

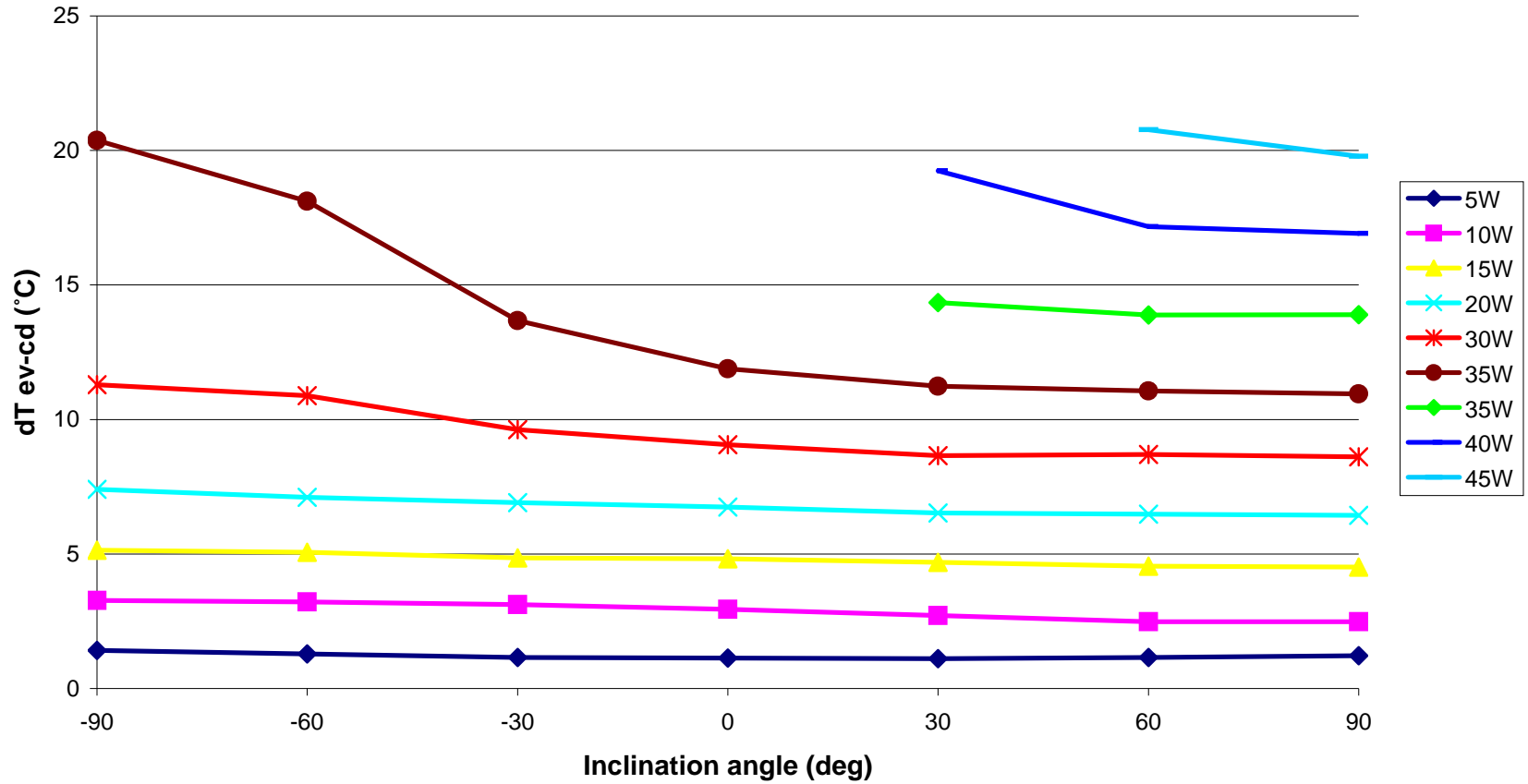
## Heat Pipe Test Report

Manufacturer		Enertron				Test conditions				Test date	9/28/2011						
Wick structure/ Working fluid		Sintered Powder Metal/ Water				Effective area (m2)		1.26E-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)		35									
Diameter	±0.05 mm	4				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	1.22	0.24	32694	1.78	0.36	22328	37.07	35.85	37.67	37.55	35.75	35.91				
	10	2.48	0.25	32062	3.61	0.36	22056	39.14	36.66	40.15	39.94	36.32	36.55				
	15	4.52	0.30	26420	5.72	0.38	20876	41.93	37.41	42.95	42.84	37.12	37.23				
	20	6.44	0.32	24706	8.14	0.41	19547	44.55	38.11	45.91	45.82	37.64	37.81				
	25	8.61	0.34	23111	10.89	0.44	18270	47.46	38.86	49.09	49.23	38.14	38.40				
	30	10.96	0.37	21790	13.85	0.46	17241	50.61	39.65	52.61	52.88	38.74	39.05				
	35	13.90	0.40	20042	17.51	0.50	15903	54.37	40.47	56.91	57.21	39.37	39.72				
	40	16.92	0.42	18817	21.31	0.53	14936	58.26	41.34	61.24	61.64	39.91	40.34				
60	5	1.15	0.23	34629	1.74	0.35	22841	37.04	35.89	37.67	37.49	35.75	35.92				
	10	2.48	0.25	32127	3.50	0.35	22730	39.13	36.66	40.13	39.93	36.48	36.58				
	15	4.54	0.30	26269	5.76	0.38	20713	41.93	37.38	42.95	42.82	37.08	37.17				
	20	6.48	0.32	24572	8.33	0.42	19113	44.64	38.16	46.06	46.01	37.64	37.77				
	25	8.70	0.35	22867	10.95	0.44	18165	47.60	38.90	49.25	49.36	38.22	38.48				
	30	11.06	0.37	21579	13.93	0.46	17143	50.73	39.66	52.80	52.96	38.82	39.09				
	35	13.89	0.40	20055	17.57	0.50	15855	54.36	40.48	56.93	57.22	39.28	39.74				
	40	17.17	0.43	18540	21.60	0.54	14740	58.42	41.25	61.44	61.89	39.87	40.27				
30	5	1.11	0.22	35846	1.78	0.36	22353	36.98	35.87	37.63	37.46	35.72	35.81				
	10	2.72	0.27	29310	3.62	0.36	22013	39.33	36.61	40.22	39.95	36.43	36.50				
	15	4.69	0.31	25457	5.95	0.40	20065	42.12	37.43	43.13	43.03	37.10	37.17				
	20	6.52	0.33	24403	8.34	0.42	19092	44.71	38.19	46.13	46.06	37.72	37.80				
	25	8.65	0.35	22997	11.00	0.44	18081	47.57	38.92	49.30	49.36	38.17	38.48				
	30	11.24	0.37	21243	14.26	0.48	16740	50.89	39.66	53.01	53.23	38.69	39.03				
	35	14.34	0.41	19423	18.06	0.52	15421	54.66	40.32	57.35	57.69	39.26	39.65				
	40	19.24	0.48	16545	24.09	0.60	13214	60.19	40.95	63.61	64.48	39.62	40.30				
0	5	1.13	0.23	35149	1.74	0.35	22893	37.01	35.87	37.65	37.45	35.73	35.90				
	10	2.95	0.29	26985	3.77	0.38	21131	39.59	36.65	40.34	40.25	36.50	36.56				
	15	4.82	0.32	24780	6.11	0.41	19543	42.21	37.40	43.27	43.22	37.06	37.21				
	20	6.75	0.34	23596	8.53	0.43	18650	44.89	38.15	46.31	46.27	37.69	37.82				

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
0	25	9.06	0.36	21963	11.44	0.46	17396	47.93	38.88	49.70	49.85	38.24	38.44
	30	11.89	0.40	20078	15.08	0.50	15827	51.50	39.61	53.80	54.15	38.79	38.99
-30	5	1.15	0.23	34569	1.79	0.36	22253	37.03	35.88	37.67	37.52	35.76	35.85
	10	3.12	0.31	25506	3.99	0.40	19959	39.74	36.62	40.50	40.40	36.41	36.51
	15	4.86	0.32	24561	6.28	0.42	19019	42.30	37.44	43.42	43.34	37.02	37.19
	20	6.91	0.35	23026	8.71	0.44	18266	45.07	38.16	46.41	46.49	37.70	37.77
	25	9.62	0.38	20676	12.20	0.49	16307	48.49	38.87	50.39	50.59	38.20	38.38
	30	13.67	0.46	17461	17.29	0.58	13809	53.23	39.56	55.71	56.43	38.56	39.01
-60	5	1.28	0.26	31036	1.86	0.37	21380	37.16	35.88	37.75	37.58	35.77	35.83
	10	3.22	0.32	24698	4.06	0.41	19610	39.85	36.62	40.58	40.50	36.43	36.52
	15	5.07	0.34	23548	6.43	0.43	18555	42.42	37.35	43.51	43.48	36.99	37.14
	20	7.11	0.36	22388	9.19	0.46	17328	45.36	38.25	46.76	46.94	37.58	37.75
	25	10.88	0.44	18285	13.75	0.55	14470	49.73	38.85	51.80	52.28	38.20	38.38
	30	18.12	0.60	13178	22.80	0.76	10472	57.55	39.43	60.92	62.16	38.44	39.04
-90	5	1.42	0.28	28080	1.90	0.38	20897	37.28	35.86	37.82	37.66	35.80	35.87
	10	3.28	0.33	24284	4.18	0.42	19060	39.94	36.67	40.69	40.63	36.43	36.53
	15	5.14	0.34	23205	6.50	0.43	18375	42.56	37.42	43.61	43.59	37.04	37.17
	20	7.41	0.37	21484	9.42	0.47	16901	45.59	38.18	47.03	47.21	37.59	37.81
	25	11.29	0.45	17621	14.30	0.57	13908	50.11	38.82	52.34	52.79	38.11	38.41
	30	20.38	0.68	11717	25.55	0.85	9346	59.81	39.44	63.78	64.81	38.41	39.09

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

Heat pipe tested:  $\phi$ 4mm x 150mm sintered powder metal/ water



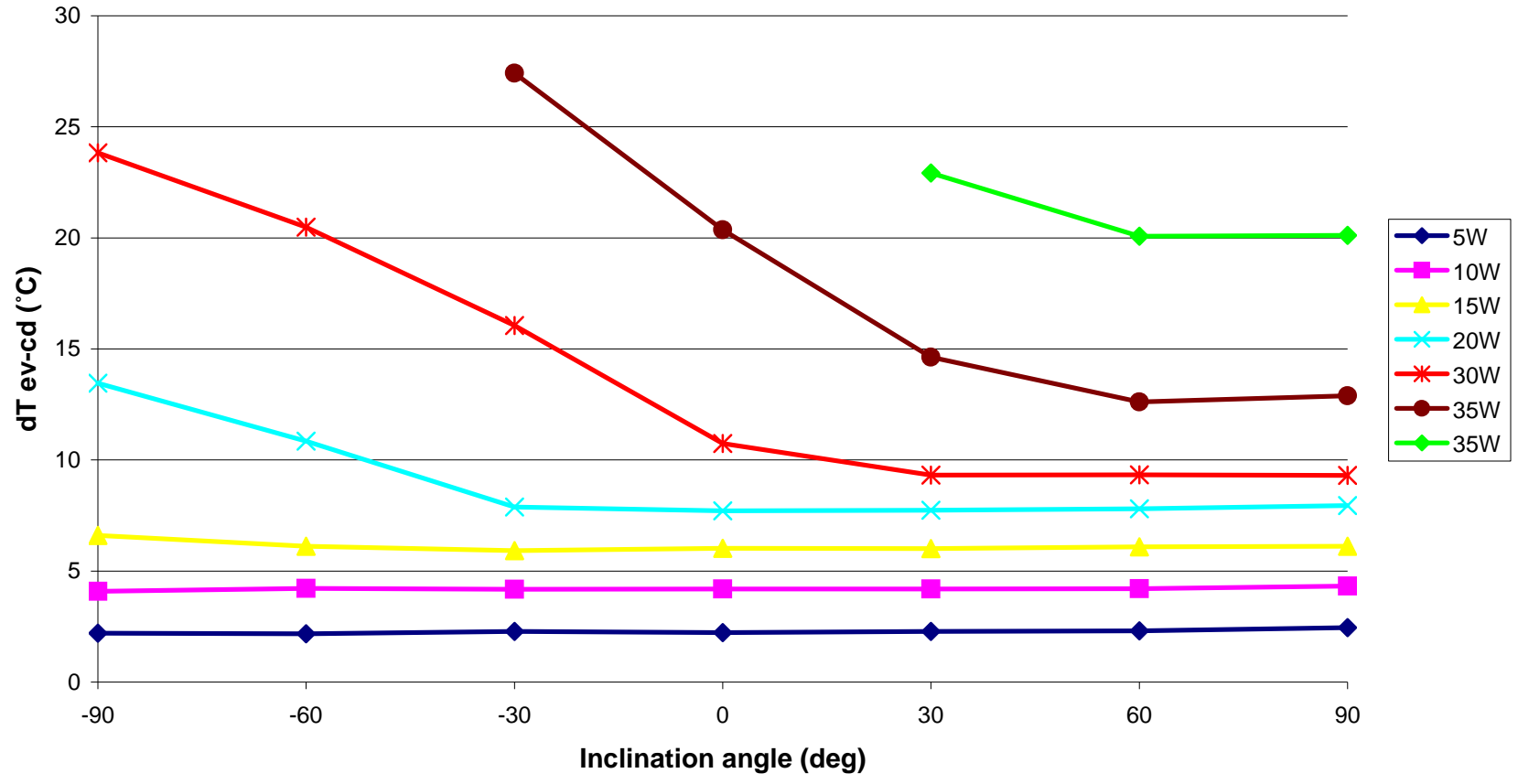
## Heat Pipe Test Report

Manufacturer		Enertron				Test conditions				Test date	9/28/2011						
Wick structure/ Working fluid		Sintered Powder Metal/ Water				Effective area (m2)		1.26E-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)		35									
Diameter	±0.05 mm	4				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	2.46	0.49	20234	2.56	0.51	19421	38.06	35.61	38.20	38.07	35.56	35.58				
	10	4.32	0.43	23037	4.72	0.47	21070	40.73	36.41	41.06	40.75	36.13	36.25				
	15	6.11	0.41	24408	6.89	0.46	21649	43.43	37.31	44.01	43.60	36.86	36.97				
	20	7.94	0.40	25043	8.89	0.44	22376	46.08	38.14	46.72	46.25	37.60	37.60				
	25	9.30	0.37	26731	10.93	0.44	22760	48.46	39.16	49.54	48.85	38.28	38.26				
	30	12.89	0.43	23156	14.79	0.49	20182	53.14	40.25	54.18	53.45	39.07	38.99				
	35	20.12	0.57	17305	21.68	0.62	16056	61.14	41.03	61.14	61.33	39.55	39.54				
60	5	2.31	0.46	21531	2.45	0.49	20325	37.90	35.59	38.03	37.89	35.46	35.56				
	10	4.20	0.42	23684	4.68	0.47	21259	40.67	36.47	41.04	40.79	36.26	36.21				
	15	6.09	0.41	24484	6.79	0.45	21962	43.43	37.33	43.91	43.52	36.91	36.93				
	20	7.80	0.39	25509	8.85	0.44	22492	46.01	38.22	46.63	46.21	37.56	37.59				
	25	9.33	0.37	26665	10.87	0.43	22882	48.47	39.14	49.41	48.84	38.29	38.23				
	30	12.62	0.42	23648	14.44	0.48	20670	52.82	40.20	53.84	53.10	39.06	39.00				
	35	20.08	0.57	17340	21.47	0.61	16219	61.01	40.93	60.78	61.29	39.53	39.62				
30	5	2.29	0.46	21766	2.42	0.48	20535	37.89	35.61	38.04	37.87	35.50	35.56				
	10	4.19	0.42	23769	4.63	0.46	21475	40.67	36.48	41.06	40.73	36.21	36.31				
	15	6.02	0.40	24802	6.78	0.45	22023	43.31	37.30	43.86	43.50	36.91	36.89				
	20	7.73	0.39	25727	8.76	0.44	22710	45.97	38.23	46.53	46.15	37.57	37.59				
	25	9.32	0.37	26685	10.82	0.43	22983	48.50	39.18	49.30	48.82	38.23	38.24				
	30	14.64	0.49	20389	15.38	0.51	19398	54.15	39.52	54.27	54.32	38.73	39.09				
	35	22.92	0.65	15191	23.64	0.68	14726	63.20	40.28	62.47	63.83	39.27	39.74				
0	5	2.23	0.45	22353	2.39	0.48	20810	37.83	35.60	37.97	37.84	35.49	35.54				
	10	4.20	0.42	23706	4.63	0.46	21489	40.69	36.49	41.08	40.77	36.27	36.32				
	15	6.02	0.40	24773	6.77	0.45	22036	43.41	37.39	43.89	43.50	36.90	36.96				
	20	7.71	0.39	25817	8.73	0.44	22789	45.99	38.29	46.45	46.15	37.58	37.56				
	25	10.75	0.43	23144	11.67	0.47	21309	49.66	38.92	50.02	49.82	38.16	38.35				
	30	20.37	0.68	14651	20.90	0.70	14278	59.71	39.34	58.84	60.57	38.38	39.23				
-30	5	2.28	0.46	21862	2.41	0.48	20680	37.86	35.59	37.98	37.86	35.50	35.53				
	10	4.18	0.42	23814	4.60	0.46	21610	40.70	36.52	41.09	40.71	36.32	36.28				
	15	5.92	0.39	25213	6.70	0.45	22263	43.29	37.37	43.85	43.39	36.95	36.87				

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
-30	20	7.89	0.39	25221	8.95	0.45	22236	46.03	38.14	46.77	46.24	37.50	37.62
	25	16.06	0.64	15488	16.76	0.67	14841	54.68	38.62	54.66	55.32	37.98	38.49
	30	27.42	0.91	10885	28.46	0.95	10487	66.60	39.19	66.15	68.08	38.19	39.13
-60	5	2.18	0.44	22836	2.40	0.48	20697	37.82	35.64	38.01	37.84	35.51	35.53
	10	4.21	0.42	23616	4.59	0.46	21657	40.72	36.51	41.02	40.75	36.29	36.29
	15	6.11	0.41	24404	6.75	0.45	22105	43.41	37.30	43.86	43.47	36.88	36.95
	20	10.85	0.54	18336	11.41	0.57	17440	48.75	37.90	49.03	49.02	37.44	37.80
	25	20.49	0.82	12137	21.48	0.86	11576	59.10	38.61	59.25	60.05	37.74	38.60
-90	5	2.20	0.44	22659	2.39	0.48	20827	37.80	35.61	38.03	37.81	35.51	35.56
	10	4.09	0.41	24315	4.65	0.46	21415	40.67	36.58	41.10	40.76	36.28	36.29
	15	6.61	0.44	22573	7.23	0.48	20629	43.87	37.26	44.30	44.01	36.84	37.00
	20	13.46	0.67	14777	14.18	0.71	14034	51.34	37.88	51.57	51.84	37.26	37.80
	25	23.84	0.95	10433	24.79	0.99	10032	62.47	38.63	62.24	63.63	37.70	38.59

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

Heat pipe tested:  $\phi$ 4mm x 175mm sintered powder metal/ water



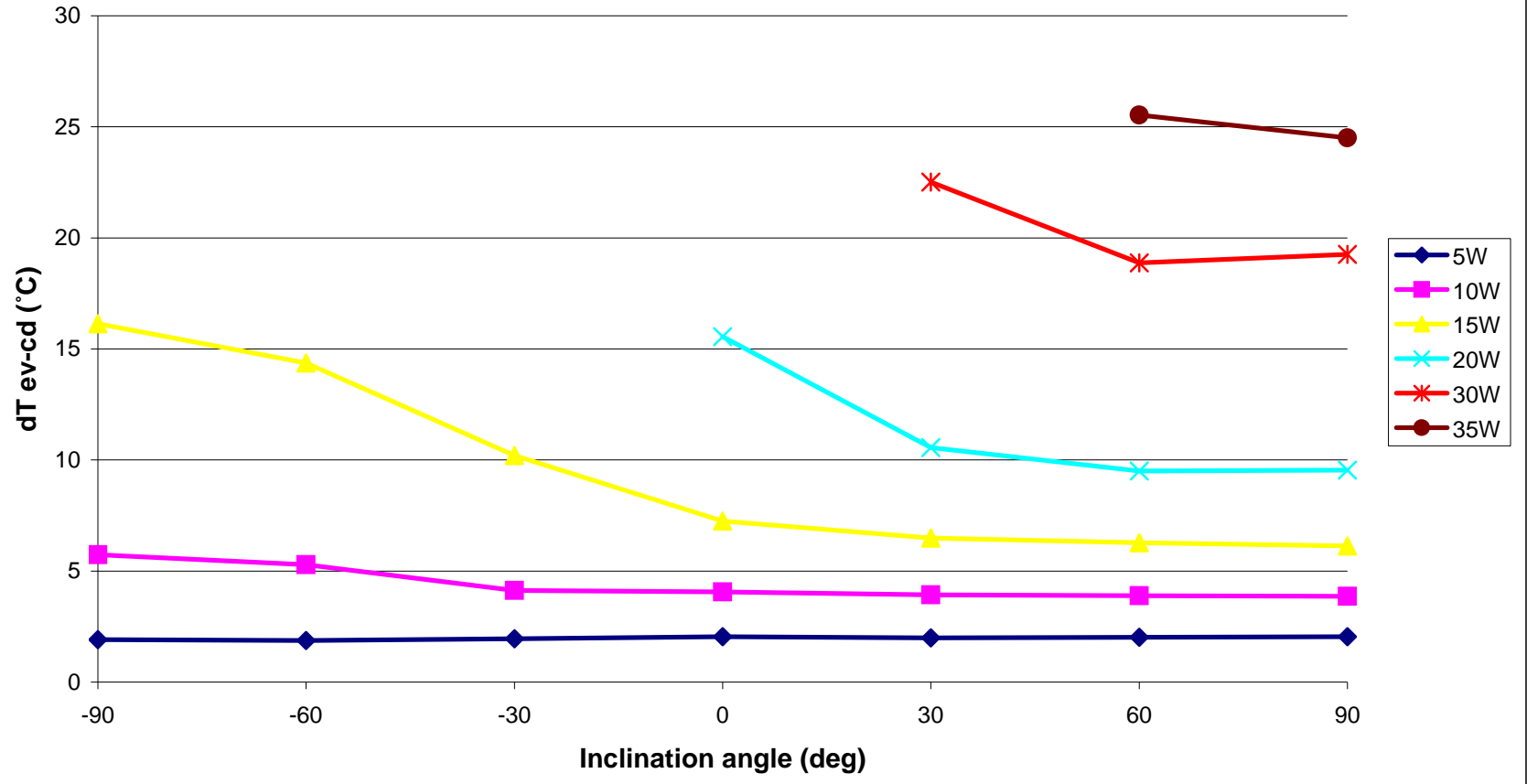
## Heat Pipe Test Report

Manufacturer		Enertron			Test conditions			Test date	9/27/2011
Wick structure/ Working fluid		Sintered Powder Metal/ Water			Effective area (m2)		1.26E-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)		35		
Diameter	±0.05 mm	4			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	2.04	0.41	29285	2.75	0.55	21687	37.93	35.89	38.35	38.43	35.60	35.68
	10	3.86	0.39	30892	5.08	0.51	23479	40.64	36.78	41.34	41.49	36.31	36.36
	15	6.12	0.41	29242	7.80	0.52	22943	43.84	37.71	44.62	44.91	37.00	36.93
	20	9.55	0.48	25006	11.20	0.56	21319	48.24	38.69	48.56	49.21	37.79	37.59
	25	19.25	0.77	15500	21.45	0.86	13913	58.84	39.59	58.95	60.50	38.57	37.98
	30	24.50	0.82	14618	27.28	0.91	13125	65.14	40.64	65.18	67.13	39.17	38.57
60	5	2.02	0.40	29531	2.68	0.54	22303	37.86	35.84	38.28	38.28	35.58	35.63
	10	3.89	0.39	30685	5.12	0.51	23300	40.67	36.78	41.37	41.49	36.34	36.28
	15	6.27	0.42	28557	7.82	0.52	22902	43.93	37.66	44.65	44.93	37.03	36.91
	20	9.51	0.48	25114	11.19	0.56	21344	48.17	38.66	48.49	49.17	37.76	37.53
	25	18.88	0.76	15808	21.00	0.84	14213	58.31	39.43	58.45	60.00	38.40	38.06
	30	25.54	0.85	14024	28.22	0.94	12691	65.87	40.34	66.02	68.04	38.99	38.64
30	5	1.99	0.40	29992	2.66	0.53	22412	37.81	35.82	38.25	38.27	35.57	35.63
	10	3.93	0.39	30396	5.18	0.52	23057	40.76	36.84	41.45	41.58	36.34	36.33
	15	6.48	0.43	27635	7.92	0.53	22602	44.21	37.73	44.74	45.12	37.06	36.96
	20	10.56	0.53	22612	12.18	0.61	19608	49.23	38.67	49.33	50.20	37.65	37.53
	25	22.51	0.90	13258	24.84	0.99	12015	61.74	39.23	62.04	63.81	37.95	38.22
0	5	2.05	0.41	29128	2.68	0.54	22262	37.84	35.79	38.21	38.31	35.57	35.60
	10	4.06	0.41	29408	5.24	0.52	22771	40.90	36.84	41.55	41.62	36.37	36.32
	15	7.25	0.48	24703	8.60	0.57	20817	45.04	37.80	45.36	45.91	37.09	36.98
	20	15.56	0.78	15346	17.34	0.87	13765	54.06	38.50	54.14	55.46	37.31	37.60
-30	5	1.96	0.39	30528	2.63	0.53	22676	37.79	35.84	38.29	38.31	35.67	35.66
	10	4.12	0.41	28951	5.39	0.54	22154	41.02	36.90	41.65	41.81	36.36	36.33
	15	10.20	0.68	17556	11.60	0.77	15434	47.78	37.58	47.97	48.86	36.75	36.89
-60	5	1.87	0.37	31899	2.69	0.54	22162	37.77	35.90	38.30	38.37	35.62	35.66
	10	5.29	0.53	22565	6.19	0.62	19293	42.06	36.77	42.29	42.65	36.25	36.32
	15	14.37	0.96	12460	16.00	1.07	11188	51.98	37.61	52.34	53.27	36.66	36.94
-90	5	1.91	0.38	31264	2.68	0.54	22262	37.77	35.86	38.36	38.37	35.71	35.65
	10	5.74	0.57	20806	6.69	0.67	17834	42.50	36.76	42.77	43.21	36.22	36.37
	15	16.14	1.08	11095	17.67	1.18	10131	53.71	37.58	54.00	54.95	36.68	36.92

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

Heat pipe tested:  $\phi$ 4mm x 200mm sintered powder metal/ water



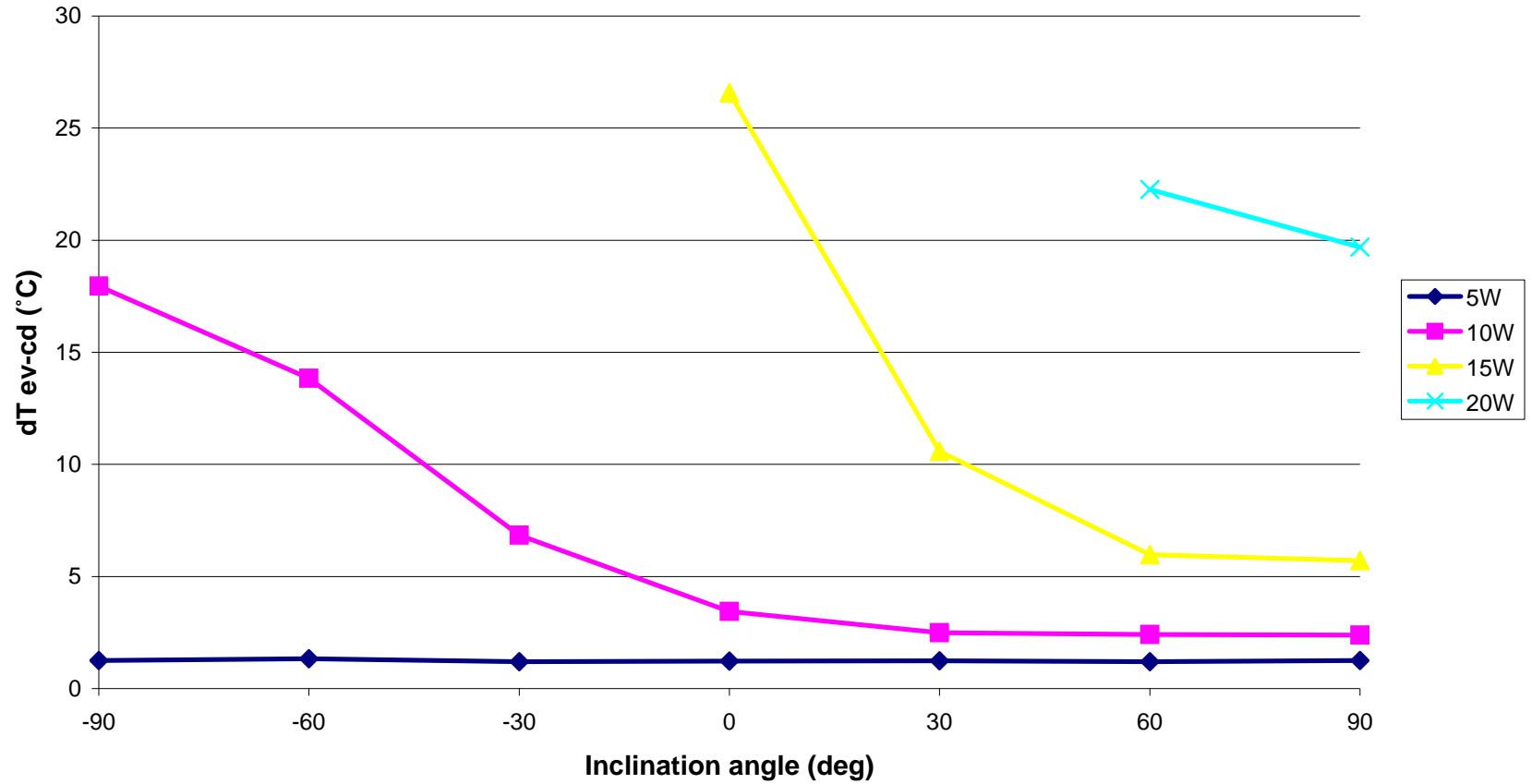


## Heat Pipe Test Report

Manufacturer		Enertron				Test conditions				Test date	9/26/2011						
Wick structure/ Working fluid		Sintered Powder Metal/ Water				Effective area (m <sup>2</sup> )		1.26E-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)		35									
Diameter	±0.05 mm	4				Contact length of ev/cd (mm)		50									
Length	±0.10 mm	225				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	1.25	0.25	55527	2.01	0.40	34676	36.75	35.49	37.70	37.24	35.48	35.44				
	10	2.39	0.24	58219	3.96	0.40	35149	38.86	36.47	40.54	39.88	36.28	36.22				
	15	5.71	0.38	36590	7.55	0.50	27664	43.12	37.41	44.94	44.33	37.13	37.04				
	20	19.69	0.98	14142	25.52	1.28	10916	57.49	37.79	63.19	62.80	37.53	37.44				
60	5	1.20	0.24	58171	1.86	0.37	37416	36.70	35.50	37.51	37.14	35.47	35.46				
	10	2.41	0.24	57737	3.87	0.39	35985	38.82	36.41	40.47	39.81	36.33	36.21				
	15	5.98	0.40	34949	7.83	0.52	26668	43.41	37.43	45.19	44.65	37.17	37.00				
	20	22.27	1.11	12508	28.30	1.41	9843	60.07	37.80	65.89	65.52	37.42	37.40				
30	5	1.24	0.25	56018	1.88	0.38	37077	36.74	35.50	37.51	37.17	35.48	35.45				
	10	2.49	0.25	55973	3.99	0.40	34946	38.94	36.45	40.57	39.88	36.30	36.18				
	15	10.59	0.71	19725	13.81	0.92	15125	47.61	37.02	50.71	50.53	36.68	36.94				
0	5	1.22	0.24	56981	1.95	0.39	35653	36.74	35.52	37.57	37.27	35.49	35.44				
	10	3.44	0.34	40447	4.61	0.46	30221	39.87	36.43	41.08	40.62	36.27	36.21				
	15	26.57	1.77	7862	29.56	1.97	7067	63.34	36.77	66.35	66.06	36.45	36.84				
-30	5	1.21	0.24	57737	1.91	0.38	36475	36.75	35.55	37.57	37.27	35.51	35.52				
	10	6.85	0.68	20339	8.87	0.89	15697	43.19	36.35	45.23	44.95	36.11	36.33				
-60	5	1.33	0.27	52197	1.96	0.39	35617	36.86	35.53	37.60	37.33	35.53	35.50				
	10	13.84	1.38	10060	16.30	1.63	8543	50.19	36.34	52.61	52.43	36.07	36.37				
-90	5	1.26	0.25	55438	1.96	0.39	35598	36.88	35.62	37.70	37.38	35.60	35.57				
	10	17.95	1.79	7760	20.03	2.00	6954	54.32	36.38	56.37	56.14	36.08	36.38				

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

Heat pipe tested:  $\phi$ 4mm x 225mm sintered powder metal/ water

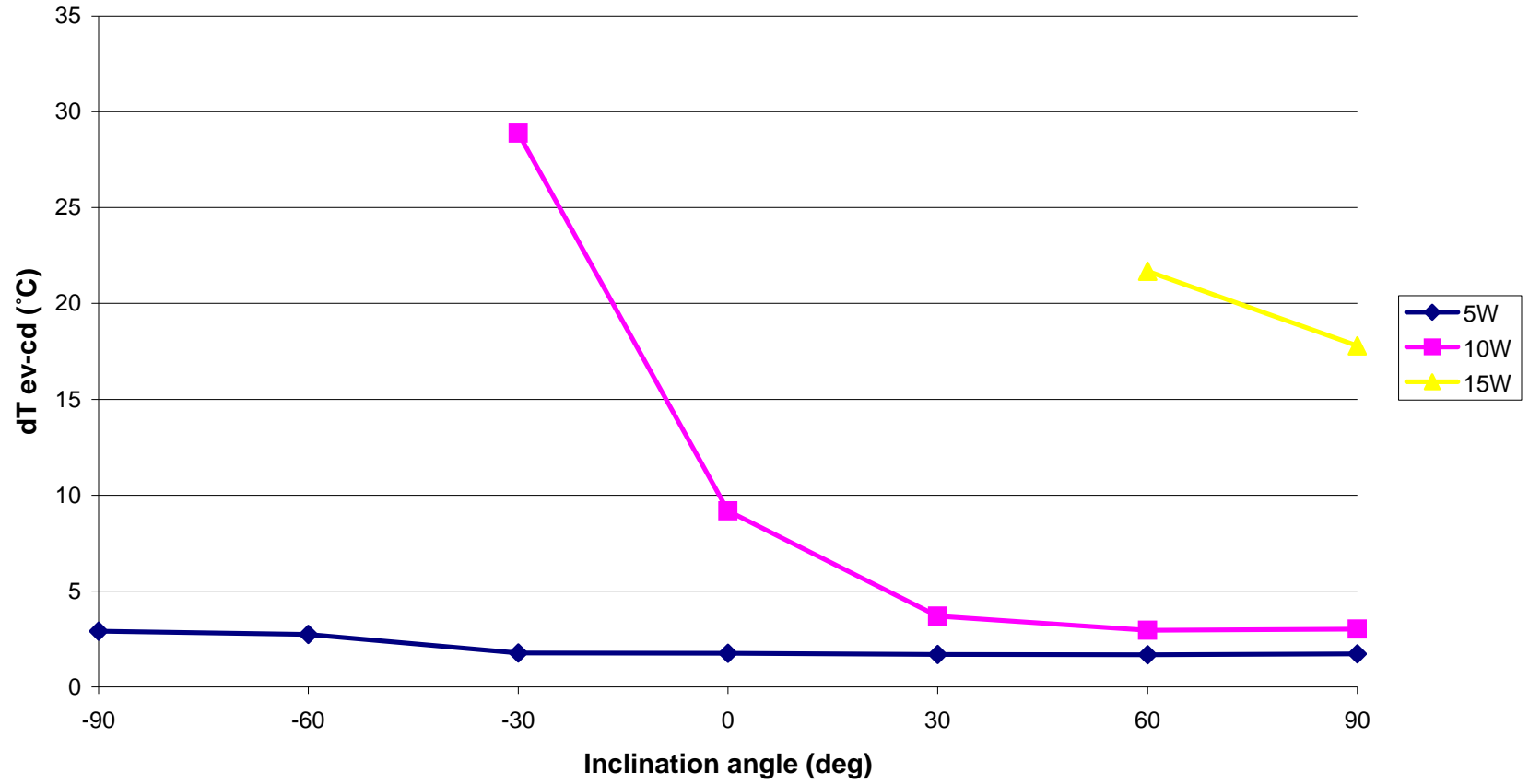


## Heat Pipe Test Report

Manufacturer		Enertron				Test conditions				Test date	9/23/2011		
Wick structure/ Working fluid		Sintered Powder Metal/ Water				Effective area (m <sup>2</sup> )		1.26E-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)		35					
Diameter	±0.05 mm	4				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	1.72	0.34	46239	2.65	0.53	29995	37.65	35.93	38.74	38.39	35.93	35.89
	10	3.01	0.30	52911	4.77	0.48	33373	39.26	36.26	41.21	40.49	36.13	36.02
	15	17.80	1.19	13415	22.52	1.50	10599	54.88	37.08	59.51	59.15	36.76	36.85
60	5	1.68	0.34	47509	2.58	0.52	30868	37.61	35.94	38.65	38.28	35.86	35.91
	10	2.95	0.30	53951	4.65	0.47	34220	39.21	36.26	41.13	40.43	36.19	36.07
	15	21.68	1.45	11013	25.63	1.71	9316	58.62	36.94	62.58	62.33	36.79	36.87
30	5	1.69	0.34	47032	2.59	0.52	30784	37.59	35.90	38.58	38.24	35.80	35.84
	10	3.69	0.37	43096	5.25	0.52	30344	40.01	36.32	41.72	41.02	36.15	36.11
0	5	1.75	0.35	45525	2.60	0.52	30607	37.58	35.83	38.62	38.23	35.85	35.80
	10	9.18	0.92	17331	11.96	1.20	13308	45.53	36.35	48.22	47.97	36.00	36.28
-30	5	1.76	0.35	45138	2.64	0.53	30132	37.61	35.85	38.64	38.27	35.83	35.80
	10	28.88	2.89	5511	30.58	3.06	5205	65.00	36.12	66.67	66.55	35.90	36.17
-60	5	2.73	0.55	29117	3.58	0.72	22216	38.61	35.88	39.43	39.27	35.68	35.85
-90	5	2.90	0.58	27441	3.76	0.75	21164	38.73	35.83	39.66	39.40	35.71	35.82

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

Heat pipe tested:  $\phi$ 4mm x 250mm sintered powder metal/ water

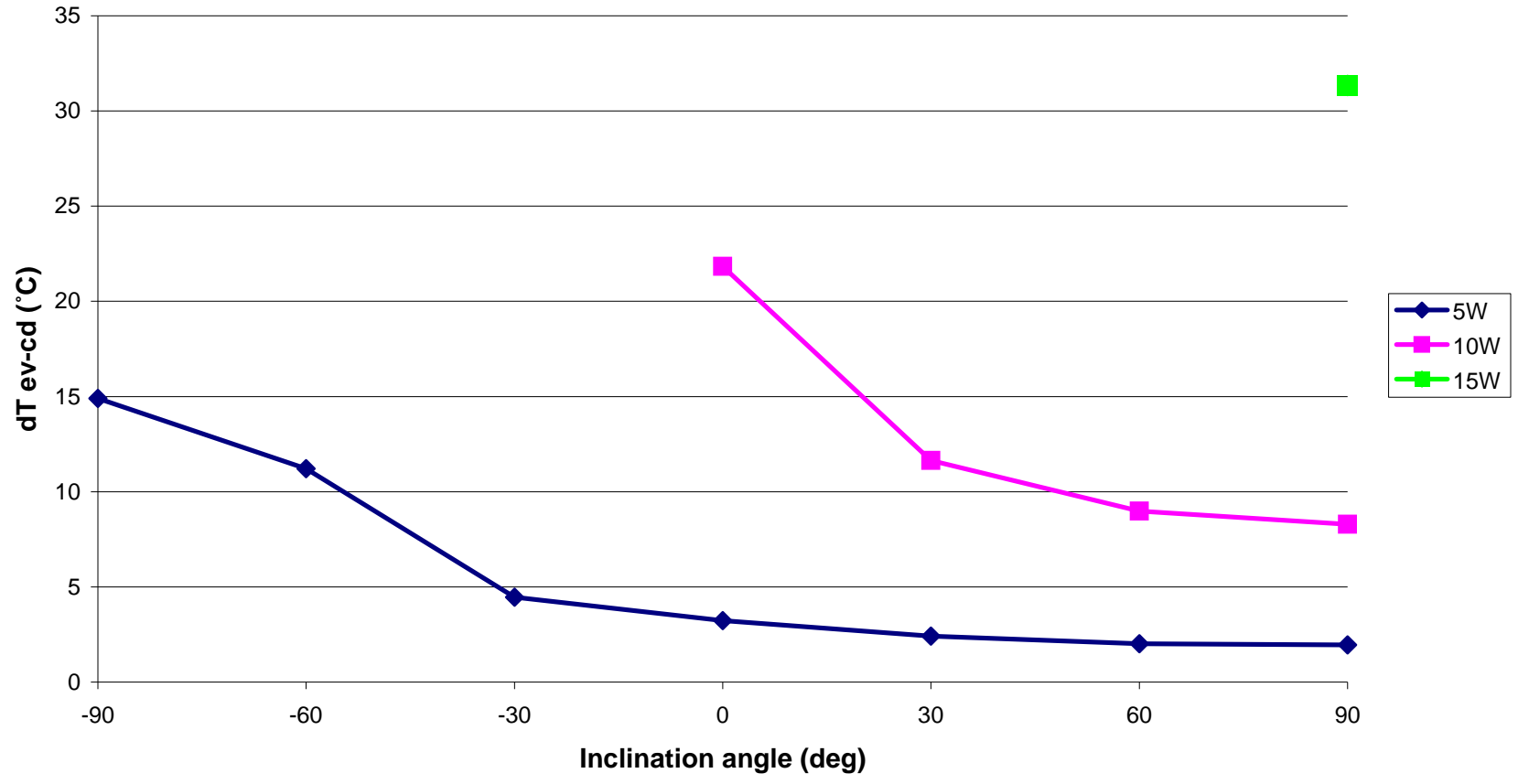


## Heat Pipe Test Report

Manufacturer		Enertron				Test conditions				Test date	9/22/2011		
Wick structure/ Working fluid		Sintered Powder Metal/ Water				Effective area (m <sup>2</sup> )		1.26E-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)		35					
Diameter	±0.05 mm	4				Contact length of ev/cd (mm)		50					
Length	±0.10 mm	275				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	1.96	0.39	45723	2.13	0.43	42011	37.53	35.57	37.78	37.57	35.53	35.56
	10	8.29	0.83	21609	11.87	1.19	15087	44.68	36.39	48.22	48.04	36.26	36.26
	15	31.35	2.09	8568	32.29	2.15	8317	68.25	36.91	69.27	68.93	36.82	36.79
60	5	2.01	0.40	44451	2.09	0.42	42753	37.54	35.52	37.75	37.53	35.55	35.54
	10	8.98	0.90	19932	12.19	1.22	14689	45.29	36.30	48.59	48.39	36.33	36.27
30	5	2.41	0.48	37178	2.58	0.52	34699	37.98	35.57	38.20	38.06	35.58	35.53
	10	11.64	1.16	15388	14.20	1.42	12610	48.02	36.39	50.62	50.39	36.29	36.32
0	5	3.22	0.64	27768	3.45	0.69	25919	38.77	35.55	39.05	38.99	35.54	35.60
	10	21.83	2.18	8200	23.45	2.35	7635	58.17	36.34	59.80	59.59	36.21	36.28
-30	5	4.46	0.89	20082	4.76	0.95	18820	40.04	35.59	40.43	40.32	35.58	35.66
-60	5	11.21	2.24	7985	11.42	2.28	7837	46.76	35.55	47.10	46.96	35.59	35.62
-90	5	14.90	2.98	6007	15.18	3.04	5896	50.39	35.49	50.79	50.61	35.49	35.55

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

Heat pipe tested:  $\phi$ 4mm x 275mm sintered powder metal/ water



## Heat Pipe Test Report

Manufacturer		Enertron				Test conditions				Test date	9/21/2011		
Wick structure/ Working fluid		Sintered Powder Metal/ Water				Effective area (m <sup>2</sup> )		1.26E-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)		35					
Diameter	±0.05 mm	4				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	1.57	0.31	63479	1.98	0.40	50340	37.03	35.46	37.38	37.41	35.48	35.36
	10	3.55	0.35	56120	4.36	0.44	45629	40.15	36.60	40.53	40.79	36.38	36.22
	15	19.69	1.31	15155	21.73	1.45	13733	56.62	36.93	57.90	58.84	36.66	36.62
60	5	1.63	0.33	60951	2.06	0.41	48334	37.05	35.41	37.29	37.46	35.33	35.30
	10	3.46	0.35	57498	4.34	0.43	45808	40.05	36.59	40.53	40.80	36.35	36.30
	15	20.79	1.39	14356	22.61	1.51	13197	57.52	36.73	58.64	59.57	36.53	36.44
30	5	1.65	0.33	60359	2.05	0.41	48523	37.11	35.46	37.45	37.47	35.45	35.38
	10	4.07	0.41	48941	4.85	0.49	41002	40.61	36.54	40.95	41.26	36.24	36.27
0	5	1.67	0.33	59564	2.08	0.42	47731	37.13	35.46	37.46	37.48	35.42	35.36
	10	18.39	1.84	10816	19.51	1.95	10197	54.79	36.39	55.40	55.83	35.99	36.22
-30	5	1.74	0.35	57069	2.18	0.44	45734	37.19	35.45	37.55	37.60	35.41	35.38
-60	5	4.63	0.93	21489	5.48	1.10	18165	40.24	35.61	40.76	41.09	35.41	35.49
-90	5	9.12	1.82	10902	9.65	1.93	10312	44.66	35.54	45.02	45.20	35.43	35.49

