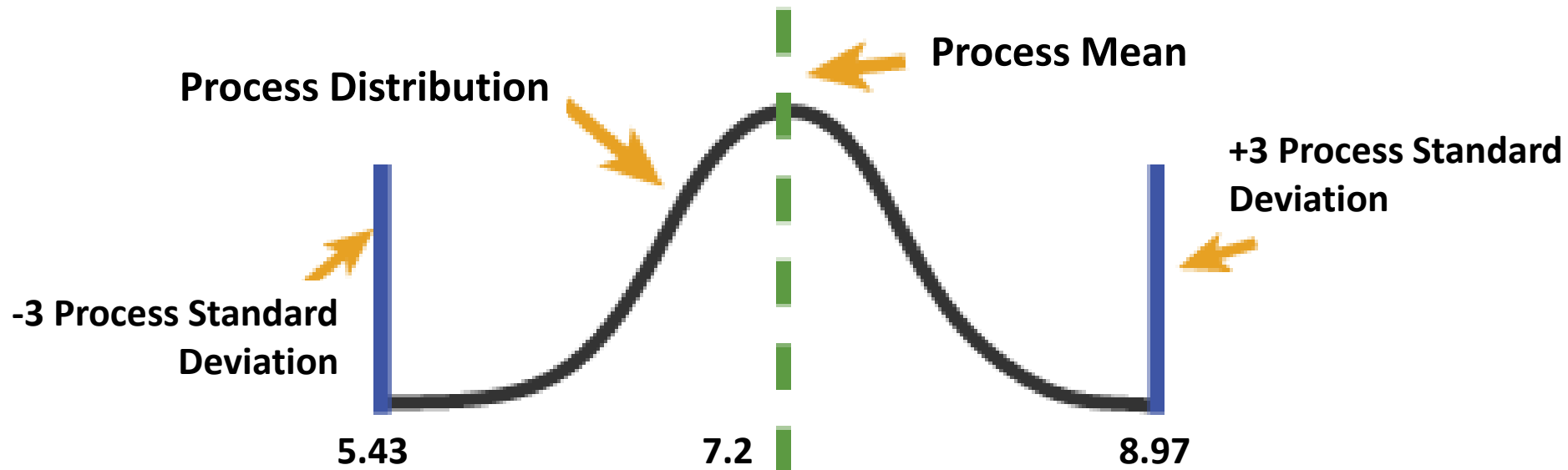
$$stdev = 0.59$$

- Statistical tables have been developed for various types of distributions that quantify the area under the curve for a given number of standard deviations from the mean.
- Shewhart found that control limits placed at three standard deviations from the mean in either direction provide an economical trade-off between the risk of reacting to a false signal and the risk of not reacting to a true signal.



- We want to calculate three-sigma, which is three standard deviations above the mean.
- $3 \times \text{STDEV} + \text{Mean}$
- ***stdev* = 0.59**
→ $(3 \times 0.59) + 7.2 = 8.97$

- The illustration below shows a normal curve for a distribution with a mean of 7.2, a mean less 3 standard deviations value of 5.43, and a mean plus 3 standard deviations value of 8.97. Values, or measurements, less than 5.43 or greater than 8.97 are extremely unlikely.
- These laws of probability are the foundation of the control chart.

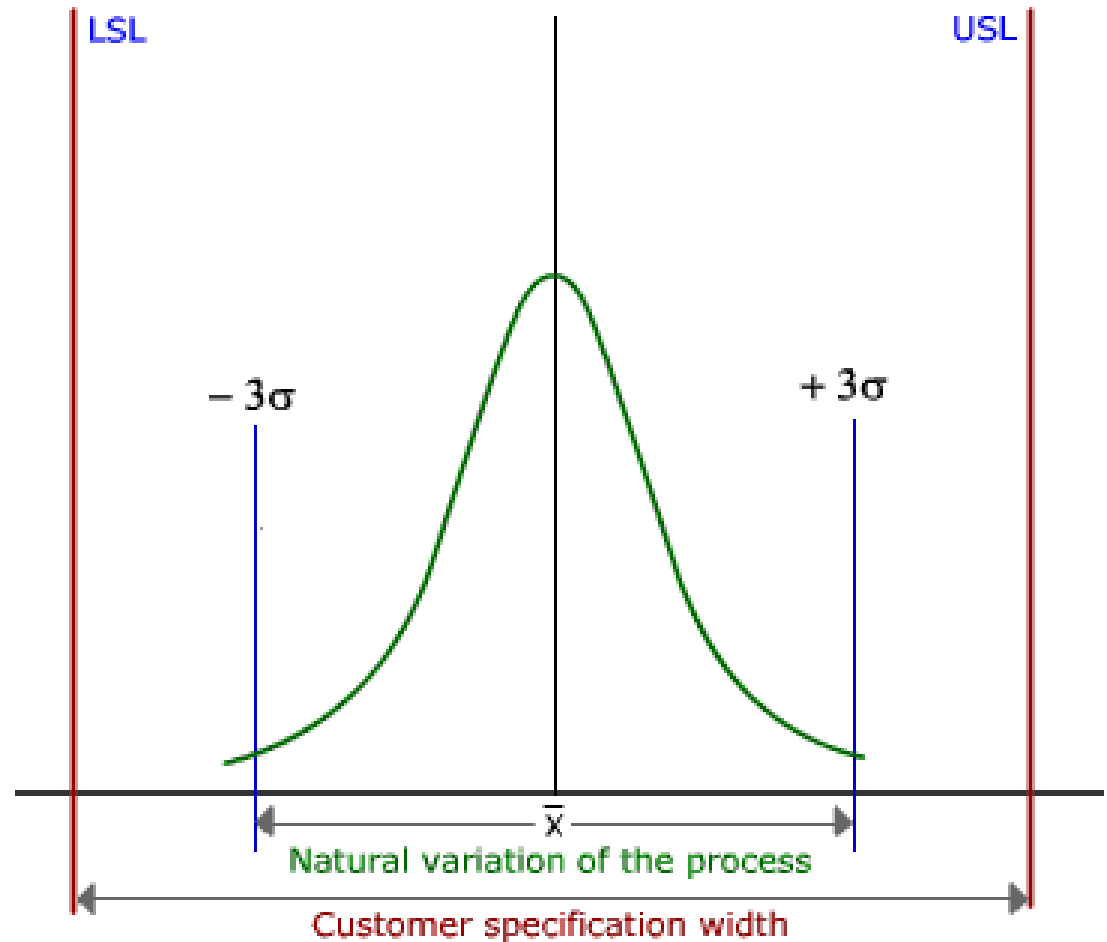


Control limits, are the 'Voice of the Process' Identified as;

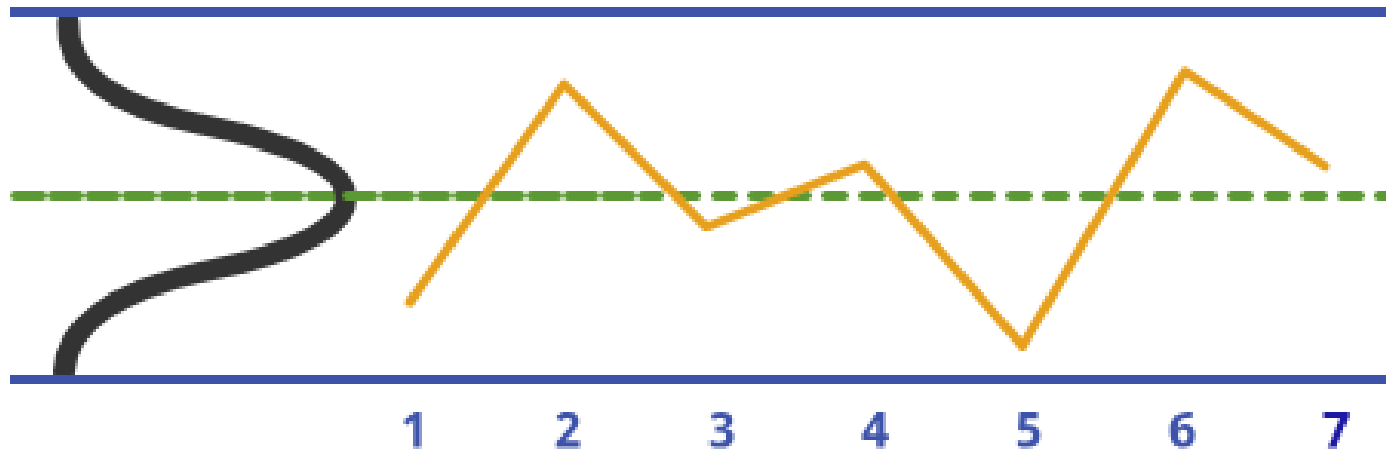
- Upper and Lower Control Limits

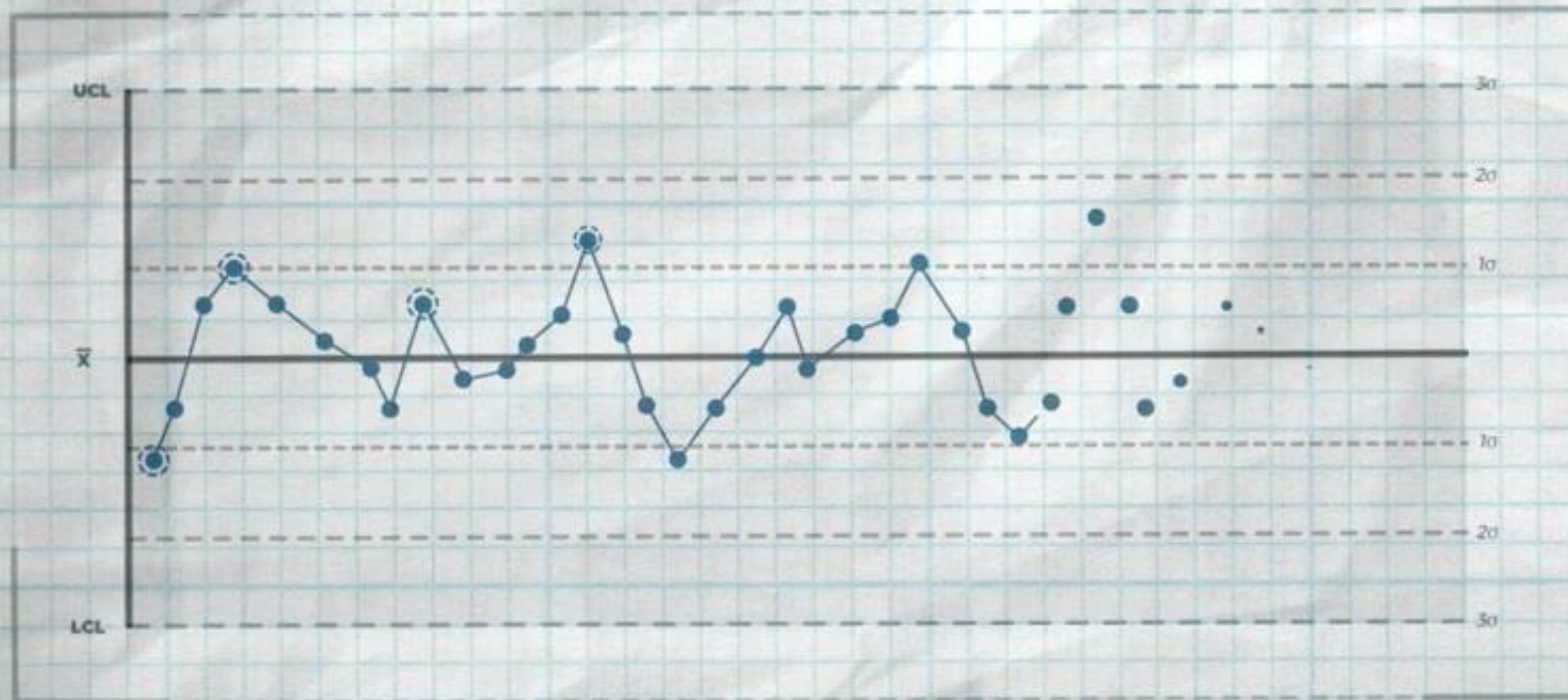
Tolerances are part of the Customer specification, and therefore the 'Voice of the Customer' Identified as;

- Upper and Lower Specification Limits (LSL & USL)



- Consider that the distribution is turned sideways, and the lines denoting the mean and ± 3 standard deviations are extended.
- This construction forms the basis of the Control chart.
- Time series data plotted on this chart can be compared to the lines, which now become control limits for the process.
- Comparing the plot points to the control limits allows a simple probability assessment.





NELSON'S RULES

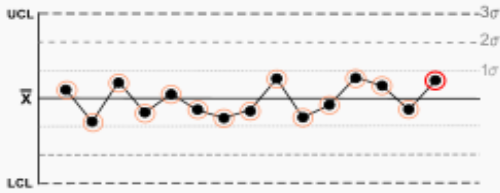
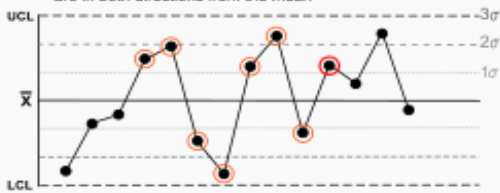
Nelson's Rules 1 to 3

Rule	Description	Chart Example	Problem Indicated
Rule 1	One point is more than 3 standard deviations from the mean.	Rule 1: One point is more than 3 standard deviations from the mean	One sample (two shown in this case) is grossly out of control.
Rule 2	Nine (or more) points in a row are on the same side of the mean.	Rule 2: Nine (or more) points in a row are on the same side of the mean	Some prolonged bias exists.
Rule 3	Six (or more) points in a row are continually increasing (or decreasing).	Rule 3: Six (or more) points in a row are continually increasing (or decreasing)	A trend exists.

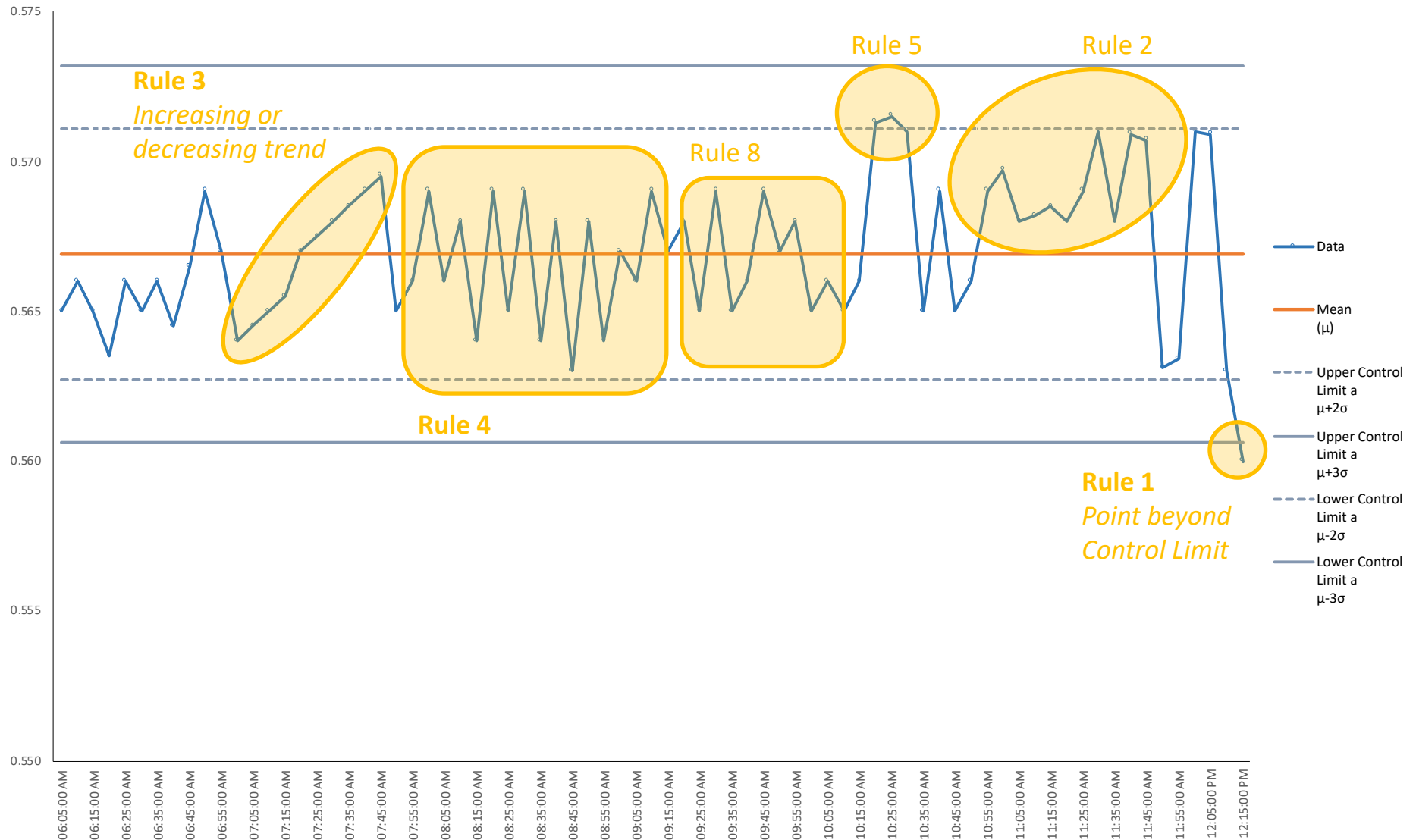
Nelson's Rules 4 to 6

Rule 4	Fourteen (or more) points in a row alternate in direction, increasing then decreasing.	Rule 4: Fourteen (or more) points in a row alternate in direction, increasing then decreasing	This much oscillation is beyond noise. This is directional and the position of the mean and size of the standard deviation do not affect this rule.
Rule 5	Two (or three) out of three points in a row are more than 2 standard deviations from the mean in the same direction.	Rule 5: Two (or three) out of three points in a row are more than 2 standard deviations from the mean in the same direction	There is a medium tendency for samples to be mediumly out of control. The side of the mean for the third point is unspecified.
Rule 6	Four (or five) out of five points in a row are more than 1 standard deviation from the mean in the same direction.	Rule 6: Four (or five) out of five points in a row are more than 1 standard deviation from the mean in the same direction	There is a strong tendency for samples to be slightly out of control. The side of the mean for the fifth point is unspecified.

Nelson's Rules 7 and 8

Rule 7	Fifteen points in a row are all within 1 standard deviation of the mean on either side of the mean.	Rule 7: Fifteen points in a row are all within 1 standard deviation of the mean on either side of the mean 	With 1 standard deviation, greater variation would be expected.
Rule 8	Eight points in a row exist with none within 1 standard deviation of the mean and the points are in both directions from the mean.	Rule 8: Eight points in a row exist with none within 1 standard deviation of the mean and the points are in both directions from the mean 	Jumping from above to below whilst missing the first standard deviation band is rarely random.

Control Chart





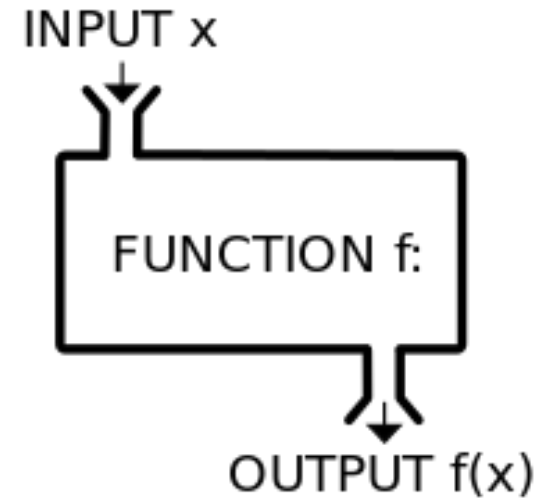
Level 5 – Continuous Improvement with Industry 4.0

Control 2 – Lessons Learnt/Recognition

$$Y = (f) X$$

$$Y = (f) X$$

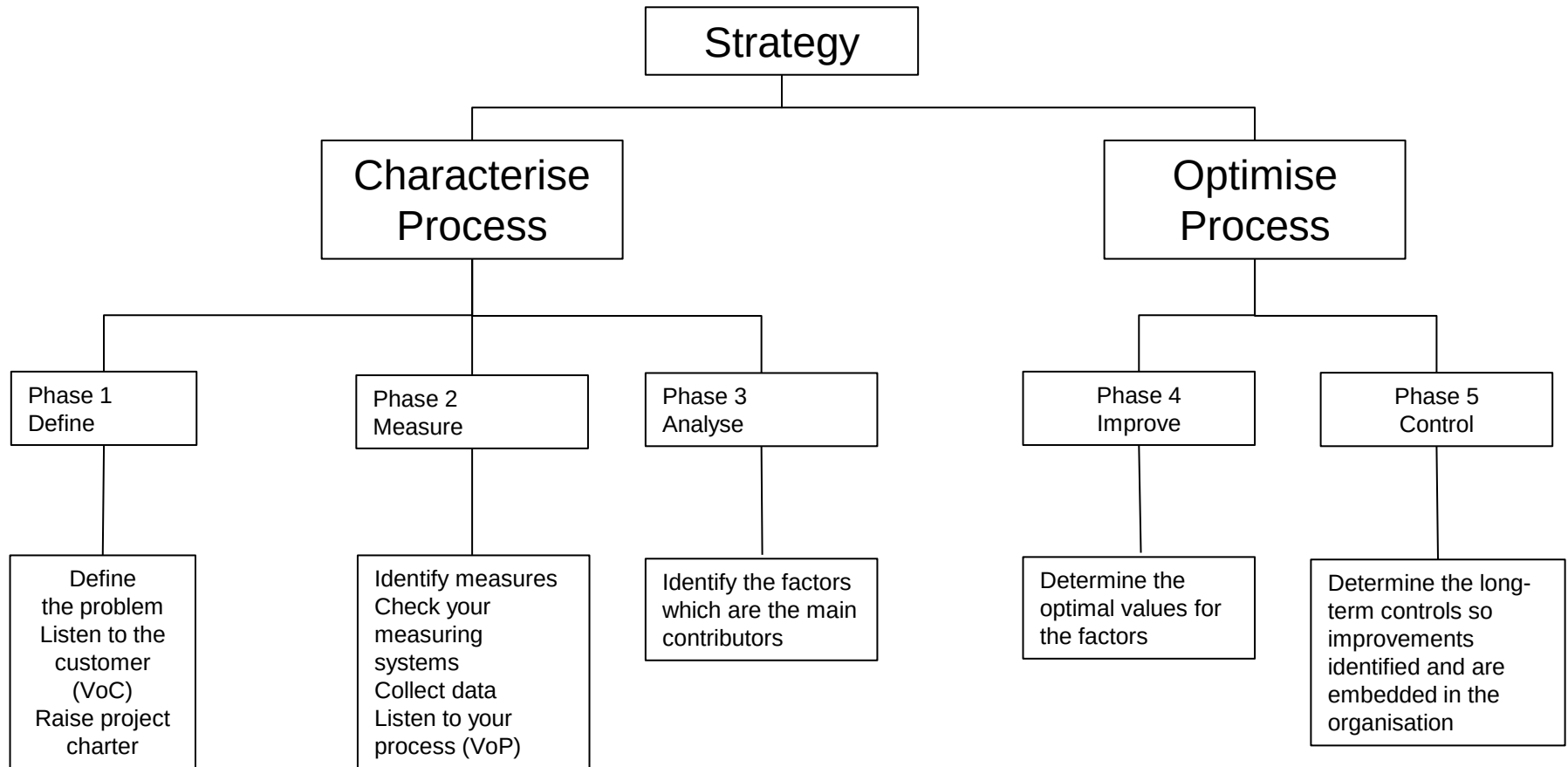
Outcome **Y** = (Function **f**) Output **X**



Level 5 – Inputs/Outputs

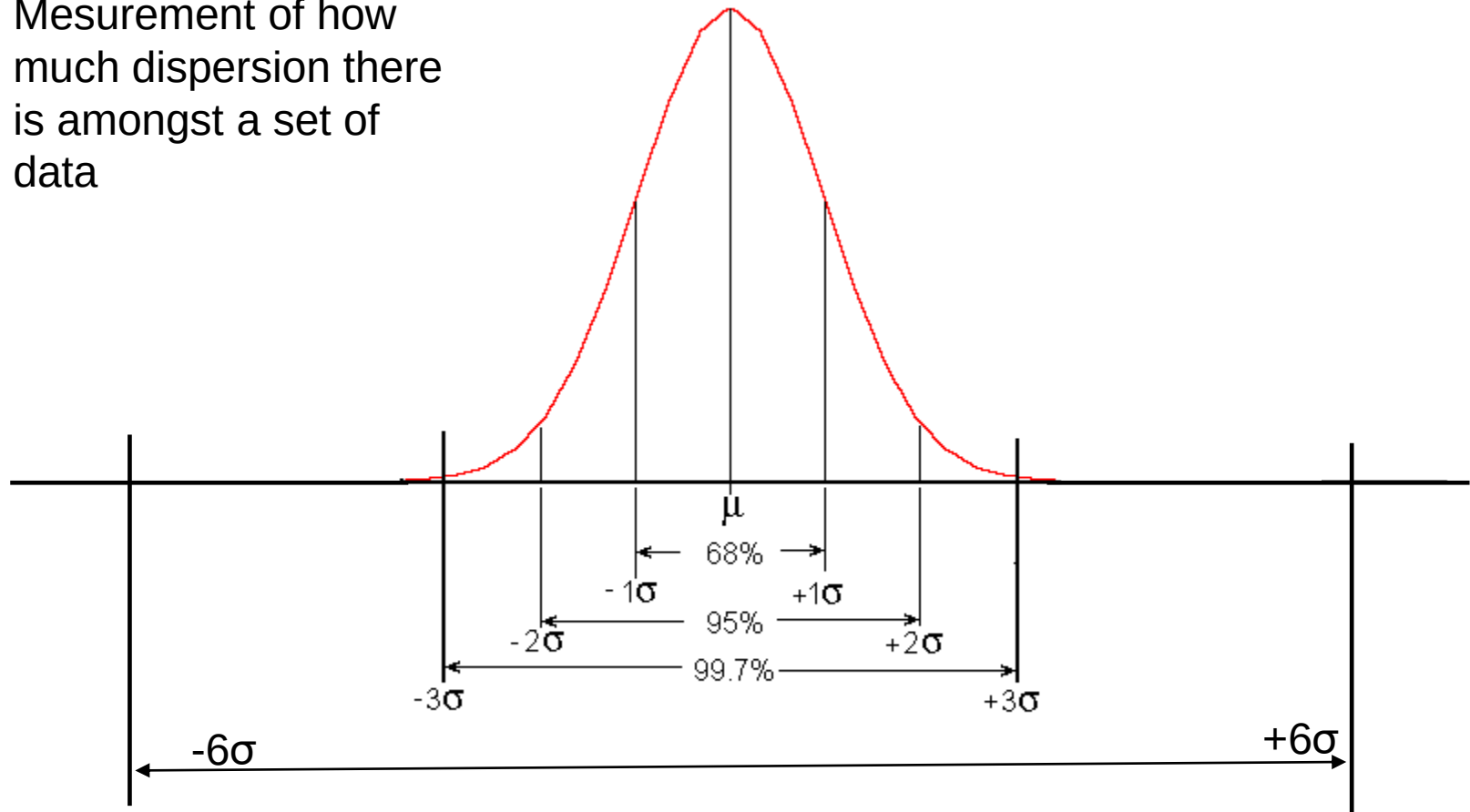
MADE





Level 5 – Capability

σ = standard deviation
Measurement of how
much dispersion there
is amongst a set of
data



99.99966% (3.4 defects / 1,000,000 opportunities)

- Mean, Mode, Median, Range, Variance and Standard Deviation
- Testing for Normality
- 2 Sample T Tests
- Analysis of Variance (ANOVA)
- Correlation
- Regression

Where do we think we are?

- No data or experience – all we can offer is an opinion
- No data – we use our experience to get through
- Some data - data collected we just look at the numbers
- Grouped data - basic charts and diagrams
- Descriptive statistics - mean, median, mode, Std Dev etc
- Characterising statistics - Cp, Cpk,
- Control statistics - SPC charts
- Inferential statistics - normality, regression, DOE etc

- Review the project
- Did the results meet the aims/targets of the project charter?
- If not, what were the issues around this
(i.e. scope, timings, resource allocation,
buy-in, application of tools, skills gap,)
- What will we do differently next time?

- Sometimes a simple verbal thank you will do
- An E-mail to the recipient will can be a more formal way of communicating – cc their boss too!
- Larger projects may require a more appropriate event
- Communicate success to the larger work environment – fly sheets, newsletter etc
- Don't forget it is always about people and how we interact and treat each other

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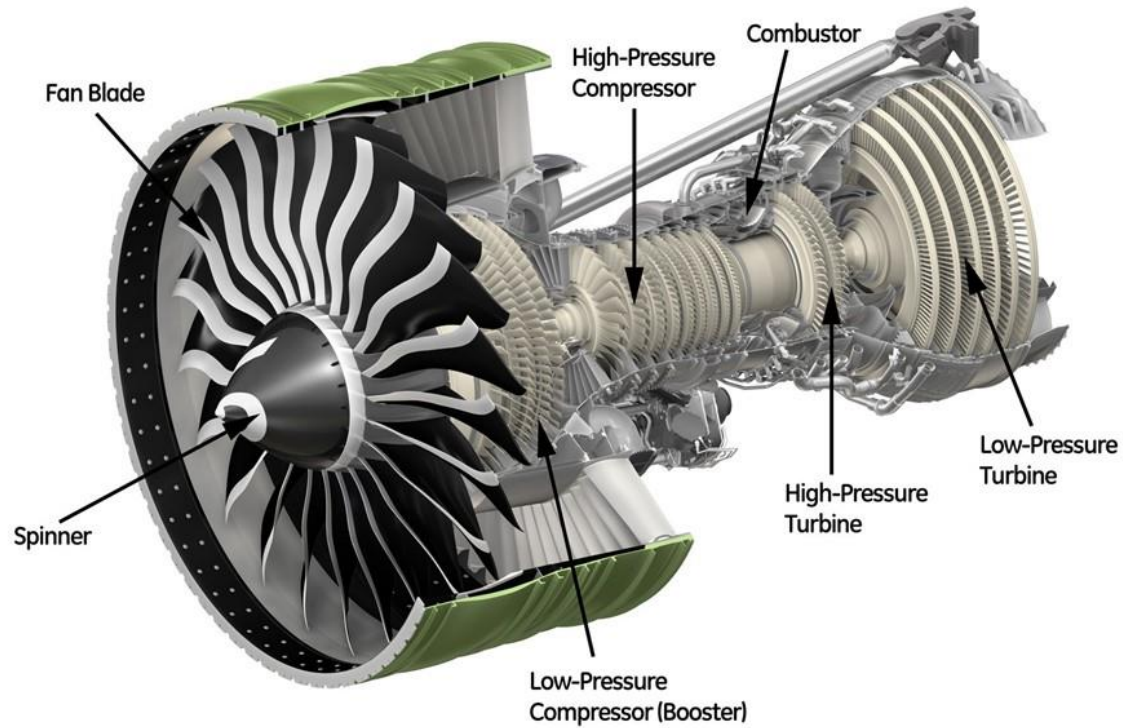




Level 5 – Continuous Improvement with Industry 4.0

Control 2 - Case Studies

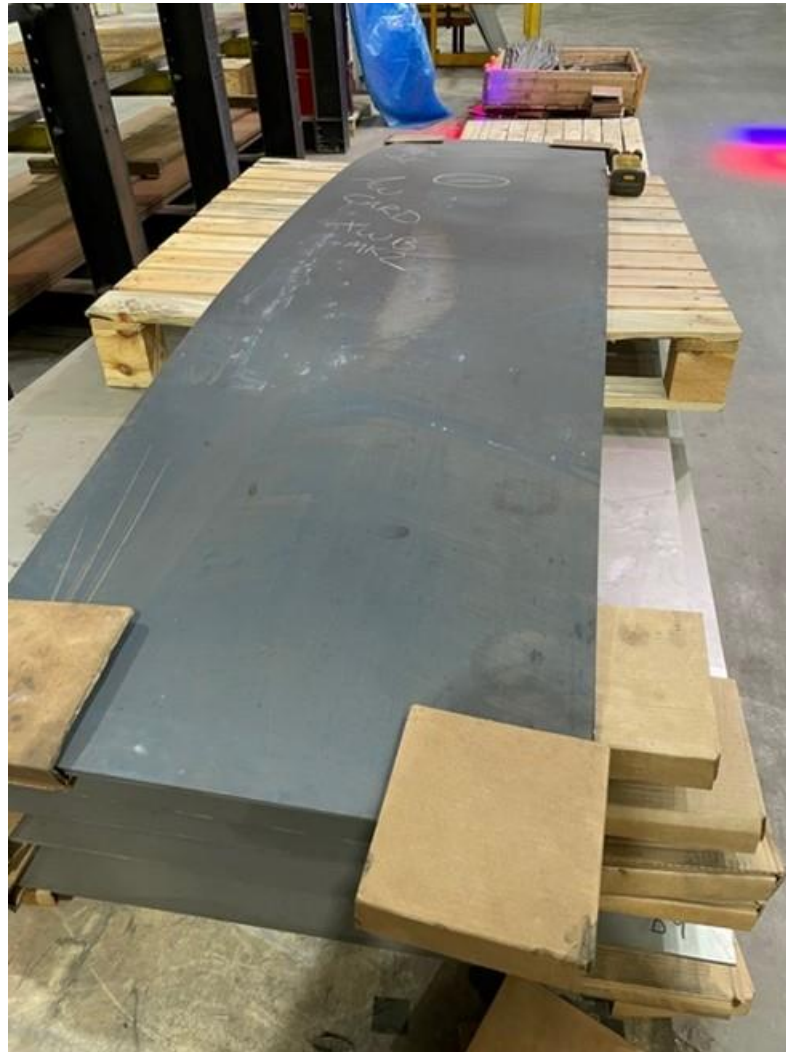
Control Chart – Case Study



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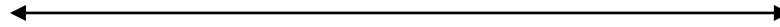
- Component sheared to length/width from mother-sheet
- 4 more value added processes undertaken until final inspection
- Approximately 10% of products rejected at FI for under- length/width (over-length/width may be re-sheared to size)

Control Chart – Case Study

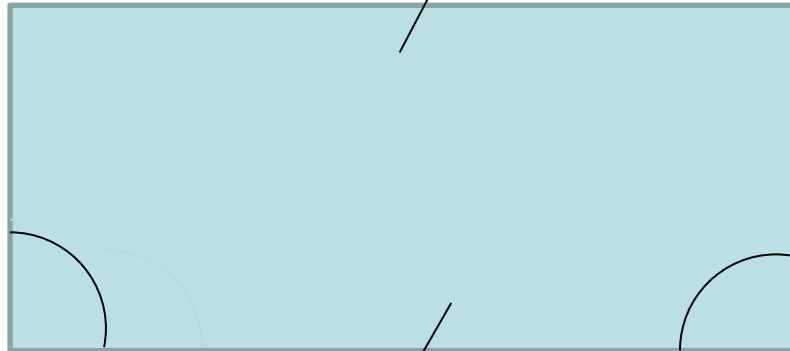


Control Chart – Case Study

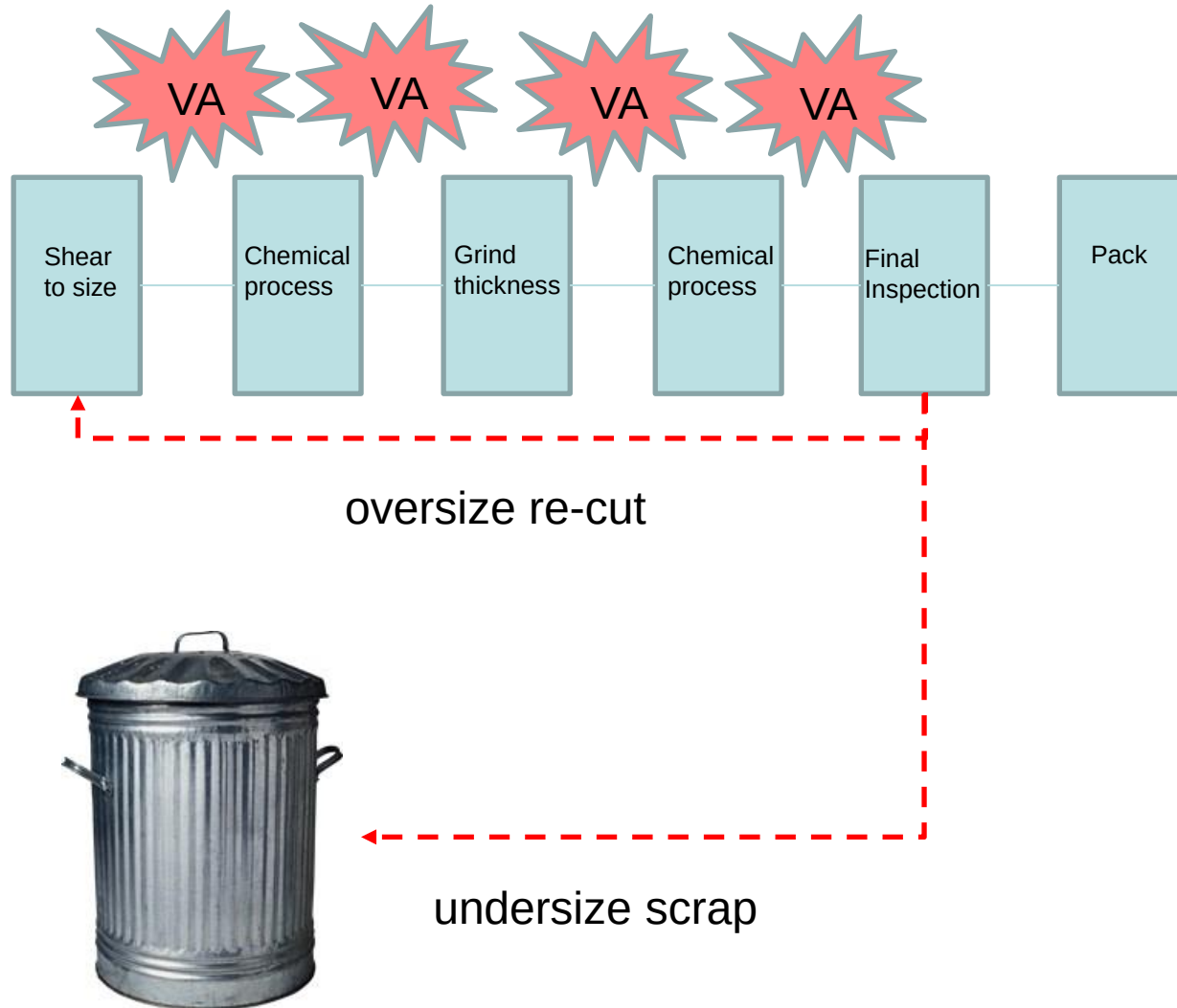
Length typically 850 -1200mm +/- 1.0



Width typically
500 - 600 mm +/-
1.0

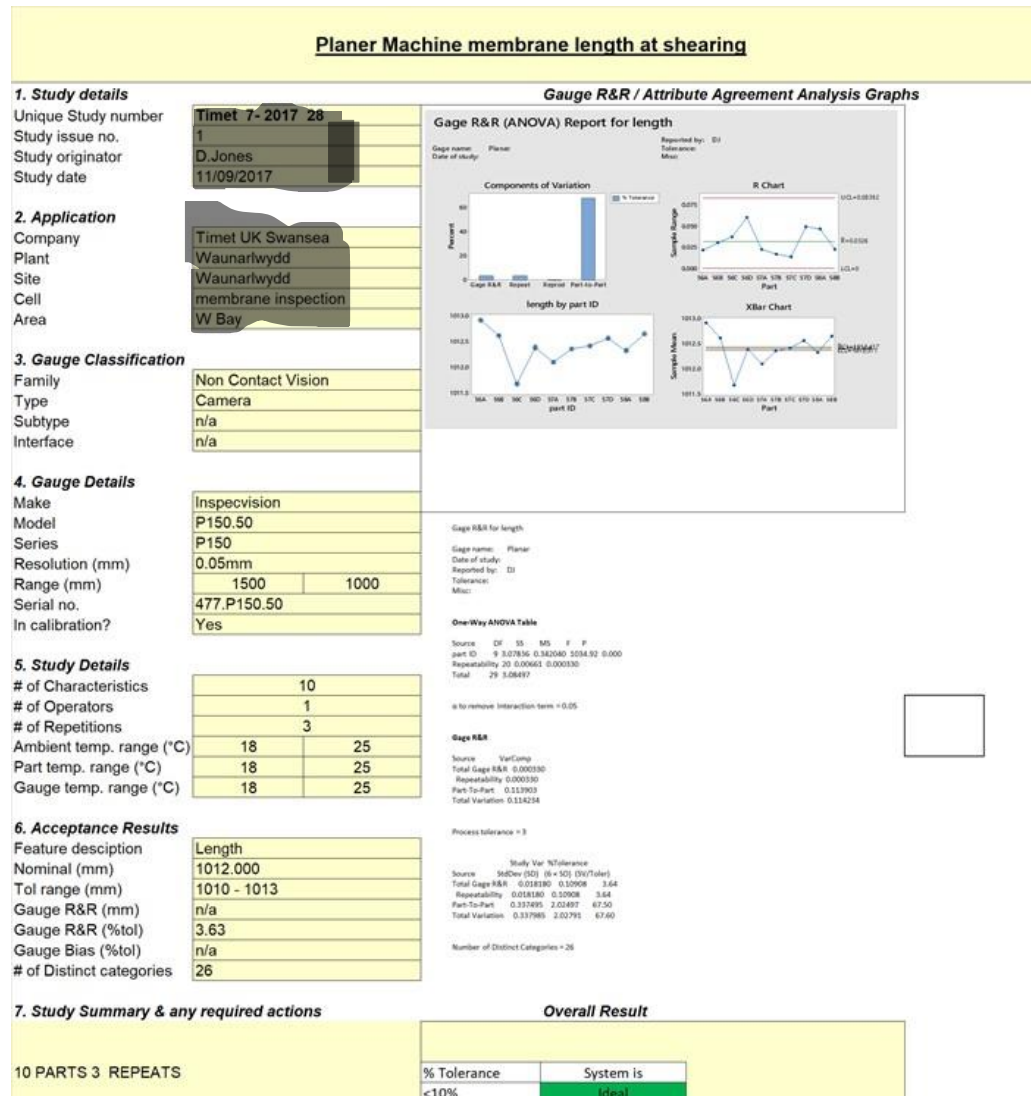


Control Chart – Case Study



- Capital case approved for new shears and visual inspection system to confirm conforming dimensions
- System commissioned and MSA undertaken on all key process characteristics
- Final Inspection of these characteristics removed

Control Chart – Case Study

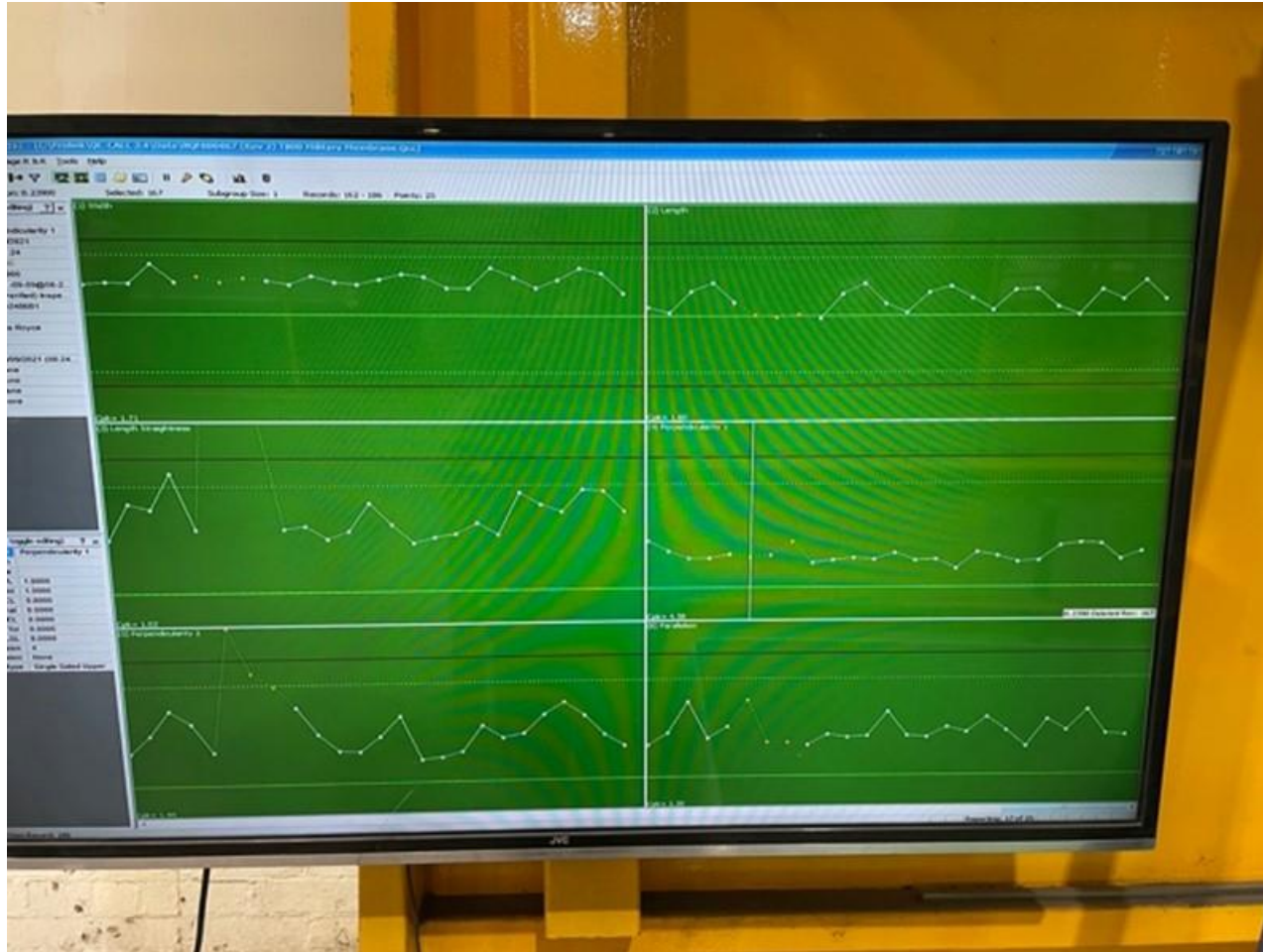


Control Chart – Case Study



- Only one mother-sheet sheared before measuring the two child panels
- Final inspection of the characteristics removed from final inspection – now only gauge and surface finish checked
- Automatic report generated for each panel
- Process control visible to all walking through the bay

Control Chart – Case Study



Six Sigma Project

Ferrous Sulphate Weigh feeder



Overview

Ferrous sulphate is a additive in the production of cement and is used to reduce the chromium content. High levels of chromium can cause dermatitis if the cement is handled.

A loss in weight screw feeder is used to deliver the quantity of ferrous sulphate dependant on Clinker federate

The system was original designed for powder and due to shortage of supply we are now having to run a higher concentration granule material. Since this change the feeder has been unreliable and inaccurate. For this reason we have been adding tin chloride which is a substitute to ferrous sulphate but is at a much higher cost.

Project Charter

Problem Statement and area of Opportunity

Ferrous Sulphate is an additive in the cement manufacturing process to reduce chromium. The material has change concentration and has gone from a power to a granular. Due to this the feeder has become unreliable and an alternative additive tin chloride is being used at a higher cost. Increase the reliability of the feeder so that ferrous sulphate can be used and improve the reliability of the feeder to ensure the minimum ferrous is used to achieve the chromium levels required.

Business need and justification

Production of cement cost too high. Substantial saving can be made if ferrous sulphate is used.

Risks and Issues

Unable to meet the deadline of April due to part delays (Covid)
Quality risk if chromium levels are not met. (Fines & reputation)
Cost of cement too high

Assumptions and Dependencies

All chemistry data is available
Assume the ferrous concentration will stay consistent
The Cement mill runs with no downtime
Cost of the Ferrous Sulphate and tin chloride doesn't change

Project Ownership / Approval

Project Manager Mike Jones

Project Champion

Approval Date

Project Number

Process Owner Hanson

Financial Benefits / Timing

Financial Benefits		
	Goal	Actual
Payback Period (yrs.)	1m	1m
Annual Savings		£414,108

Estimated Expenses / Investment		
	Goal	Actual
Parts to improve the reliability of the feeder	£5k	£6,359
Cost of contactors	£2k	£789

Schedule		
	Goal	Actual
Measure	28-Jan-22	29-Apr-22
Analyse	25-Feb-22	29-Apr-22
Improve	25-Mar-22	29-Apr-22
Control	22-Apr-22	06-May-22

Project Team

Supplier Representatives		
Name	Supplier	Title
N/A	N/A	N/A
N/A	N/A	N/A
N/A	N/A	N/A
N/A	N/A	N/A
N/A	N/A	N/A

Internal Team		
Name	Function	Role
Mike Jones	Electrical	Electrical sup
Andy Fairhurst	Mechanical	Mec. Team lead
Paul Anderson	Process	Cement Eng.
Chris Jones	Quality	Quality Man.

Customer Representatives		
Name	Cust.	Title
Michael Worrall	Rospen	Engineer
N/A	N/A	N/A
N/A	N/A	N/A
N/A	N/A	N/A
N/A	N/A	N/A

SIPOC

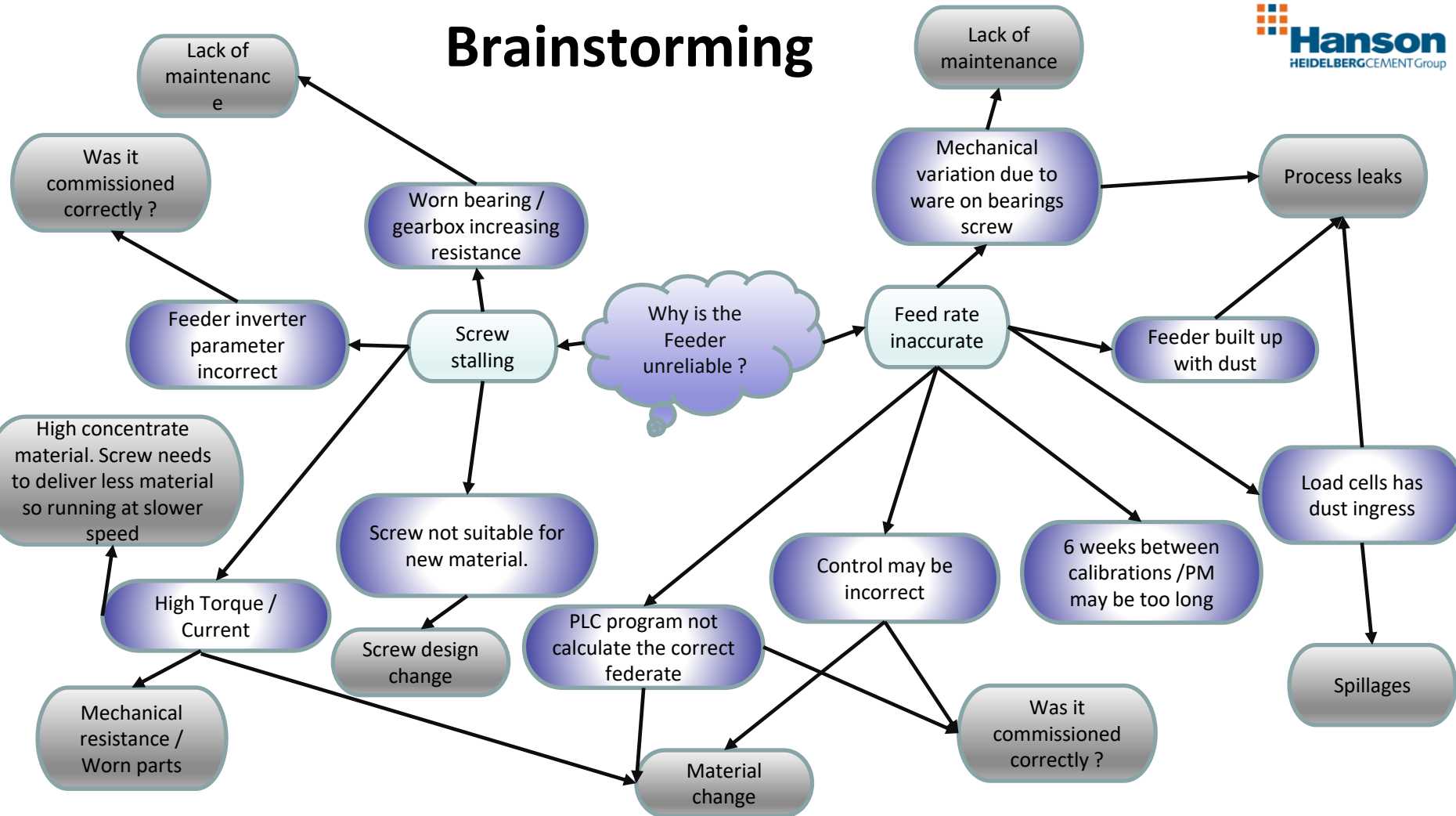
Suppliers	Inputs	Processes	Outputs	Customers
Who supplies the process inputs?	What inputs are required?	What are the major steps in the process?	What are the process outputs?	Who receives the outputs?
Process Control				
Ferrous supplier	Delivery request from levels in silo	Ferrous sulphate is delivered to site and blown into silo	Silo is filled ready for adding to the process	Hanson
	Day bin level low. Request to fill	When the feed bin calls for material, the sluice starts and fills the bin to the set level	Day bin is filled to high level	Hanson
Hanson	Mill federate setpoint	Screw feeder set point generated as a percentage of clinker feed rate.	Kg/h setpoint for feeder	Output is input into the PLC control
	Kg/h setpoint	Software control to calculate the VSD speed setpoint from the Kg/H setpoint.	Setpoint is sent to VSD and adjusts the speed of the screw	
	MV excitation voltage from the bin loadcell scaled to Kg	Kg loss is measured over a fill cycle to calculate the amount federate	Kg/h actual reading.	
Hanson	Ferrous is screwed into the inlet of the mill.	Ferrous is ground with the other materials in the charge mill	Cement is transported to silo	Customer
Hanson	sample of cement is taken to the lab	Lab test for chromium levels	Percentage of ferrous is altered to adjust chromium levels	Quality standards are met for customer
Maintenance				
Hanson	SAP requests PM to maintain the feeder.	PM is put in planning process.	Time and labour allocated to perform PM	Planning department
Planning department	Pm scheduled and machine down ready for PM work	Feeder is cleaned and inspected.	Cleaning will alter the load on the cell altering the calibration	
	Clean screw feeder that has been inspected for sign that would affect the calibration.	Tare the feeder and span with 20KG weight. Accuracy of 1 %	Bin is calibrated to ensure feeder is reading accurately	Production
Hanson	Data collected from PM	Records updated to make production aware of how the correction will <u>effect</u> quality.	Federate of ferrous adjusted if any major adjustments have been made.	Quality improvement and potential cost saving.

Cost saving when using Ferrous sulphate instead of tin chloride

Material	Cost	Quantity per tone of cement	Cost / tonne
Tin chloride	£7870/ 1000 liters	250ml	£1.97
Ferrous sulphate	£663 / tonne	1.2 kg	£0.76

Additive	Federate (t/h)	Cost / h	Cost /day	Cost/week	Cost/year
Tin chloride	45	£88.65	£2,127.60		
Ferrous sulphate	45	£34.20	£820.80		
				Cost saving	

Brainstorming



Reliability root cause

First we had to get the feed screw operationally and look in to each possible cause more in depth to find the root cause of the problem. We took the possible causes from the brainstorming session and drilled down further down to disregard or confirm the root cause.

- Mechanical issue with the screw/drive which was increasing load on the motor.
- Motor not set up correctly in the inverter or connected incorrectly.
- Fault with motor
- Motor running too slow due to the introduction of new material.
- Screw not suitable for new material increasing load.

First task was to clean the feeder and area and ensure lighting and any leaks where addressed prior to any inspections or tests.

Evaluating each possible root cause

Mechanical issue with the screw/drive

- Gearbox inspected and oil level checked
- Bearing inspected for wear on the motor, gearbox and screw and greased.

Faulty wiring
All turning easily by hand showing no signs of resistance.

- Motor winding were checked to ensure each winding was the same resistance. (Balanced)
- Insulation resistance test carried out to ensure the motor wasn't breaking down under load down to earth or between windings

Motor not set up correctly in the inverter or connected incorrectly

- Inverter motor settings was checked in the ACS 550 inverter (parameter 99). An ID run was also carried to ensure the drive in was set up for the specific motor . Connection and wiring was check . Insulation resistance of the cable from the inverter to the motor was also check for any breakdown of insulation resistance .No issue found.

Screw delivery test

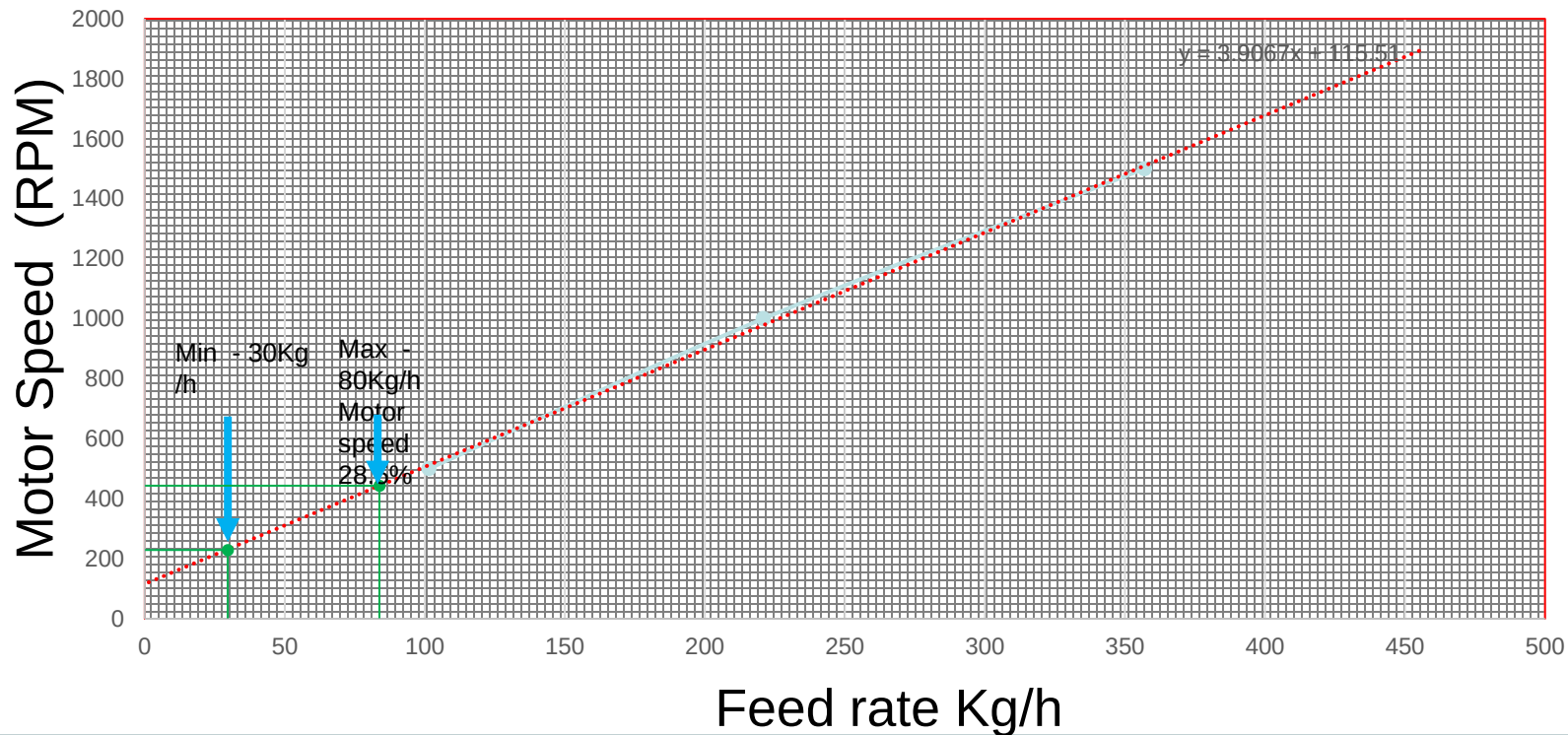
Motor running too slow due to the introduction of a higher concentration material.

An experiment was carried out to determine the feed rate of the screw across its speed range. 10min samples were taken at 3 different fixed speeds. The samples were taken and weighed on a calibrated scale and the feed rate calculated.

The feeder needs to deliver between 30 – 80 Kg/h dependant on the clinker setpoint

Time (m)	Motor speed (RPM)	Gearbox	Screw speed (RPM)	Weight delivered (Kg)	Weight delivered (Kg/h)
10	500	20.1	25	16.9	101.4
10	1000	20.1	50	36.8	220.8
10	1500	20.1	75	59.5	357

Ferrous Sulphate Feed rate Kg/h vs motor speed RPM



Screw delivery outcome

From the motor data sheet the frequency range of optimum torque when driven by a VSD was 25-50Hz. Which is between 50-100% motor speed. By using the screw speed required the gearbox ratio was calculated to ensure the motor was running in this optimum speed band for the desired federates.

Feed rate Kg/H	Gearbox ratio selected	Screw speed(RPM)	Actual motor speed at feed rate (RPM)	Motor Speed (%)
30	70.1	11.6347	814.43	54.30
80	70.1	21.3997	1497.98	99.87

Is material causing more resistance

?

Screw not suitable for new material increasing load.

- A test was carried out to determine what current the motor was drawing over it speed range to see if the motor was getting

Motor Speed %	Motor Speed RPM	Gearbox ratio	Screw speed	Screw motor current	FLC (A)
10%	150	20.1	8	4.5	1.1
20%	300	20.1	15	4.5	1.1
30%	450	20.1	23	4.5	1.1
40%	600	20.1	30	4.4	1.1
50%	750	20.1	38	2.3	1.1
60%	900	20.1	45	2.5	1.1
70%	1050	20.1	53	2.6	1.1
80%	1200	20.1	60	2.7	1.1
90%	1350	20.1	68	2.4	1.1
100%	1500	20.1	75	2.3	1.1

From the data gathered it can be see that the motor is pulling to much current across the speed range and if it was solely down to the motor turning too slow the current should have reduce below FLC at higher speeds.

The motor shouldn't draw motor than FLC as the VSD should limit the output. The max current was set at 4.5A and suspect this was done to try and get the motor to run but would lead to premature failure of the motor.

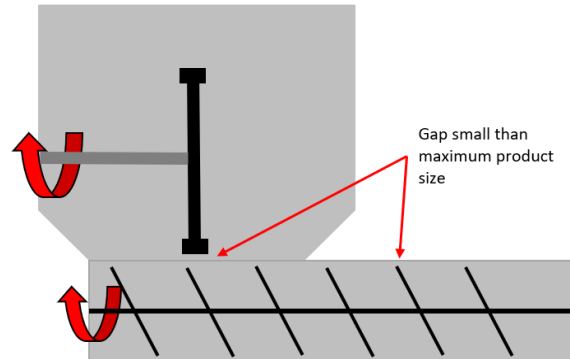
Material suspected issues

Suspect problems with granular material

- The gap between the screw casing and the screw too small allowing granules to jam.
- Gap between the agitator and the screw too small having the same effect

Sample testing

- Rospen carried out material sample test to ensure the screw and agitator was suitable for the application.
- The result confirmed the suspicion and the screw casing was replaced so the scraper was also replaced for the application.
- Same size s



Retest motor current when delivering material.

Once the new screw was install with the new gearbox a the test was carried out again to confirm the motor is not being overloaded and pulling less than FLC.

Motor speed	Motor Speed RPM	Gearbox ratio	Screw speed	Screw motor current	FLC (A)
10%	150	70.1	2	0.8	1.1
20%	300	70.1	4	0.8	1.1
30%	450	70.1	6	0.8	1.1
40%	600	70.1	9	0.8	1.1
50%	750	70.1	11	0.8	1.1
60%	900	70.1	13	0.83	1.1
70%	1050	70.1	15	0.85	1.1
80%	1200	70.1	17	0.89	1.1
90%	1350	70.1	19	0.89	1.1
100%	1500	70.1	21	0.91	1.1

Overview chromium content in cement

- The max limit of chromium in cement is 1ppm. This is a legal requirement so it cannot get higher.
- Reducing chromium lower than 1 has no benefit and is just extra cost of ferrous sulphate not required. (Waste)
- To measure chromium a Cement sample must be analysed in a lab.
- During the test there is a risk over having chromium level too high. This is being controlled by the quality department and as long as it is monitored cement can be blended before going out to the customer.

Running test of the control process

Test to check the process controls

Variable measured

- Chromium content
- Ferrous sulphate setpoint
- Ferrous sulphate actual

Fixed

- Clinker federate 40t/h

Sample

- Sample data every 4 hours for 7 days (running hours)

Prior to the test the feeder was cleaned and calibrated following the Hanson procedure.

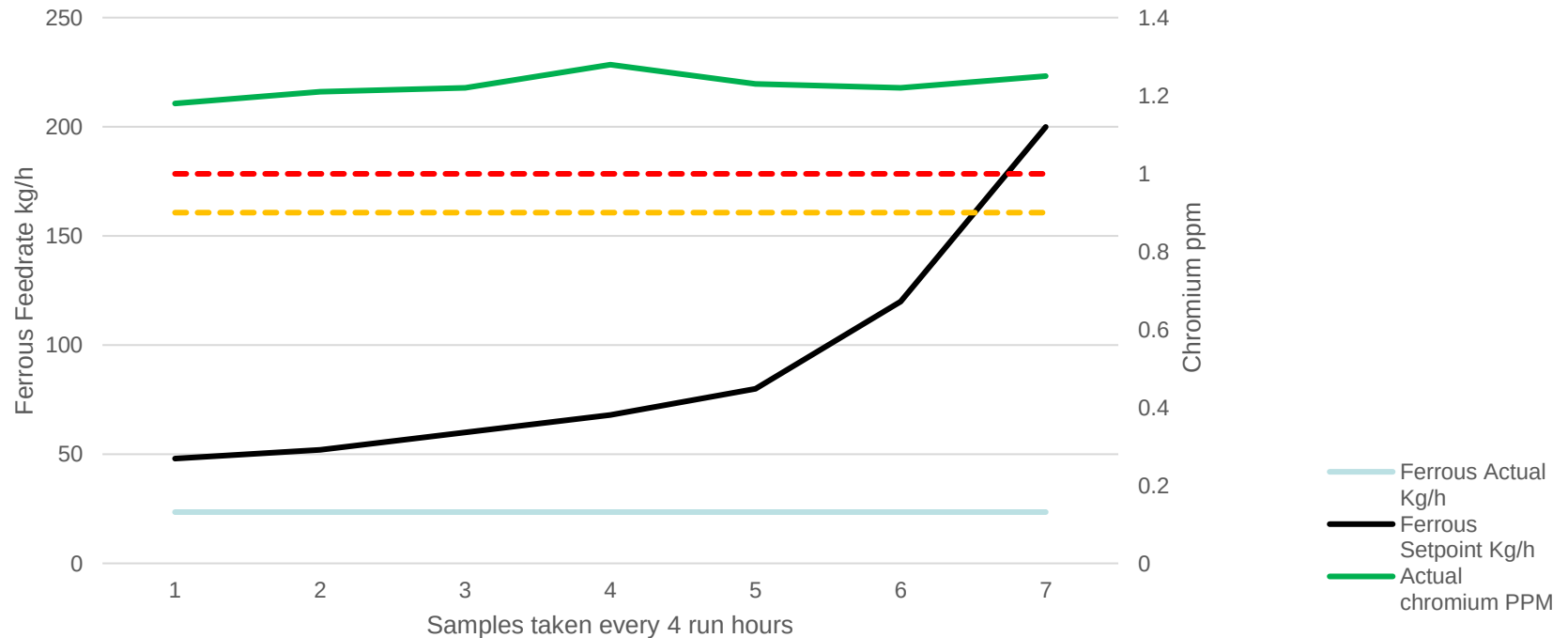
Test 1

The test was cut short as it was obvious from the data the setpoint has no affect on the actual federate and the level of chromium was too high.

The actual clinker federate was set at 48 Kg/h which equates to 1.2Kg / t of clicker with a set point of 40t/h

The operator increased the setpoint to 200 kg/h with no significant change in chromium content and the actual federate didn't change from 23.5Kg/h

Accuracy of the Ferrous feeder

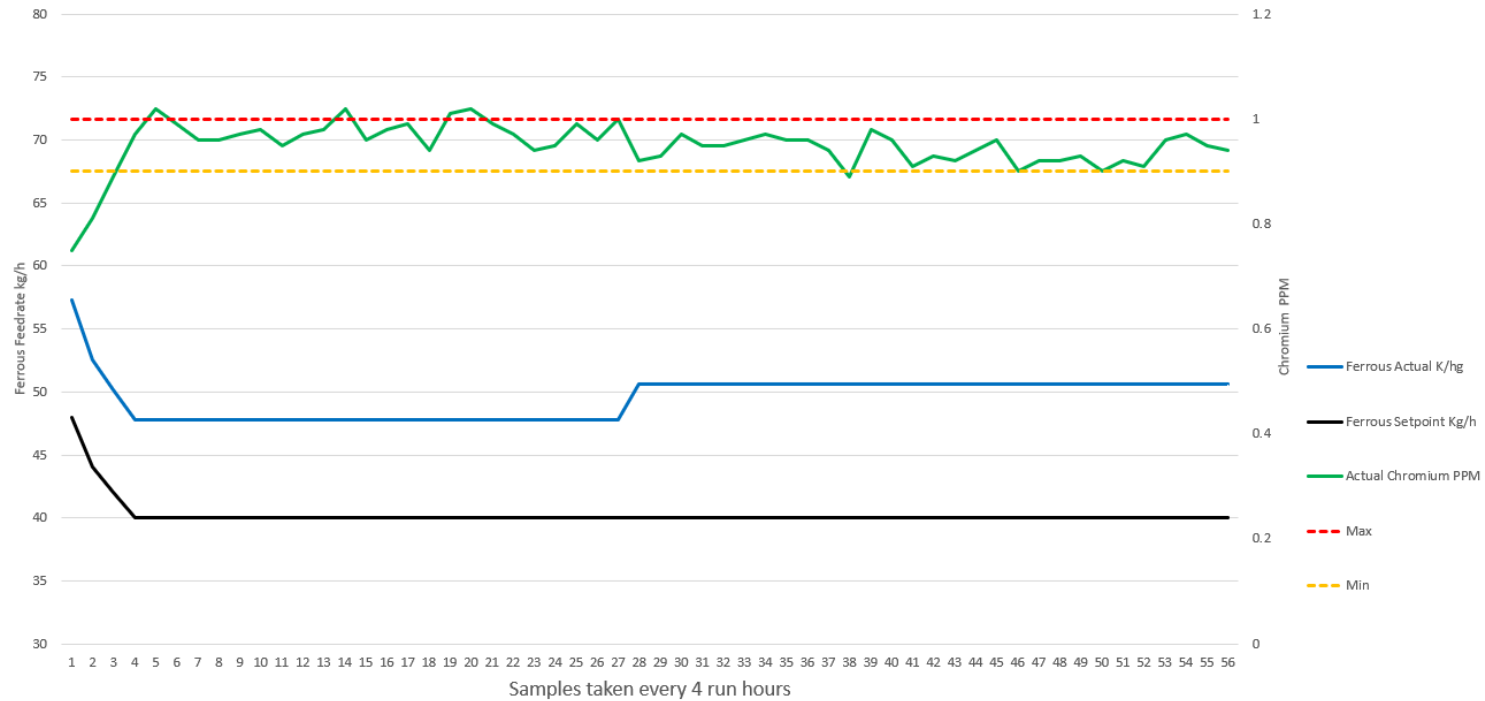


Test 1- Analysis and corrective actions

The control of the system was none existent so the PLC logic was analysed to find the cause of the problem. The control of the screw was forced out causing the feeder to deliver a continues output of 23.5Kg/hr. There was comment in the logic that it was ~~put in for same test~~ out with the force remove.

1. It was found that there was step difference between the actual and the setpoint of ferrous sulphate federate.
2. Between sample 27 and 28 there was a step change in the federate but with no significant step change in the chromium content indicating that it was not an actual change.

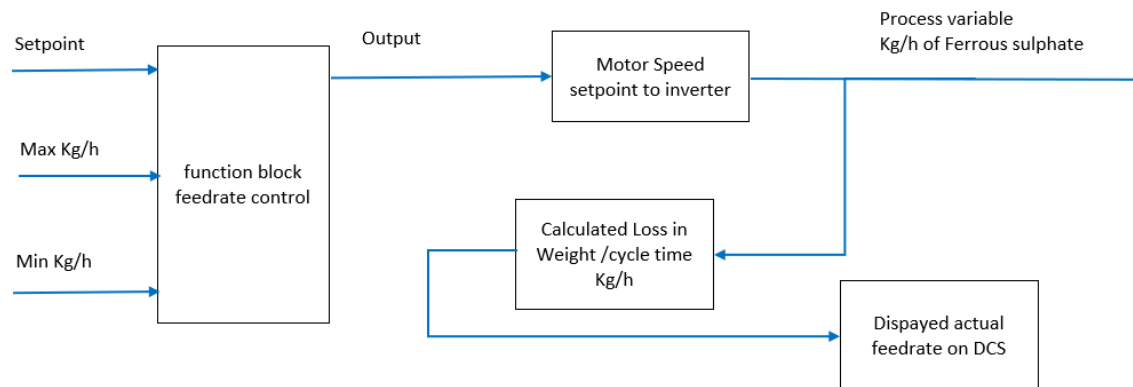
Test two control chart



Analysis and improvements of feeder control

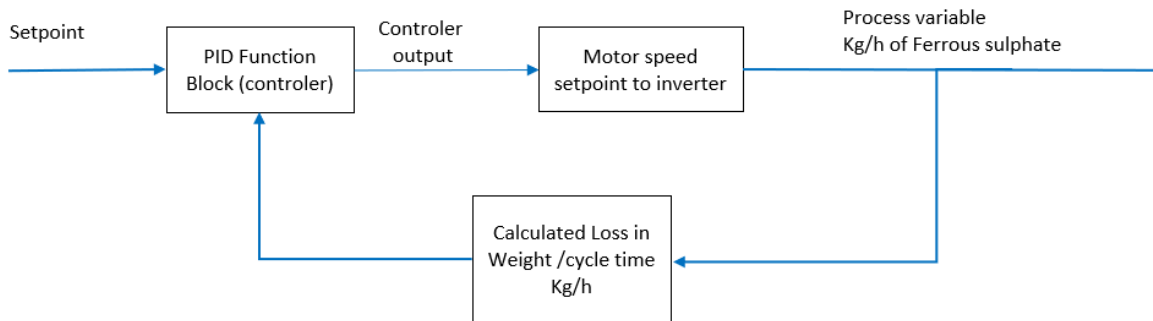
Test 2- Analysis and improvement

1. The PLC logic for controlling the setpoint of the screw was analysed and the Setpoint was directly proportional to screw speed and was not governed by weight at all



Accuracy of the Ferrous feeder

New control process



Analysing the Data

2. Feedback step change.

Looking back at the production log between sample 27 and 28 the machine was down for maintenance and the ferrous feeder was calibrated.

Equipment issue

The feeder was ran empty and load cells checked for any signs of damage or impingement that would cause a problem. The feeder was also physically checked for build-up inside but all was as expected.

Calibration issue

The procedure on the WO was looked at and the instruction to zero and span the feeder was clear and what test weight was to be applied and also for it to be checked in the settings prior to calibration. What it didn't stat is where to apply the weight.

Calibration experiment

If the calibration wasn't accurate then this would allow for variation in the feedback and control making it run

Test was carried out to check the accuracy of the calibration and ensuring it is repeatable with in 1% tolerance every time. (site standard)

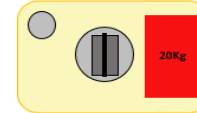
There 5 different variations of weights positions and sizes where set.

For each calibration method the was 10 calibrations carried out. The feeder bin was completely ran out and zeroed, then weight applied and spanned. Then an exact measurement of the product was put in the feeder the comparison was calculated.

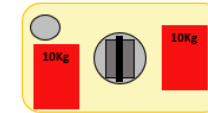
It was found that method 3 was the most accurate but three of the methods would have met the site tolerances of 1% .

Test number	Weight size and position	calibrated zero	Calibrated Span	Measured reading of 20kg of material (Kg)	Percentage out of scale (%)	Calibration within tolerance	Maximum deviation %
1	1	0.00Kg	20.00Kg	20.84	4.2	FAIL	8.80
2	1	0.00Kg	20.00Kg	21.01	5.05	FAIL	
3	1	0.00Kg	20.00Kg	20.94	4.7	FAIL	
4	1	0.00Kg	20.00Kg	21	5	FAIL	
5	1	0.00Kg	20.00Kg	21.08	5.4	FAIL	
6	1	0.00Kg	20.00Kg	20.98	4.9	FAIL	
7	1	0.00Kg	20.00Kg	21.03	5.15	FAIL	
8	1	0.00Kg	20.00Kg	21.19	5.95	FAIL	
9	1	0.00Kg	20.00Kg	21.76	8.8	FAIL	
10	1	0.00Kg	20.00Kg	21.23	6.15	FAIL	
11	2	0.00Kg	20.00Kg	20.43	2.15	FAIL	2.60
12	2	0.00Kg	20.00Kg	20.52	2.6	FAIL	
13	2	0.00Kg	20.00Kg	19.98	-0.1	PASS	
14	2	0.00Kg	20.00Kg	20.35	1.75	FAIL	
15	2	0.00Kg	20.00Kg	20.23	1.15	FAIL	
16	2	0.00Kg	20.00Kg	20.12	0.6	PASS	
17	2	0.00Kg	20.00Kg	19.89	-0.55	PASS	
18	2	0.00Kg	20.00Kg	19.72	-1.4	FAIL	
19	2	0.00Kg	20.00Kg	20.13	0.65	PASS	
20	2	0.00Kg	20.00Kg	20.01	0.05	PASS	
21	3	0.00Kg	20.00Kg	20.02	0.1	PASS	-0.25
22	3	0.00Kg	20.00Kg	20.04	0.2	PASS	
23	3	0.00Kg	20.00Kg	19.99	-0.05	PASS	
24	3	0.00Kg	20.00Kg	20.02	0.1	PASS	
25	3	0.00Kg	20.00Kg	20.04	0.2	PASS	
26	3	0.00Kg	20.00Kg	20.01	0.05	PASS	
27	3	0.00Kg	20.00Kg	20.04	0.2	PASS	
28	3	0.00Kg	20.00Kg	19.95	-0.25	PASS	
29	3	0.00Kg	20.00Kg	19.98	-0.1	PASS	
30	3	0.00Kg	20.00Kg	20.03	0.15	PASS	
31	4	0.00Kg	20.00Kg	19.98	-0.1	PASS	0.95
32	4	0.00Kg	20.00Kg	20.03	0.15	PASS	
33	4	0.00Kg	20.00Kg	20.01	0.05	PASS	
34	4	0.00Kg	20.00Kg	20.19	0.95	PASS	
35	4	0.00Kg	20.00Kg	19.89	-0.55	PASS	
36	4	0.00Kg	20.00Kg	20.08	0.4	PASS	
37	4	0.00Kg	20.00Kg	20.03	0.15	PASS	
38	4	0.00Kg	20.00Kg	19.98	-0.1	PASS	
39	4	0.00Kg	20.00Kg	19.84	-0.8	PASS	
40	4	0.00Kg	20.00Kg	20.01	0.05	PASS	
41	5	0.00Kg	20.00Kg	19.98	-0.1	PASS	-0.40
42	5	0.00Kg	20.00Kg	19.92	-0.4	PASS	
43	5	0.00Kg	20.00Kg	20.04	0.2	PASS	
44	5	0.00Kg	20.00Kg	20.02	0.1	PASS	
45	5	0.00Kg	20.00Kg	20	0	PASS	
46	5	0.00Kg	20.00Kg	20.03	0.15	PASS	
47	5	0.00Kg	20.00Kg	20.1	0.5	PASS	
48	5	0.00Kg	20.00Kg	19.98	-0.1	PASS	
49	5	0.00Kg	20.00Kg	19.97	-0.15	PASS	
50	5	0.00Kg	20.00Kg	20.01	0.05	PASS	

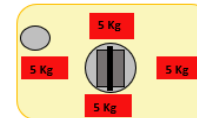
1



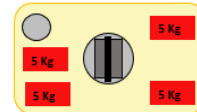
2



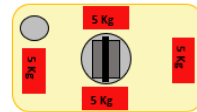
3



4

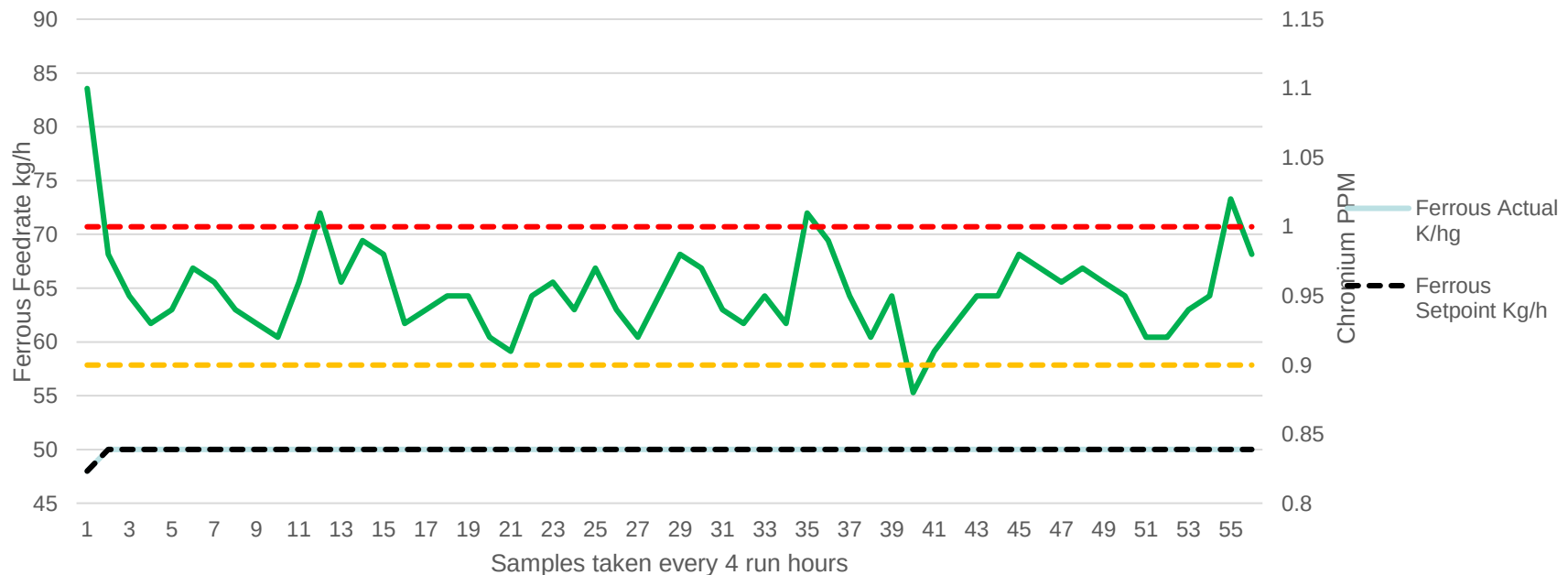


5



Accuracy of the Ferrous feeder

Test 3 - Control of the PLC software is accurate so the data can now be analysed.



Analysing the data testing for normality

Mean	0.951090909
Standard Error	0.003620673
Median	0.95
Mode	0.95
Standard Deviation	0.026851631
Sample Variance	0.00072101
Kurtosis	0.54929821
Skewness	0.266523651
Range	0.14
Minimum	0.88
Maximum	1.02
Sum	52.31
Count	55

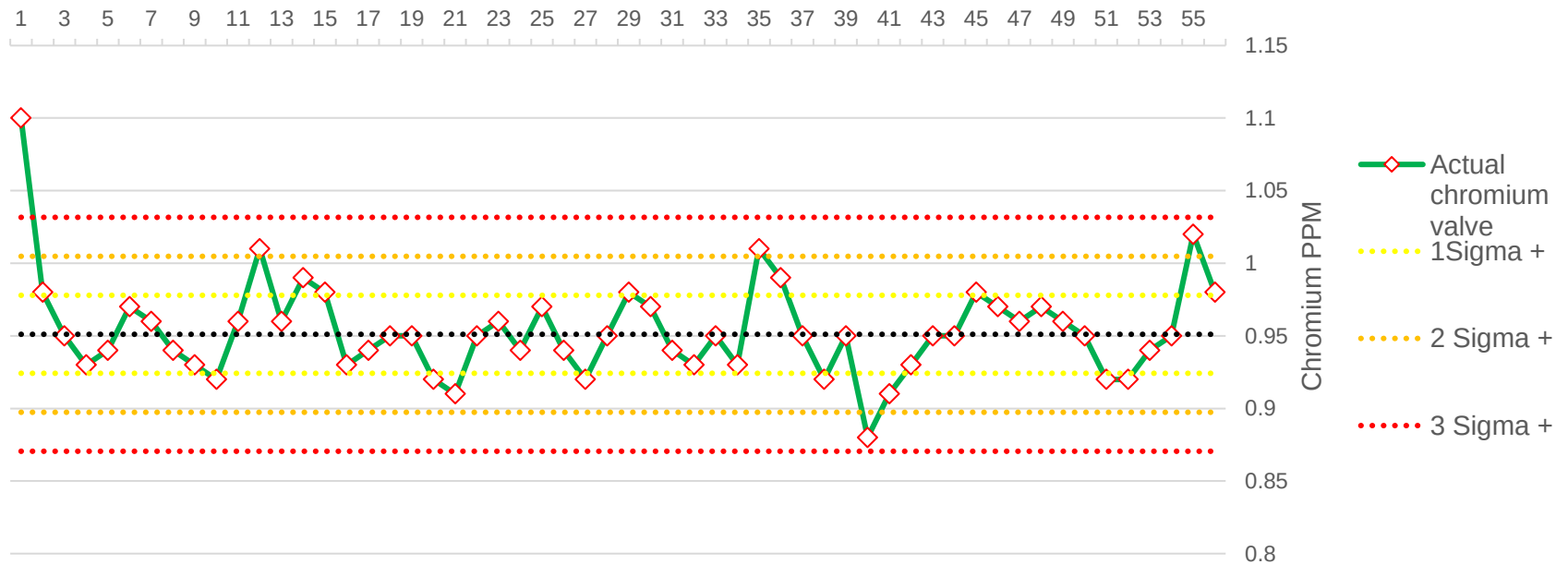
Kurtosis – 0.55 Close to normal shows the distribution between Skewness – 0.276 shows that the data is symmetrical and normal

Range is greater than 0.1 indicating that the control limits are too close
 Low limit less than 0.9

High limit over 1

Analysing the control chart

Test 3 - Analysing the data and control limits



Accuracy of the feeder control

Test 3 - Analysing the data and control limits

The data was assessed using Nelson's rules to determine if the variance in chromium was common cause variation or special cause variation. Due to none of Nelson's rules applying it shows that this is the natural rhythm of the process.

The control limits will be set at ± 3 sigma which will ensure that the chromium content will 99.7% of the time fall within these limits.

Mean = 0.951ppm

Standard deviation = 0.02685

High limit = $0.951 + (3 \times 0.02685) = 1.0316$ ppm

Low limit = $0.951 - (3 \times 0.02685) = 0.8705$ ppm

This takes us above our maximum 1ppm so the mean value needs to be lowered by adjusting the percentage setpoint.

Accuracy of the Ferrous feeder

Test 3 – How to correct the setpoint of the federate to ensure chromium levels are maintained as close to 1ppm as possible.

The 4hr chromium test will continue as part of the process and a rolling mean is calculated over a 56 sample period. This mean will be used to adjust the setpoint of the ferrous to ensure the chromium values are within range.

Mean target will be 0.91145 ppm with a +/- 5% error.

Top limit 0.9194 ppm and lower limit of 0.9034 ppm

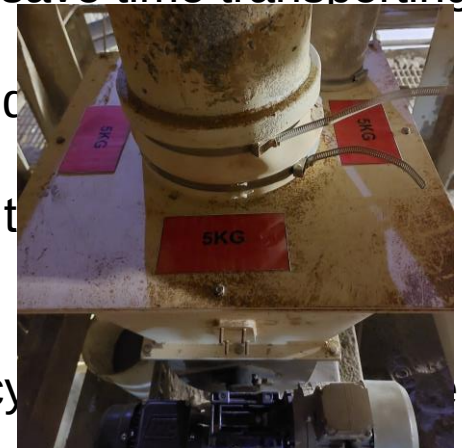
The lab gather the data after each test and adjust the ferrous federate the average move between these limit.

When starting the Ferrous feeder without historic data the setpoint will be set at 1.3kg/h until the data is gathered to ensure the ferrous is not underfeeding and will be increment reduced to run in the mean

Improve and control

Calibration

- SOP has been amended and attach the WO when issued. Step by step instruction with images.
- Location of weight placement marked on feeder.
- Weight and SOP located in locked panel next to feeder to save time transporting and looking for equipment.
- Test result to be entered on work order and admin ensure data entered in the calibration data folder.
- On the job training provided to all electrification's to ensure the process.
- Calibrations now carried out every 4 weeks not 6.
- Loss in weight check PM created weekly to check accuracy of run.



Improve and control

Maintenance

- Preventative maintenance schedule in place to ensure the feeder is mechanically inspected every 6 weeks. SAP system is used to issue PM and capture any issues in the form of notifications.
- Ferrous feeder added to the daily root of the cement operators to visual inspect the feeder. This covers housekeeping , leaks , 5 sense inspection , lighting etc. Any issue reported by notification via SAP system. Training provided.

[illegible]

Actions completed to reverse modification/change if temporary (or supplementary note)

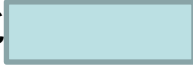
Cost Saving

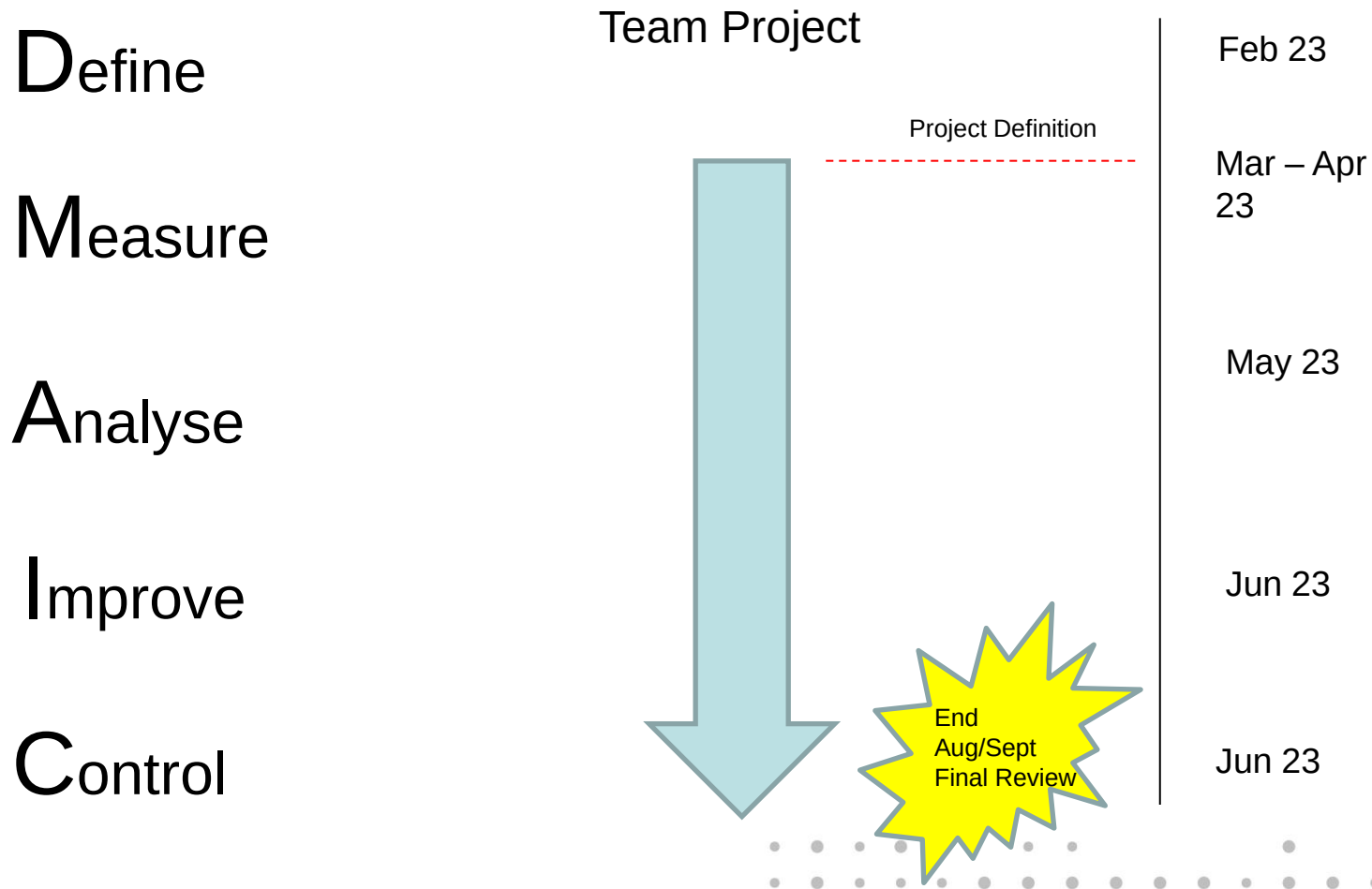
Cost - Total cost of improvements was

Cost motor and gearbox	£460
Cost of material	£789
Cost of new screw and housing	£4399
Cost other	£1500
Total cost	£7148

Additive	Federate (t/h)	Cost / h	Cost /day	Cost/week	Cost/year
Tin chloride	45	£88.65	£2,127.60	£13,829.40	
Ferrous sulphate	45	£36.72	£881.28	£5,728.32	
			Cost saving of material		
			Cost of project		
			Actual Savings		

Conclusion

- Ferrous feeder is now operational and tin chloride is not used in the milling process
- The reliability of the feeder in the short term has been 100% with no problems but this is not sustainable.
- The saving over a year production would account to £ 
- Further long term trials ongoing to ensure the process doesn't have any large step changes in chromium content in clinker if so the mean setpoint will not react quick enough to the process needs. May have to reduce limits to ensure quality regulations are met.
- The project took longer than expected waiting for parts and analysing material wasn't accounted for.
Completion not till start of May.





Forthcoming Events

For your diaries:-

Friday 23rd – Drop- in session (let me know what time!)

Test #2

Friday 30th June (covering complete course materials)

Open from 1pm on the Friday – close midnight following Monday

1 hour duration, multi-choice (approx. 40 questions)

Project Reviews

Friday 25th August - **08:30 – 12:00**

Friday 1st September - **08:30 – 12:00**

30 mins – 5 mins each phase, 5 mins Q&A

I Keep Six Honest Serving-Men

by Rudyard Kipling

I Keep six honest serving-men:

(They taught me all I knew)

Their names are What and Where and When

And How and Why and Who.