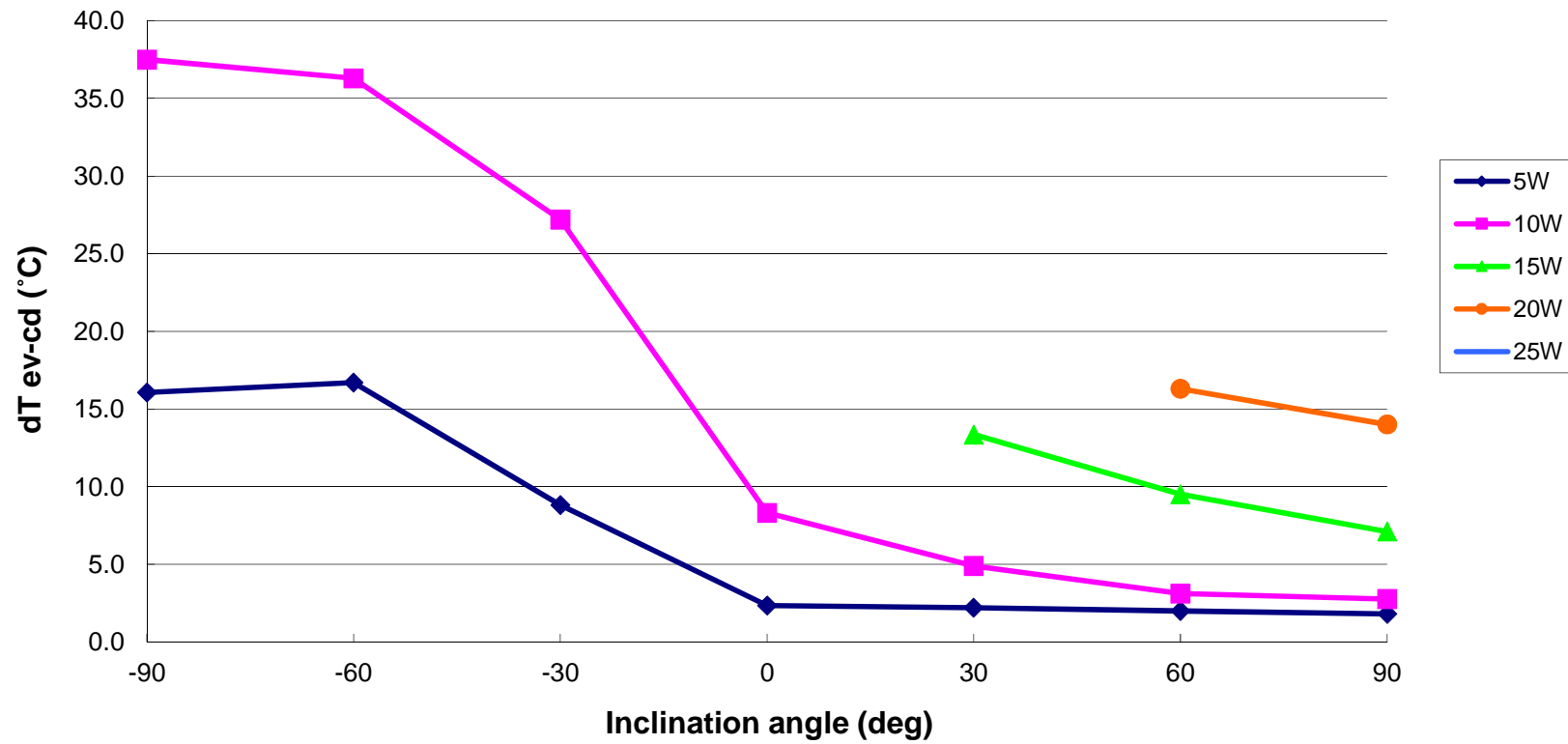


## Heat Pipe Test Report

Manufacturer		Enertron			Test conditions				Test date	2017/12/28			
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol			Effective area (m <sup>2</sup> )		2.83E-05		Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block				
Pipe specification		C110 Copper 0.3mm wall thickness			Coolant temp (°C)		-10						
Diameter	±0.05 mm	6			Contact length of ev/cd (mm)		50						
Length	±0.10 mm	150			At 90° the evaporator is directly below the condenser; 0° is horizontal.								
Flatten thickness	±0.05 mm	n/a											
Bend angle	±1 deg	n/a											
Inclination Angle (°)	Heat Load (W)	dT ev-cd (°C)	Thermal resistance ev-cd (°C/W)	Thermal conductivity ev-cd (W/mK)	dT eb-cb (°C)	Thermal resistance eb-cb (°C/W)	Thermal Conductivity eb-cb (W/mK)	Measured Temperature T (°C)					
								ev	cd	eb1	eb2	cb1	cb2
90	5	1.80	0.36	9824	2.10	0.42	8421	-7.40	-9.20	-7.20	-7.20	-9.30	-9.30
	10	2.75	0.28	12861	3.00	0.30	11789	-5.65	-8.40	-5.50	-5.50	-8.50	-8.50
	15	7.10	0.47	7472	7.45	0.50	7121	-0.40	-7.50	-0.20	-0.20	-7.70	-7.60
	20	14.00	0.70	5053	14.15	0.71	4999	7.15	-6.85	7.10	7.10	-7.10	-7.00
	25	42.60	1.70	2076	42.60	1.70	2076	35.00	-7.60	35.00	35.00	-7.60	-7.60
60	5	2.00	0.40	8842	2.10	0.42	8421	-7.30	-9.30	-7.20	-7.20	-9.30	-9.30
	10	3.10	0.31	11409	3.30	0.33	10718	-5.40	-8.50	-5.30	-5.30	-8.60	-8.60
	15	9.50	0.63	5584	9.65	0.64	5498	2.10	-7.40	2.10	2.00	-7.60	-7.60
	20	16.30	0.82	4340	16.45	0.82	4300	8.90	-7.40	8.90	8.90	-7.50	-7.60
30	5	2.20	0.44	8038	2.35	0.47	7525	-6.90	-9.10	-6.80	-6.80	-9.10	-9.20
	10	4.90	0.49	7218	5.00	0.50	7074	-3.35	-8.25	-3.40	-3.40	-8.40	-8.40
	15	13.35	0.89	3974	13.50	0.90	3930	5.60	-7.75	5.60	5.60	-7.90	-7.90
0	5	2.35	0.47	7525	2.55	0.51	6935	-6.85	-9.20	-6.70	-6.80	-9.30	-9.30
	10	8.30	0.83	4261	8.30	0.83	4261	-0.50	-8.80	-0.50	-0.50	-8.80	-8.80
-30	5	8.80	1.76	2010	8.80	1.76	2010	-0.50	-9.30	-0.50	-0.50	-9.30	-9.30
	10	27.20	2.72	1300	27.20	2.72	1300	18.25	-8.95	18.30	18.20	-8.90	-9.00
-60	5	16.70	3.34	1059	16.70	3.34	1059	7.40	-9.30	7.40	7.40	-9.30	-9.30
	10	36.30	3.63	974	36.25	3.63	976	27.40	-8.90	27.30	27.30	-8.90	-9.00
-90	5	16.05	3.21	1102	16.10	3.22	1098	6.80	-9.25	6.80	6.80	-9.30	-9.30
	10	37.50	3.75	943	37.50	3.75	943	28.55	-8.95	28.60	28.50	-8.90	-9.00

**Heat pipe performance (dT vs Inclination angles at various heat loads)**  
Heat pipe tested: 6mm x 150mm sintered powder metal/ methanol

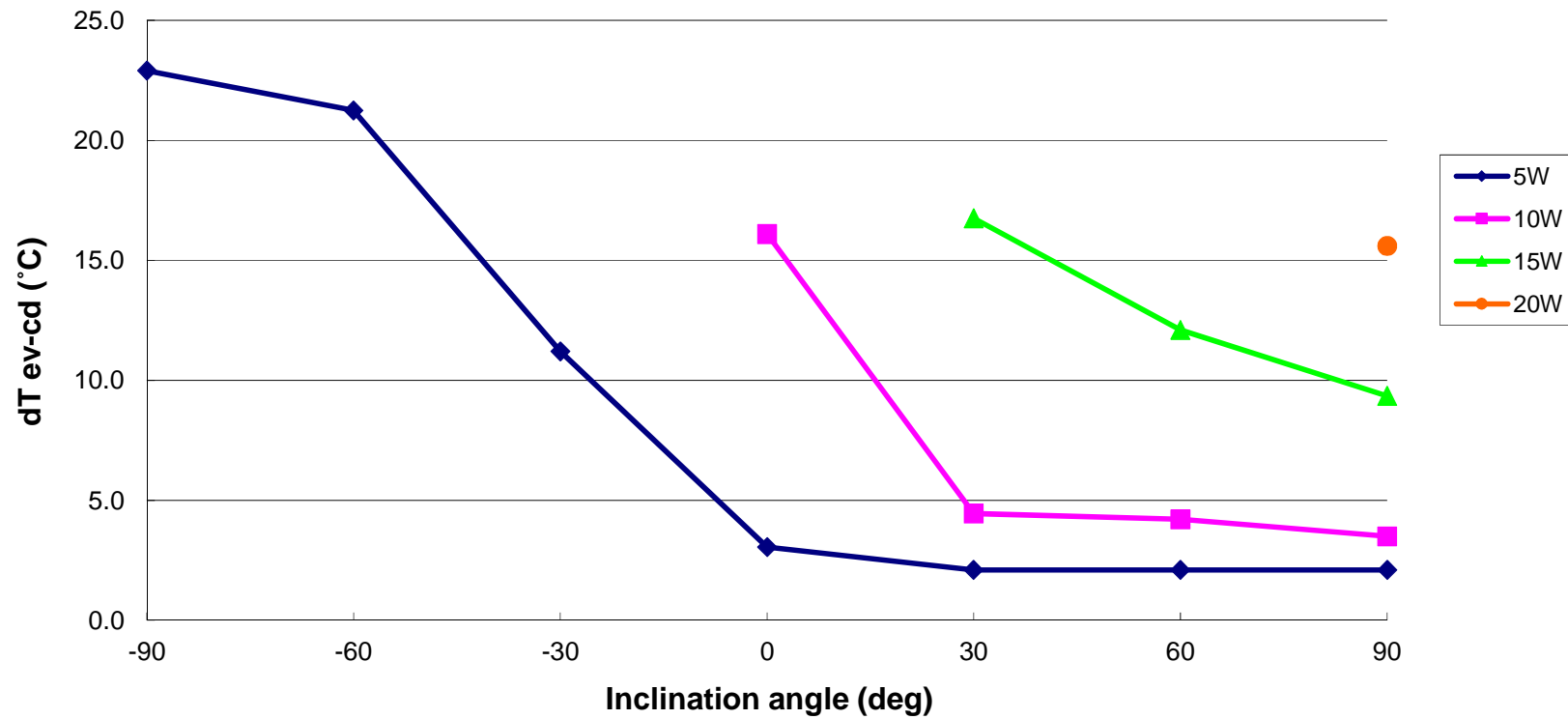


## Heat Pipe Test Report

Manufacturer		Enertron			Test conditions				Test date	2017/12/28				
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol			Effective area (m <sup>2</sup> )		2.83E-05		Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block					
Pipe specification		C110 Copper 0.3mm wall thickness			Coolant temp (°C)		-10							
Diameter	±0.05 mm	6			Contact length of ev/cd (mm)		50							
Length	±0.10 mm	175			At 90° the evaporator is directly below the condenser; 0° is horizontal.									
Flatten thickness	±0.05 mm	n/a												
Bend angle	±1 deg	n/a												
Inclination Angle (°)	Heat Load (W)	dT ev-cd (°C)	Thermal resistance ev-cd (°C/W)	Thermal conductivity ev-cd (W/mK)	dT eb-cb (°C)	Thermal resistance eb-cb (°C/W)	Thermal Conductivity eb-cb (W/mK)	Measured Temperature T (°C)						
								ev	cd	eb1	eb2	cb1	cb2	
90	5	2.10	0.42	10526	2.30	0.46	9611	-7.10	-9.20	-6.90	-7.00	-9.30	-9.20	
	10	3.50	0.35	12631	3.65	0.37	12112	-5.00	-8.50	-4.70	-4.80	-8.40	-8.40	
	15	9.35	0.62	7092	9.55	0.64	6944	1.85	-7.50	2.10	2.10	-7.40	-7.50	
	20	15.60	0.78	5668	15.65	0.78	5650	8.65	-6.95	8.70	8.70	-6.90	-7.00	
60	5	2.10	0.42	10526	2.25	0.45	9824	-7.10	-9.20	-6.90	-7.00	-9.20	-9.20	
	10	4.20	0.42	10526	4.45	0.45	9935	-4.15	-8.35	-4.00	-4.00	-8.40	-8.50	
	15	12.10	0.81	5481	12.55	0.84	5284	4.45	-7.65	4.50	4.50	-8.10	-8.00	
30	5	2.10	0.42	10526	2.30	0.46	9611	-7.20	-9.30	-7.00	-7.00	-9.30	-9.30	
	10	4.45	0.45	9935	4.75	0.48	9307	-3.85	-8.30	-3.60	-3.70	-8.40	-8.40	
	15	16.75	1.12	3959	17.00	1.13	3901	8.50	-8.25	8.50	8.50	-8.50	-8.50	
0	5	3.05	0.61	7247	3.20	0.64	6908	-6.20	-9.25	-6.10	-6.10	-9.30	-9.30	
	10	16.10	1.61	2746	16.30	1.63	2712	7.20	-8.90	7.20	7.20	-9.10	-9.10	
-30	5	11.20	2.24	1974	11.20	2.24	1974	1.80	-9.40	1.80	1.80	-9.40	-9.40	
-60	5	21.25	4.25	1040	21.30	4.26	1038	11.80	-9.45	11.80	11.80	-9.50	-9.50	
-90	5	22.90	4.58	965	23.00	4.60	961	13.50	-9.40	13.50	13.50	-9.50	-9.50	

**Heat pipe performance (dT vs Inclination angles at various heat loads)**

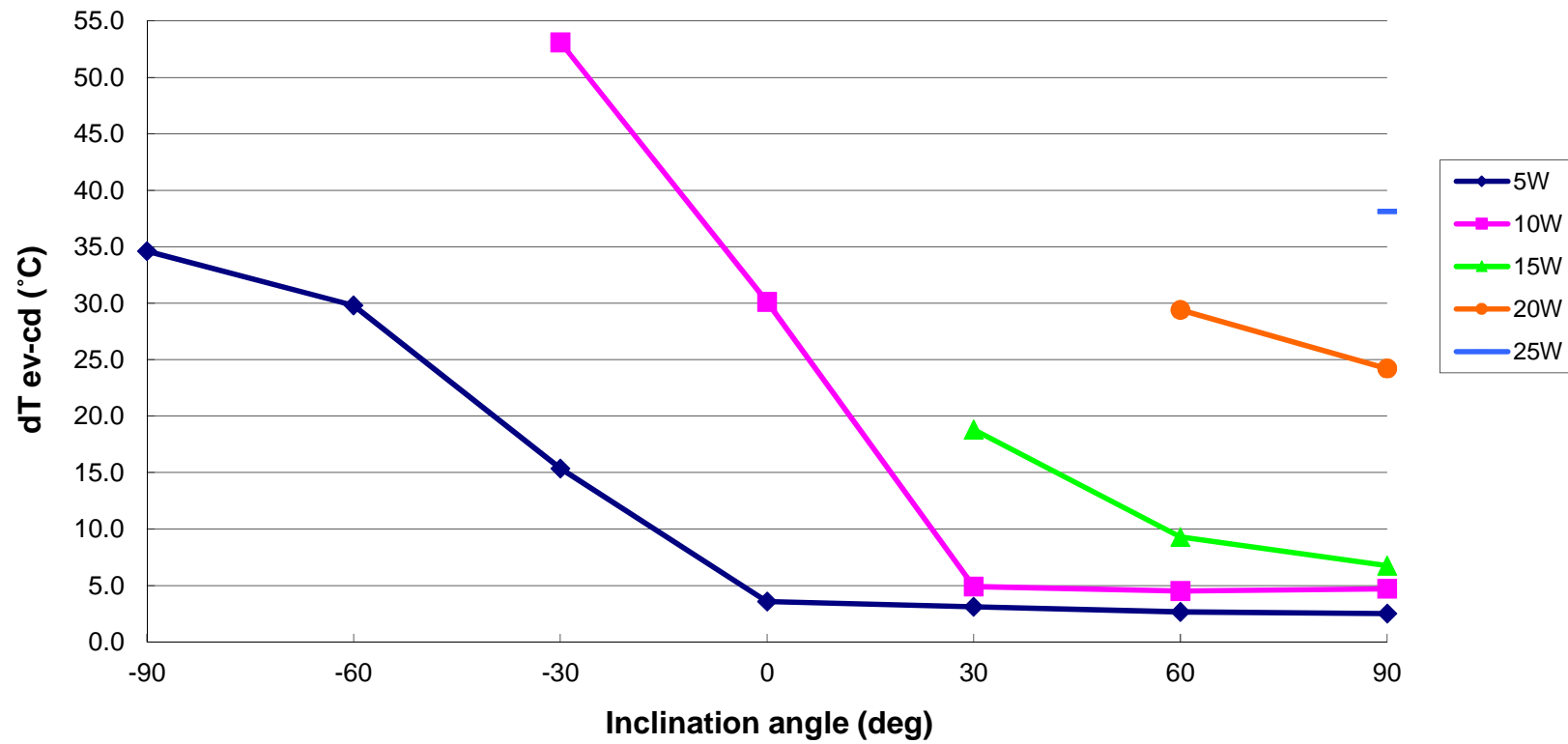
Heat pipe tested: 6mm x 175mm sintered powder metal/ methanol



## Heat Pipe Test Report

Manufacturer		Enertron			Test conditions				Test date	2017/12/28				
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol			Effective area (m <sup>2</sup> )		2.83E-05		Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block					
Pipe specification		C110 Copper 0.3mm wall thickness			Coolant temp (°C)		-10							
Diameter	±0.05 mm	6			Contact length of ev/cd (mm)		50							
Length	±0.10 mm	200			At 90° the evaporator is directly below the condenser; 0° is horizontal.									
Flatten thickness	±0.05 mm	n/a												
Bend angle	±1 deg	n/a												
Inclination Angle (°)	Heat Load (W)	dT ev-cd (°C)	Thermal resistance ev-cd (°C/W)	Thermal conductivity ev-cd (W/mK)	dT eb-cb (°C)	Thermal resistance eb-cb (°C/W)	Thermal Conductivity eb-cb (W/mK)	Measured Temperature T (°C)						
								ev	cd	eb1	eb2	cb1	cb2	
90	5	2.50	0.50	10610	2.50	0.50	10610	-6.80	-9.30	-6.80	-6.80	-9.30	-9.30	
	10	4.70	0.47	11288	4.95	0.50	10718	-3.55	-8.25	-3.40	-3.40	-8.20	-8.50	
	15	6.75	0.45	11789	7.10	0.47	11208	-0.60	-7.35	-0.50	-0.50	-7.40	-7.80	
	20	24.20	1.21	4384	24.10	1.21	4403	16.35	-7.85	16.30	16.30	-7.70	-7.90	
	25	38.10	1.52	3481	38.00	1.52	3490	30.30	-7.80	30.30	30.30	-7.70	-7.70	
60	5	2.65	0.53	10010	2.70	0.54	9824	-6.65	-9.30	-6.60	-6.60	-9.30	-9.30	
	10	4.50	0.45	11789	4.70	0.47	11288	-3.80	-8.30	-3.70	-3.70	-8.30	-8.50	
	15	9.30	0.62	8557	9.65	0.64	8246	1.65	-7.65	1.80	1.80	-7.60	-8.10	
	20	29.40	1.47	3609	29.35	1.47	3615	21.25	-8.15	21.20	21.20	-8.10	-8.20	
30	5	3.10	0.62	8557	3.05	0.61	8697	-6.10	-9.20	-6.10	-6.10	-9.10	-9.20	
	10	4.90	0.49	10827	5.15	0.52	10301	-3.30	-8.20	-3.20	-3.20	-8.20	-8.50	
	15	18.80	1.25	4233	18.80	1.25	4233	10.30	-8.50	10.30	10.30	-8.40	-8.60	
0	5	3.55	0.71	7472	3.50	0.70	7579	-5.85	-9.40	-5.90	-5.90	-9.40	-9.40	
	10	30.10	3.01	1763	30.05	3.01	1765	20.90	-9.20	20.90	20.80	-9.20	-9.20	
-30	5	15.35	3.07	1728	15.40	3.08	1722	5.85	-9.50	5.90	5.90	-9.50	-9.50	
	10	53.10	5.31	999	53.10	5.31	999	43.80	-9.30	43.80	43.80	-9.30	-9.30	
-60	5	29.80	5.96	890	29.75	5.95	892	20.20	-9.60	20.10	20.20	-9.60	-9.60	
-90	5	34.60	6.92	767	34.60	6.92	767	25.00	-9.60	25.00	25.00	-9.60	-9.60	

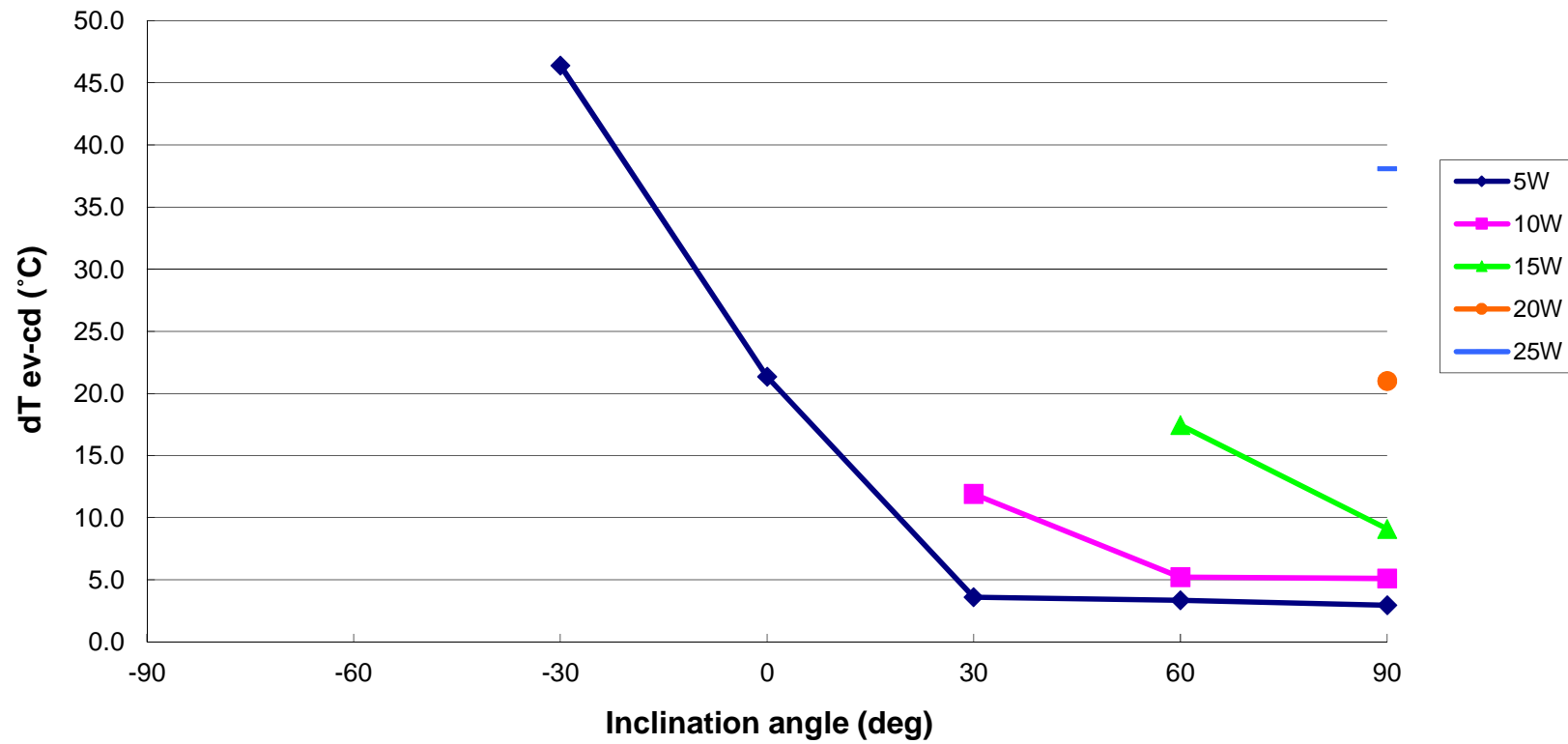
**Heat pipe performance (dT vs Inclination angles at various heat loads)**  
Heat pipe tested: 6mm x 200mm sintered powder metal/ methanol



## Heat Pipe Test Report

Manufacturer		Enertron			Test conditions				Test date	2017/12/28				
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol			Effective area (m2)		2.83E-05		Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block					
Pipe specification		C110 Copper 0.3mm wall thickness			Coolant temp (°C)		-10							
Diameter	±0.05 mm	6			Contact length of ev/cd (mm)		50							
Length	±0.10 mm	250			At 90° the evaporator is directly below the condenser; 0° is horizontal.									
Flatten thickness	±0.05 mm	n/a												
Bend angle	±1 deg	n/a												
Inclination Angle (°)	Heat Load (W)	dT ev-cd (°C)	Thermal resistance ev-cd (°C/W)	Thermal conductivity ev-cd (W/mK)	dT eb-cb (°C)	Thermal resistance eb-cb (°C/W)	Thermal Conductivity eb-cb (W/mK)	Measured Temperature T (°C)						
								ev	cd	eb1	eb2	cb1	cb2	
90	5	2.95	0.59	11989	3.05	0.61	11596	-6.45	-9.40	-6.40	-6.30	-9.40	-9.40	
	10	5.10	0.51	13870	5.10	0.51	13870	-3.25	-8.35	-3.30	-3.20	-8.40	-8.30	
	15	9.10	0.61	11660	9.20	0.61	11533	1.70	-7.40	1.70	1.70	-7.50	-7.50	
	20	21.00	1.05	6737	21.10	1.06	6705	13.80	-7.20	13.80	13.70	-7.30	-7.40	
	25	38.10	1.52	4641	38.15	1.53	4635	30.60	-7.50	30.70	30.70	-7.50	-7.40	
60	5	3.35	0.67	10558	3.20	0.64	11052	-5.95	-9.30	-6.10	-6.10	-9.30	-9.30	
	10	5.20	0.52	13603	5.10	0.51	13870	-3.15	-8.35	-3.30	-3.30	-8.40	-8.40	
	15	17.45	1.16	6080	17.55	1.17	6046	9.40	-8.05	9.40	9.40	-8.10	-8.20	
30	5	3.60	0.72	9824	3.50	0.70	10105	-5.70	-9.30	-5.80	-5.80	-9.30	-9.30	
	10	11.90	1.19	5944	11.85	1.19	5969	3.20	-8.70	3.10	3.10	-8.70	-8.80	
0	5	21.35	4.27	1657	21.40	4.28	1653	11.85	-9.50	11.90	11.90	-9.50	-9.50	
-30	5	46.40	9.28	762	46.50	9.30	761	36.80	-9.60	36.80	36.80	-9.70	-9.70	

**Heat pipe performance (dT vs Inclination angles at various heat loads)**  
 Heat pipe tested: 6mm x 250mm sintered powder metal/ methanol



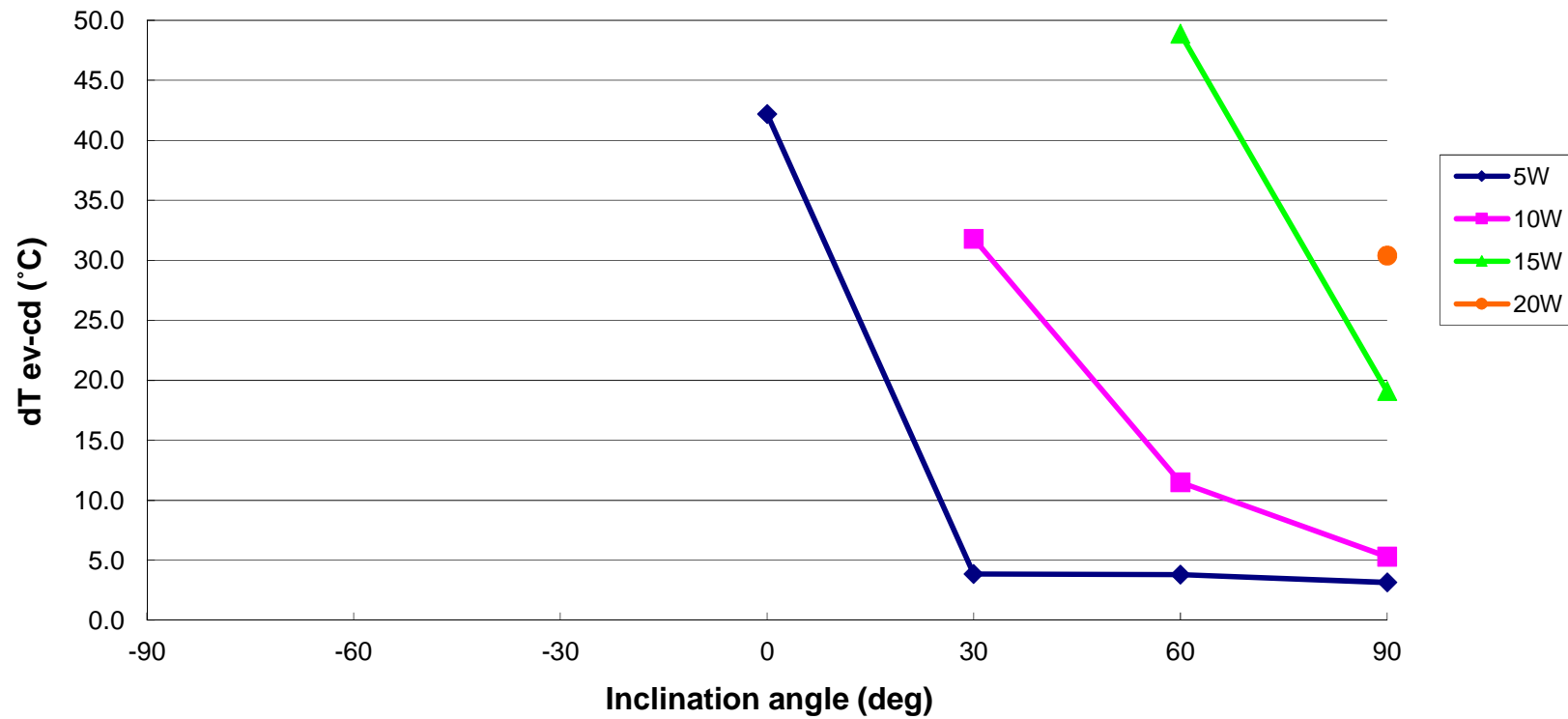


## Heat Pipe Test Report

Manufacturer		Enertron			Test conditions				Test date	2017/12/28				
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol			Effective area (m2)		2.83E-05		Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block					
Pipe specification		C110 Copper 0.3mm wall thickness			Coolant temp (°C)		-10							
Diameter ±0.05 mm		6			Contact length of ev/cd (mm)		50							
Length ±0.10 mm		300			At 90° the evaporator is directly below the condenser; 0° is horizontal.									
Flatten thickness ±0.05 mm		n/a												
Bend angle ±1 deg		n/a												
Inclination Angle (°)	Heat Load (W)	dT ev-cd (°C)	Thermal resistance ev-cd (°C/W)	Thermal conductivity ev-cd (W/mK)	dT eb-cb (°C)	Thermal resistance eb-cb (°C/W)	Thermal Conductivity eb-cb (W/mK)	Measured Temperature T (°C)						
								ev	cd	eb1	eb2	cb1	cb2	
90	5	3.15	0.63	14035	3.20	0.64	13816	-6.00	-9.15	-6.00	-6.00	-9.20	-9.20	
	10	5.30	0.53	16683	5.40	0.54	16374	-2.90	-8.20	-2.90	-2.90	-8.40	-8.20	
	15	19.10	1.27	6944	19.15	1.28	6926	11.15	-7.95	11.10	11.10	-8.10	-8.00	
	20	30.40	1.52	5817	30.45	1.52	5808	22.65	-7.75	22.60	22.60	-7.90	-7.80	
60	5	3.80	0.76	11634	3.95	0.79	11192	-5.15	-8.95	-5.10	-5.00	-9.00	-9.00	
	10	11.50	1.15	7689	11.55	1.16	7655	3.05	-8.45	3.00	3.10	-8.40	-8.60	
	15	48.90	3.26	2712	48.80	3.25	2718	40.20	-8.70	40.10	40.10	-8.70	-8.70	
30	5	3.85	0.77	11483	3.90	0.78	11336	-5.15	-9.00	-5.10	-5.10	-9.00	-9.00	
	10	31.80	3.18	2780	31.75	3.18	2785	22.75	-9.05	22.70	22.70	-9.00	-9.10	
0	5	42.20	8.44	1048	42.20	8.44	1048	32.60	-9.60	32.60	32.60	-9.60	-9.60	

### Heat pipe performance (dT vs Inclination angles at various heat loads)

Heat pipe tested: 6mm x 300mm sintered powder metal/ methanol

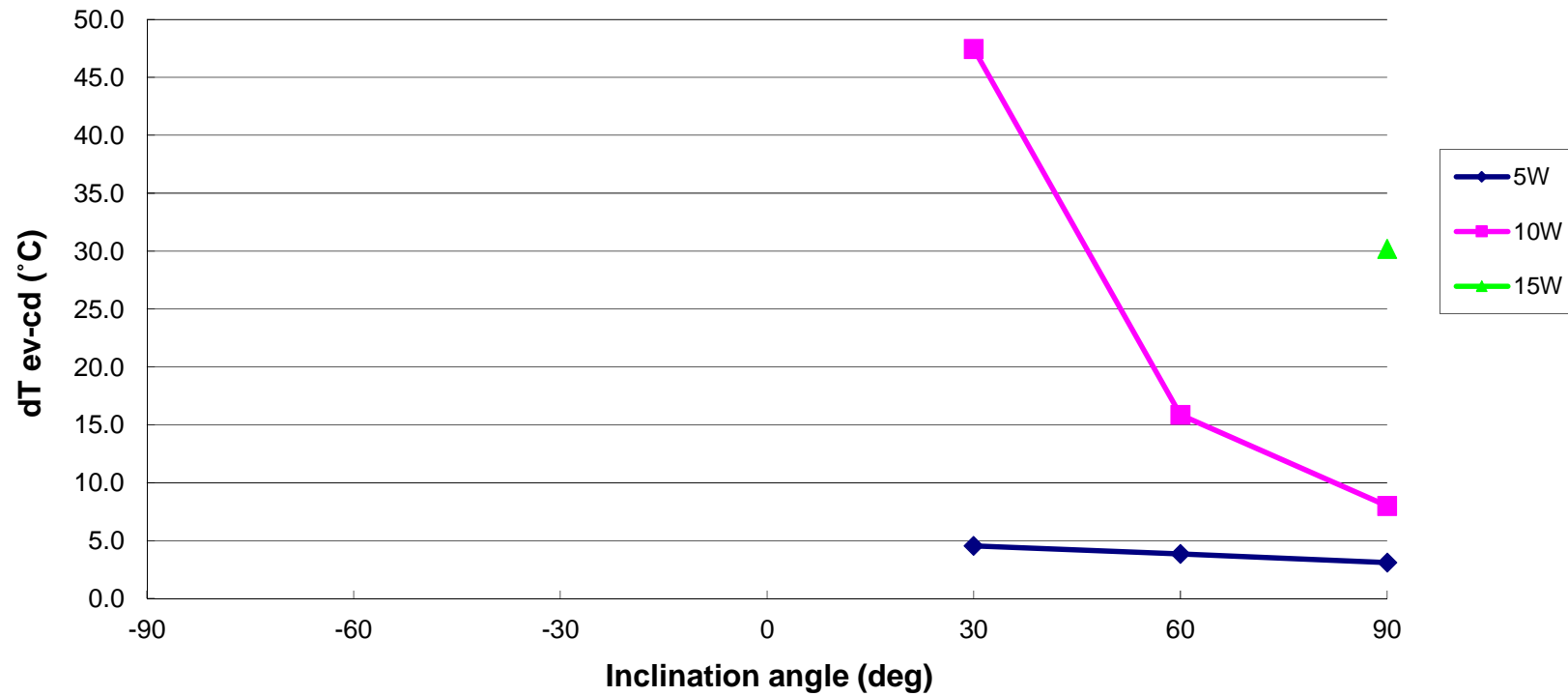


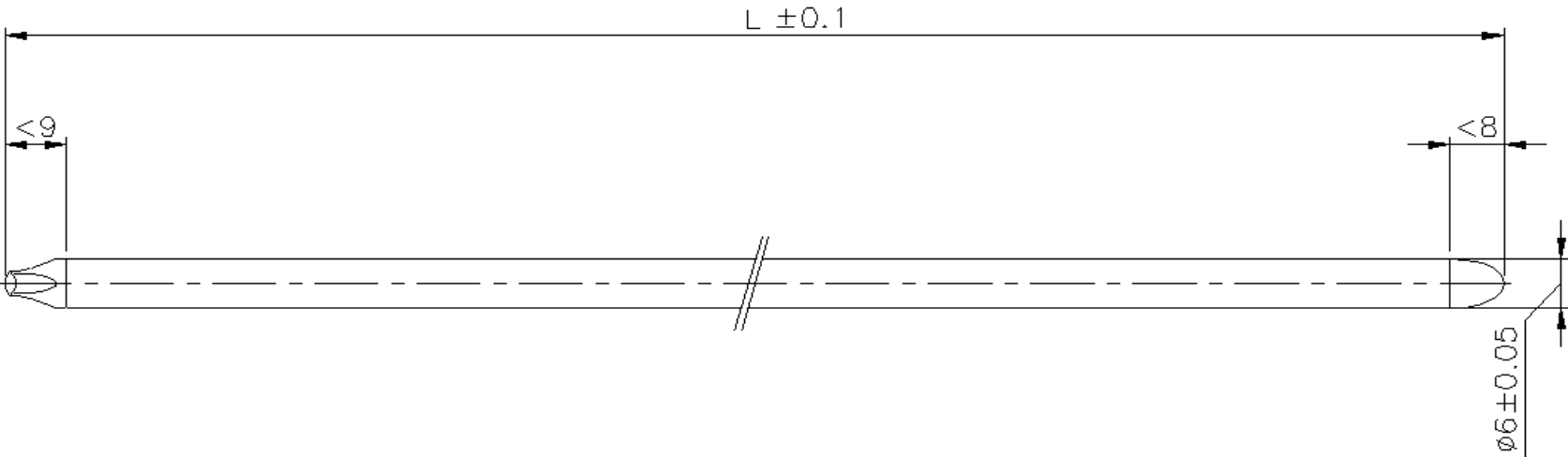
## Heat Pipe Test Report

Manufacturer		Enertron			Test conditions			Test date	2017/12/28					
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol			Effective area (m2)		2.83E-05	Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block						
Pipe specification		C110 Copper 0.3mm wall thickness			Coolant temp (°C)		-10							
Diameter	±0.05 mm	6			Contact length of ev/cd (mm)		50							
Length	±0.10 mm	350			At 90° the evaporator is directly below the condenser; 0° is horizontal.									
Flatten thickness	±0.05 mm	n/a												
Bend angle	±1 deg	n/a												
Inclination Angle (°)	Heat Load (W)	dT ev-cd (°C)	Thermal resistance ev-cd (°C/W)	Thermal conductivity ev-cd (W/mK)	dT eb-cb (°C)	Thermal resistance eb-cb (°C/W)	Thermal Conductivity eb-cb (W/mK)	Measured Temperature T (°C)						
								ev	cd	eb1	eb2	cb1	cb2	
90	5	3.10	0.62	17113	3.10	0.62	17113	-6.10	-9.20	-6.10	-6.10	-9.20	-9.20	
	10	8.00	0.80	13263	8.20	0.82	12939	-0.10	-8.10	-0.10	-0.10	-8.30	-8.30	
	15	30.20	2.01	5270	30.30	2.02	5253	22.75	-7.45	22.70	22.70	-7.50	-7.70	
60	5	3.85	0.77	13780	3.90	0.78	13603	-5.10	-8.95	-5.10	-5.10	-9.00	-9.00	
	10	15.85	1.59	6694	16.00	1.60	6631	7.60	-8.25	7.60	7.60	-8.30	-8.50	
30	5	4.55	0.91	11660	4.60	0.92	11533	-4.50	-9.05	-4.50	-4.50	-9.10	-9.10	
	10	47.45	4.75	2236	47.60	4.76	2229	38.80	-8.65	38.80	38.80	-8.70	-8.90	

### Heat pipe performance (dT vs Inclination angles at various heat loads)

Heat pipe tested: 6mm x 350mm sintered powder metal/ methanol





unit: mm