New Developments in Surface Profile and Roughness Measurement Techniques

Craig Woolhouse
Elcometer

Contents

- Why do we measure the blasted profile?
- Part 1
  - What is Profile and what is Roughness?
  - Measuring Surface Profile
  - Measuring Surface Roughness
- Part 2
  - Limitations of current methods
  - New Gauge Developments
- Conclusions

Introduction

Why do we measure the Surface Profile?

- Blasting removes old coating and corrosion and produces a ‘rough’ surface
- The rough surface provides a ‘key’ for the coating to adhere to the surface
- The ‘rough’ surface increases the surface area providing better adhesion
- Paint is designed to benefit from this surface characteristic
- The surface profile affects coating performance

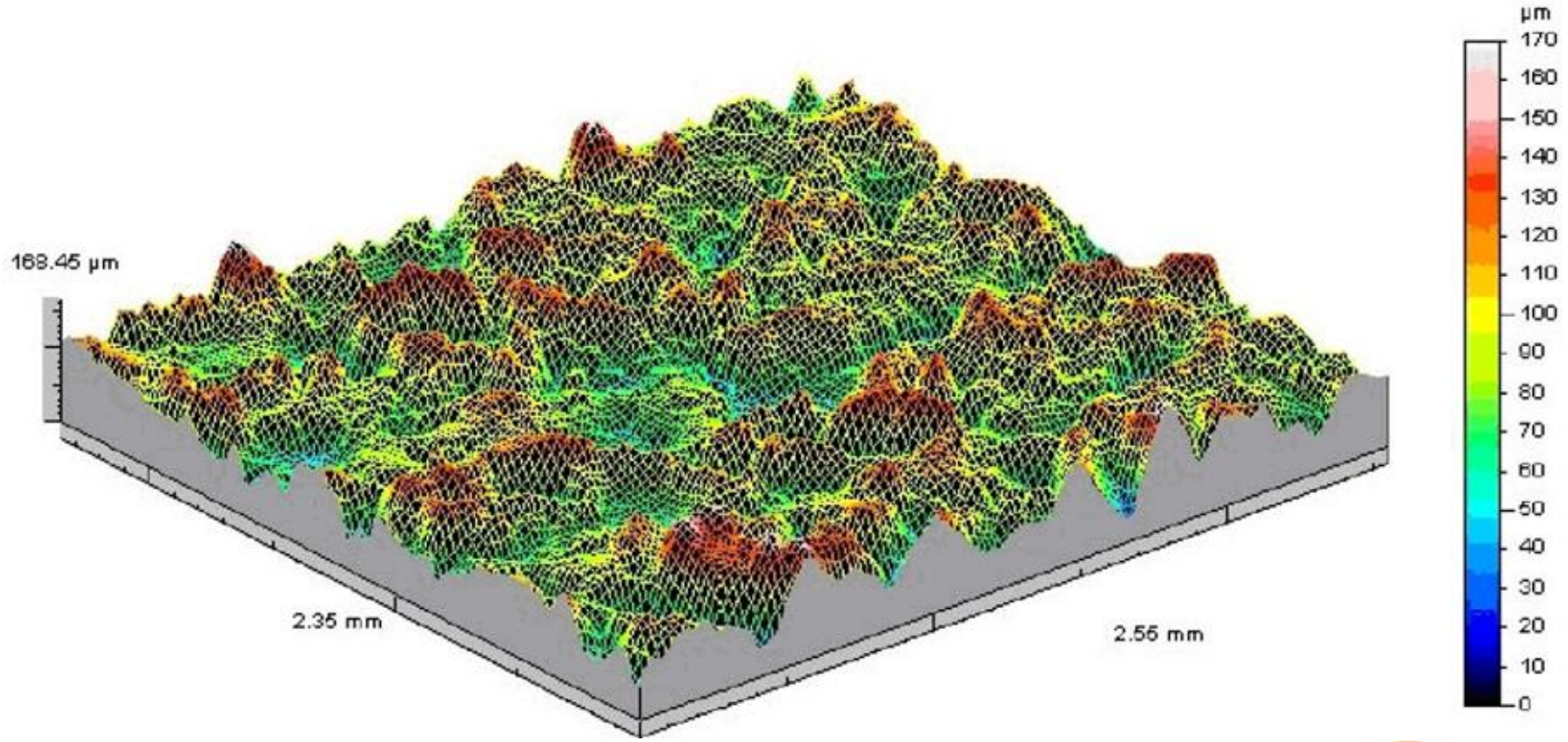
Profile v Roughness

Part 1

Explaining the current methods

Profile v Roughness

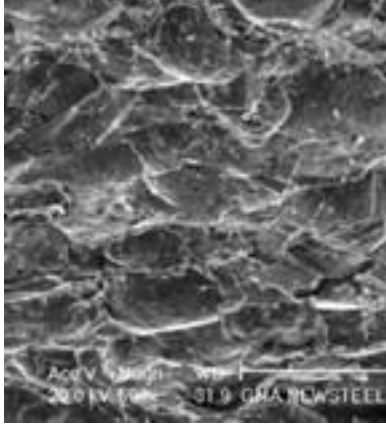
What does a real Grit Blasted surface look like?



70 YEARS

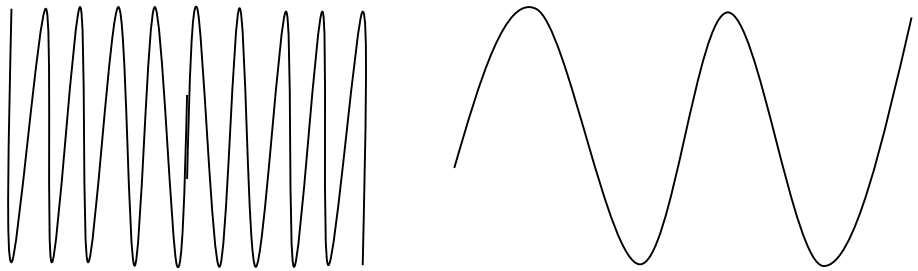
elcometer®

Profile v Roughness



Defining the difference

- Surface Profile is not the same as Surface Roughness
- Surface Profile is a measure of peak to valley height in a small area
- Surface Roughness is not only a measure of peak height and valley depth but also includes the frequency of those fluctuations
- Consider the following ‘simplified’ surfaces

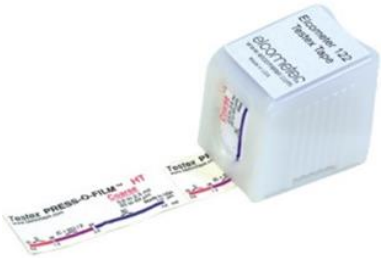


- Logically we should measure Surface Roughness

How do we measure Surface Profile?

Within the widely used ASTM D4417 Standard there are 3 accepted methods for measuring surface profile

- Comparator
- Needle Gauge
- Replica Tape



Note that they all measure different characteristics

70 YEARS
elcometer®

How do we measure Surface Profile?

Surface Comparator – ASTM Method A

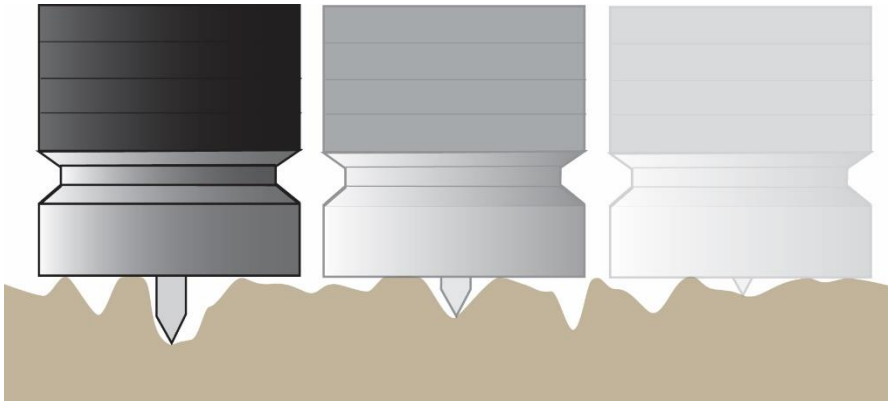
- A Surface Comparator is a "planar plate of four segments on which are imparted reference surface profiles"
- Produced by stamping of steel plate
- The comparator is placed on the blasted surface. The surface is then compared to the 4 reference profile and one of five "relative" profiles is noted. For example: 'Smoother than segment 1' or 'rougher than 1 but smoother than 2' etc.

70 YEARS
elcometer®

How do we measure Surface Profile?

Digital Needle or Dial Gauge – ASTM Method B

- The gauge is repeatedly placed on the blasted surface at the ‘same’ location. The depth of profile under the gauge is measured using a fine pointed probe and either the mean of 10 readings or the maximum reading seen is recorded

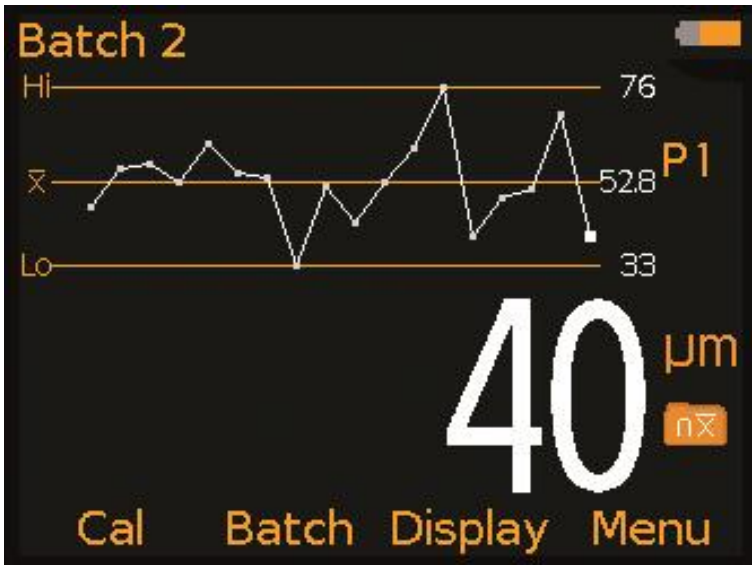


70 YEARS
elcometer®

How do we measure Surface Profile?

Digital Needle or Dial Gauge – Method B

- In more recent times these gauges have been digitised and whilst they work on the same principle, data management, statistical analysis within the gauge and measurement on curved surfaces is now possible

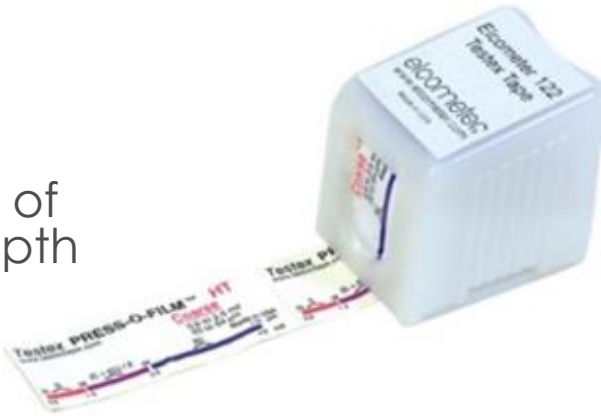


70 YEARS
elcometer®

How do we measure Surface Profile?

Replica Tape – Method C

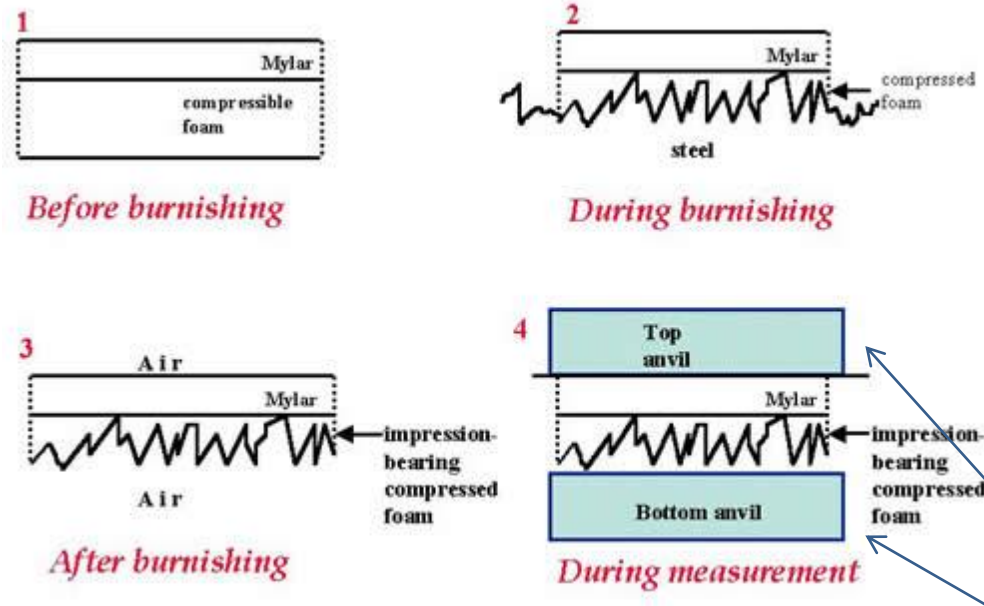
- Replica tape contains compressible foam attached to a flexible, incompressible plastic substrate of uniform thickness
- To determine the profile each piece of tape is placed on the blasted surface at the ‘same’ location
- The tape is ‘burnished’ and a replica of the blasted surface under the tape is replicated into the compressible element of the tape
- Using a caliper gauge the height of the highest peak of the tape is measured. This translates to the typical depth of the valleys of the material
- The Standard asks that the mean of a re-determined number of tape readings is recorded
- Values are intended to be equivalent to Rt roughness measurement



70 YEARS
elcometer®

How do we measure Surface Profile?

Replica Tape – Method C

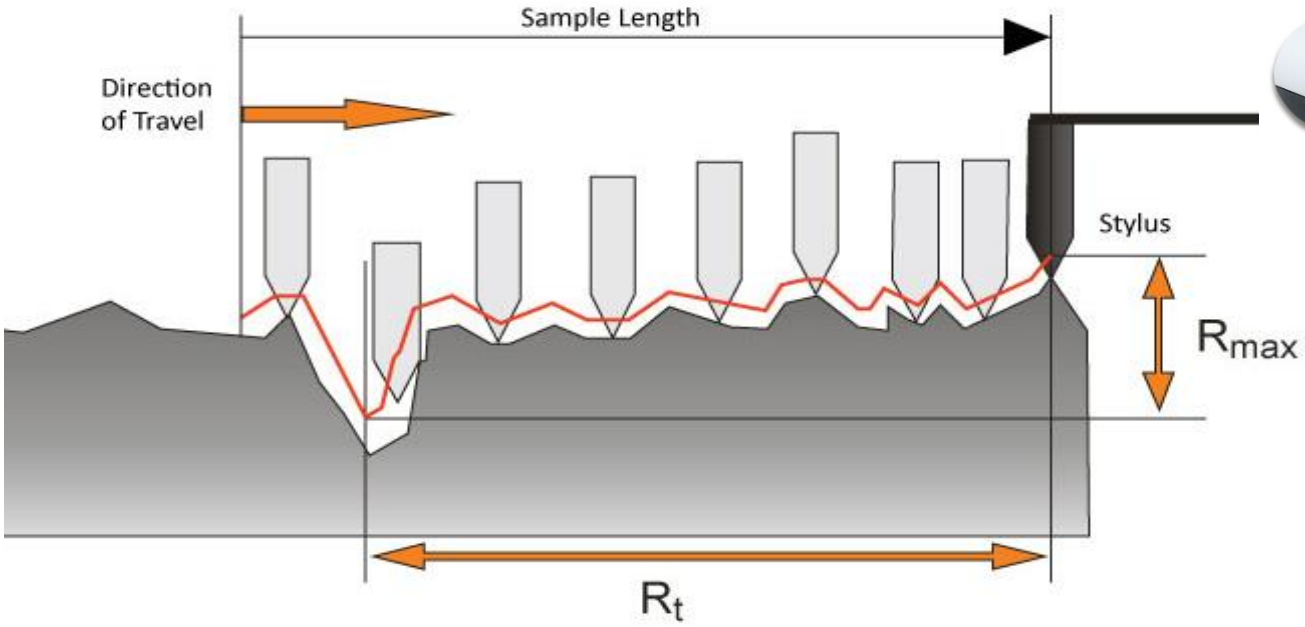


70 YEARS
elcometer®

How do we measure Surface Roughness?

Roughness Stylus Gauge

- Moving 'Stylus' method originally developed for measurement of machined surfaces
- Very delicate laboratory based equipment

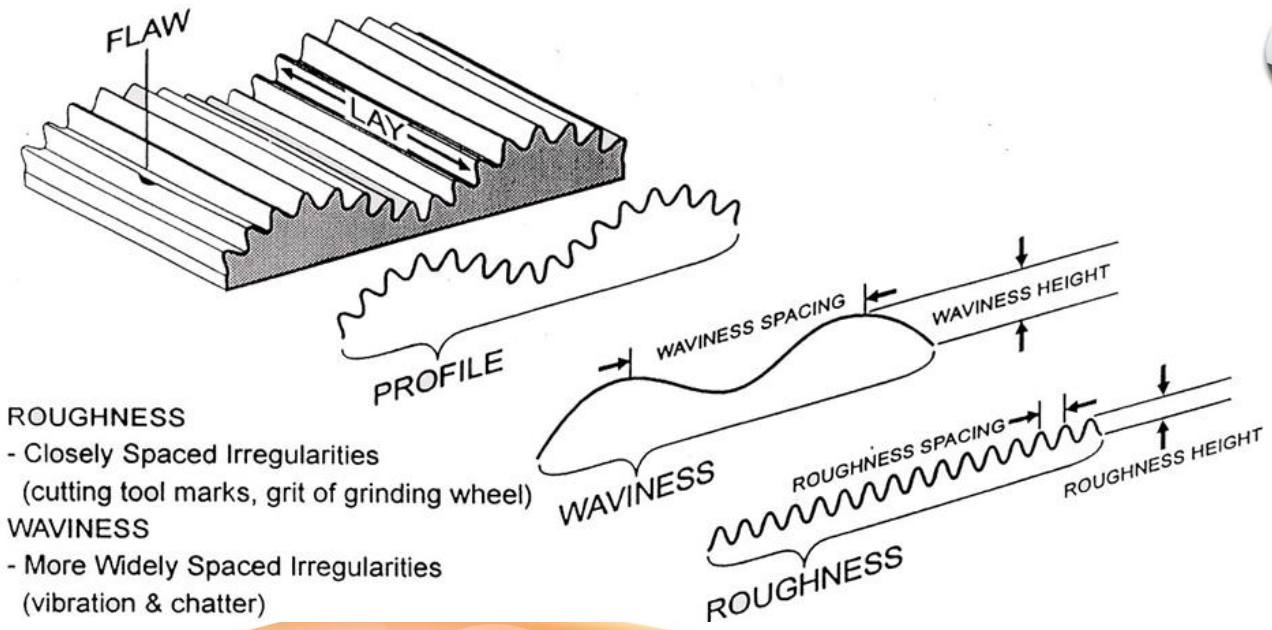


70 YEARS
elcometer®

How do we measure Surface Roughness?

Understanding the measurement (terminology is different)

- Profile – a combination of Waviness and Roughness
- Waviness – widely spaced irregularities
- Roughness – closely spaced irregularities



ROUGHNESS
- Closely Spaced Irregularities
  (cutting tool marks, grit of grinding wheel)

WAVINESS
- More Widely Spaced Irregularities
  (vibration & chatter)

70 YEARS
elcometer®

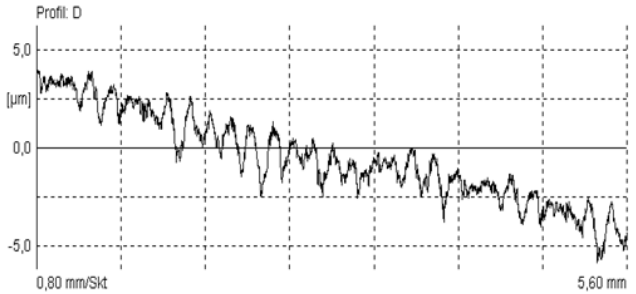
How do we measure Surface Roughness?

Trying to understand the measurement

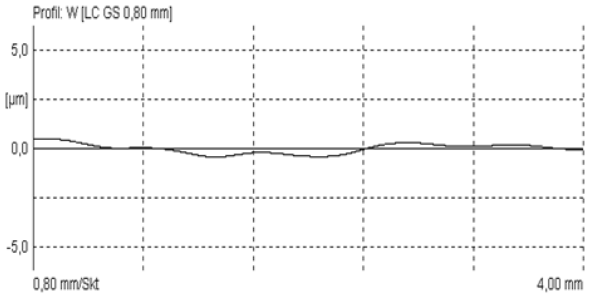
- Waviness (the hills) & Roughness (the trees)

How do we measure Surface Roughness?

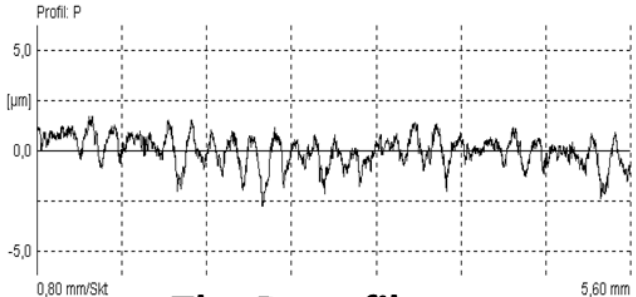
The recorded profiles



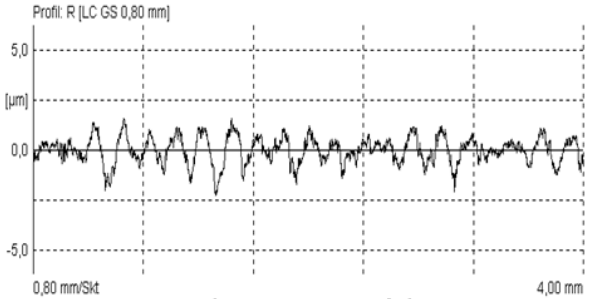
The D-profile



The W-profile



The P-profile



The R-profile

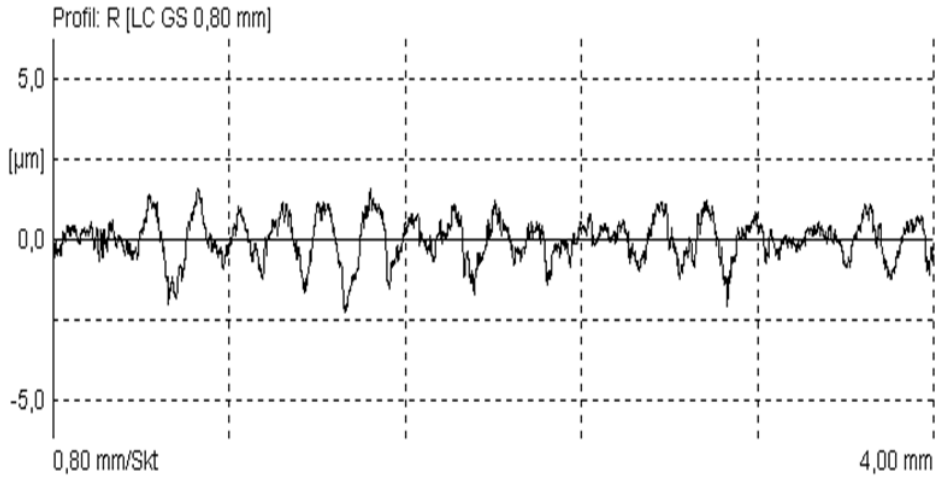
We typically use the R profile for our industry

70 YEARS

elcometer®

How do we measure Surface Roughness?

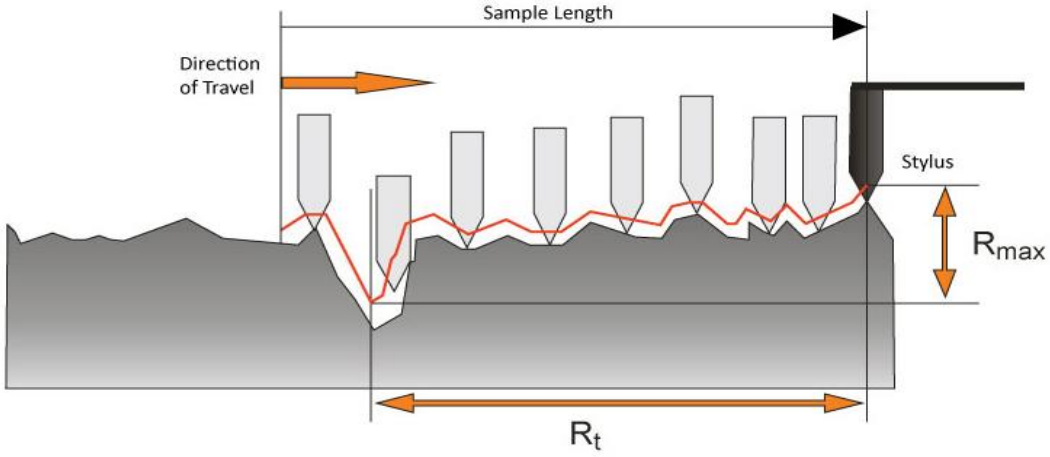
The R profile



The R profile (Roughness Profile) is calculated from the traced profile (P profile) excluding the waviness and inclination. When representing the R profile the mean line is the zero line

How do we measure Surface Roughness?

R profile terminology



Rmax – the 'height' between the highest peak and the lowest valley along the sampling length (there are usually 5 sampling lengths per measurement

Ra – the average roughness over the sampling length

Rt – the longitudinal distance between the highest peak and the lowest valley within any sampling length

Rz – the average 'height' between the highest peak and the lowest valley over a number of sampling lengths

Profile v Roughness

Part 2

How to solve the problem

Limitations of current methods

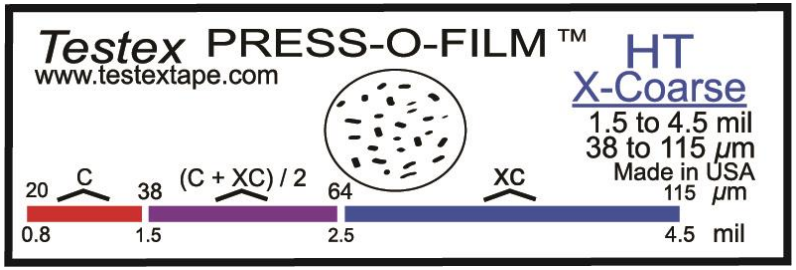
Needle Gauge – Method B

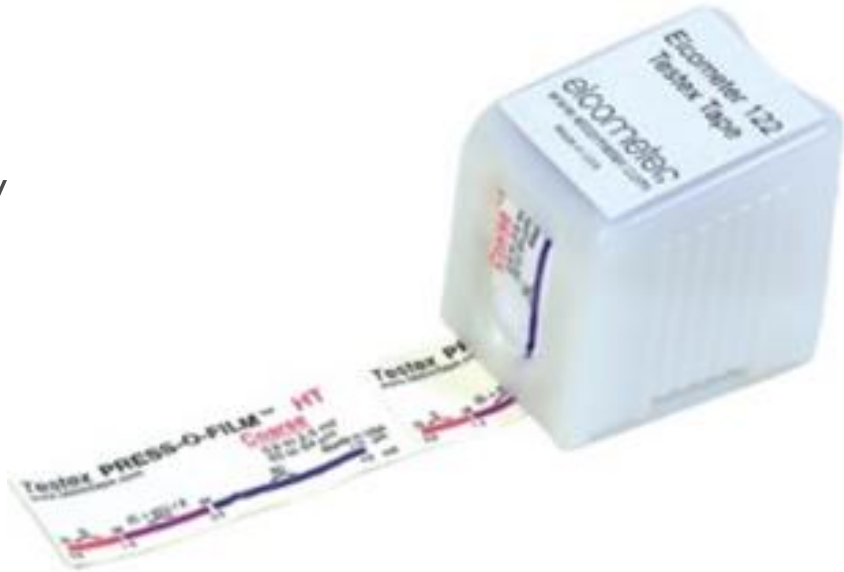
- Limited curved surface measurement capability
- Not as popular as Method C Replica Tape
- Can measure either peak to valley average or highest value
- Confusion over the content of ASTM D4417 Standard
- Data can be recorded
- Fast reading rate

Limitations of current methods

Replica Tape – Method C

- Slow reading rate
- Data cannot be recorded
- Tape cannot be re-measured
- Poor Reproducibility and Accuracy

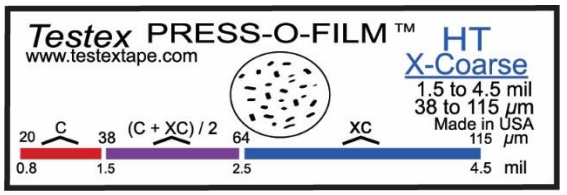




70 YEARS
elcometer®

Limitations of current methods

Replica Tape – Method C



- Poor Reproducibility

ASTM D4417-03 states that: two results, each the mean of four replicates…..should be considered suspect if they differ by more than 37% (for X Coarse tape)…..or 28% (for Coarse tape)

Profile	Maximum Error	Percentage
25 µm	8 µm (Coarse)	**28%**
50 µm	18 µm (X Coarse)	**36%**
75 µm	27 µm (X Coarse)	**36%**
100 µm	37 µm (X Coarse)	**37%**

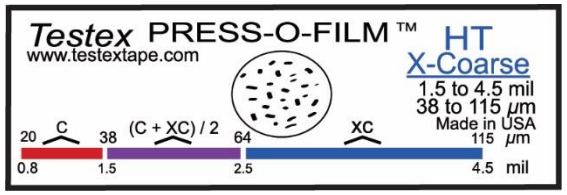
Limitations of current methods

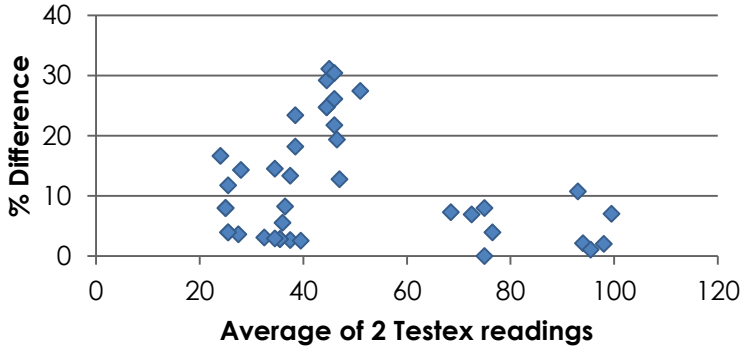
Replica Tape – Method C

- Poor Accuracy

  Testex' own testing on grit-blasted steel surfaces shows a surface error of 6µm except in the profile range extending from 38 to 64 um. The error associated with measurements in this range has a more complicated behaviour

  Pass/Fail determinations of profile around the values 38, 50 and 64 um will tend to be quite accurate. Pass/Fail assessments centred on other values in this range will be less accurate





70 YEARS
elcometer®

Limitations of current methods

Stylus Gauges

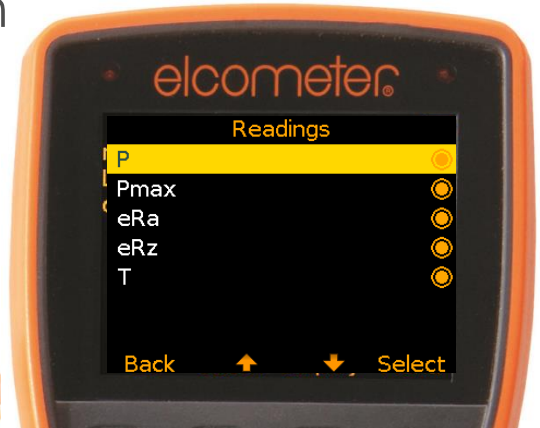
- Excellent high quality products designed for measurement of machined surfaces
- Not really suitable to measure field based applications
- Terminology used is not widely understood in our industry
- Stylus gauges are the subject of different ASTM guidelines

70 YEARS
elcometer

New Gauge Developments

Introducing the new Elcometer 324 Surface Measurement Gauge

- Measures P, Pmax, T/Rt, eRa and eRz where:
  - P – Method B average peak to valley profile
  - Pmax – Highest Method B value seen
  - T/Rt – Method C Testex and Rt equivalence
  - eRa – equivalent Ra value
  - eRz – equivalent Rz value
- Uses Magnetic Induction principle (rather than replica tape or needle method) to asses surface condition
- Available late 2018



New Gauge Developments

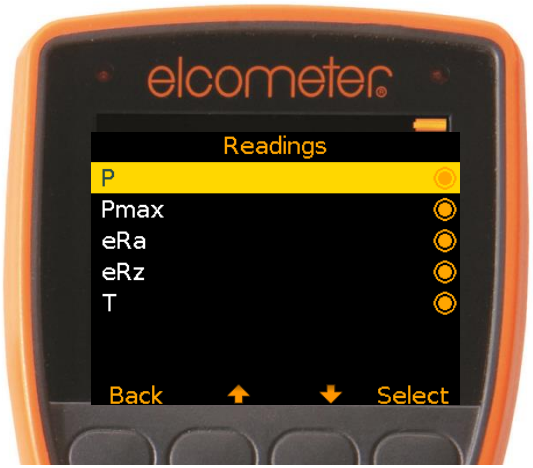
Using the gauge

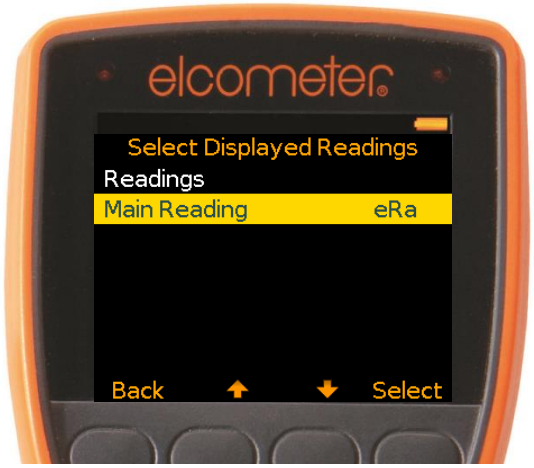
- Calibration technique similar to DFT gauge
- User selectable parameters on screen
- Data can be recorded and uploaded to the ElcoMaster software package
- Suitable for use on all blasted surfaces
- Probe cap can be replaced when worn
- Live Demonstration showing real data
- Prototype product so not all screens and firmware are finalised

70 YEARS
elcometer

New Gauge Developments

Elcometer 324 screenshots

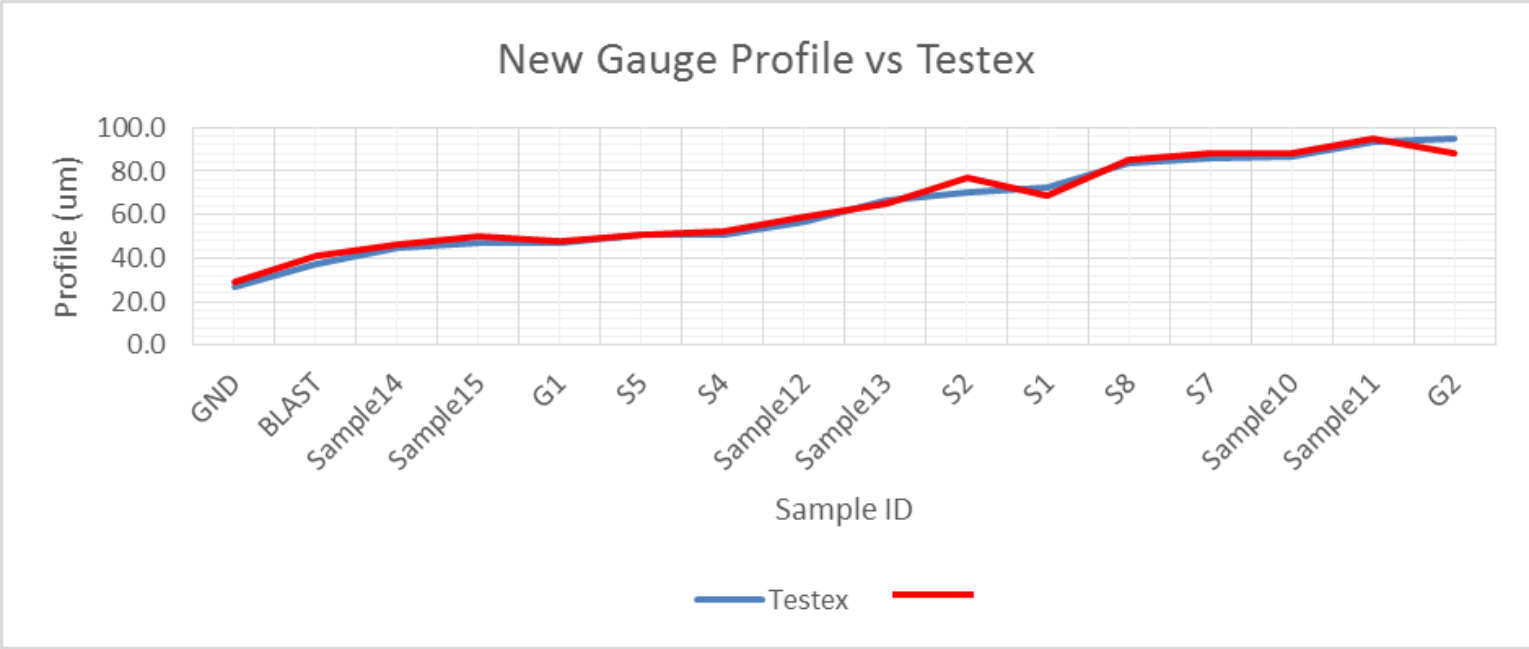




70 YEARS
elcometer®

New Gauge Developments

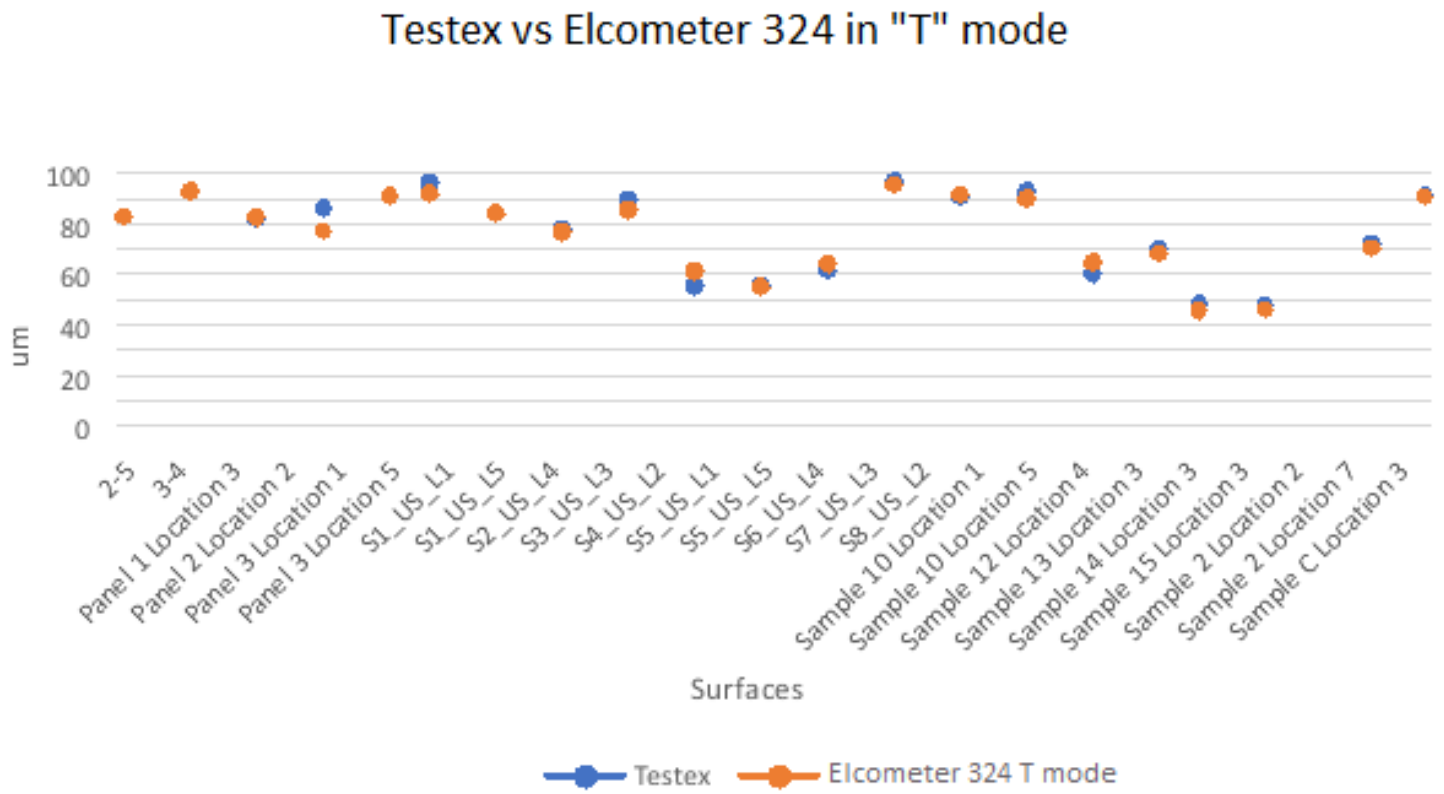
Validating the new Elcometer 324 in T/Rt mode



70 YEARS
elcometer®

New Gauge Developments

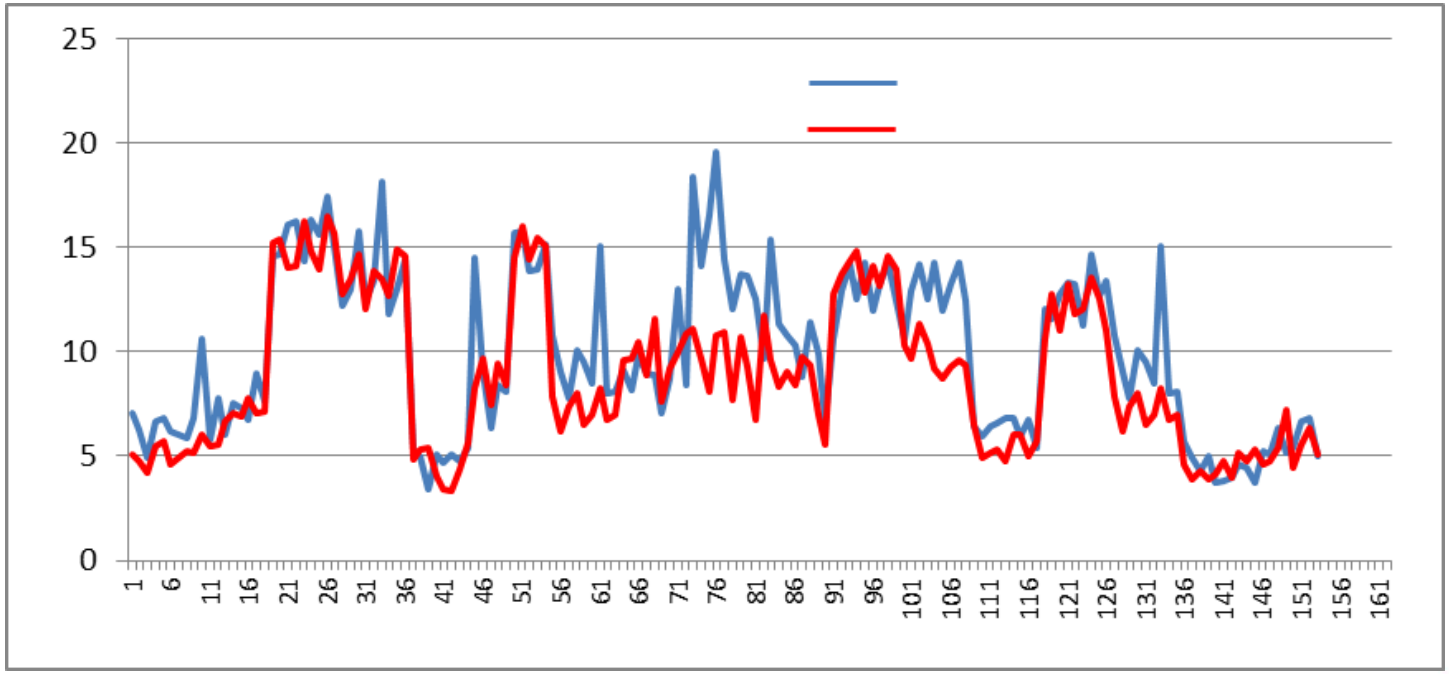
Validating the new Elcometer 324 in T/Rt mode



70 YEARS
elcometer®

New Gauge Developments

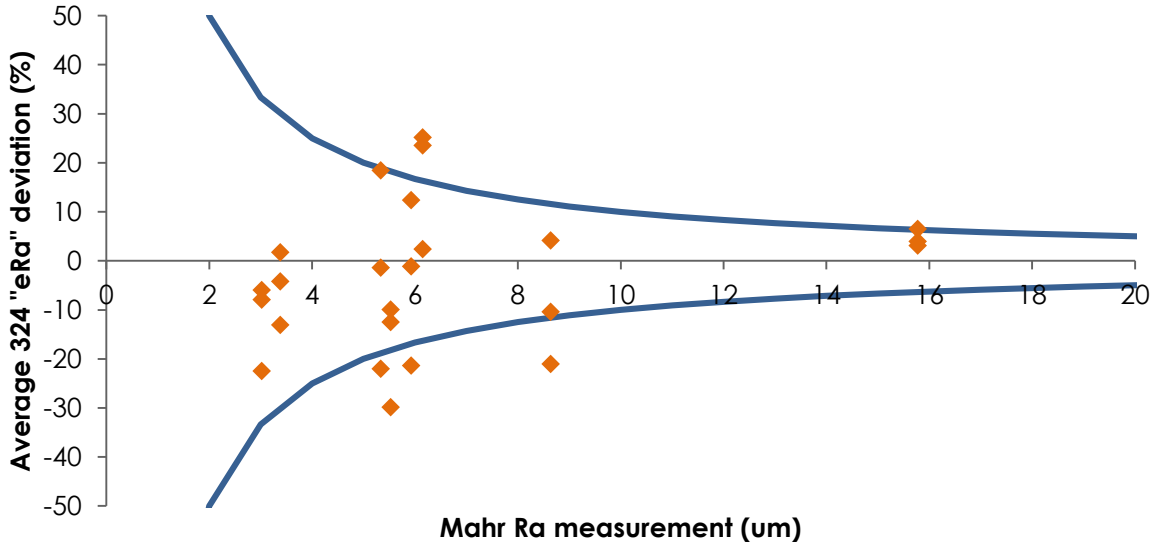
Validating the new Elcometer 324 in eRa mode



70 YEARS
elcometer®

New Gauge Developments

Validating the new Elcometer 324 in eRa mode

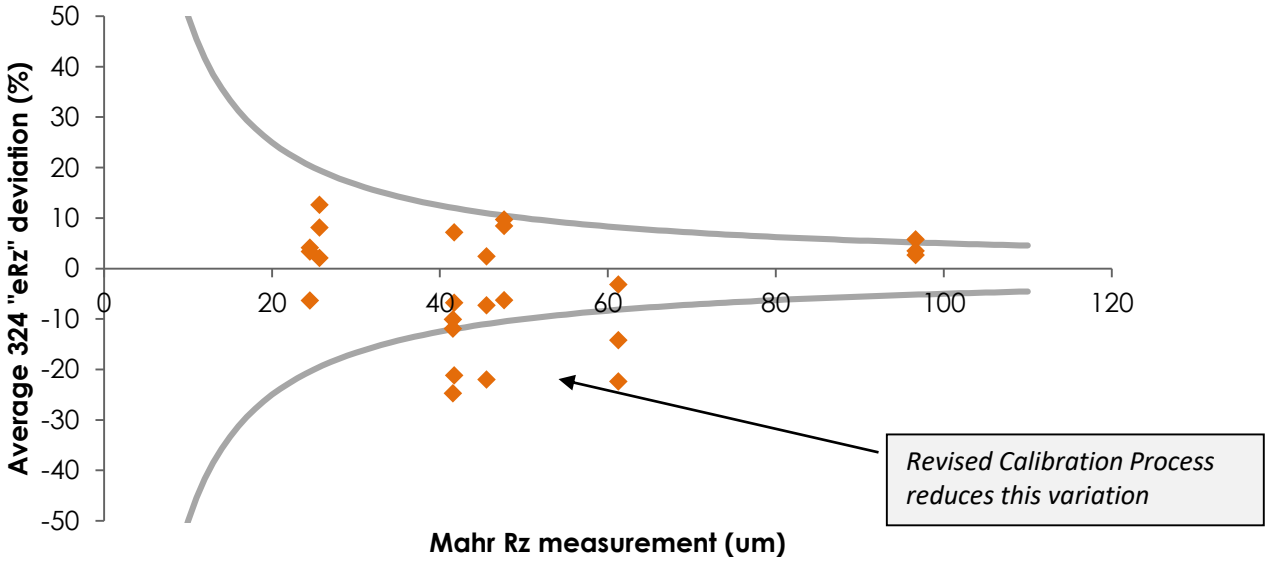


- Mahr Ra = average of ***5*** measurements in each location
- 324 eRa = ***single*** Standard measurement in each location

70 YEARS
elcometer®

New Gauge Developments

Validating the new Elcometer 324 in eRz mode



- Mahr Rz = average of ***5*** measurements in each location
- 324 eRz = ***single*** Standard measurement in each location

70 YEARS
elcometer®

Conclusions

- The 3 current profile measurement techniques all characterise different parameters and are not usually comparable
- Ultimately the profile needs to be recorded in the way that the job or specification requests it
- The majority of paint specifications, if they do request a profile measurement, request just that, a micron depth rather than roughness values such as R_a and R_z
- However the benefit of recording both profile and roughness values is clear
- The new Elcometer 324 gauge provides the capability to record all 5 parameters in one easy to use durable package

Thank you for you attention

Questions?