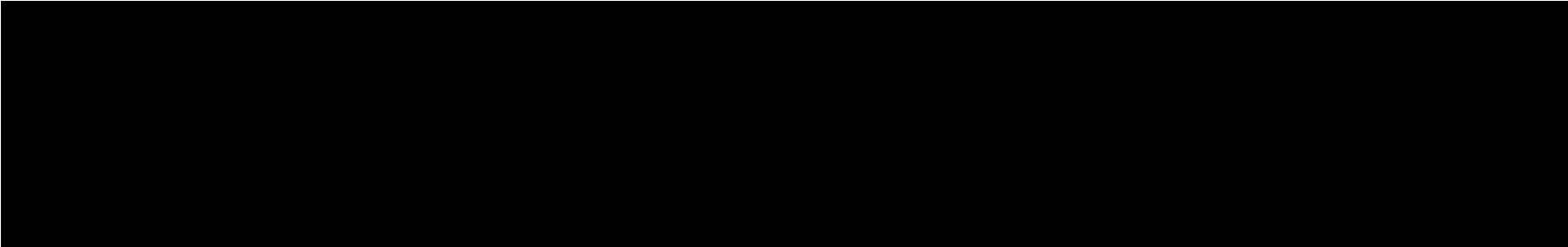


Conductor Resistance of Cables

- 
- ⓘ First time the program operates for CTL
 - ⓘ Limited participants
 - ⓘ Generally well done
 - ⓘ Results are very good – but when not, then VERY bad

- ❗ Sample A and B were duplicates.
- ❗ Participants performed 8 “duplicate” tests (half knowingly duplicate, half “blind duplicate”)
- ❗ Checked the actual results by averaging them
- ❗ Also checked the reproducibility of the results by determining the %CV

2.1 Electrical resistance of conductors

In order to check the electrical resistance of conductors, the resistance of each conductor shall be measured from a sample of cable of at least 1 m in length, and the length of each sample shall be measured.

If necessary, a correction to 20 °C and to a length of 1 km shall be obtained by the formula:

$$R_{20} = R_t \frac{254,5}{234,5 + t} \cdot \frac{1000}{L}$$

where

- t is the temperature of the sample at the moment of measurement, in degrees Celsius
- R_{20} is the resistance at 20 °C, in ohm/kilometre
- R_t is the resistance of L metres of cable at t °C in ohms
- L is the length of the sample of cable, in metres (length of the complete sample and not of the individual cores or wires)

What are the main factors in this measurement?

- Access to good quality micro-ohm meter

$$R_{20} = R_t \frac{254,5}{234,5 + t} \cdot \frac{1000}{L}$$

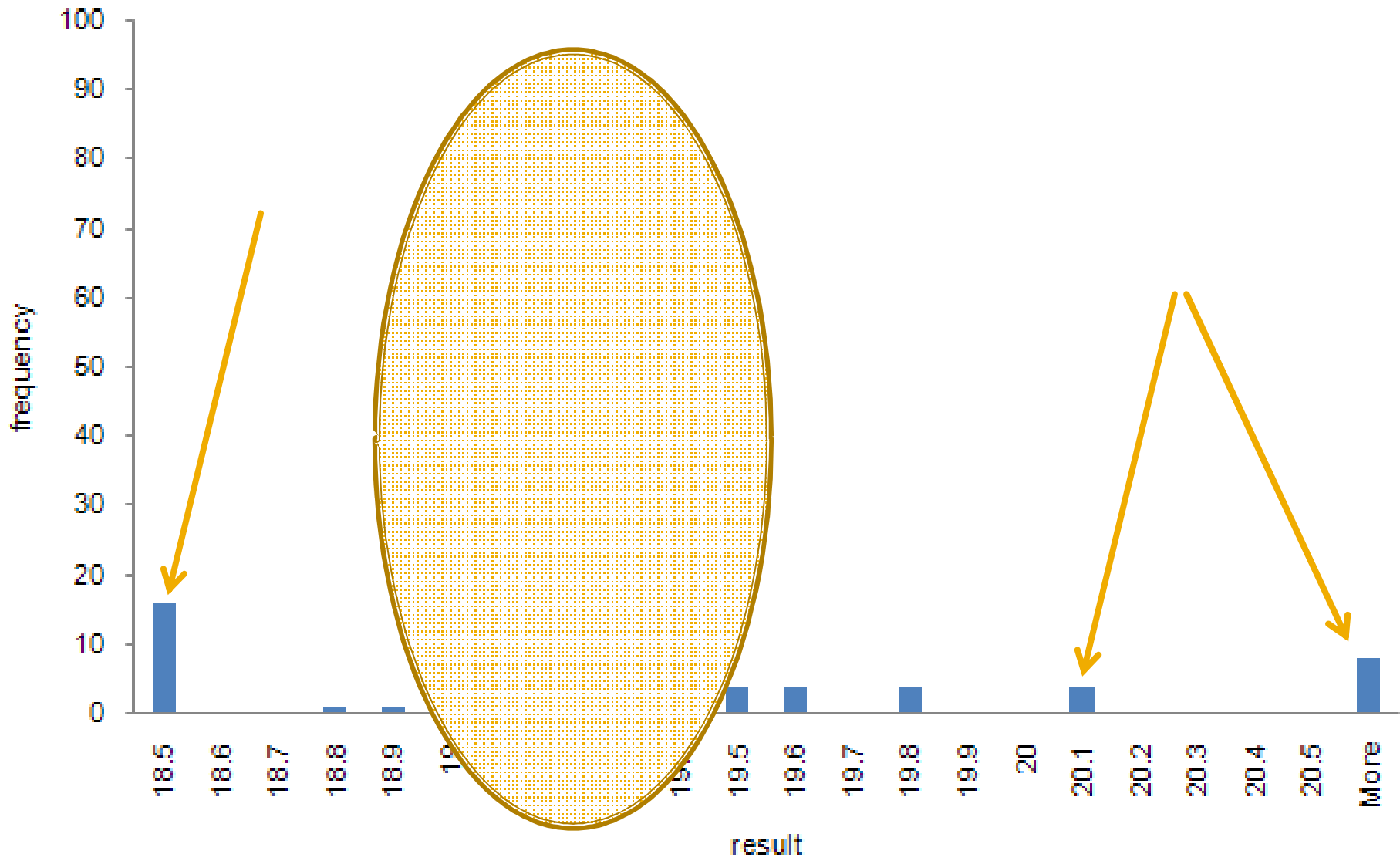
- t and L are equation denominators, therefore will affect the result, the lower or more inaccurate they are....

Minimising effects of t and L ??

Accuracy of "R"

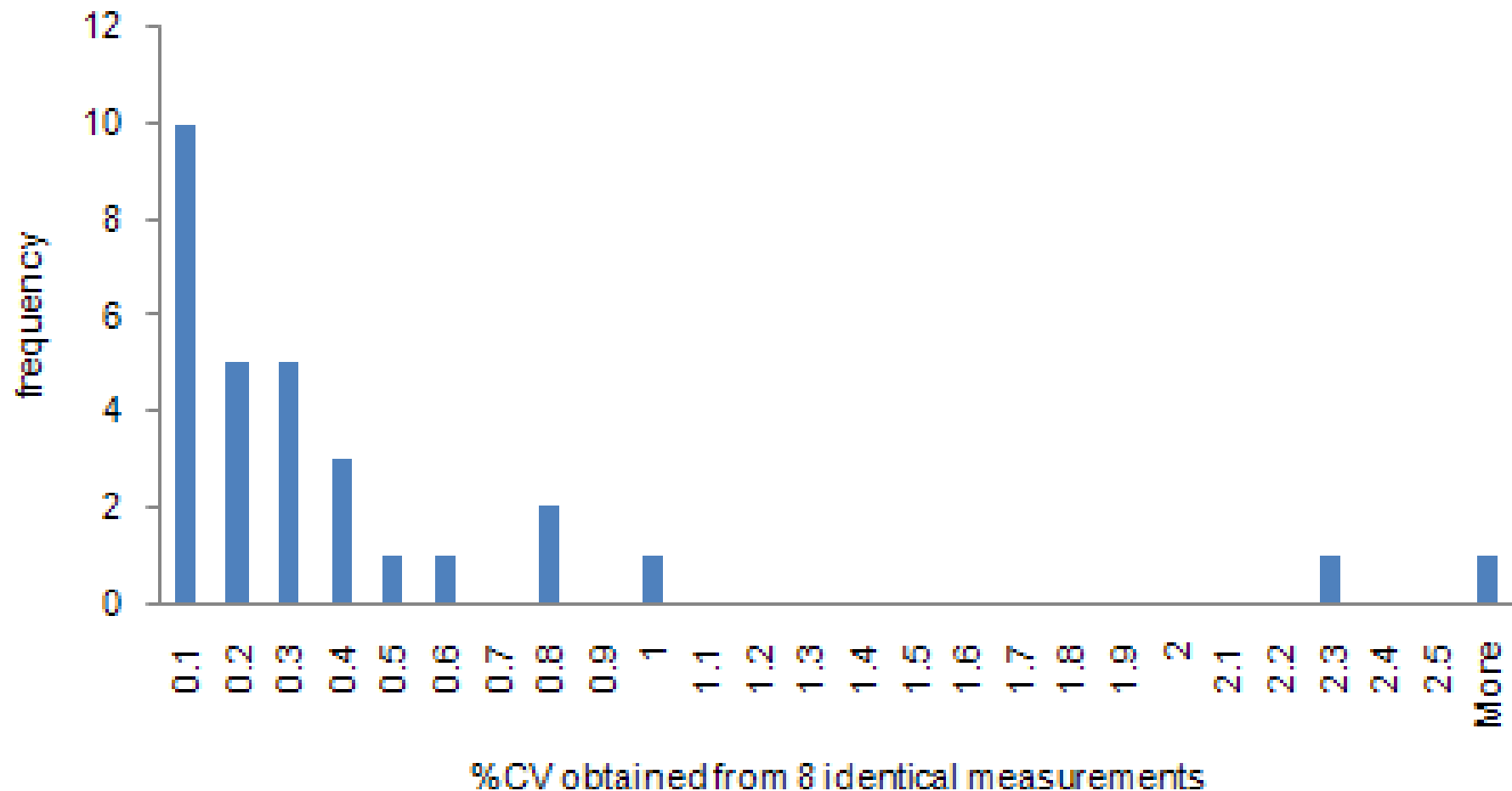
- ! Calibration?
- ! Repeatability?

Individual determinations of conductor resistance (Ohm/km)



What variation is OK for conductor resistance? (nominal 2% in PTP)

%CV for measurements of conductor resistance



Group task

- ⓘ Complete the handout for cables conductor resistance determination
- ⓘ Identify all the steps in the testing process
- ⓘ Highlight the possible risks of obtaining inaccurate test results
- ⓘ Prioritise them
- ⓘ Suggest some mitigating activities that could be implemented as preventive actions

Insulation thickness

- ❗ In the 07e35, we requested report of “minimum” insulation thickness, plus data that contributed to measurement.
- ❗ We assessed participants, not on minimum that they reported but on minimum of the group of reported measurements.
- ❗ Statistics were performed on calculated minimum and the average thickness.
- ❗ Whole test was offered as after following procedure

- ⓘ Cut 6 pieces
- ⓘ Measure 3 parts of each
- ⓘ Report each result

- ⓘ Chose not to assess.
 - Firstly, TA's described the test as "difficult to perform consistently"
 - Secondly because we requested procedure contrary to standard, due to sample lengths available.

Example of data

readings in mm	reading _1	reading _1	reading _1	reading _2	reading _2	reading _2	reading _3	reading _3	reading _3
Code #	Piece 1	Piece 2	Piece 3	Piece 1	Piece 2	Piece 3	Piece 1	Piece 2	Piece 3
1	0.691	0.672	0.667	0.612	0.724	0.654	0.658	0.653	0.588
3	0.555	0.58	0.572	0.58	0.598	0.678	0.599	0.692	0.583
4	0.55	0.518	0.532	0.63	0.592	0.627	0.632	0.594	0.648
5	0.52	0.52	0.56	0.6	0.63	0.63	0.63	0.65	0.59
6	0.57	0.55	0.58	0.54	0.54	0.58	0.55	0.54	0.56
7	0.52	0.52	0.52	0.59	0.6	0.6	0.59	0.6	0.58

Code #	Average insulation thickness mm	Minimum insulation thickness (mm)	Z score for insulation thickness using average values	Z score for insulation thickness using minimum values
1	0.642	0.542	2.83	0.87
3	0.63	0.56	2.02	1.59
4	0.613	0.518	0.88	-0.08
5	0.61	0.52	0.67	0.00
6	0.6	0.52	0.00	0.00
7	0.57	0.52	-2.02	0.00
8	0.606	0.528	0.40	0.32
9	0.605	0.478	0.34	-1.67
10	0.58	0.52	-1.35	0.00
11	0.61	0.54	0.67	0.79
12	0.6	0.5	0.00	-0.79
13	0.63	0.62	2.02	3.97
14	0.58	0.501	-1.35	-0.75
16	0.59	0.54	-0.67	0.79
17	0.572	0.45	1.89	2.78

! The results were:

	using average values	using minimum values
deviation between median and limit (%)	8	17
%CV	2	5

	using average values	using minimum values
median	0.60	0.52
quartile 1	0.59	0.50
quartile 3	0.61	0.53
NIQR	0.01	0.03
upper limit (Z=3)	0.64	0.60
lower limit (Z=-3)	0.56	0.44

- ⓘ Average values were, as expected, a more “reliable” measure of insulation thickness.
- ⓘ Success of “minimum thickness” (from PTP perspective) is dependent on participant choosing exactly where to cut the sample, (good luck)
- ⓘ Future programs: if this test is included, allow participants to test a larger sample length and follow the standard exactly.

IEC 60112: 2003

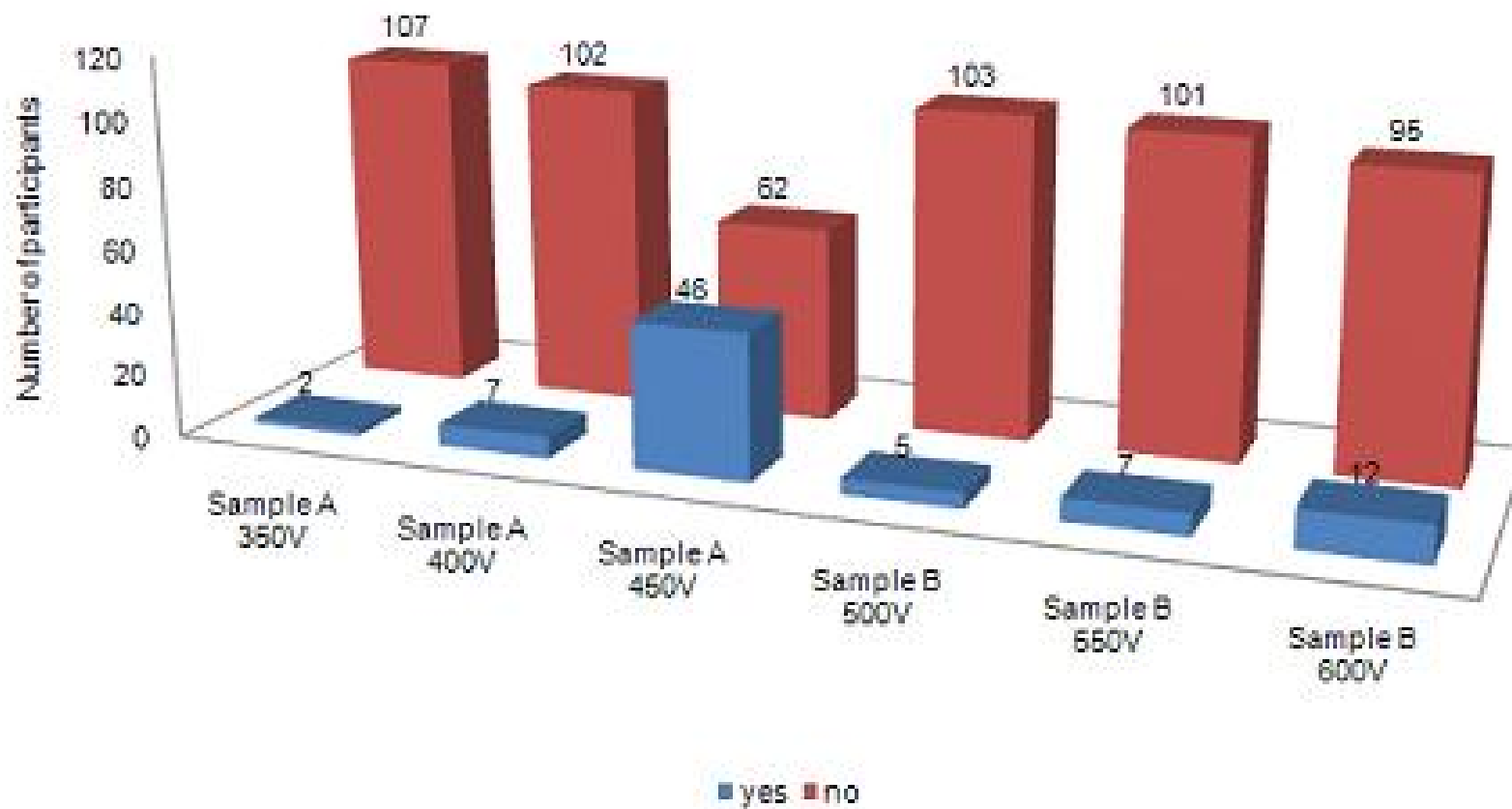
Tracking Test

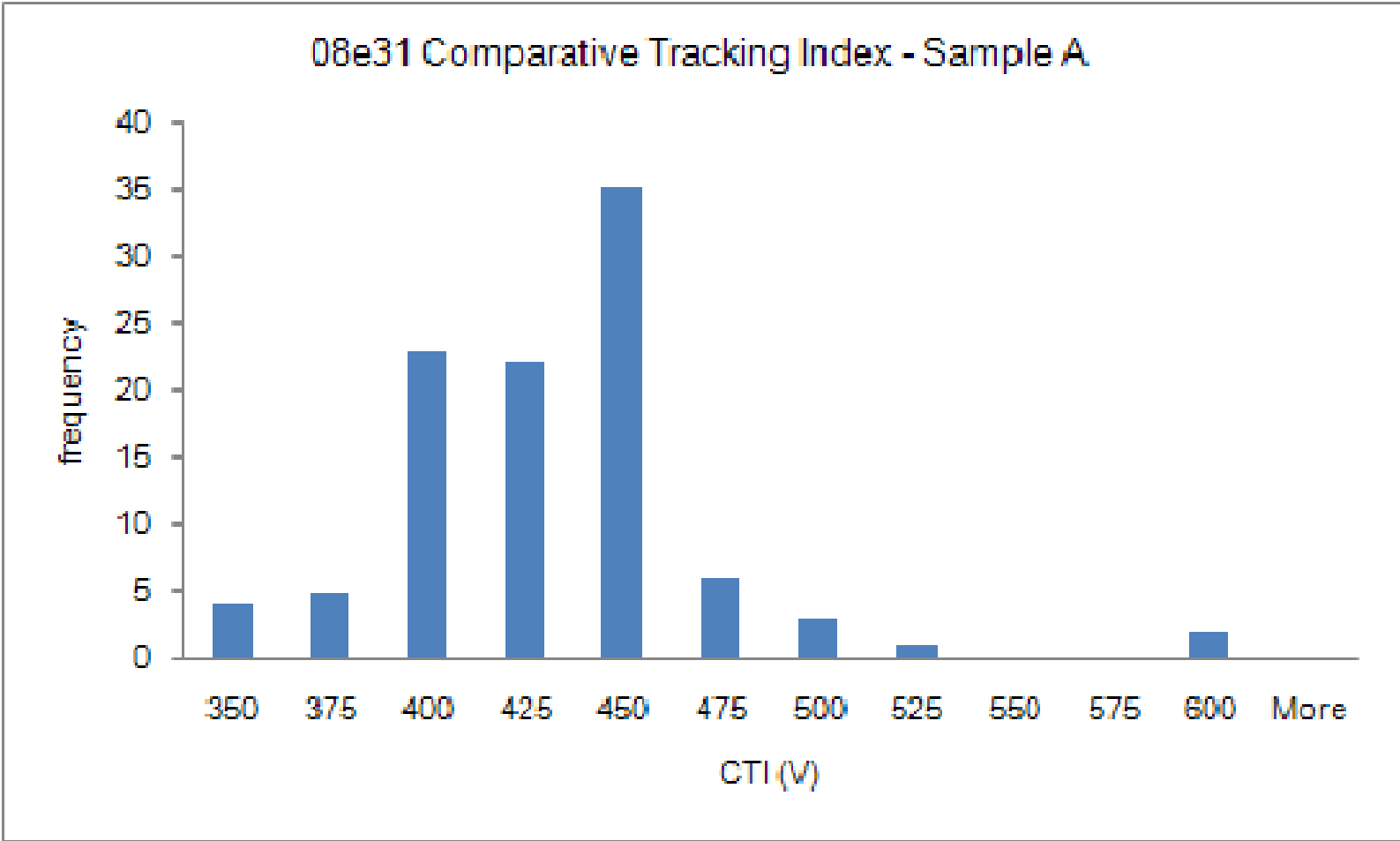
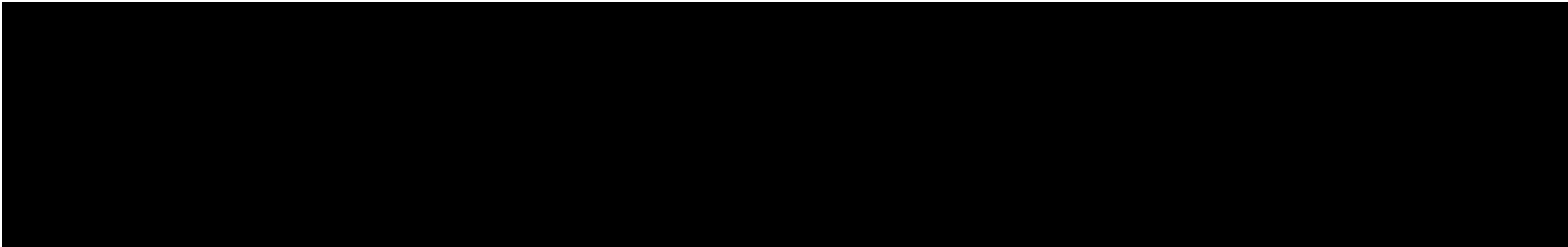
08e31

- ! Two materials offered: one a thermoplastic blend
- ! The other PVC

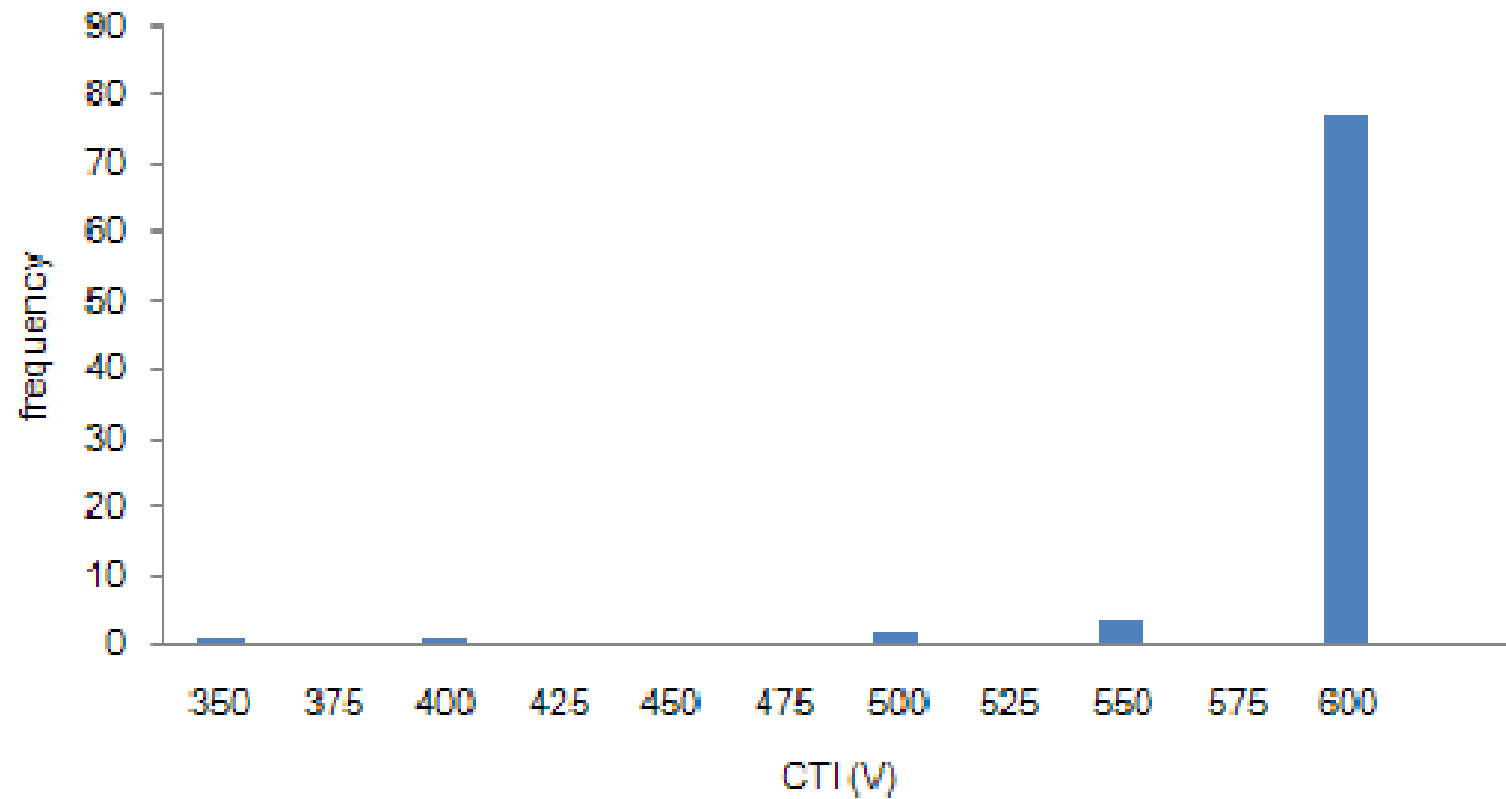
- ⓘ The blend had CTI about 450V, PVC has CTI_≥600V
- ⓘ Requested tracking results at specific voltages
- ⓘ Determine CTI (modified, based on previous results plus additional tests)

08e31: Did tracking occur?





08e31 Comparative Tracking Index - Sample B



Principle

4 Principle

The upper surface of the test specimen is supported in an approximately horizontal plane and subjected to an electrical stress via two electrodes. The surface between the electrodes is subjected to a succession of drops of electrolyte either until the over-current device operates, or until a persistent flame occurs, or until the test period has elapsed.

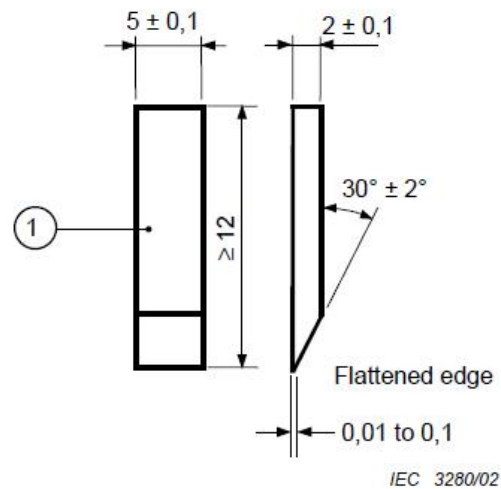
The individual tests are of short duration (less than 1 h) with up to 50 or 100 drops of about 20 mg of electrolyte falling at 30 s intervals between platinum electrodes, 4 mm apart on the test specimen surface.

An a.c. voltage between 100 V and 600 V is applied to the electrodes during the test.

During the test, specimens may also erode or soften, thereby allowing the electrodes to penetrate them. The formation of a hole through the test specimen during a test is to be reported together with the hole depth (test specimen thickness). Retests may be made using thicker test specimens, up to a maximum of 10 mm.

NOTE The number of drops needed to cause failure by tracking usually increases with decreasing applied voltage and, below a critical value, tracking ceases to occur.

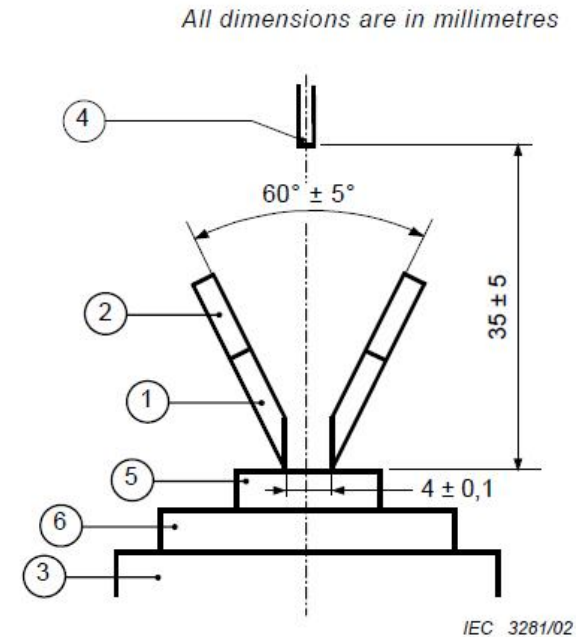
Equipment requirements



Key

- 1 Platinum electrode
- 3 Table
- 5 Specimen

Figure B.1 – Electrode

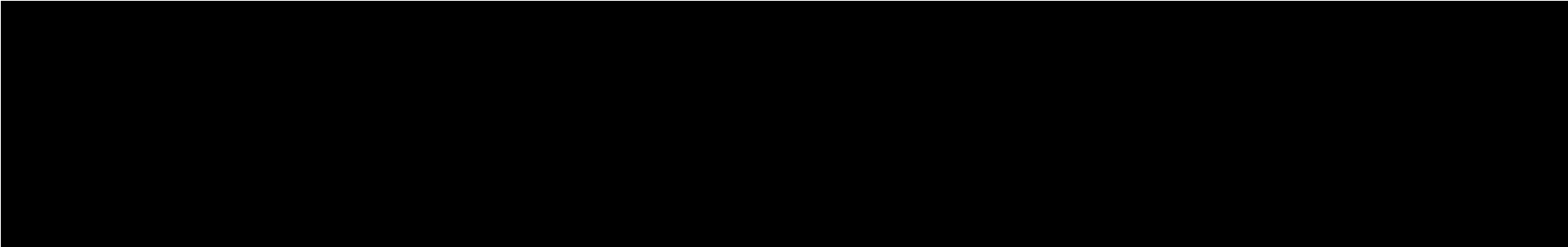


- 2 Brass extension (optional)
- 4 Tip of dropping device
- 6 Glass specimen support

Figure B.2 – Electrode / specimen arrangement

Performance Critical Features

- ⓘ Test Solution – freshness, risk of chemical change
- ⓘ Delivery of test solution: accumulation of salts on tube may affect delivery
- ⓘ Ability of test solution to remain on sample (tilt of sample bed, fit of electrodes to sample, distance between electrodes)

- 
- Electrodes
 - Distance between electrodes
 - Condition of electrodes (cleaning)
 - Fitting of electrodes to sample (contact surface)

Detection of tracking

- ⚠ Current detection indicating tracking (0.5A)
- ⚠ Permissible time that current flows before “fail” is registered.

Group Exercise

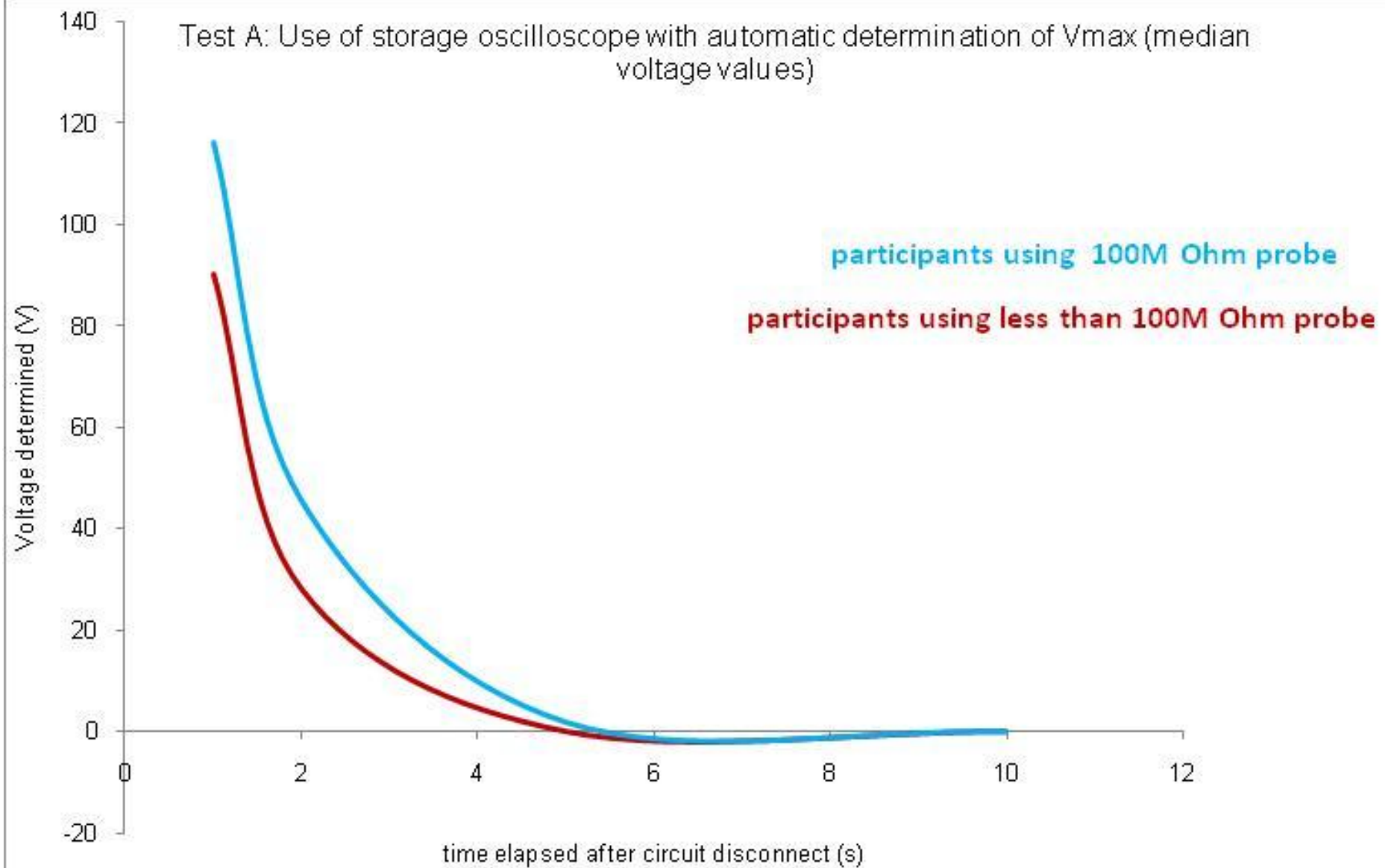
- Complete the handout for tracking test
- Identify all the steps in the testing process
- Highlight the possible risks of obtaining inaccurate test results
- Prioritise them
- Suggest some mitigating activities that could be implemented as preventive actions

Voltage decay test (plug discharge)

Voltage Decay (Plug Discharge)

- ⓘ Summary of further findings.
- ⓘ The choice of probe is important for determining the “correct” result.
- ⓘ Higher probe impedance yields higher voltage readings.
- ⓘ Alternate measurement systems (where measurement is separate to live circuit) can be employed, but timing of measurements is critical.

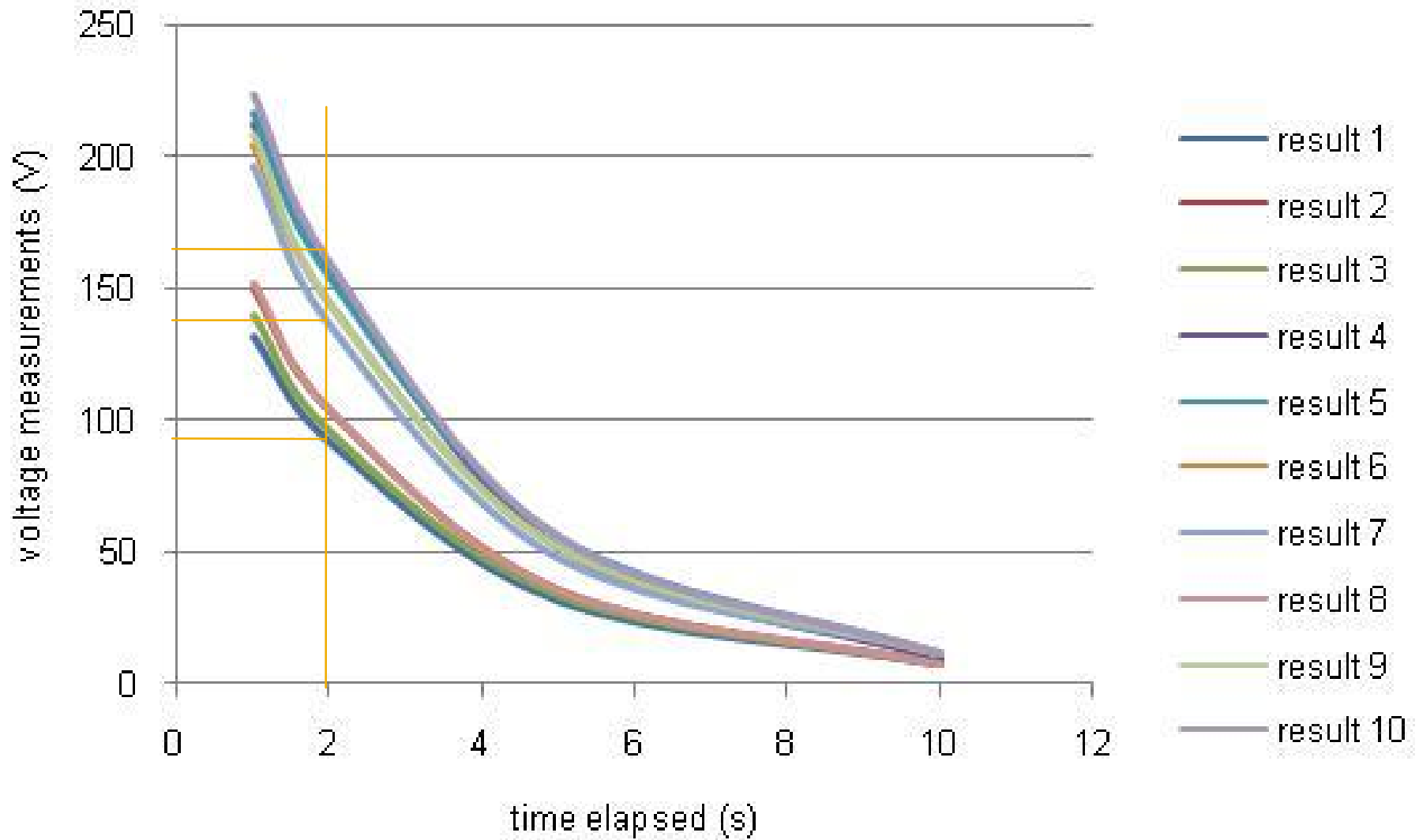
Test A: Use of storage oscilloscope with automatic determination of V_{max} (median voltage values)



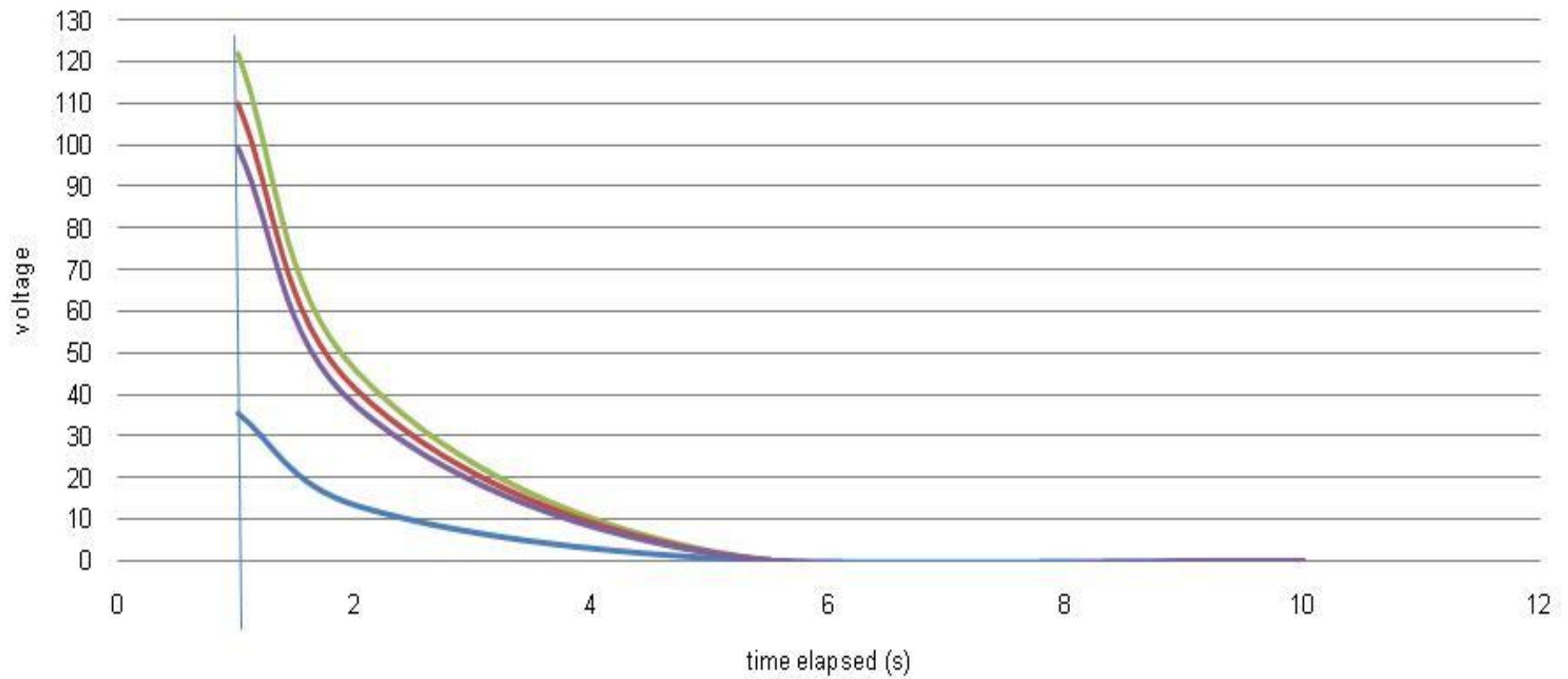
Voltage Decay

- ⓘ Critical points:
- ⓘ Reading at the top of the A/C curve

Example of 10 voltage decay measurements



Theoretical voltage decay (study of factors)

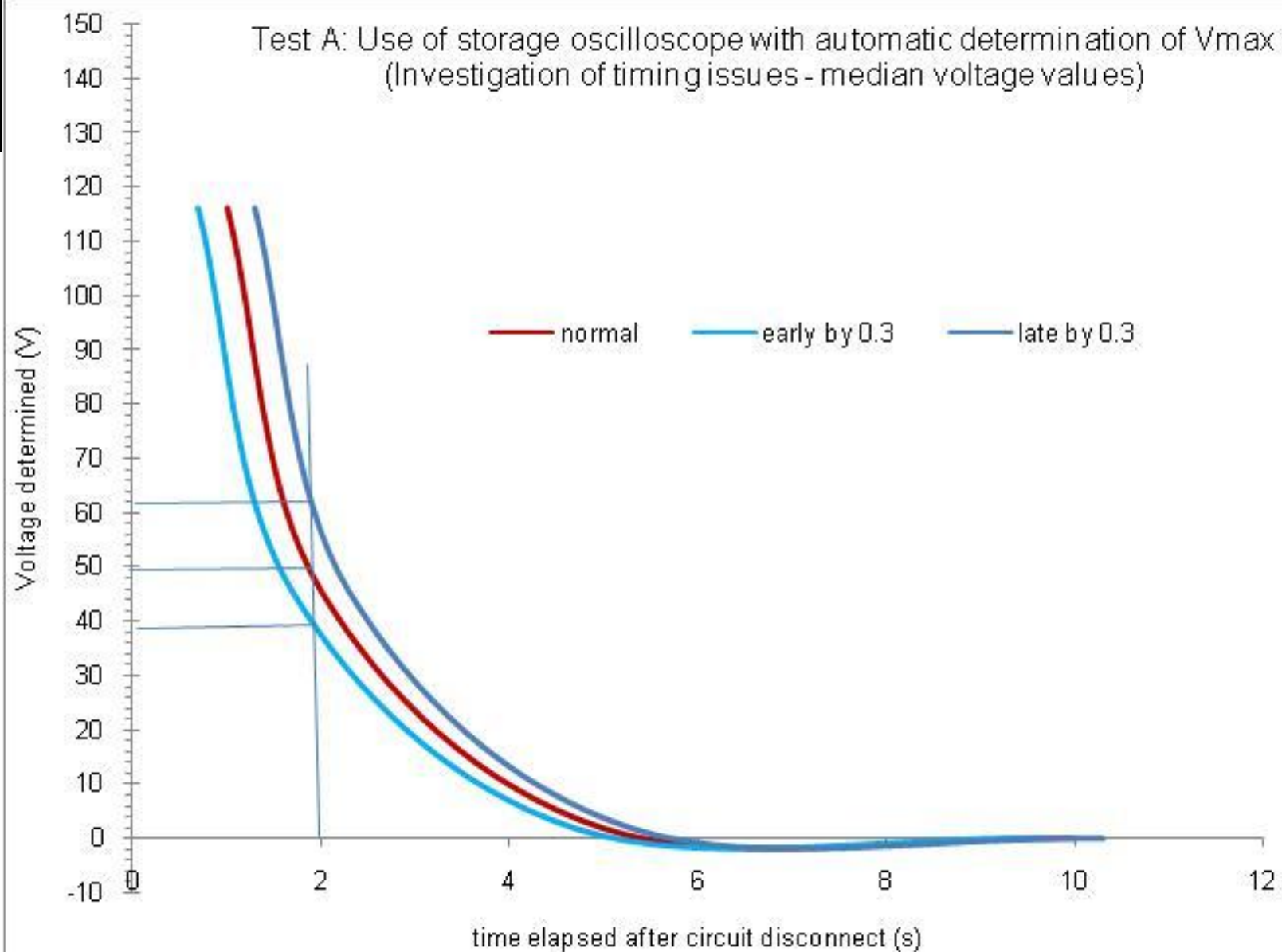


— theoretical maximum — theoretical minimum — 90% of maximum — 90% of maximum + 0.1 second inaccuracy

Voltage Decay

- ⓘ Critical points:
- ⓘ Timing the readings.
- ⓘ Curve is a the shape of exponential decay, therefore the readings taken at the beginning **MUST** be accurate.

Test A: Use of storage oscilloscope with automatic determination of V_{max}
(Investigation of timing issues - median voltage values)



Group exercise

- ⓘ Complete the handout for voltage decay test
- ⓘ Identify all the steps in the testing process
- ⓘ Highlight the possible risks of obtaining inaccurate test results
- ⓘ Prioritise them
- ⓘ Suggest some mitigating activities that could be implemented as preventive actions