Thermal measurement

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Agenda

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- Different types of thermocouple
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What is thermocouple and how they work

•Two different conductors (different alloys) that are welded at one end

•Example of alloys can be Chromel, Constantan, Iron.

•A voltage is produced when the two junctions are heated or cooled. The voltage is then converted into temperature.

Different types of thermocouple

Some examples of commonly used thermocouples in industry

Type	Typical color code	Typical Temperature range
E	Purple and Red	-270 to 1000C
J	Red and White	-210 to 1200C
K	Red and Yellow	-270 to 1372C
T	Blue and Red	-270 to 400C

Major difference between US and IEC is the color code. E.g. Type J is R/W in the US but is B/W according to IEC chart.

IEC 584-3 described color code for TC

Things to check when using thermocouples

- Choose thermocouple based on application. E.g. temperature, climate, abrasion, oil, etc.
- Thermocouple wires type must be compatible with the chart recorder or data logger, etc.
- Ensure the recorder is set for the correct type
- Check the outer jacket by hand
- Check the tip visually
- Check its function by holding the thermocouple between your fingers.
- Be careful when using these in a noisy (EMI) area. These are very thin and have no shield.
- Ensure that they are calibrated.

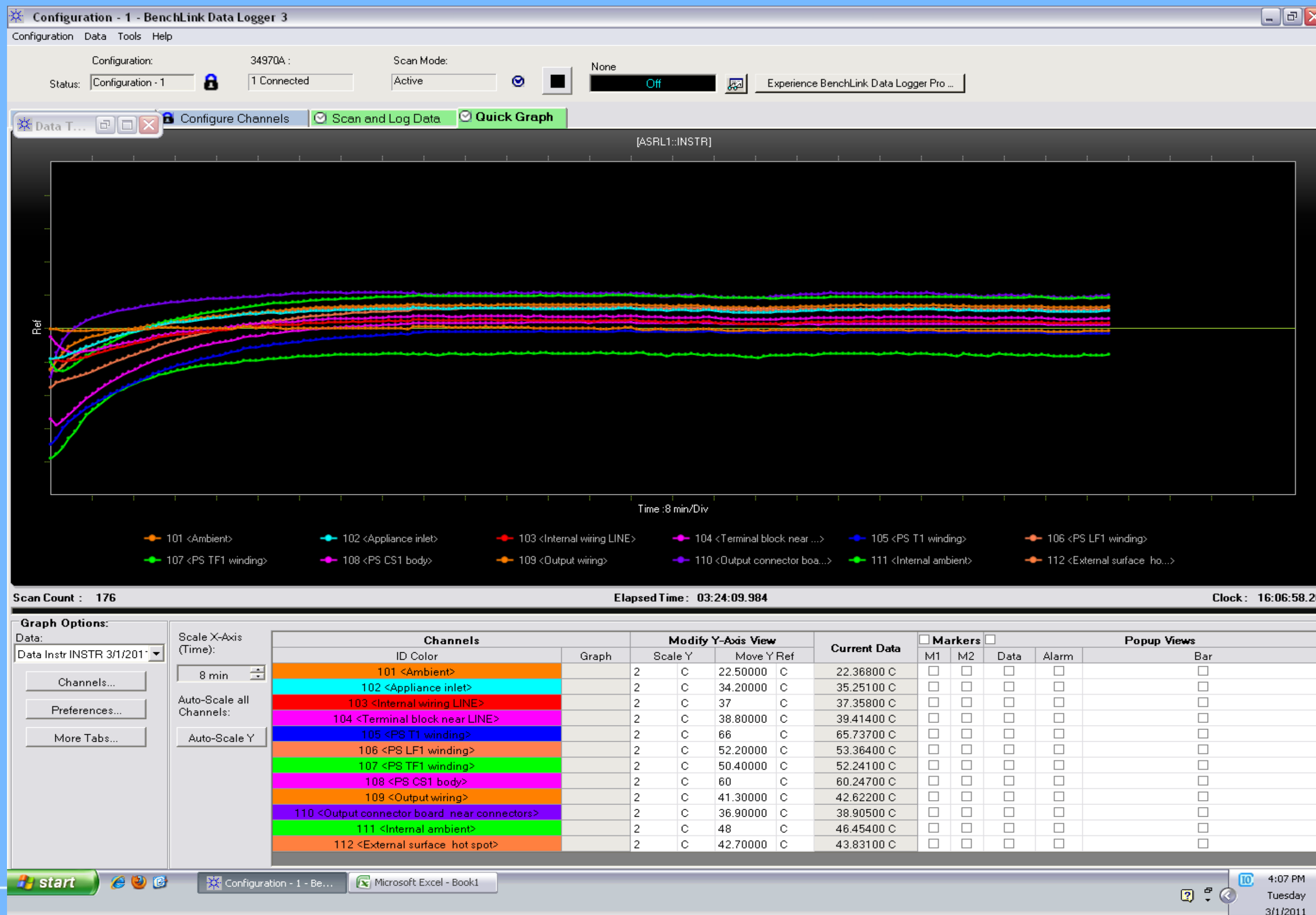
Things to check when using thermocouples Continued.

- Weld accurately and re-check after welding
- Watch out when measuring windings of transformer
- Avoid long length thermocouples as these have high resistance which may lead to some error. Use extension wire and adapter if long length is needed.
- Avoid doing the test in a high traffic area or any exposure to air conditioning.

Factors affecting the final results

- Excess air movement
- Position of thermocouple
- Use of excessive glue or cement
- Poor tip
- EUT load
- EUT voltage
- EUT not stabilized completely
- Local ambient not monitored properly

Sample of good thermal stabilization



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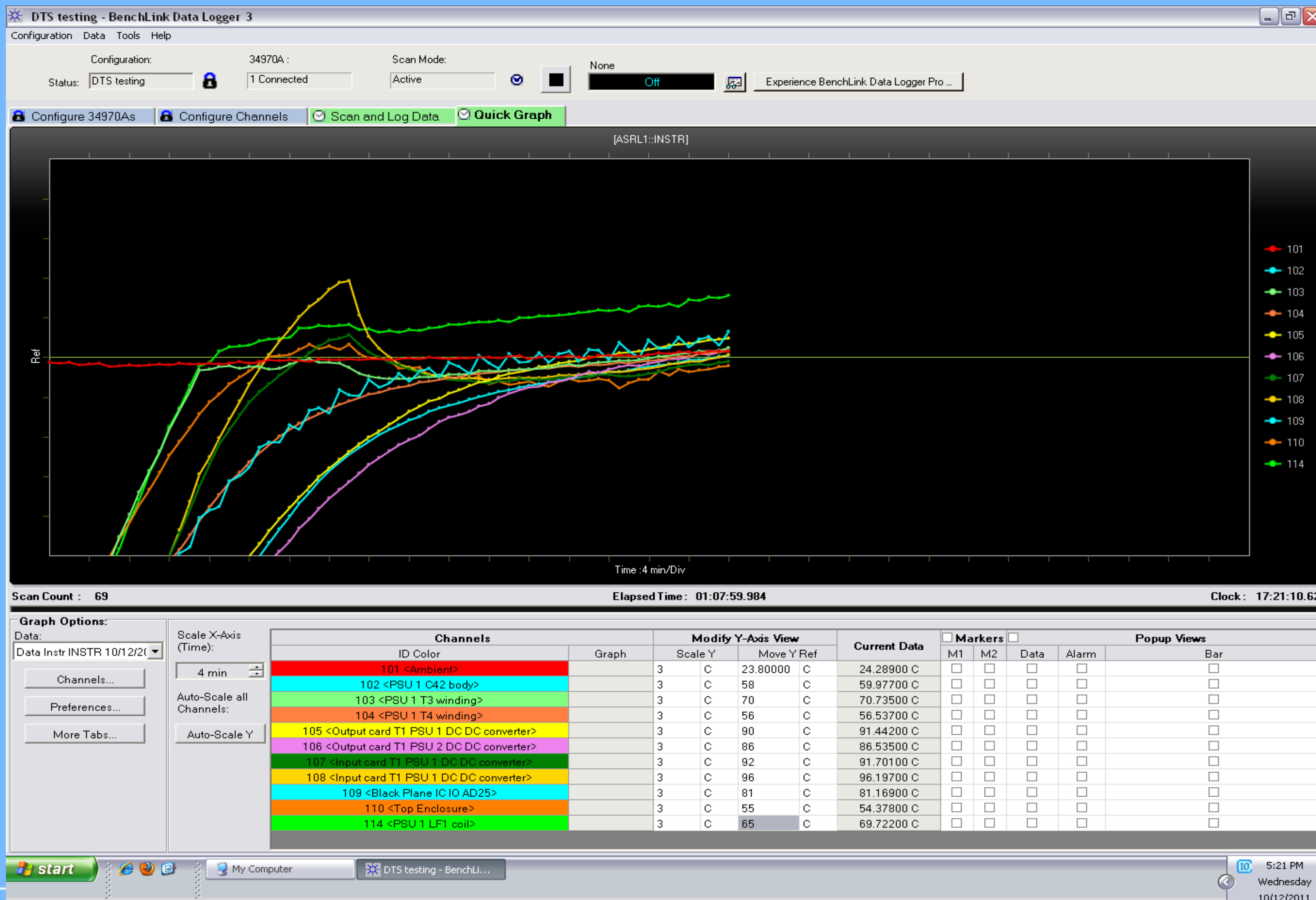
Sample of poor thermal stabilization



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Things to do when testing is completed

- Review raw data to ensure that nothing stands out
- Compare to last results where possible
- Use engineering judgment when reviewing data
- Use correct limits (use internal SOP, manufacturer data, various standards, etc)
- Prepare the report by tabulating the data, correcting them to the corresponding Tmra and include the limits for each component where possible.
- Clearly document the direction of airflow

Some of the limits used by IEC60950-1

Table 4B – Temperature limits, materials and components

Part	Maximum temperature (T_{max}) °C
Insulation, including winding insulation:	
– of Class 105 material (A)	100 [a b c]
– of Class 120 material (E)	115 [a b c]
– of Class 130 material (B)	120 [a b c]
– of Class 155 material (F)	140 [a b c]
– of Class 180 material (H)	165 [a b c]
– of Class 200 material	180 [a b]
– of Class 220 material	200 [a b]
– of Class 250 material	225 [a b]
Rubber or PVC insulation of internal and external wiring, including power supply cords:	
– without temperature marking	75 [d]
– with temperature marking	Temperature marking
Other thermoplastic insulation	See [e]
Terminals, including earthing terminals for external earthing conductors of STATIONARY EQUIPMENT, unless provided with a NON-DETACHABLE POWER SUPPLY CORD	85
Parts in contact with a flammable liquid	See 4.3.12
Components	See 1.5.1

[a] If the temperature of a winding is determined by thermocouples, these values are reduced by 10 °C, except in the case of

- a motor, or
- a winding with embedded thermocouples.

[b] For each material, account shall be taken of the data for that material to determine the appropriate maximum temperature.

[c] The designations A to H, formerly assigned in IEC 60085 to thermal classes 105 to 180, are given in parentheses.

[d] If there is no marking on the wire, the marking on the wire spool or the temperature rating assigned by the wire manufacturer is considered acceptable.

[e] It is not possible to specify maximum permitted temperatures for thermoplastic materials, due to their wide variety. These shall pass the tests specified in 4.5.5.

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Some of the limits used by IEC60950-1

Table 4C – Touch temperature limits

Parts in OPERATOR ACCESS AREAS	Maximum temperature (T_{max}) °C		
	Metal	**Glass, porcelain and vitreous material**	**Plastic and rubber** [b]
Handles, knobs, grips, etc., held or touched for short periods only	60	70	85
Handles, knobs, grips, etc., continuously held in normal use	55	65	75
External surfaces of equipment that may be touched [a]	70	80	95
Parts inside the equipment that may be touched [c]	70	80	95

[a] Temperatures up to 100 °C are permitted on the following parts:

– areas on the external surface of equipment that have no dimension exceeding 50 mm, and that are not likely to be touched in normal use; and

– a part of equipment requiring heat for the intended function (for example, a document laminator), provided that this condition is obvious to the USER. A warning shall be marked on the equipment in a prominent position adjacent to the hot part.

The warning shall be either

• the symbol (IEC 60417-5041 (DB:2002-10)): 

• or the following or similar wording

WARNING
HOT SURFACE
DO NOT TOUCH

[b] For each material, account shall be taken of the data for that material to determine the appropriate maximum temperature.

[c] Temperatures exceeding the limits are permitted provided that the following conditions are met:

– unintentional contact with such a part is unlikely; and

– the part has a marking indicating that this part is hot. It is permitted to use the following symbol (IEC 60417-5041 (DB:2002-10)) to provide this information.

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Calculation example

$T < T_{max}+T_{amb}-T_{ma}$

T = Measured temperature

T_{max} = Maximum limit allowed

T_{amb} = Local ambient

T_{ma} = Maximum ambient temp permitted by the manufacturer.

Example:

An electrolytic capacitor is measured to be 63^{o}C at a room ambient of 23^{o}C. The capacitor is rated for 105^{o}C and the manufacturer needs to qualify this product to 50^{o}C operation. Is this component passing or failing?

Calculation example-Continued

$T < T_{max}+T_{amb}-T_{ma}$

T = Measured temperature

T_{max} = Maximum limit allowed

T_{amb} = Local ambient

T_{ma} = Maximum ambient temp permitted by the manufacturer.

$63 < 105+23-50$

$63 < 78$

Component has passed

Testing on the bench verses in the Heating chamber

- Oven is used when either there is a specific request or the lab environment is unstable.
- Additionally oven is used when the product is temperature controlled. Clause 1.5.4.12.2 of IEC60950-1 2nd Ed.
- Most test agencies and standards allow both.
- In most cases a Tma is generally higher than the Tamb. Eg. 40C or 50C, etc.
- If the Tma is 50C or less, it is recommended that the testing to be done on the bench.
- If Tma is higher than 50C, then it is recommended that the testing to be done in the oven.
- Testing in the chamber is typically exponential where is testing on the bench is typically linear when mathematically corrected .

Testing on the bench verses in the oven

TC Locations	Bench	Bench adjusted to 50C	Oven at 50C
T3 windings	78.48	105.61	92.57
L24 winding	99.16	126.29	112.1
PCB next to Q9	91.36	118.73	104.56
PCB next to CR32	63.84	90.97	77.73
PCB next to U19	50.02	77.15	65.59
PCB next to Q40	77.40	104.53	91.19
Top Enclosure	38.30	65.43	53.6
Ambient	22.87		48.98

CFM and LFM

CFM = Cubic Feet per Minute

LFM = Linear Feet per Minute

Power supplies that requires forced air cooling are typically rated in terms of LFM

Additionally LFM is needed by mechanical designers to calculate heat dissipation on a heat sink.

LFM is equivalent to CFM divided by the cross-sectional area of interest

The larger the cross-sectional area, the smaller the LFM for a given CFM

LFM = CFM/Area (ft^2)

Area here means the cross sectional area of the fan box size.

If the fan is square the cross sectional area is L x W and if the fan is circular the cross sectional area is πr^2

CFM and LFM-Continued

Example:

Fan is 40x40mm and has a CFM of 5.2. Therefore the LFM is calculated as:

1mm = 0.00328ft

40mm = 0.1312ft

$40mm^2$ = 0.0172 ft^2

LFM = 5.2/0.0172

LFM = 302