Cable Current Measurements

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Test Procedure

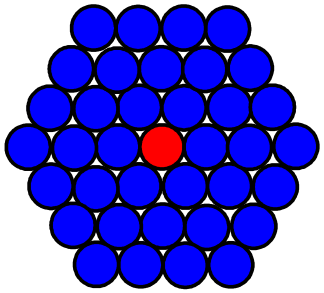
- **The heating tests were carried out using the procedure on the IEEE website (Jo Walling).**
- **We owe our thanks and appreciation to D. Anderson and E. Bech from Delta for carrying out these trials and for their suggestions to improve the test procedure.**

Testing

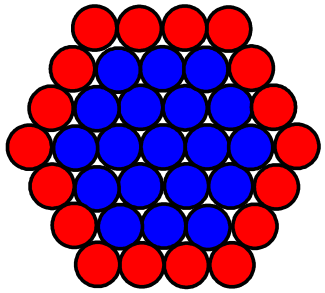
- **The heating was done under two– and four–pair current loading with 420 mA per conductor.**
- **Measurement objective was the equilibrium temperature difference of the resulting operating temperatures of the conductors and the ambient temperature.**
- **The following configurations with of the heated cables in the bundle were used:**

Configurations

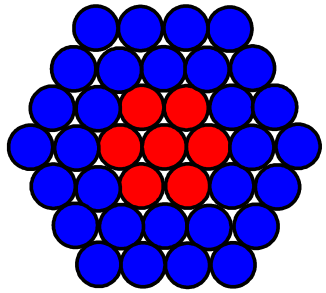
1st Trial



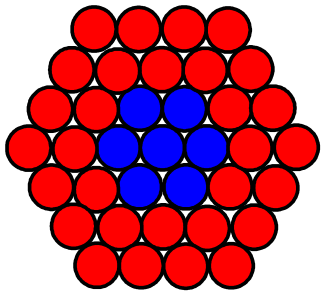
4th Trial



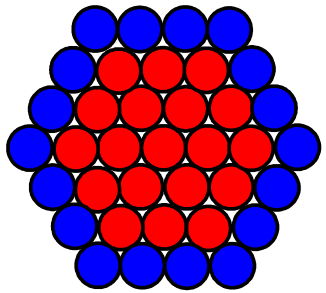
5th Trial



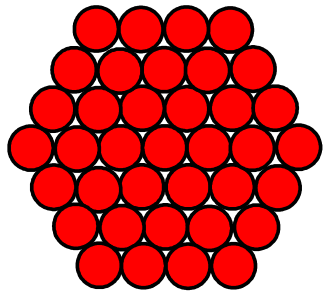
The heated cables are indicated in red. Temperature in the centre cable and in each layer on the main diagonal of the hexagon are measured



10th Trial



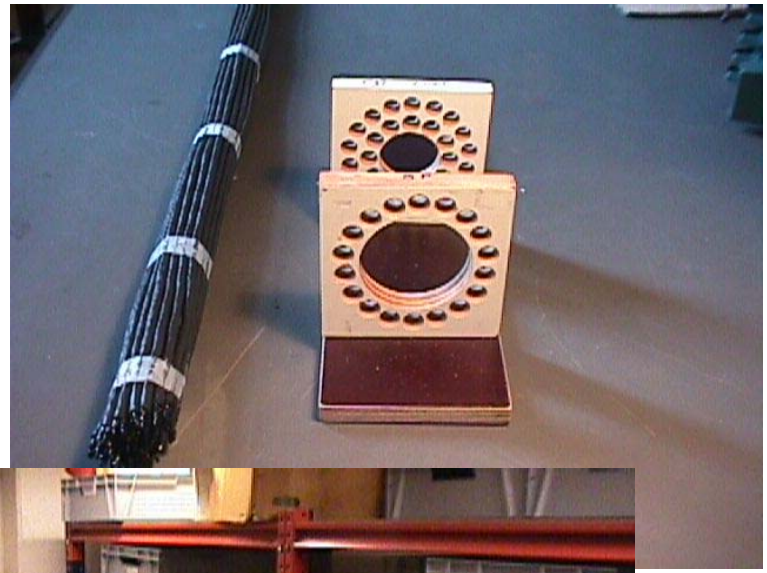
11th Trial

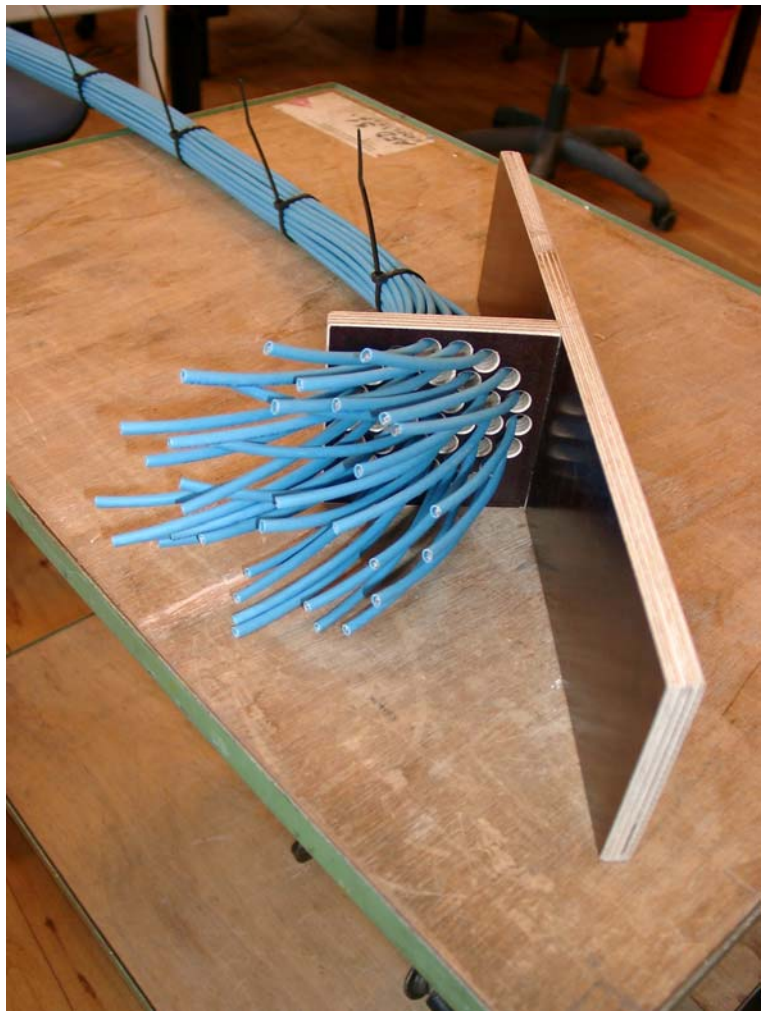


15th Trial

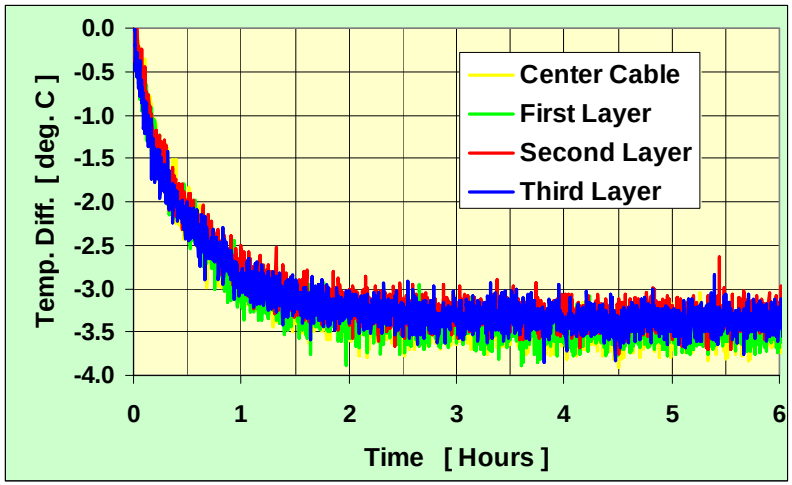
- **The numbers of the trials refer to the configuration described in the test procedure.**

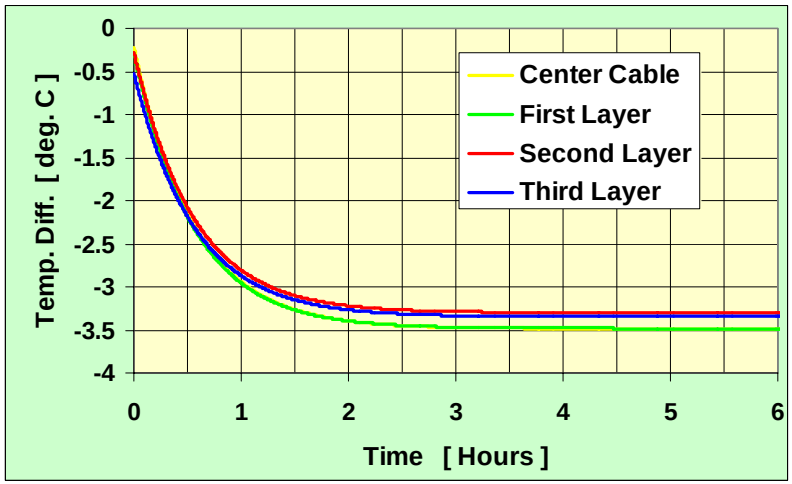
Testing – some pictures of the setup





Cooling Time



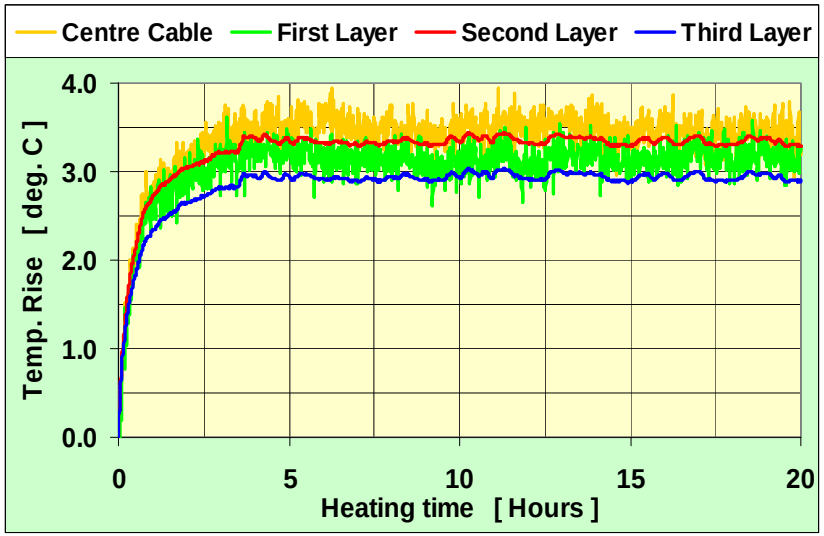


- **Cooling of a patch cable bundle after heating all cables with a current of 0.420 A on two pairs for 20 hours.**
- **Top is raw data, Bottom is curve fitted.**
- **The ambient temperature is reached again after approximately 3 hours.**
- **Therefore a cooling time of 4 hours was used.**

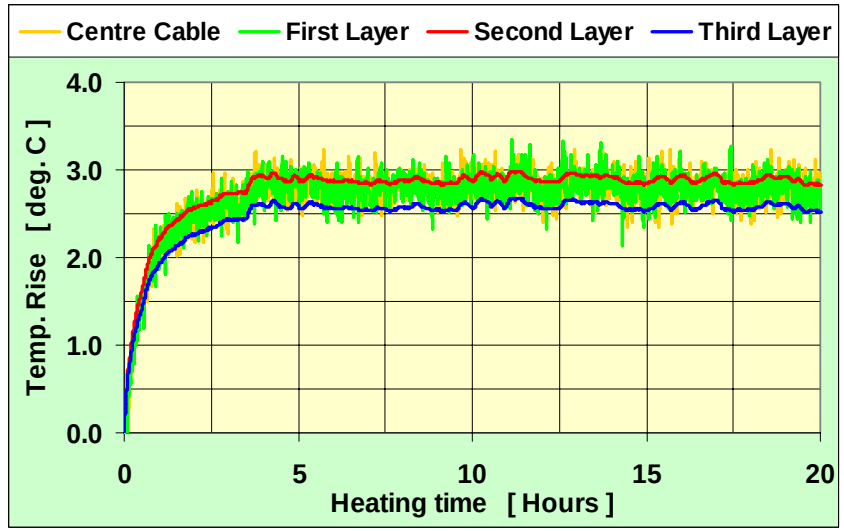
Cat 5 - Cable Characteristics

Pair #	Solid Cable			Patch Cable		
	LR (ohms)	CRU %	CMCRU %	LR (ohms)	CRU %	CMCRU %
1	16.8	0.0	-	15.5	0.3	-
1 – 2			0.599			1.273
1 – 3			0.000			0.000
1 – 4			0.901			0.321
2 – 1			0.599			1.273
2	16.6	0.2	-	15.9	0.5	-
2 – 3			0.599			1.273
2 – 4			0.302			0.952
3 – 1			0.000			0.000
3 – 2			0.599			1.273
3	16.8	0.1	-	15.5	0.3	-
3 – 4			0.901			0.000
4 – 1			0.901			1.273
4 – 2			0.302			0.952
4 – 3			0.901			0.321
4	16.5	0.0	-	15.6	0.4	-

Results – 2-pair trial 10

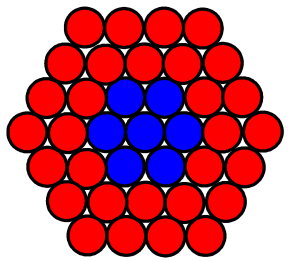


2–Pair heating



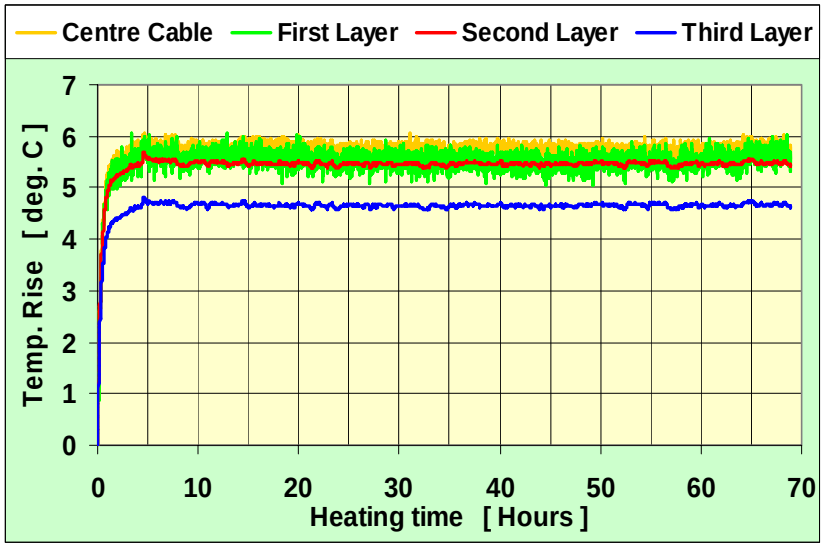
Horizontal Cable

Trial configuration

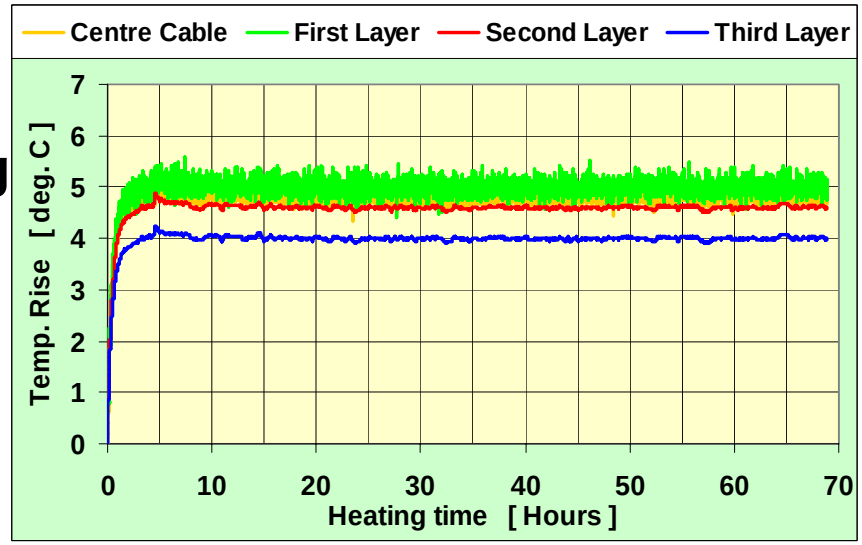


Patch Cable

Results – 4-pair trial 10

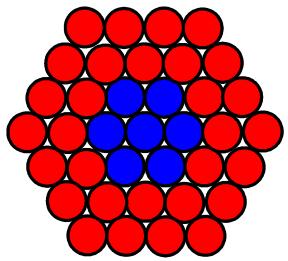


4–Pair heating



Horizontal Cable

Trial configuration

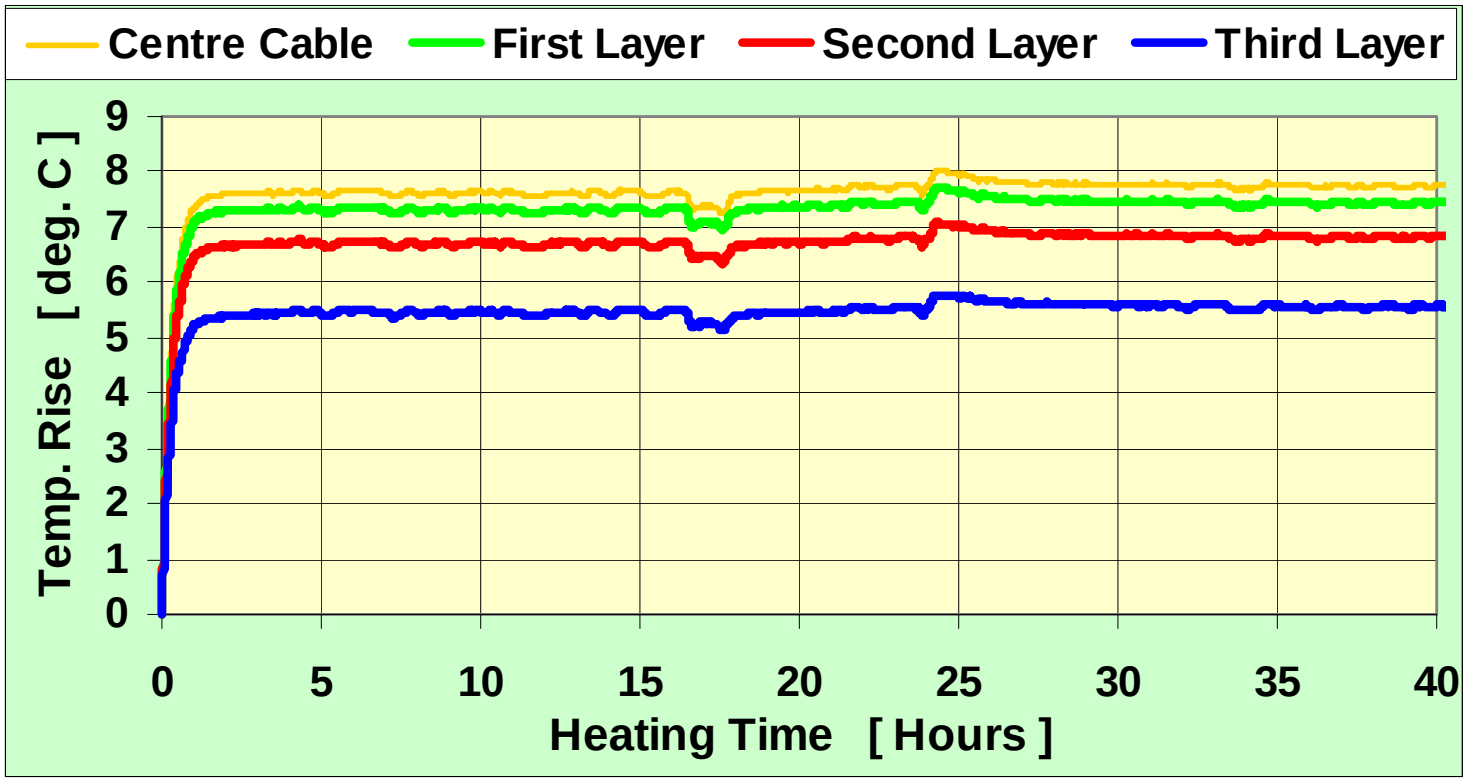


Patch Cable

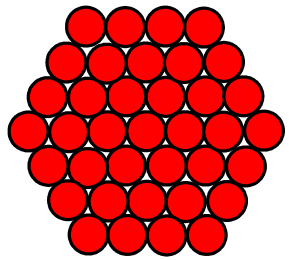
Thoughts

- **The 2–pair heating trials measurements may have been influenced by crosstalk from a noisy constant current source.**
- **The 4–pair trial was done with a new constant current source and seems to be less noisy on the inner layer and the center cable.**

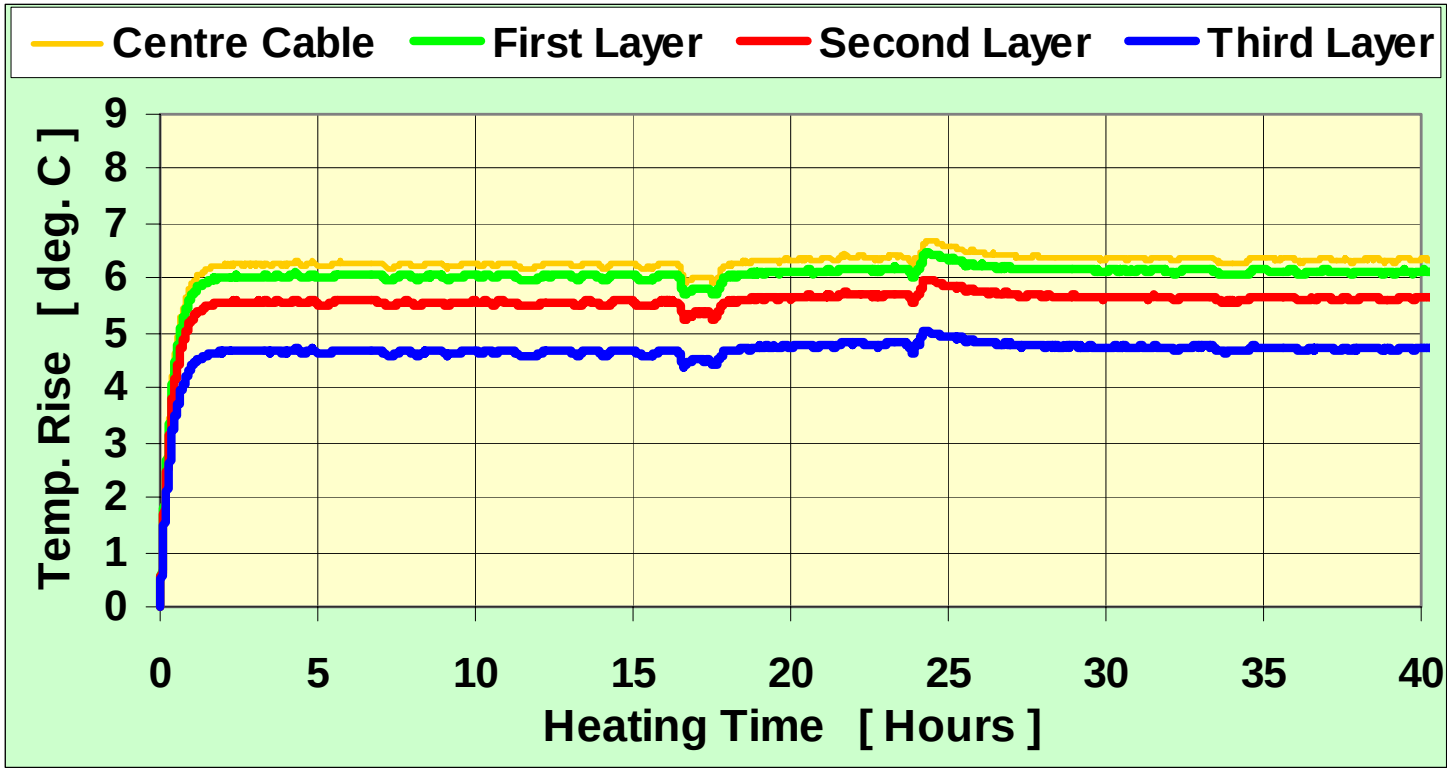
Results – 4-pair trial 15



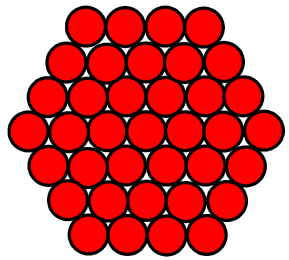
Horizontal Cable



Results – 4-pair trial 15



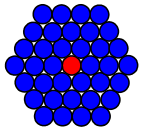
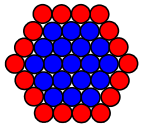
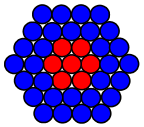
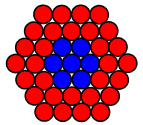
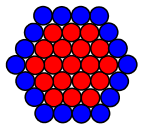
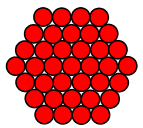
Patch Cable



Thoughts

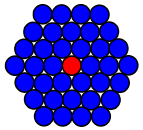
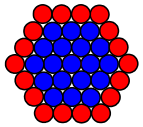
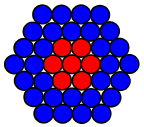
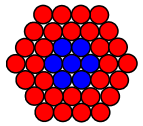
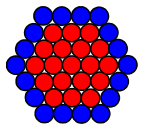
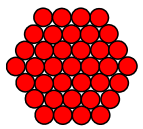
- **You can see irregularities at the time intervals of 16th hour and the 24th hour.**
- **These irregularities occurred across all layers, including the center cable. It is therefore due to the current supply, as both cable bundles were connected in series for the test.**

Temperature rise – Horizontal cable

Results on the solid (horizontal) cable					
Trial #	LAYER	Temperature Rise over Ambient [deg. C]			
		2 Pair Heating		4 Pair Heating	
		Mean	Error	Mean	Error
	Centre Cable	0.94	0.04	**0.82**	**0.03**
	First Layer	1.04	0.04	**0.61**	**0.03**
	Second Layer	0.87	0.04	**0.56**	**0.02**
	Third Layer	0.99	0.04	**0.53**	**0.02**
	Centre Cable	2.02	0.08	3.56	0.15
	First Layer	2.13	0.09	3.40	0.14
	Second Layer	2.08	0.08	3.01	0.12
	Third Layer	2.15	0.09	3.12	0.13
	Centre Cable	1.50	0.03	2.58	0.06
	First Layer	1.46	0.03	2.34	0.06
	Second Layer	1.13	0.02	1.74	0.04
	Third Layer	1.13	0.02	1.50	0.04
	Centre Cable	3.48	0.14	5.77	0.14
	First Layer	3.16	0.13	5.51	0.13
	Second Layer	3.35	0.14	5.46	0.13
	Third Layer	2.95	0.12	4.65	0.11
	Centre Cable	3.42	0.08	4.99	0.20
	First Layer	3.31	0.08	4.93	0.20
	Second Layer	2.99	0.07	4.33	0.18
	Third Layer	1.67	0.04	3.10	0.13
	Centre Cable	4.22	0.13	7.68	0.31
	First Layer	4.12	0.13	7.38	0.30
	Second Layer	3.81	0.12	6.76	0.28
	Third Layer	3.23	0.10	5.51	0.22

- **Average values over 10 hours minimium**
- **Results of the equilibrium temperature rise over ambient of the horizontal cable.**
- **Obviously the results for the first trial of the 4–pair heating are faulty. This may be due to the data acquisition system.**

Temperature rise – Patch cable

Results on the patch (work area or equipment cord) cable					
Trial #	LAYER	Temperature Rise over Ambient [deg. C]			
		2 Pair Heating		4 Pair Heating	
		Mean	Error	Mean	Error
	Centre Cable	1.05	0.05	**0.72**	**0.03**
	First Layer	1.07	0.04	**0.60**	**0.03**
	Second Layer	1.05	0.04	**0.66**	**0.03**
	Third Layer	1.63	0.07	**1.10**	**0.05**
	Centre Cable	1.97	0.08	2.90	0.12
	First Layer	2.05	0.09	2.98	0.12
	Second Layer	2.17	0.09	3.01	0.12
	Third Layer	1.92	0.08	2.68	0.11
	Centre Cable	1.36	0.03	2.14	0.05
	First Layer	1.31	0.03	1.96	0.05
	Second Layer	1.03	0.02	1.76	0.04
	Third Layer	1.27	0.03	1.87	0.04
	Centre Cable	2.81	0.12	4.78	0.11
	First Layer	2.81	0.11	5.00	0.12
	Second Layer	2.90	0.12	4.59	0.11
	Third Layer	2.59	0.11	3.99	0.09
	Centre Cable	2.92	0.07	4.21	0.17
	First Layer	2.82	0.07	4.00	0.16
	Second Layer	2.56	0.06	3.50	0.14
	Third Layer	**13.73**	**0.32**	3.32	0.14
	Centre Cable	3.59	0.15	6.30	0.26
	First Layer	3.50	0.14	6.08	0.25
	Second Layer	3.25	0.13	5.60	0.23
	Third Layer	2.81	0.11	4.69	0.19

- **Average values over 10 hours minimium**
- **Results of the equilibrium temperature rise over ambient of the patch cable.**
- **Again the first trial results for the 4–pair heating are faulty. The trial was made in series with the corresponding trial of the horizontal cable.**

Moving Forward

- **Determine for a cable type the temperature difference between operating and ambient temperature as a function of the current. This is a parabolic function, hence a linear relationship in a log–log plot.**
- **Establish a graph for the de-rating factor as a function of the number of cables in the bundle.**
- **Establish a graph for the de-rating factor as a function of the number of conductors used in the cable in the bundle.**

Questions …

… or comments