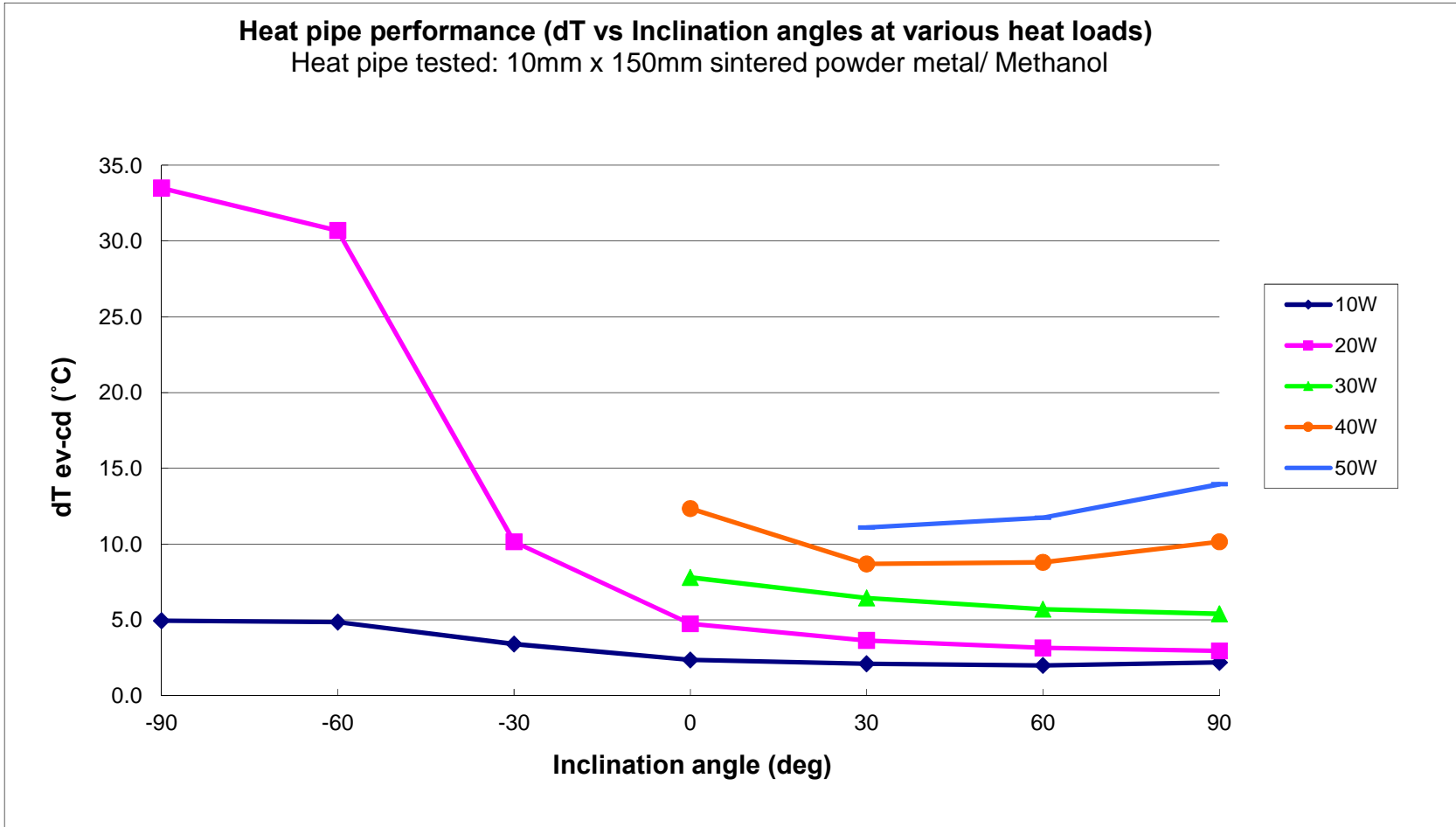


Heat Pipe Test Report

Manufacturer		Enertron				Test conditions				Test date	2018/2/5		
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol				Effective area (m2)		7.85E-05		Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block			
Pipe specification		C110 Copper 0.5mm wall thickness				Coolant temp (°C)		-10					
Diameter	±0.05 mm	10				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	10	2.20	0.22	5787	2.35	0.24	5418	-6.40	-8.60	-6.20	-6.50	-8.70	-8.70
	20	2.95	0.15	8632	3.35	0.17	7601	-4.10	-7.05	-3.80	-4.30	-7.50	-7.30
	30	5.40	0.18	7074	5.90	0.20	6474	-0.30	-5.70	0.20	-0.70	-6.30	-6.00
	40	10.15	0.25	5018	11.05	0.28	4609	6.40	-3.75	6.90	5.90	-4.90	-4.40
	50	13.95	0.28	4564	14.95	0.30	4258	11.65	-2.30	12.20	10.90	-3.70	-3.10
60	10	2.00	0.20	6366	2.20	0.22	5787	-6.60	-8.60	-6.30	-6.70	-8.70	-8.70
	20	3.15	0.16	8084	3.40	0.17	7490	-3.85	-7.00	-3.30	-4.50	-7.40	-7.20
	30	5.70	0.19	6701	6.20	0.21	6161	0.15	-5.55	1.00	-0.80	-6.20	-6.00
	40	8.80	0.22	5787	9.30	0.23	5476	4.85	-3.95	6.00	3.30	-4.70	-4.60
	50	11.75	0.24	5418	12.35	0.25	5155	9.15	-2.60	10.60	7.20	-3.50	-3.40
30	10	2.10	0.21	6063	2.25	0.23	5659	-6.30	-8.40	-5.90	-6.60	-8.50	-8.50
	20	3.65	0.18	6977	3.95	0.20	6447	-3.25	-6.90	-2.60	-3.90	-7.30	-7.10
	30	6.45	0.22	5922	6.75	0.23	5659	1.00	-5.45	1.90	-0.10	-5.80	-5.90
	40	8.70	0.22	5854	9.05	0.23	5628	4.60	-4.10	5.70	3.00	-4.70	-4.70
	50	11.10	0.22	5735	11.60	0.23	5488	8.15	-2.95	8.90	7.20	-3.50	-3.60
0	10	2.35	0.24	5418	2.40	0.24	5305	-6.05	-8.40	-5.70	-6.40	-8.40	-8.50
	20	4.75	0.24	5361	4.90	0.25	5197	-2.25	-7.00	-1.60	-3.00	-7.10	-7.30
	30	7.80	0.26	4897	8.05	0.27	4745	2.30	-5.50	3.10	1.10	-5.80	-6.10
	40	12.35	0.31	4124	12.50	0.31	4074	8.15	-4.20	9.20	6.30	-4.60	-4.90
-30	10	3.40	0.34	3745	3.40	0.34	3745	-4.90	-8.30	-4.60	-5.40	-8.40	-8.40
	20	10.15	0.51	2509	10.00	0.50	2546	2.80	-7.35	3.40	1.80	-7.40	-7.40
-60	10	4.85	0.49	2625	4.90	0.49	2598	-3.55	-8.40	-3.30	-3.80	-8.40	-8.50
	20	30.70	1.54	829	30.45	1.52	836	23.00	-7.70	23.10	22.40	-7.70	-7.70
-90	10	4.95	0.50	2572	5.00	0.50	2546	-3.40	-8.35	-3.10	-3.70	-8.40	-8.40
	20	33.50	1.68	760	33.25	1.66	766	25.85	-7.65	26.30	24.80	-7.70	-7.70

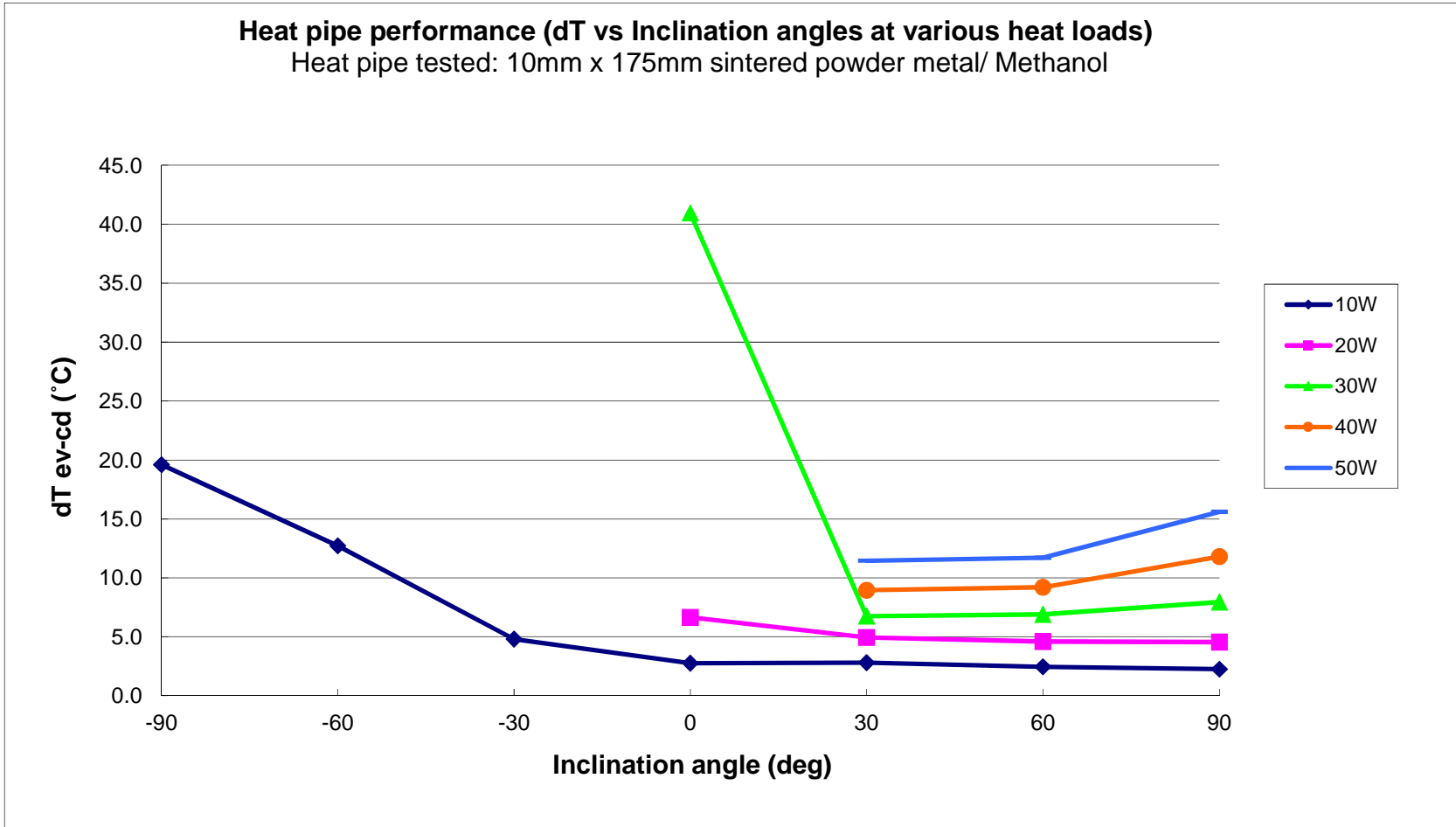
Heat pipe performance (dT vs Inclination angles at various heat loads)
 Heat pipe tested: 10mm x 150mm sintered powder metal/ Methanol



Heat Pipe Test Report

Manufacturer		Enertron				Test conditions				Test date	2018/2/5		
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol				Effective area (m2)		7.85E-05		Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block			
Pipe specification		C110 Copper 0.5mm wall thickness				Coolant temp (°C)		-10					
Diameter	±0.05 mm	10				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	10	2.25	0.23	7074	2.30	0.23	6920	-6.40	-8.65	-6.10	-6.60	-8.60	-8.70
	20	4.55	0.23	6996	4.75	0.24	6701	-2.55	-7.10	-2.00	-2.90	-7.10	-7.30
	30	7.95	0.27	6006	8.40	0.28	5684	2.25	-5.70	3.20	1.90	-5.80	-5.90
	40	11.80	0.30	5395	12.45	0.31	5113	7.50	-4.30	8.80	7.00	-4.50	-4.60
	50	15.60	0.31	5101	16.45	0.33	4838	12.50	-3.10	14.10	12.00	-3.30	-3.50
60	10	2.45	0.25	6496	2.50	0.25	6366	-6.05	-8.50	-5.90	-6.20	-8.50	-8.60
	20	4.60	0.23	6920	4.80	0.24	6631	-2.55	-7.15	-2.00	-2.90	-7.10	-7.40
	30	6.90	0.23	6920	7.20	0.24	6631	1.00	-5.90	1.80	0.50	-5.90	-6.20
	40	9.20	0.23	6920	9.60	0.24	6631	4.55	-4.65	5.60	3.90	-4.70	-5.00
	50	11.70	0.23	6801	12.15	0.24	6550	8.20	-3.50	9.40	7.50	-3.50	-3.90
30	10	2.80	0.28	5684	2.90	0.29	5488	-5.75	-8.55	-5.50	-5.90	-8.50	-8.70
	20	4.95	0.25	6431	5.05	0.25	6303	-2.35	-7.30	-1.90	-2.70	-7.20	-7.50
	30	6.75	0.23	7074	6.95	0.23	6870	0.60	-6.15	1.30	0.20	-6.00	-6.40
	40	8.95	0.22	7113	9.35	0.23	6809	4.10	-4.85	5.00	3.70	-4.80	-5.20
	50	11.45	0.23	6950	11.85	0.24	6715	7.80	-3.65	8.90	7.20	-3.50	-4.10
0	10	2.75	0.28	5787	2.80	0.28	5684	-5.85	-8.60	-5.60	-6.00	-8.50	-8.70
	20	6.65	0.33	4787	6.70	0.34	4751	-0.75	-7.40	-0.30	-1.30	-7.20	-7.80
	30	40.95	1.37	1166	41.00	1.37	1165	34.35	-6.60	34.50	34.00	-6.30	-7.20
-30	10	4.80	0.48	3316	5.10	0.51	3121	-4.05	-8.85	-3.50	-4.00	-8.80	-8.90
-60	10	12.70	1.27	1253	12.65	1.27	1258	3.80	-8.90	3.90	3.70	-8.80	-8.90
-90	10	19.60	1.96	812	19.55	1.96	814	10.75	-8.85	10.90	10.50	-8.80	-8.90

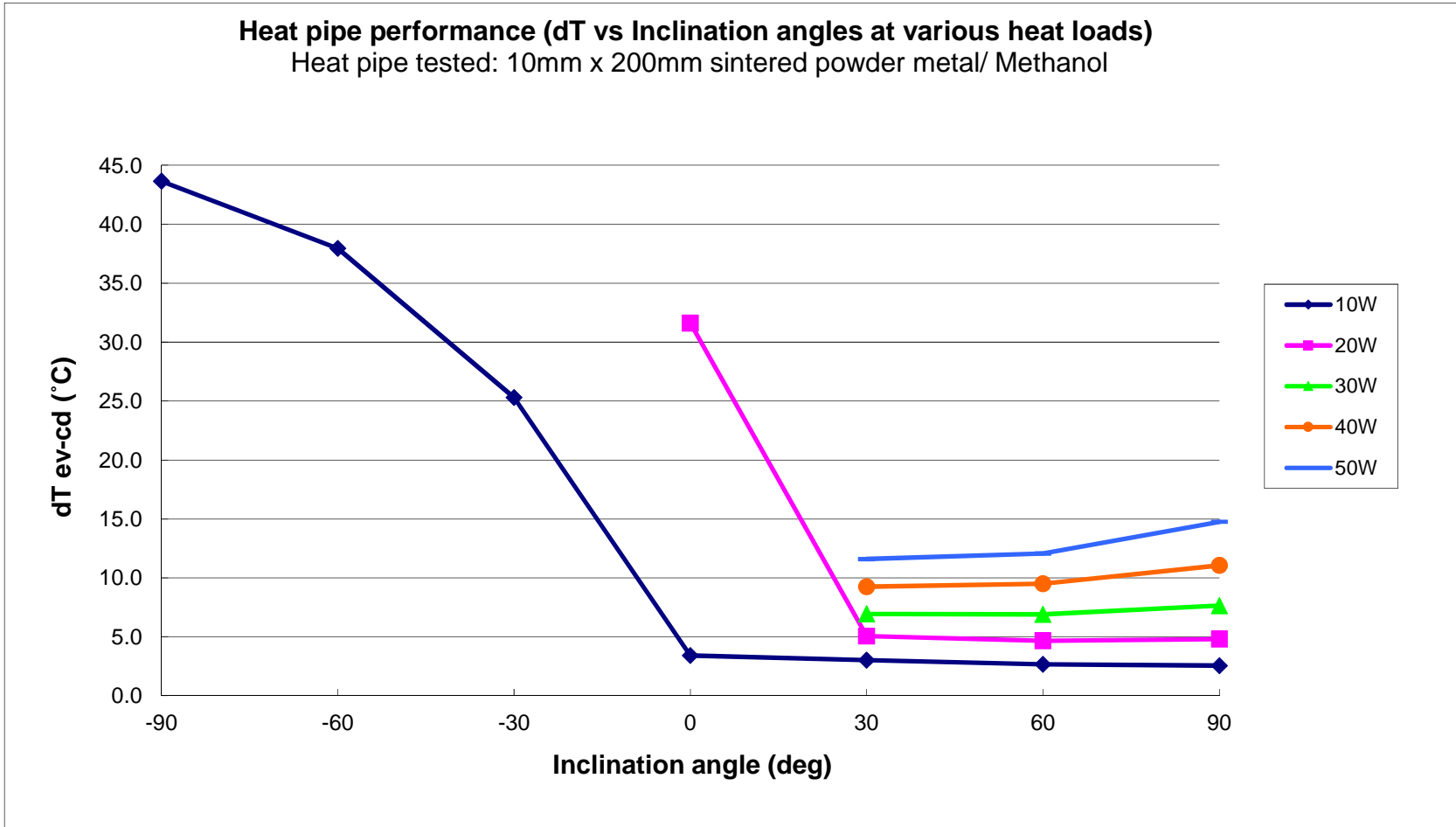
Heat pipe performance (dT vs Inclination angles at various heat loads)
 Heat pipe tested: 10mm x 175mm sintered powder metal/ Methanol



Heat Pipe Test Report

Manufacturer		Enertron			Test conditions			Test date	2018/2/5					
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol			Effective area (m2)		7.85E-05	Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block						
Pipe specification		C110 Copper 0.5mm wall thickness			Coolant temp (°C)		-10							
Diameter	±0.05 mm	10			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	10	2.55	0.26	7490	2.65	0.27	7207	-6.05	-8.60	-5.80	-6.20	-8.60	-8.70	
	20	4.80	0.24	7958	5.10	0.26	7490	-2.15	-6.95	-1.40	-2.60	-7.00	-7.20	
	30	7.65	0.26	7490	8.15	0.27	7030	2.10	-5.55	3.20	1.50	-5.70	-5.90	
	40	11.05	0.28	6914	11.90	0.30	6420	7.00	-4.05	8.50	6.20	-4.60	-4.50	
	50	14.75	0.30	6474	15.75	0.32	6063	12.05	-2.70	13.90	11.00	-3.20	-3.40	
60	10	2.65	0.27	7207	2.80	0.28	6821	-5.80	-8.45	-5.60	-5.90	-8.50	-8.60	
	20	4.65	0.23	8214	4.95	0.25	7717	-2.40	-7.05	-2.00	-2.60	-7.10	-7.40	
	30	6.90	0.23	8304	7.35	0.25	7795	1.25	-5.65	1.70	1.10	-5.80	-6.10	
	40	9.50	0.24	8042	10.05	0.25	7601	5.05	-4.45	5.60	4.90	-4.60	-5.00	
	50	12.05	0.24	7925	12.75	0.26	7490	8.65	-3.40	9.30	8.50	-3.60	-4.10	
30	10	3.00	0.30	6366	3.05	0.31	6262	-5.45	-8.45	-5.20	-5.80	-8.50	-8.60	
	20	5.05	0.25	7564	5.40	0.27	7074	-2.05	-7.10	-1.40	-2.50	-7.20	-7.50	
	30	6.95	0.23	8244	7.40	0.25	7743	1.10	-5.85	2.00	0.60	-5.90	-6.30	
	40	9.25	0.23	8259	9.80	0.25	7795	4.60	-4.65	5.80	3.80	-4.80	-5.20	
	50	11.60	0.23	8232	12.25	0.25	7795	8.20	-3.40	9.70	7.20	-3.50	-4.10	
0	10	3.40	0.34	5617	3.45	0.35	5536	-5.15	-8.55	-5.00	-5.40	-8.50	-8.80	
	20	31.60	1.58	1209	31.65	1.58	1207	23.85	-7.75	24.10	23.50	-7.70	-8.00	
-30	10	25.30	2.53	755	25.20	2.52	758	16.25	-9.05	16.40	16.00	-9.00	-9.00	
-60	10	37.95	3.80	503	37.85	3.79	505	28.90	-9.05	29.00	28.70	-9.00	-9.00	
-90	10	43.65	4.37	438	43.65	4.37	438	34.65	-9.00	34.80	34.50	-9.00	-9.00	

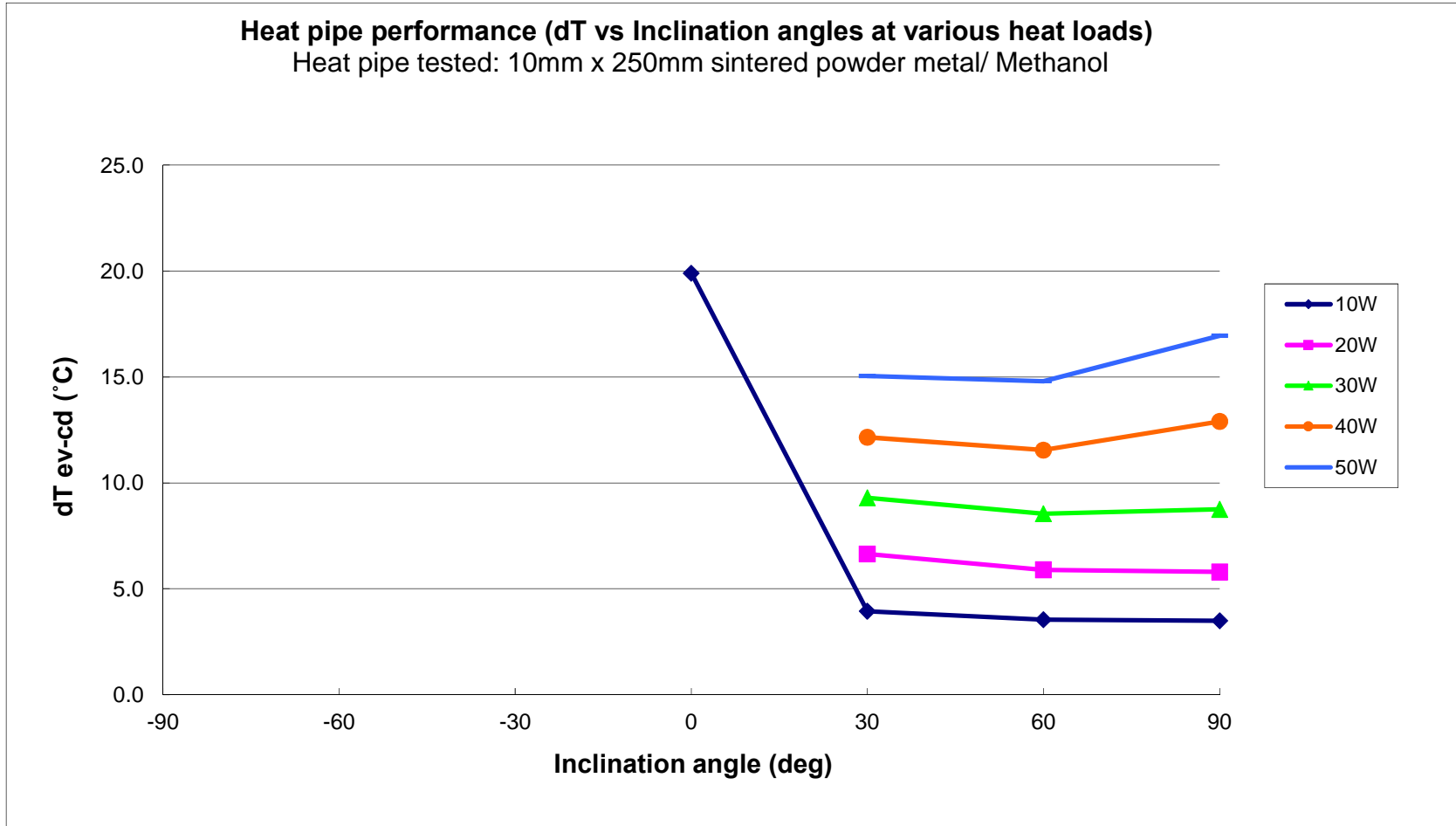
Heat pipe performance (dT vs Inclination angles at various heat loads)
 Heat pipe tested: 10mm x 200mm sintered powder metal/ Methanol



Heat Pipe Test Report

Manufacturer		Enertron				Test conditions				Test date	2018/2/5		
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol				Effective area (m2)		7.85E-05		Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block			
Pipe specification		C110 Copper 0.5mm wall thickness				Coolant temp (°C)		-10					
Diameter	±0.05 mm	10				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	3.50	0.35	7276	3.55	0.36	7173	-4.70	-8.20	-4.70	-4.70	-8.20	-8.30
	20	5.80	0.29	8781	5.95	0.30	8560	-0.60	-6.40	-0.50	-0.60	-6.50	-6.50
	30	8.75	0.29	8731	8.90	0.30	8584	4.10	-4.65	4.10	4.00	-4.90	-4.80
	40	12.90	0.32	7896	13.00	0.33	7835	9.75	-3.15	9.80	9.50	-3.40	-3.30
	50	16.95	0.34	7512	17.40	0.35	7317	15.35	-1.60	15.60	15.20	-2.00	-2.00
60	10	3.55	0.36	7173	3.55	0.36	7173	-4.70	-8.25	-4.70	-4.70	-8.20	-8.30
	20	5.90	0.30	8632	6.05	0.30	8418	-0.55	-6.45	-0.50	-0.50	-6.50	-6.60
	30	8.55	0.29	8935	8.75	0.29	8731	3.60	-4.95	3.60	3.60	-5.10	-5.20
	40	11.55	0.29	8819	11.85	0.30	8596	8.05	-3.50	8.00	8.10	-3.70	-3.90
	50	14.80	0.30	8603	15.15	0.30	8404	12.75	-2.05	12.70	12.90	-2.20	-2.50
30	10	3.95	0.40	6447	4.00	0.40	6366	-4.15	-8.10	-4.20	-4.10	-8.10	-8.20
	20	6.65	0.33	7659	6.75	0.34	7545	0.15	-6.50	0.10	0.20	-6.50	-6.70
	30	9.30	0.31	8214	9.40	0.31	8127	4.20	-5.10	4.00	4.30	-5.10	-5.40
	40	12.15	0.30	8383	12.30	0.31	8281	8.45	-3.70	8.20	8.70	-3.70	-4.00
	50	15.05	0.30	8460	15.25	0.31	8349	12.80	-2.25	12.50	13.10	-2.20	-2.70
0	10	19.90	1.99	1280	19.90	1.99	1280	11.25	-8.65	11.30	11.20	-8.60	-8.70

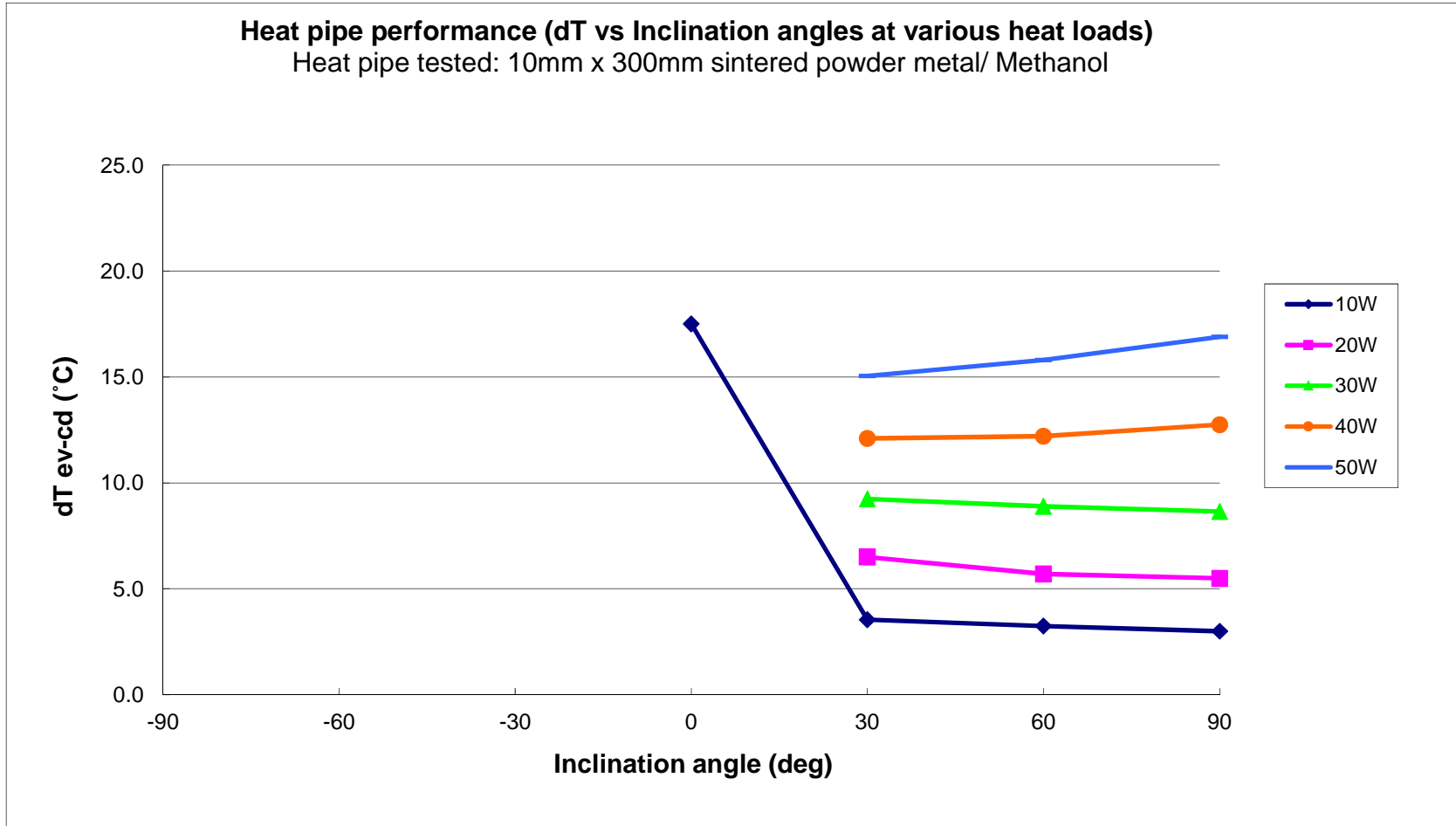
Heat pipe performance (dT vs Inclination angles at various heat loads)
 Heat pipe tested: 10mm x 250mm sintered powder metal/ Methanol



Heat Pipe Test Report

Manufacturer		Enertron				Test conditions			Test date	2018/2/5			
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol				Effective area (m2)		7.85E-05	Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block				
Pipe specification		C110 Copper 0.5mm wall thickness				Coolant temp (°C)		-10					
Diameter	±0.05 mm	10				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	3.00	0.30	10610	3.15	0.32	10105	-4.90	-7.90	-4.90	-4.90	-7.90	-8.20
	20	5.50	0.28	11575	5.70	0.29	11169	-0.65	-6.15	-0.60	-0.60	-6.10	-6.50
	30	8.65	0.29	11040	8.90	0.30	10730	4.20	-4.45	4.30	4.30	-4.30	-4.90
	40	12.75	0.32	9986	13.10	0.33	9719	9.90	-2.85	10.10	10.10	-2.60	-3.40
	50	16.90	0.34	9417	17.35	0.35	9173	15.60	-1.30	15.90	15.90	-1.00	-1.90
60	10	3.25	0.33	9794	3.25	0.33	9794	-5.10	-8.35	-5.20	-5.10	-8.40	-8.40
	20	5.70	0.29	11169	5.80	0.29	10976	-1.15	-6.85	-1.20	-1.10	-6.90	-7.00
	30	8.90	0.30	10730	8.95	0.30	10670	3.45	-5.45	3.40	3.50	-5.40	-5.60
	40	12.20	0.31	10436	12.30	0.31	10352	8.10	-4.10	8.00	8.30	-4.00	-4.30
	50	15.80	0.32	10073	15.85	0.32	10041	13.10	-2.70	12.90	13.30	-2.60	-2.90
30	10	3.55	0.36	8966	3.60	0.36	8842	-4.75	-8.30	-4.80	-4.70	-8.30	-8.40
	20	6.50	0.33	9794	6.55	0.33	9719	-0.35	-6.85	-0.50	-0.20	-6.90	-6.90
	30	9.25	0.31	10324	9.30	0.31	10268	3.75	-5.50	3.50	4.00	-5.50	-5.60
	40	12.10	0.30	10523	12.10	0.30	10523	7.85	-4.25	7.50	8.20	-4.10	-4.40
	50	15.05	0.30	10575	15.10	0.30	10540	12.20	-2.85	11.80	12.70	-2.70	-3.00
0	10	17.50	1.75	1819	17.60	1.76	1809	9.25	-8.25	9.30	9.20	-8.20	-8.50

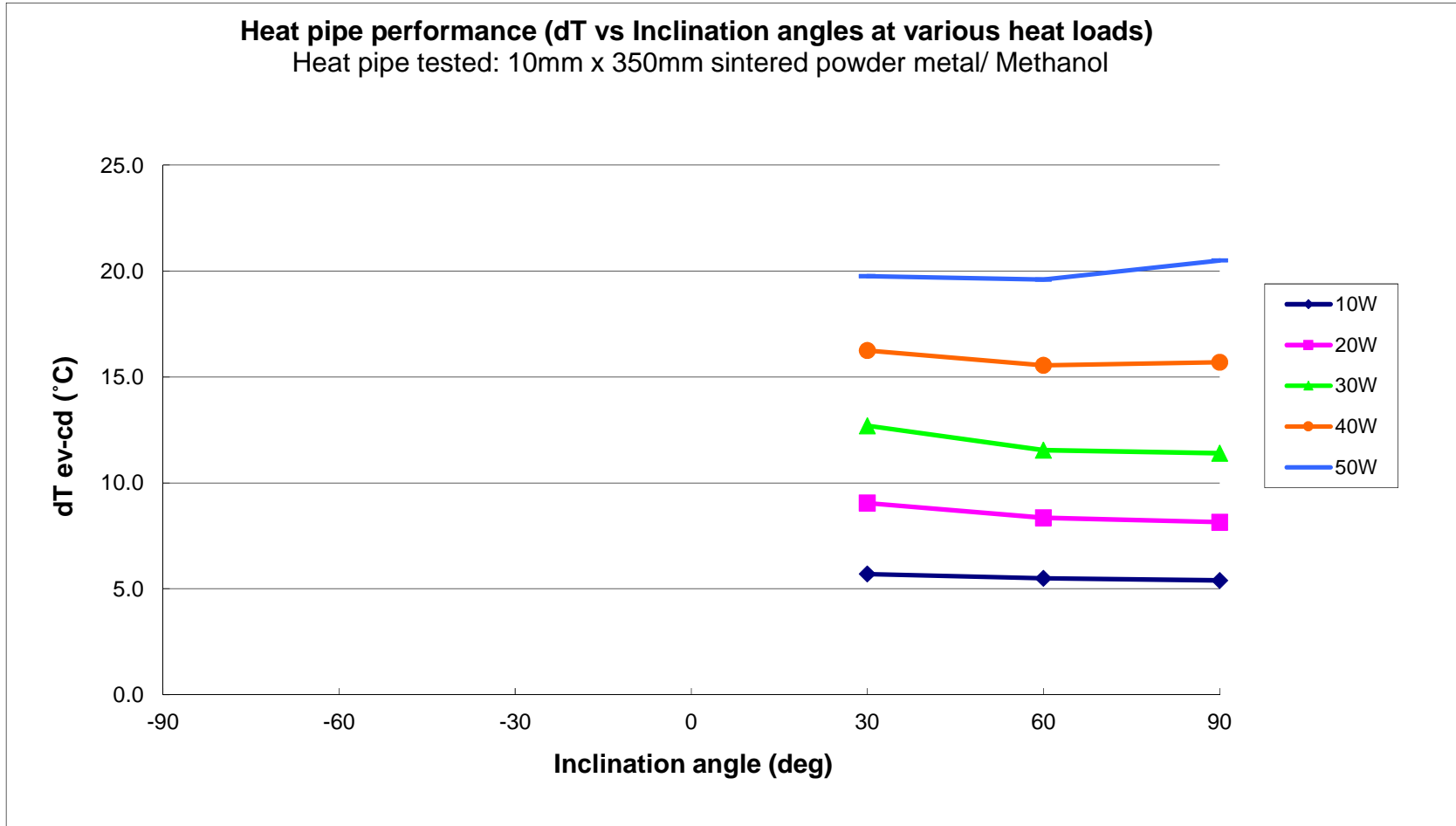
Heat pipe performance (dT vs Inclination angles at various heat loads)
 Heat pipe tested: 10mm x 300mm sintered powder metal/ Methanol

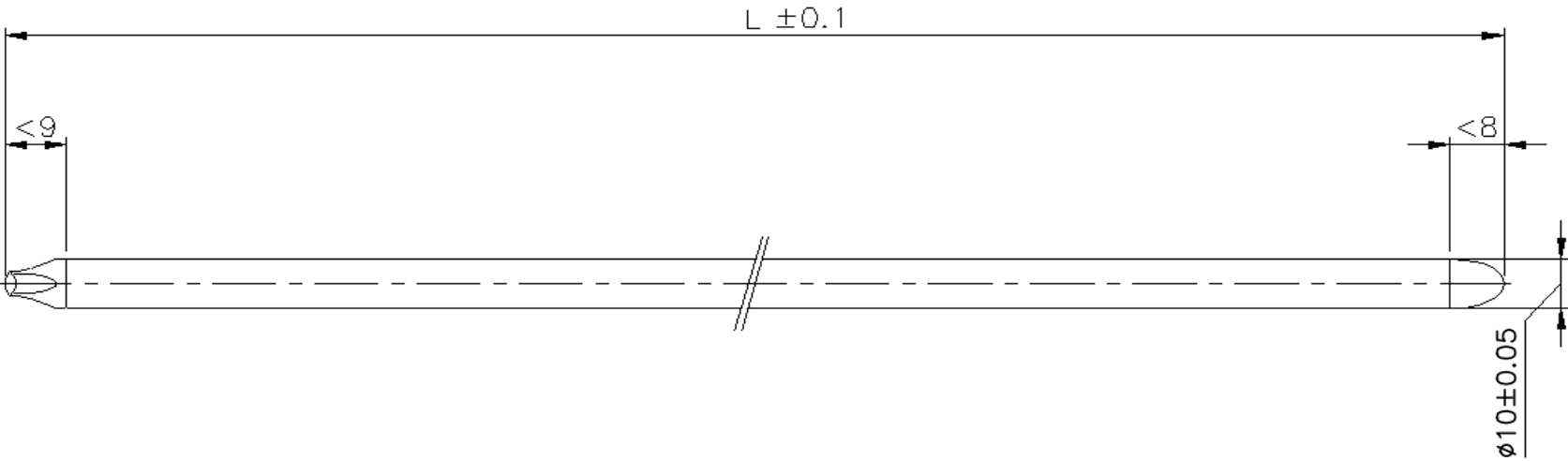


Heat Pipe Test Report

Manufacturer		Enertron				Test conditions				Test date	2018/2/5		
Wick structure/ Working fluid		Sintered Powder Metal/ Methanol				Effective area (m ²)		7.85E-05		Note: ev- Evaporator of heat pipe cd- Condenser of heat pipe eb- Evaporator Block cb- Condenser Block			
Pipe specification		C110 Copper 0.5mm wall thickness				Coolant temp (°C)		-10					
Diameter	±0.05 mm	10				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	5.40	0.54	7074	5.45	0.55	7009	-3.00	-8.40	-3.10	-2.90	-8.40	-8.50
	20	8.15	0.41	9374	8.25	0.41	9260	1.35	-6.80	1.10	1.70	-6.80	-6.90
	30	11.40	0.38	10052	11.50	0.38	9964	6.00	-5.40	5.70	6.50	-5.40	-5.40
	40	15.70	0.39	9732	15.80	0.40	9670	11.60	-4.10	11.10	12.40	-4.10	-4.00
	50	20.50	0.41	9316	20.75	0.42	9204	17.65	-2.85	17.00	18.90	-2.90	-2.70
60	10	5.50	0.55	6945	5.55	0.56	6882	-2.85	-8.35	-3.10	-2.70	-8.40	-8.50
	20	8.35	0.42	9149	8.45	0.42	9041	1.55	-6.80	1.20	2.00	-6.80	-6.90
	30	11.55	0.39	9921	11.75	0.39	9752	6.05	-5.50	5.60	6.70	-5.50	-5.70
	40	15.55	0.39	9826	15.70	0.39	9732	11.30	-4.25	10.50	12.40	-4.20	-4.30
	50	19.60	0.39	9744	19.80	0.40	9646	16.60	-3.00	15.50	18.00	-3.00	-3.10
30	10	5.70	0.57	6701	5.70	0.57	6701	-2.55	-8.25	-2.90	-2.30	-8.20	-8.40
	20	9.05	0.45	8441	9.20	0.46	8304	2.20	-6.85	1.70	2.90	-6.80	-7.00
	30	12.70	0.42	9023	12.85	0.43	8918	7.10	-5.60	6.20	8.20	-5.50	-5.80
	40	16.25	0.41	9402	16.55	0.41	9232	11.95	-4.30	10.90	13.50	-4.20	-4.50
	50	19.75	0.40	9670	20.10	0.40	9502	16.60	-3.15	15.30	18.60	-3.00	-3.30

Heat pipe performance (dT vs Inclination angles at various heat loads)
 Heat pipe tested: 10mm x 350mm sintered powder metal/ Methanol





unit: mm