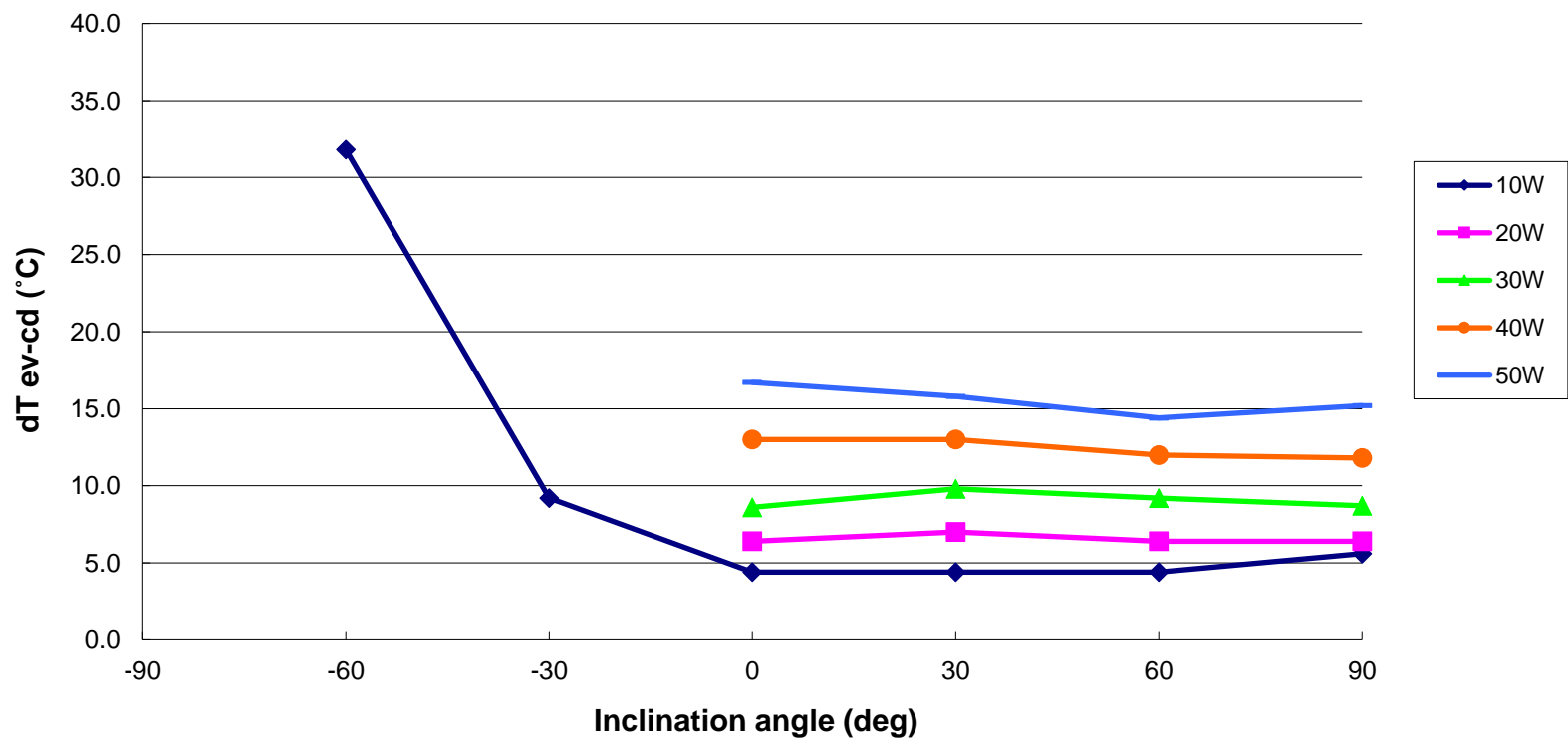


Heat Pipe Test Report

Manufacturer		Enertron				Test conditions			Test date	6/21/2018				
Wick structure/ Working fluid		Sintered Powder Metal / Methanol				Effective area (m2)		1.13E-04	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	12				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	10	5.60	0.56	3158	5.00	0.50	3537	-3.20	-8.80	-3.80	-3.80	-8.80	-8.80	
	20	6.40	0.32	5526	5.65	0.28	6260	-0.90	-7.30	-1.80	-1.90	-7.40	-7.60	
	30	8.70	0.29	6098	7.70	0.26	6890	2.60	-6.10	1.30	1.20	-6.30	-6.60	
	40	11.80	0.30	5995	10.65	0.27	6642	7.40	-4.40	5.80	5.70	-4.70	-5.10	
	50	15.25	0.31	5798	13.90	0.28	6361	11.90	-3.35	10.10	10.00	-3.90	-3.80	
60	10	4.35	0.44	4065	6.10	0.61	2899	-4.40	-8.75	-4.80	-0.50	-8.70	-8.80	
	20	6.35	0.32	5570	5.85	0.29	6046	-1.00	-7.35	-1.60	-1.70	-7.40	-7.60	
	30	9.25	0.31	5735	8.55	0.29	6205	3.50	-5.75	2.50	2.40	-5.90	-6.30	
	40	12.05	0.30	5870	11.20	0.28	6316	7.70	-4.35	6.40	6.30	-4.60	-5.10	
	50	14.35	0.29	6162	13.55	0.27	6525	11.10	-3.25	9.70	9.60	-3.60	-4.20	
30	10	4.30	0.43	4113	4.00	0.40	4421	-4.30	-8.60	-4.60	-4.60	-8.60	-8.60	
	20	7.00	0.35	5053	6.75	0.34	5240	0.00	-7.00	-0.50	-0.60	-7.10	-7.50	
	30	9.85	0.33	5386	9.50	0.32	5584	4.10	-5.75	3.40	3.30	-5.90	-6.40	
	40	12.95	0.32	5462	12.55	0.31	5636	8.40	-4.55	7.60	7.50	-4.70	-5.30	
	50	15.75	0.32	5614	15.40	0.31	5742	12.40	-3.35	11.50	11.40	-3.60	-4.30	
0	10	4.35	0.44	4065	4.00	0.40	4421	-4.15	-8.50	-4.60	-4.50	-8.40	-8.70	
	20	6.35	0.32	5570	6.10	0.31	5798	-0.85	-7.20	-1.40	-1.30	-7.10	-7.80	
	30	8.55	0.29	6205	8.15	0.27	6509	2.60	-5.95	1.70	1.90	-5.90	-6.80	
	40	12.95	0.32	5462	13.15	0.33	5379	7.95	-5.00	7.70	7.60	-4.90	-6.10	
	50	16.75	0.34	5279	14.10	0.28	6271	12.40	-4.35	9.40	9.20	-4.20	-5.40	
-30	10	9.2	0.92	1922	8.85	0.89	1998	0.3	-8.9	0	-0.1	-8.9	-8.9	
-60	10	31.8	3.18	556	31.40	3.14	563	22.7	-9.1	22.3	22.3	-9.1	-9.1	

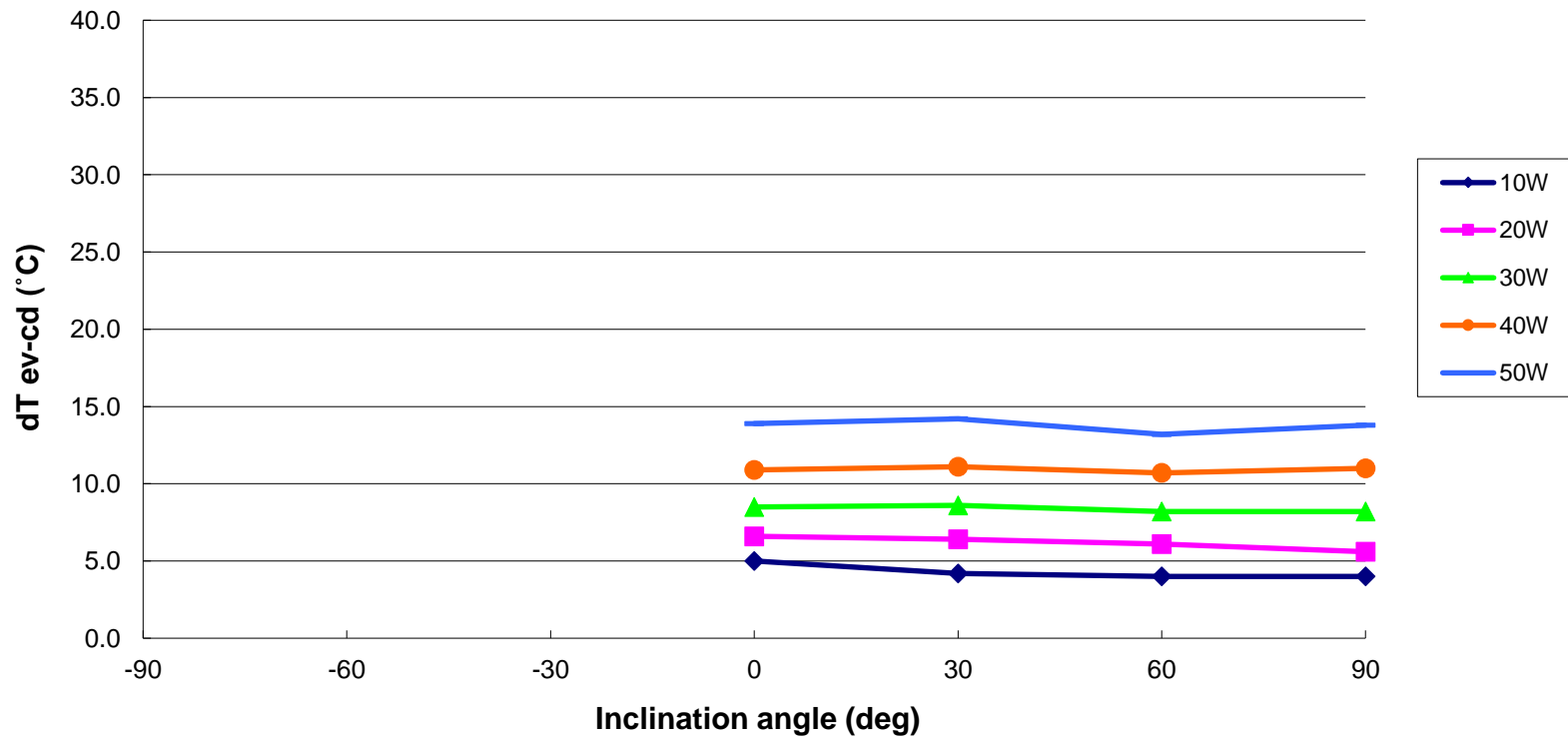
Heat pipe performance (dT vs Inclination angles at various heat loads)
Heat pipe tested: 12mm x 250mm sintered powder metal / methanol



Heat Pipe Test Report

Manufacturer		Enertron			Test conditions			Test date	6/21/2018					
Wick structure/ Working fluid		Sintered Powder Metal / Methanol			Effective area (m ²)		1.13E-04	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	12			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	10	4.00	0.40	5526	5.05	0.51	4377	-4.30	-8.30	-3.50	-4.20	-8.80	-9.00	
	20	5.60	0.28	7895	5.75	0.29	7689	-1.90	-7.50	-1.10	-2.60	-7.50	-7.70	
	30	8.15	0.27	8137	8.40	0.28	7895	2.20	-5.95	3.30	1.20	-6.10	-6.20	
	40	11.00	0.28	8038	11.40	0.29	7756	6.30	-4.70	7.80	4.90	-5.00	-5.10	
	50	13.75	0.28	8038	14.30	0.29	7729	10.40	-3.35	11.30	9.70	-3.70	-3.90	
60	10	3.95	0.40	5596	4.00	0.40	5526	-4.85	-8.80	-4.50	-5.20	-8.80	-8.90	
	20	6.05	0.30	7307	6.20	0.31	7131	-1.35	-7.40	-0.70	-2.00	-7.40	-7.70	
	30	8.20	0.27	8087	8.50	0.28	7802	2.05	-6.15	3.10	1.00	-6.30	-6.60	
	40	10.70	0.27	8263	11.05	0.28	8002	5.80	-4.90	7.20	4.40	-5.10	-5.40	
	50	13.15	0.26	8405	13.65	0.27	8097	9.40	-3.75	10.10	8.80	-4.00	-4.40	
30	10	4.15	0.42	5326	4.25	0.43	5201	-4.50	-8.65	-4.30	-4.70	-8.70	-8.80	
	20	6.35	0.32	6962	6.60	0.33	6698	-1.10	-7.45	-0.80	-1.30	-7.50	-7.80	
	30	8.60	0.29	7711	8.95	0.30	7409	2.30	-6.30	2.70	2.00	-6.40	-6.80	
	40	11.05	0.28	8002	11.45	0.29	7722	6.00	-5.05	7.30	4.90	-5.10	-5.60	
	50	14.15	0.28	7811	14.60	0.29	7570	10.40	-3.75	12.10	8.90	-3.80	-4.40	
0	10	4.95	0.50	4466	5.05	0.51	4377	-3.80	-8.75	-3.50	-3.90	-8.60	-8.90	
	20	6.60	0.33	6698	6.90	0.35	6407	-0.95	-7.55	-0.4	-1.2	-7.5	-7.9	
	30	8.45	0.28	7848	8.95	0.30	7409	2.15	-6.3	3.1	1.8	-6.2	-6.8	
	40	10.95	0.27	8075	10.80	0.27	8187	5.75	-5.2	6.3	4.4	-5.1	-5.8	
	50	13.95	0.28	7923	12.85	0.26	8601	9.95	-4	8.7	8.3	-4	-4.7	

Heat pipe performance (dT vs Inclination angles at various heat loads)
Heat pipe tested: 12mm x 300mm sintered powder metal / methanol



Heat Pipe Test Report

Manufacturer		Enertron		Test conditions				Test date	6/21/2018					
Wick structure/ Working fluid		Sintered Powder Metal / Methanol		Effective area (m2)		1.13E-04		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	12		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	10	5.00	0.50	5305	5.00	0.50	5305	-3.90	-8.90	-3.20	-4.50	-8.80	-8.90	
	20	5.80	0.29	9147	5.75	0.29	9226	-2.00	-7.80	-1.00	-3.00	-7.60	-7.90	
	30	7.90	0.26	10073	8.10	0.27	9824	1.60	-6.30	2.40	0.90	-6.20	-6.70	
	40	10.50	0.26	10105	10.65	0.27	9963	5.50	-5.00	6.50	4.50	-4.90	-5.40	
	50	13.40	0.27	9898	13.80	0.28	9611	9.80	-3.60	11.00	8.80	-3.60	-4.20	
60	10	4.20	0.42	6316	4.15	0.42	6392	-4.80	-9.00	-4.60	-5.00	-8.90	-9.00	
	20	6.00	0.30	8842	6.05	0.30	8769	-1.80	-7.80	-1.30	-2.20	-7.70	-7.90	
	30	8.10	0.27	9824	8.20	0.27	9705	1.70	-6.40	2.30	1.00	-6.30	-6.80	
	40	10.10	0.25	10505	10.50	0.26	10105	5.10	-5.00	5.90	4.30	-5.10	-5.70	
	50	13.00	0.26	10202	13.20	0.26	10048	8.90	-4.10	9.70	8.00	-4.00	-4.70	
30	10	4.40	0.44	6029	4.45	0.45	5961	-4.50	-8.90	-4.20	-4.60	-8.80	-8.90	
	20	6.50	0.33	8162	6.60	0.33	8038	-1.10	-7.60	-0.80	-1.40	-7.50	-7.90	
	30	8.90	0.30	8941	9.00	0.30	8842	2.30	-6.60	2.80	1.90	-6.40	-6.90	
	40	11.70	0.29	9069	11.90	0.30	8916	6.30	-5.40	6.90	5.80	-5.20	-5.90	
	50	14.20	0.28	9340	14.40	0.29	9210	9.80	-4.40	10.50	9.30	-4.10	-4.90	
0	10	4.70	0.47	5644	4.65	0.47	5704	-4.2	-8.9	-4	-4.3	-8.7	-8.9	
	20	39.80	1.99	1333	39.75	1.99	1335	31.5	-8.3	31.9	31	-8.2	-8.4	

Heat pipe performance (dT vs Inclination angles at various heat loads)
Heat pipe tested: 12mm x 350mm sintered powder metal / methanol

