

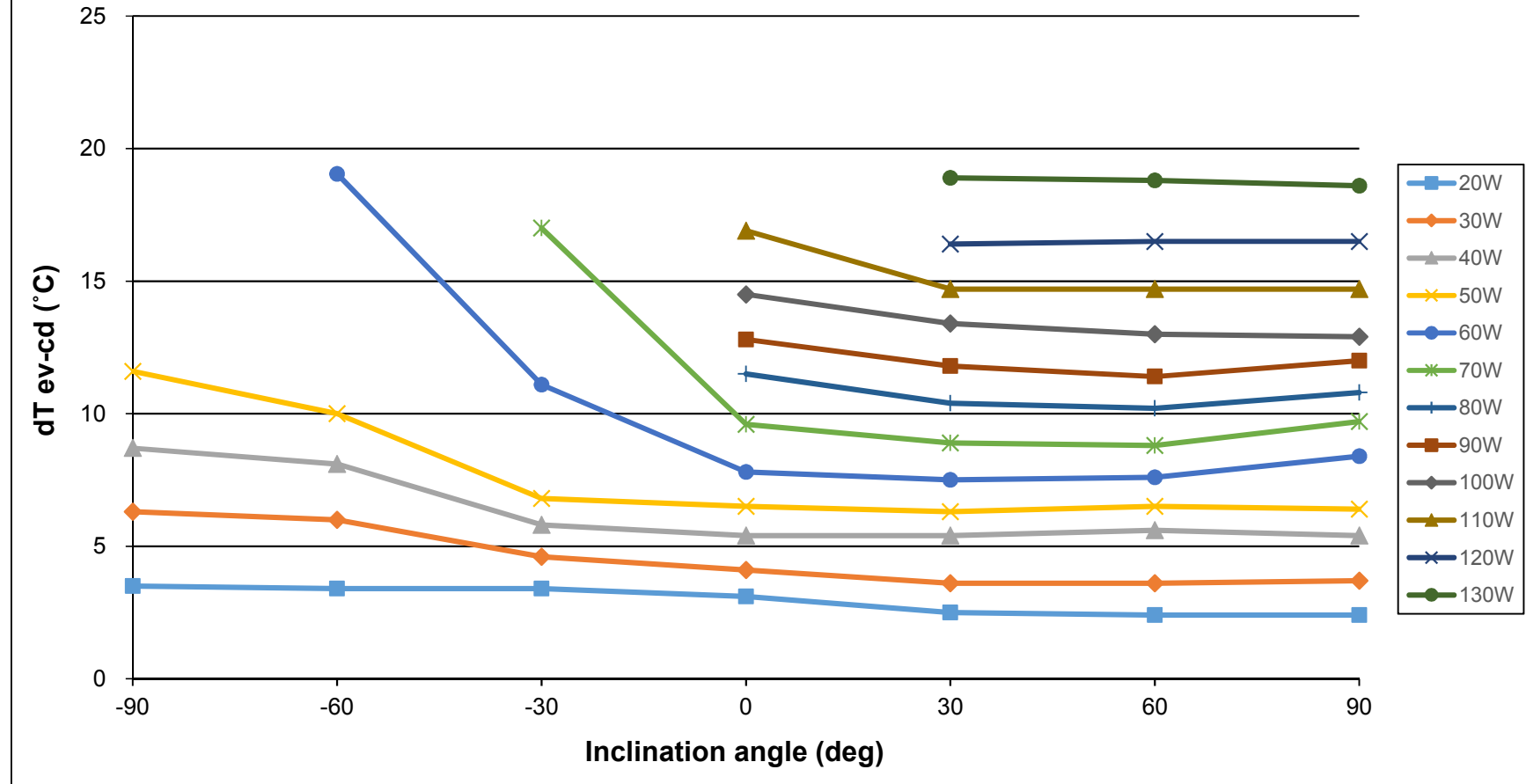
Heat Pipe Test Report

Manufacturer		Enertron			Test conditions			Test date	2018/8/7					
Wick structure/ Working fluid		Sintered Powder Metal/ Water			Effective area (m2)		5.03E-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	8			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	20	2.40	0.12	24868	3.55	0.18	16812	39.85	37.45	40.80	40.50	37.10	37.10	
	30	3.70	0.12	24196	5.50	0.18	16277	42.45	38.75	43.80	43.30	37.90	38.20	
	40	5.35	0.13	22311	7.40	0.19	16131	43.70	38.35	45.50	44.70	37.80	37.60	
	50	6.35	0.13	23497	8.75	0.18	17052	45.70	39.35	47.80	46.90	38.40	38.80	
	60	8.40	0.14	21315	9.95	0.17	17995	48.50	40.10	50.50	49.50	40.10	40.00	
	70	9.70	0.14	21535	11.20	0.16	18651	50.50	40.80	52.60	51.60	40.90	40.90	
	80	10.75	0.13	22208	12.45	0.16	19175	52.35	41.60	54.80	53.60	41.70	41.80	
	90	12.00	0.13	22381	13.95	0.16	19253	54.45	42.45	57.10	55.90	42.50	42.60	
	100	12.90	0.13	23133	15.45	0.15	19315	56.10	43.20	59.40	58.00	43.30	43.20	
	110	14.70	0.13	22330	17.60	0.16	18651	58.80	44.10	62.50	61.10	44.50	43.90	
	120	16.50	0.14	21703	20.05	0.17	17860	61.75	45.25	66.00	64.50	45.20	45.20	
	130	18.60	0.14	20857	22.45	0.17	17280	64.80	46.20	69.40	67.80	46.20	46.10	
140	19.85	0.14	21047	24.10	0.17	17335	66.85	47.00	71.90	70.30	46.80	47.20		
60	20	2.40	0.12	24868	4.15	0.21	14381	39.65	37.25	40.40	40.10	36.20	36.00	
	30	3.60	0.12	24868	5.55	0.19	16131	42.20	38.60	42.90	42.40	37.20	37.00	
	40	5.60	0.14	21315	7.20	0.18	16579	43.55	37.95	45.40	44.80	37.90	37.90	
	50	6.50	0.13	22955	8.45	0.17	17658	45.70	39.20	47.60	46.90	38.70	38.90	
	60	7.55	0.13	23715	9.30	0.16	19253	47.35	39.80	49.50	48.70	39.80	39.80	
	70	8.85	0.13	23603	10.85	0.16	19253	49.55	40.70	52.00	51.10	40.70	40.70	
	80	10.20	0.13	23405	12.40	0.16	19253	51.85	41.65	54.50	53.40	41.50	41.60	
	90	11.35	0.13	23663	14.10	0.16	19048	53.85	42.50	57.10	55.90	42.40	42.40	
	100	12.95	0.13	23044	16.05	0.16	18593	56.30	43.35	59.80	58.60	43.20	43.10	
	110	14.65	0.13	22407	18.15	0.17	18086	59.10	44.45	63.00	61.60	44.10	44.20	
	120	16.50	0.14	21703	20.60	0.17	17383	62.15	45.65	66.30	64.90	44.90	45.10	
	130	18.75	0.14	20690	23.00	0.18	16867	65.30	46.55	69.60	67.90	45.20	46.30	
30	20	2.50	0.13	23873	3.90	0.20	15303	39.05	36.55	39.90	39.60	35.60	36.10	
	30	3.60	0.12	24868	5.55	0.19	16131	41.30	37.70	42.40	41.90	36.10	37.10	
	40	5.40	0.14	22105	7.05	0.18	16931	43.25	37.85	44.90	44.30	37.00	38.10	
	50	6.30	0.13	23684	8.65	0.17	17249	45.35	39.05	47.40	46.60	37.80	38.90	

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	60	7.50	0.13	23873	9.75	0.16	18364	47.60	40.10	49.90	49.10	39.80	39.70
	70	8.90	0.13	23471	11.45	0.16	18244	49.90	41.00	52.70	51.70	40.80	40.70
	80	10.35	0.13	23066	13.30	0.17	17950	52.30	41.95	55.40	54.30	41.60	41.50
	90	11.75	0.13	22857	15.30	0.17	17554	54.55	42.80	58.40	57.10	42.50	42.40
	100	13.35	0.13	22353	17.20	0.17	17350	57.05	43.70	61.30	59.90	43.30	43.50
	110	14.65	0.13	22407	19.30	0.18	17008	59.35	44.70	63.90	62.50	43.60	44.20
	120	16.35	0.14	21902	21.50	0.18	16656	61.95	45.60	66.80	65.30	43.90	45.20
	130	18.90	0.15	20526	23.30	0.18	16650	65.20	46.30	69.40	67.70	44.60	45.90
0	140	19.15	0.14	21816	24.95	0.18	16745	66.25	47.10	71.90	70.20	45.40	46.80
	20	3.10	0.16	19253	3.90	0.20	15303	39.15	36.05	40.10	39.80	36.20	35.90
	30	4.05	0.14	22105	5.30	0.18	16891	41.20	37.15	42.50	42.10	37.00	37.00
	40	5.40	0.14	22105	6.75	0.17	17684	43.40	38.00	45.00	44.50	38.00	38.00
	50	6.45	0.13	23133	8.45	0.17	17658	45.65	39.20	47.70	46.90	38.80	38.90
	60	7.80	0.13	22955	10.35	0.17	17299	48.00	40.20	50.50	49.60	39.80	39.60
	70	9.60	0.14	21759	12.15	0.17	17193	50.50	40.90	53.30	52.40	40.90	40.50
	80	11.50	0.14	20759	14.30	0.18	16695	53.25	41.75	56.30	55.40	41.60	41.50
	90	12.80	0.14	20982	16.20	0.18	16579	55.60	42.80	59.00	58.00	42.10	42.50
	100	14.50	0.15	20580	18.60	0.19	16044	58.20	43.70	61.90	60.90	42.30	43.30
-30	110	16.90	0.15	19423	21.35	0.19	15375	61.80	44.90	65.60	64.20	42.40	44.70
	20	3.35	0.17	17816	4.30	0.22	13880	39.60	36.25	40.60	40.30	36.40	35.90
	30	4.55	0.15	19676	5.95	0.20	15046	41.70	37.15	43.10	42.70	37.20	36.70
	40	5.75	0.14	20759	7.50	0.19	15915	44.00	38.25	45.70	45.20	38.10	37.80
	50	6.85	0.14	21782	8.95	0.18	16671	46.05	39.20	48.00	47.40	38.90	38.60
	60	11.10	0.19	16131	12.35	0.21	14498	51.00	39.90	53.30	51.00	40.40	39.20
-60	70	17.00	0.24	12288	18.95	0.27	11023	57.55	40.55	61.90	56.90	41.50	39.40
	20	3.40	0.17	17554	4.15	0.21	14381	39.75	36.35	40.60	40.30	36.80	35.80
	30	5.95	0.20	15046	6.65	0.22	13462	43.35	37.40	44.50	43.40	37.80	36.80
	40	8.05	0.20	14828	8.95	0.22	13337	46.20	38.15	47.80	46.20	38.60	37.50
-90	50	9.95	0.20	14996	10.95	0.22	13626	49.05	39.10	50.90	48.90	39.70	38.20
	20	3.50	0.18	17052	4.10	0.21	14557	39.80	36.30	40.60	40.40	37.00	35.80
	30	6.30	0.21	14210	5.70	0.19	15706	43.50	37.20	43.20	42.80	37.80	36.80
	40	8.70	0.22	13720	8.30	0.21	14381	47.00	38.30	47.20	46.00	39.00	37.60
	50	11.55	0.23	12918	12.55	0.25	11889	50.70	39.15	53.20	50.20	40.10	38.20

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

Heat pipe tested: 8mm x 200mm groove / powder metal + water



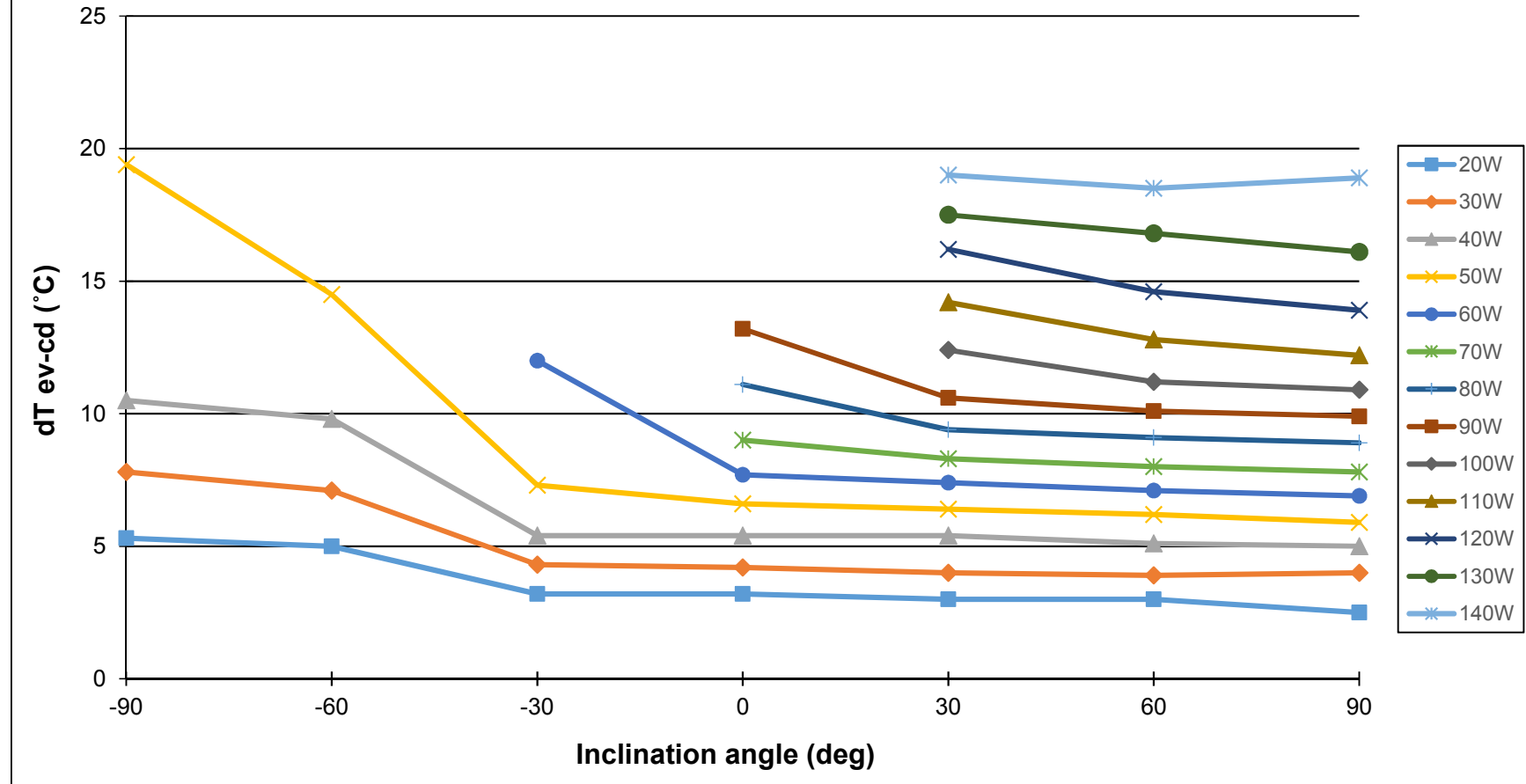
Heat Pipe Test Report

Manufacturer		Enertron		Test conditions				Test date	2018/8/17					
Wick structure/ Working fluid		Sintered Powder Metal/ Water		Effective area (m2)		5.03E-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	8		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	20	2.50	0.13	27852	2.55	0.13	27306	39.05	36.55	38.50	39.10	36.30	36.20	
	30	4.00	0.13	26111	4.30	0.14	24290	41.50	37.50	41.20	41.70	37.20	37.10	
	40	5.00	0.13	27852	5.25	0.13	26526	43.50	38.50	43.30	43.30	37.90	38.20	
	50	5.90	0.12	29504	6.60	0.13	26375	45.30	39.40	45.10	45.60	38.40	39.10	
	60	6.85	0.11	30495	7.80	0.13	26781	47.20	40.35	47.20	47.60	39.30	39.90	
	70	7.75	0.11	31446	8.85	0.13	27537	48.95	41.20	49.00	49.50	40.10	40.70	
	80	8.85	0.11	31471	10.05	0.13	27714	50.90	42.05	51.00	51.50	40.90	41.50	
	90	9.90	0.11	31650	11.35	0.13	27607	52.85	42.95	53.10	53.60	41.60	42.40	
	100	10.90	0.11	31940	12.50	0.13	27852	54.70	43.80	54.90	55.60	42.40	43.10	
	110	12.15	0.11	31520	14.00	0.13	27355	56.90	44.75	57.20	58.00	43.20	44.00	
	120	13.90	0.12	30056	16.05	0.13	26030	59.70	45.80	60.00	60.90	44.10	44.70	
	130	16.10	0.12	28112	18.35	0.14	24665	63.05	46.95	63.30	64.40	45.10	45.90	
140	18.85	0.13	25857	20.75	0.15	23490	66.60	47.75	66.60	67.90	45.90	47.10		
60	20	2.95	0.15	23603	3.10	0.16	22461	39.50	36.55	39.00	39.50	36.20	36.10	
	30	3.85	0.13	27129	4.20	0.14	24868	41.40	37.55	41.00	41.50	37.00	37.10	
	40	5.05	0.13	27576	5.45	0.14	25552	43.45	38.40	43.10	43.60	37.80	38.00	
	50	6.15	0.12	28305	6.65	0.13	26177	45.55	39.40	45.20	45.70	38.60	39.00	
	60	7.10	0.12	29421	7.90	0.13	26442	47.50	40.40	47.20	47.80	39.30	39.90	
	70	7.95	0.11	30655	8.95	0.13	27230	49.20	41.25	49.00	49.60	40.10	40.60	
	80	9.10	0.11	30607	10.35	0.13	26910	51.40	42.30	51.40	52.00	41.10	41.60	
	90	10.10	0.11	31023	11.50	0.13	27247	53.20	43.10	53.20	53.80	41.70	42.30	
	100	11.15	0.11	31224	12.75	0.13	27306	55.20	44.05	55.20	55.90	42.50	43.10	
	110	12.75	0.12	30037	14.60	0.13	26231	57.65	44.90	57.70	58.50	43.20	43.80	
	120	14.55	0.12	28714	16.60	0.14	25168	60.55	46.00	60.70	61.60	44.20	44.90	
	130	16.75	0.13	27021	19.05	0.15	23758	63.75	47.00	63.70	64.90	44.70	45.80	
140	18.50	0.13	26347	20.90	0.15	23321	66.50	48.00	66.40	67.70	45.30	47.00		
30	20	2.95	0.15	23603	3.10	0.16	22461	39.50	36.55	39.10	39.40	36.30	36.00	
	30	3.95	0.13	26442	4.20	0.14	24868	41.40	37.45	41.10	41.40	37.10	37.00	
	40	5.35	0.13	26030	5.85	0.15	23805	43.95	38.60	43.70	44.10	38.00	38.10	

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	50	6.40	0.13	27199	7.10	0.14	24518	45.95	39.55	45.70	46.20	38.70	39.00
	60	7.40	0.12	28228	8.30	0.14	25168	47.95	40.55	47.80	48.30	39.60	39.90
	70	8.30	0.12	29362	9.40	0.13	25926	49.75	41.45	49.60	50.10	40.30	40.60
	80	9.35	0.12	29788	10.60	0.13	26276	51.65	42.30	51.60	52.20	41.10	41.50
	90	10.55	0.12	29700	12.05	0.13	26003	53.70	43.15	53.70	54.40	41.80	42.20
	100	12.40	0.12	28077	14.05	0.14	24779	56.60	44.20	56.60	57.40	42.80	43.10
	110	14.20	0.13	26969	16.15	0.15	23713	59.40	45.20	59.40	60.30	43.10	44.30
	120	16.15	0.13	25869	18.30	0.15	22830	62.15	46.00	62.20	63.20	43.90	44.90
	130	17.50	0.13	25863	19.95	0.15	22687	64.45	46.95	64.50	65.90	44.70	45.80
140	18.95	0.14	25721	21.50	0.15	22670	66.70	47.75	66.90	68.00	45.30	46.60	
0	20	3.20	0.16	21759	3.40	0.17	20479	39.85	36.65	39.40	39.80	36.40	36.00
	30	4.15	0.14	25168	4.65	0.16	22461	41.80	37.65	41.40	41.90	37.20	36.80
	40	5.35	0.13	26030	5.80	0.15	24010	43.95	38.60	43.60	44.10	38.10	38.00
	50	6.55	0.13	26576	7.10	0.14	24518	46.00	39.45	45.70	46.20	38.80	38.90
	60	7.70	0.13	27129	8.50	0.14	24575	48.20	40.50	47.90	48.50	39.60	39.80
	70	9.00	0.13	27078	9.90	0.14	24617	50.25	41.25	50.00	50.70	40.40	40.50
	80	11.05	0.14	25206	11.95	0.15	23307	53.25	42.20	53.00	53.80	41.50	41.40
	90	13.20	0.15	23738	14.50	0.16	21609	56.50	43.30	56.20	57.20	41.70	42.70
-30	20	3.20	0.16	21759	3.45	0.17	20183	39.90	36.70	39.40	39.90	36.50	35.90
	30	4.30	0.14	24290	4.55	0.15	22955	41.80	37.50	41.30	41.80	37.20	36.80
	40	5.40	0.14	25789	5.75	0.14	24219	43.90	38.50	43.50	44.00	38.10	37.90
	50	7.30	0.15	23846	7.75	0.16	22461	46.80	39.50	46.60	46.50	39.00	38.60
	60	11.95	0.20	17480	12.30	0.21	16983	52.15	40.20	53.10	50.40	40.00	38.90
-60	20	4.95	0.25	14067	5.00	0.25	13926	41.80	36.85	41.80	40.90	36.80	35.90
	30	7.05	0.24	14815	7.10	0.24	14711	44.65	37.60	45.00	43.40	37.60	36.60
	40	9.75	0.24	14283	9.95	0.25	13996	48.20	38.45	49.20	46.50	38.50	37.30
	50	14.50	0.29	12005	14.90	0.30	11683	53.90	39.40	55.90	51.30	39.50	37.90
-90	20	5.30	0.27	13138	3.15	0.16	22105	42.20	36.90	39.40	39.70	36.80	36.00
	30	7.80	0.26	13390	4.55	0.15	22955	45.40	37.60	41.90	41.80	37.80	36.80
	40	10.50	0.26	13263	8.50	0.21	16384	49.05	38.55	47.70	45.50	38.80	37.40
	50	19.35	0.39	8996	19.55	0.39	8904	58.85	39.50	61.80	55.10	39.90	37.90

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

Heat pipe tested: 8mm x 225mm groove / powder metal + water



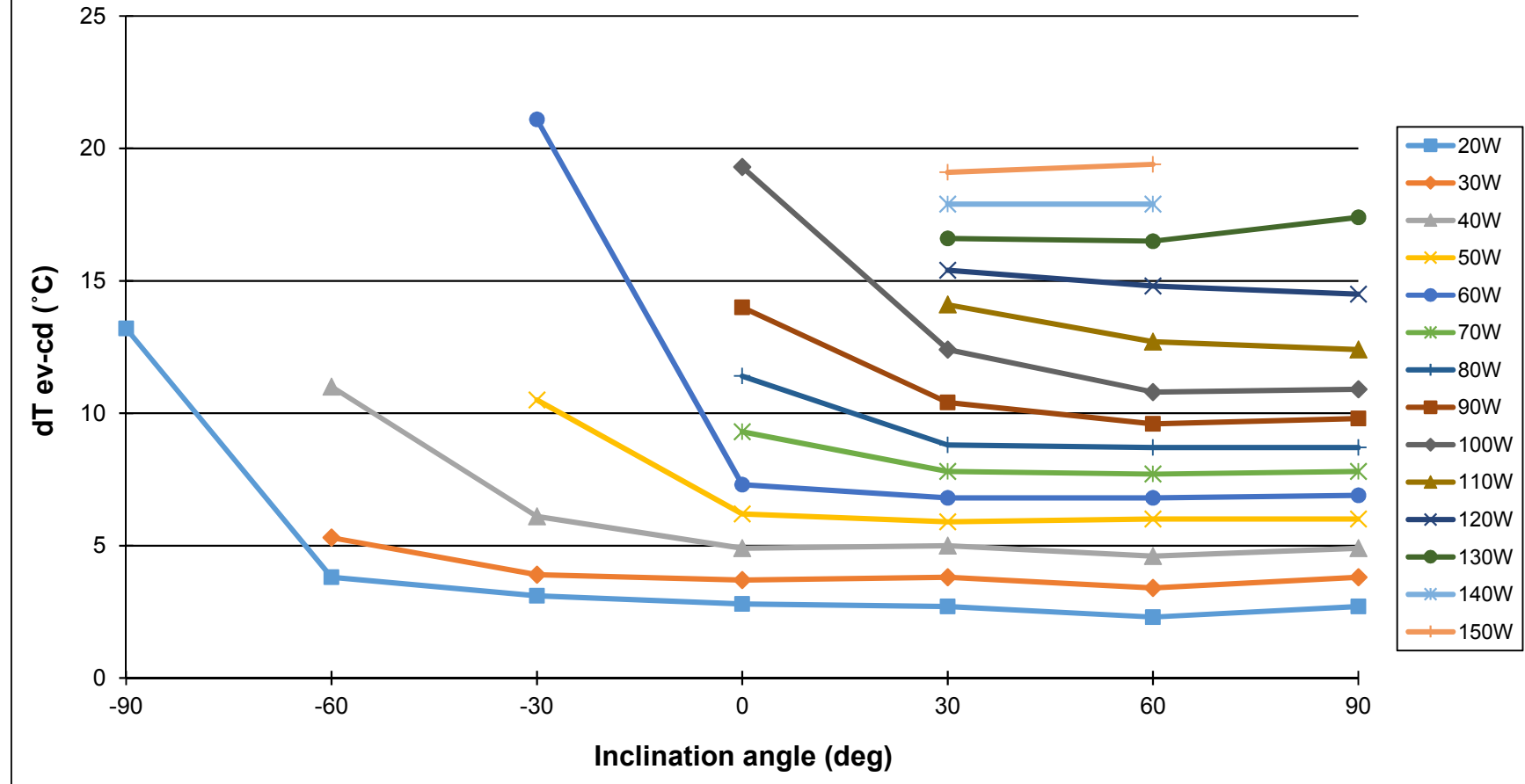
Heat Pipe Test Report

Manufacturer		Enertron		Test conditions				Test date		2018/8/31			
Wick structure/ Working fluid		Sintered Powder Metal/ Water		Effective area (m2)		5.03E-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	8		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	20	2.65	0.13	30029	2.75	0.14	28937	39.20	36.55	38.90	39.10	36.20	36.30
	30	3.85	0.13	31004	4.00	0.13	29842	41.30	37.45	41.00	41.30	37.00	37.30
	40	4.85	0.12	32815	5.10	0.13	31207	43.35	38.50	43.10	43.50	38.00	38.40
	50	5.95	0.12	33436	6.25	0.13	31831	45.40	39.45	45.10	45.60	38.90	39.30
	60	6.85	0.11	34851	7.40	0.12	32261	47.25	40.40	47.00	47.60	39.70	40.10
	70	7.80	0.11	35708	8.55	0.12	32576	49.15	41.35	48.90	49.60	40.40	41.00
	80	8.70	0.11	36587	9.65	0.12	32985	50.95	42.25	50.70	51.60	41.10	41.90
	90	9.80	0.11	36541	10.80	0.12	33157	52.95	43.15	52.60	53.70	41.90	42.80
	100	10.85	0.11	36672	12.00	0.12	33157	54.85	44.00	54.40	55.80	42.70	43.50
	110	12.35	0.11	35439	13.70	0.12	31947	57.40	45.05	57.00	58.50	43.60	44.50
	120	14.45	0.12	33043	16.10	0.13	29656	60.70	46.25	60.30	62.00	44.60	45.50
130	17.40	0.13	29727	19.25	0.15	26870	64.70	47.30	64.20	66.20	45.00	46.90	
60	20	2.30	0.12	34599	2.45	0.12	32481	38.90	36.60	38.60	38.90	36.20	36.40
	30	3.35	0.11	35632	3.60	0.12	33157	40.90	37.55	40.60	41.00	37.00	37.40
	40	4.55	0.11	34979	4.80	0.12	33157	42.95	38.40	42.70	43.20	38.00	38.30
	50	5.95	0.12	33436	6.35	0.13	31330	45.40	39.45	45.10	45.70	38.90	39.20
	60	6.80	0.11	35108	7.35	0.12	32481	47.20	40.40	46.90	47.60	39.70	40.10
	70	7.65	0.11	36408	8.45	0.12	32961	49.05	41.40	48.80	49.60	40.50	41.00
	80	8.65	0.11	36799	9.50	0.12	33506	50.90	42.25	50.70	51.60	41.40	41.90
	90	9.65	0.11	37109	10.75	0.12	33311	52.85	43.20	52.50	53.70	42.00	42.70
	100	10.75	0.11	37013	11.95	0.12	33296	54.75	44.00	54.40	55.70	42.70	43.50
	110	12.70	0.12	34463	14.15	0.13	30931	57.85	45.15	57.50	59.10	43.80	44.50
	120	14.80	0.12	32261	16.65	0.14	28677	61.05	46.25	60.70	62.50	44.30	45.60
	130	16.50	0.13	31349	18.65	0.14	27735	63.65	47.15	63.30	65.30	44.70	46.60
	140	17.85	0.13	31207	20.20	0.14	27576	65.85	48.00	65.50	67.70	45.30	47.50
150	19.40	0.13	30764	21.85	0.15	27315	68.25	48.85	67.90	70.30	46.10	48.40	
30	20	2.70	0.14	29473	2.90	0.15	27441	39.30	36.60	39.00	39.30	36.40	36.10
	30	3.80	0.13	31412	3.95	0.13	30219	41.25	37.45	40.90	41.30	37.20	37.10
	40	4.95	0.12	32153	5.20	0.13	30607	43.35	38.40	43.10	43.60	38.10	38.20

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	50	5.90	0.12	33719	6.35	0.13	31330	45.35	39.45	45.00	45.60	38.80	39.10
	60	6.75	0.11	35368	7.30	0.12	32703	47.15	40.40	46.80	47.50	39.70	40.00
	70	7.80	0.11	35708	8.55	0.12	32576	49.20	41.40	48.80	49.70	40.50	40.90
	80	8.75	0.11	36378	9.70	0.12	32815	51.10	42.35	50.70	51.80	41.30	41.80
	90	10.40	0.12	34433	11.60	0.13	30871	53.70	43.30	53.30	54.60	42.20	42.50
	100	12.35	0.12	32218	13.75	0.14	28937	56.65	44.30	56.30	57.80	42.90	43.70
	110	14.10	0.13	31041	15.80	0.14	27701	59.45	45.35	59.10	60.70	43.30	44.90
	120	15.35	0.13	31105	17.20	0.14	27760	61.50	46.15	61.20	63.00	44.20	45.60
	130	16.55	0.13	31254	18.70	0.14	27661	63.60	47.05	63.40	65.40	44.90	46.50
	140	17.85	0.13	31207	20.15	0.14	27645	65.75	47.90	65.50	67.70	45.60	47.30
150	19.10	0.13	31248	21.45	0.14	27824	67.80	48.70	67.60	69.70	46.30	48.10	
0	20	2.75	0.14	28937	2.90	0.15	27441	39.25	36.50	38.90	39.30	36.40	36.00
	30	3.70	0.12	32261	3.90	0.13	30607	41.10	37.40	40.70	41.30	37.20	37.00
	40	4.85	0.12	32815	5.15	0.13	30904	43.20	38.35	42.90	43.50	38.10	38.00
	50	6.15	0.12	32349	6.55	0.13	30373	45.60	39.45	45.30	46.00	39.10	39.10
	60	7.25	0.12	32929	7.90	0.13	30219	47.70	40.45	47.40	48.20	39.90	39.90
	70	9.30	0.13	29949	9.95	0.14	27992	50.65	41.35	50.40	51.30	40.90	40.90
	80	11.40	0.14	27922	12.55	0.16	25363	53.80	42.40	53.60	54.60	41.00	42.10
	90	14.00	0.16	25578	15.55	0.17	23029	57.40	43.40	57.40	58.40	41.30	43.40
-30	20	3.10	0.16	25670	3.30	0.17	24114	39.65	36.55	39.30	39.70	36.50	35.90
	30	3.90	0.13	30607	4.30	0.14	27760	41.35	37.45	41.20	41.50	37.40	36.70
	40	6.10	0.15	26091	6.50	0.16	24485	44.55	38.45	44.80	44.20	38.40	37.60
	50	10.50	0.21	18947	10.90	0.22	18252	49.90	39.40	51.40	48.20	39.60	38.20
-60	20	3.80	0.19	20941	2.35	0.12	33863	40.45	36.65	38.60	38.80	36.40	36.30
	30	5.30	0.18	22522	4.65	0.16	25670	42.80	37.50	42.30	41.50	37.50	37.00
	40	11.00	0.28	14469	11.30	0.28	14085	49.35	38.35	51.40	47.20	38.60	37.40
-90	20	13.20	0.66	6029	12.75	0.64	6241	49.80	36.60	50.70	47.50	36.80	35.90

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

Heat pipe tested: 8mm x 250mm groove / powder metal + water



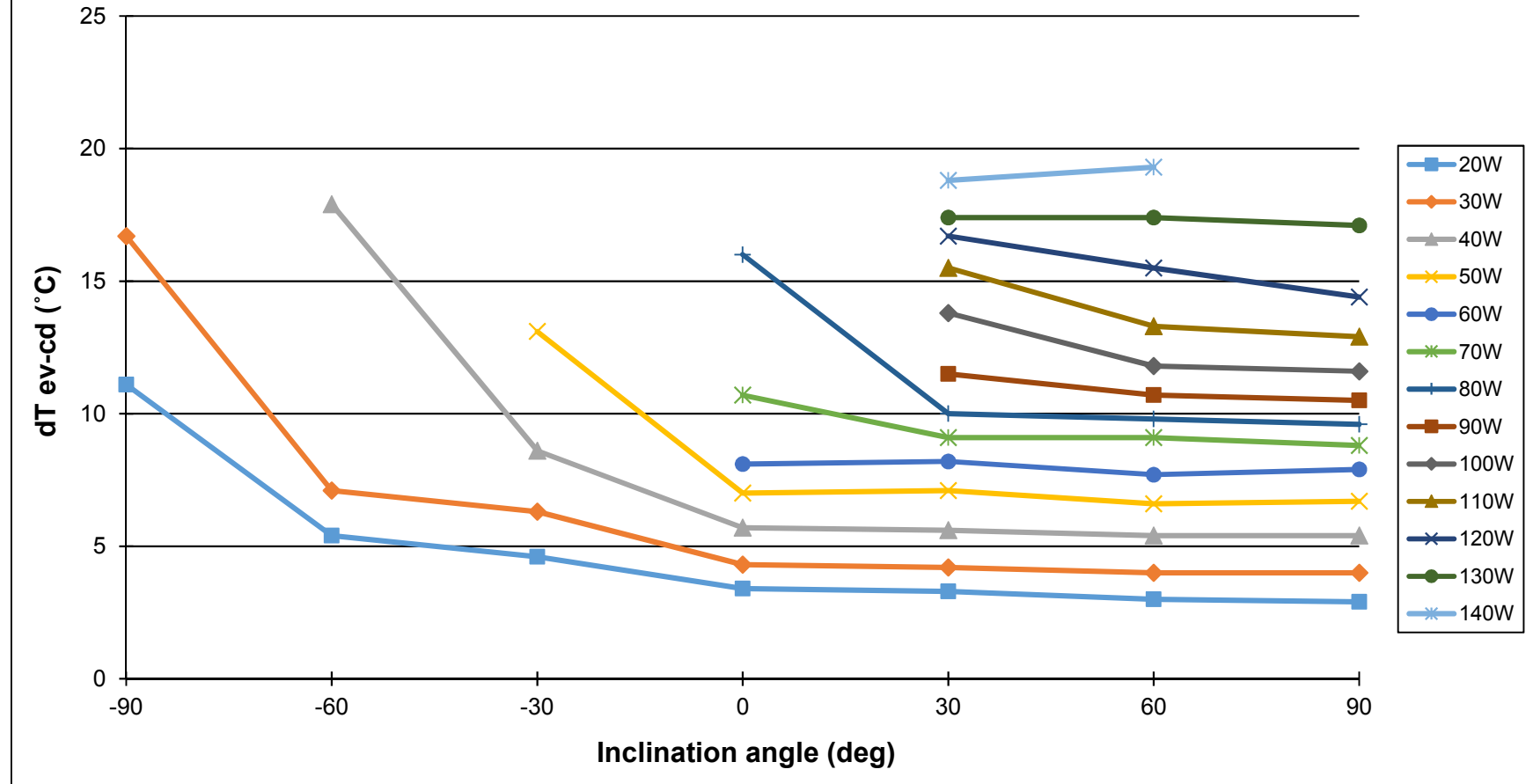
Heat Pipe Test Report

Manufacturer		Enertron			Test conditions			Test date	2018/9/7					
Wick structure/ Working fluid		Sintered Powder Metal/ Water			Effective area (m2)		5.03E-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	8			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	20	2.85	0.14	31412	3.40	0.17	26331	39.60	36.75	39.70	39.90	36.50	36.30	
	30	3.95	0.13	33997	4.55	0.15	29514	41.65	37.70	41.80	42.10	37.40	37.40	
	40	5.35	0.13	33467	6.40	0.16	27976	44.20	38.85	44.50	44.90	38.30	38.30	
	50	6.70	0.13	33405	8.05	0.16	27803	46.65	39.95	47.00	47.50	39.20	39.20	
	60	7.85	0.13	34213	9.45	0.16	28421	48.65	40.80	49.10	49.70	39.80	40.10	
	70	8.75	0.13	35810	10.70	0.15	29284	50.65	41.90	51.20	51.90	40.60	41.10	
	80	9.55	0.12	37497	11.60	0.15	30871	52.35	42.80	52.80	53.70	41.40	41.90	
	90	10.50	0.12	38368	12.80	0.14	31474	54.35	43.85	54.90	56.00	42.40	42.90	
	100	11.60	0.12	38588	14.20	0.14	31523	56.40	44.80	56.90	58.30	43.10	43.70	
	110	12.90	0.12	38169	15.70	0.14	31362	58.60	45.70	59.10	60.70	43.90	44.50	
	120	14.40	0.12	37302	17.75	0.15	30262	61.20	46.80	61.80	63.70	44.70	45.30	
130	17.10	0.13	34030	20.65	0.16	28180	65.05	47.95	65.60	67.60	45.40	46.50		
60	20	3.00	0.15	29842	3.55	0.18	25218	39.65	36.65	39.70	40.00	36.40	36.20	
	30	4.00	0.13	33572	4.75	0.16	28271	41.65	37.65	41.80	42.20	37.20	37.30	
	40	5.40	0.14	33157	6.45	0.16	27760	44.15	38.75	44.40	44.80	38.20	38.10	
	50	6.60	0.13	33911	8.00	0.16	27976	46.45	39.85	46.80	47.30	39.00	39.10	
	60	7.65	0.13	35108	9.40	0.16	28572	48.50	40.85	48.90	49.60	39.70	40.00	
	70	9.05	0.13	34623	11.20	0.16	27976	51.10	42.05	51.70	52.40	40.70	41.00	
	80	9.85	0.12	36355	12.00	0.15	29842	52.75	42.90	53.20	54.10	41.40	41.90	
	90	10.70	0.12	37651	13.20	0.15	30520	54.55	43.85	55.10	56.20	42.10	42.80	
	100	11.75	0.12	38096	14.45	0.14	30977	56.60	44.85	57.20	58.50	43.10	43.70	
	110	13.25	0.12	37161	16.20	0.15	30394	59.05	45.80	59.50	61.10	43.80	44.40	
	120	15.45	0.13	34767	18.90	0.16	28421	62.50	47.05	63.10	64.90	44.60	45.60	
	130	17.35	0.13	33539	21.35	0.16	27256	65.30	47.95	66.00	68.00	44.80	46.50	
140	19.25	0.14	32554	23.70	0.17	26442	68.20	48.95	68.90	71.70	45.70	47.50		
30	20	3.30	0.17	27129	3.80	0.19	23559	40.00	36.70	40.00	40.30	36.60	36.10	
	30	4.15	0.14	32358	5.05	0.17	26591	41.95	37.80	42.20	42.60	37.50	37.20	
	40	5.60	0.14	31973	6.70	0.17	26724	44.55	38.95	44.80	45.30	38.50	38.20	
	50	7.05	0.14	31746	8.60	0.17	26025	47.10	40.05	47.50	48.00	39.20	39.10	

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	60	8.15	0.14	32954	9.80	0.16	27406	49.05	40.90	49.50	50.10	40.00	40.00
	70	9.10	0.13	34433	11.10	0.16	28228	51.10	42.00	51.60	52.40	40.80	41.00
	80	9.95	0.12	35990	12.35	0.15	28996	52.95	43.00	53.40	54.50	41.40	41.80
	90	11.45	0.13	35184	14.05	0.16	28673	55.40	43.95	55.90	57.20	42.30	42.70
	100	13.75	0.14	32554	16.65	0.17	26884	58.85	45.10	59.30	60.80	43.10	43.70
	110	15.45	0.14	31870	18.70	0.17	26331	61.55	46.10	62.00	63.60	43.30	44.90
	120	16.65	0.14	32261	20.25	0.17	26526	63.70	47.05	64.20	66.00	44.00	45.70
	130	17.35	0.13	33539	21.65	0.17	26878	65.10	47.75	66.20	68.30	44.80	46.40
0	140	18.80	0.13	33334	23.35	0.17	26838	67.65	48.85	68.80	71.10	45.80	47.40
	20	3.35	0.17	26724	4.00	0.20	22381	40.15	36.80	40.20	40.60	36.70	36.10
	30	4.30	0.14	31230	5.30	0.18	25337	42.05	37.75	42.30	42.80	37.50	37.00
	40	5.65	0.14	31690	6.95	0.17	25762	44.55	38.90	44.80	45.50	38.40	38.00
	50	7.00	0.14	31973	8.70	0.17	25725	47.00	40.00	47.40	48.20	39.20	39.00
	60	8.10	0.14	33157	9.90	0.17	27129	49.05	40.95	49.40	50.40	40.00	40.00
	70	10.65	0.15	29421	12.60	0.18	24868	52.50	41.85	52.90	54.10	41.00	40.80
-30	80	16.00	0.20	22381	18.10	0.23	19784	58.70	42.70	61.00	58.60	41.80	41.60
	20	4.60	0.23	19462	5.25	0.26	17052	41.45	36.85	41.90	41.40	36.80	36.00
	30	6.30	0.21	21315	7.15	0.24	18781	44.05	37.75	44.80	43.90	37.60	36.80
	40	8.55	0.21	20941	9.75	0.24	18364	47.40	38.85	48.70	47.10	38.60	37.70
-60	50	13.05	0.26	17150	15.20	0.30	14724	52.90	39.85	56.00	52.30	39.50	38.40
	20	5.40	0.27	16579	4.10	0.21	21835	42.20	36.80	40.40	40.70	36.90	36.00
	30	7.10	0.24	18914	8.10	0.27	16579	45.05	37.95	46.30	44.70	38.00	36.80
-90	40	17.90	0.45	10003	21.70	0.54	8251	56.75	38.85	62.10	57.60	38.90	37.40
	20	11.10	0.56	8065	12.75	0.64	7022	48.05	36.95	50.40	48.20	37.20	35.90
	30	16.70	0.56	8041	19.35	0.65	6940	54.65	37.95	58.50	54.90	38.10	36.60

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

Heat pipe tested: 8mm x 275mm groove / powder metal + water



Heat Pipe Test Report

Manufacturer		Enertron			Test conditions			Test date		2018/9/7				
Wick structure/ Working fluid		Sintered Powder Metal/ Water			Effective area (m2)		5.03E-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	8			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	20	5.15	0.26	19315	5.65	0.28	17606	42.10	36.95	42.00	42.10	37.10	35.70	
	30	6.30	0.21	23684	6.80	0.23	21942	44.05	37.75	43.90	44.00	38.00	36.30	
	40	7.30	0.18	27253	7.90	0.20	25183	45.95	38.65	45.80	45.90	38.80	37.10	
	50	8.35	0.17	29782	9.15	0.18	27178	47.90	39.55	47.80	47.90	39.60	37.80	
	60	9.55	0.16	31248	10.60	0.18	28152	50.15	40.60	50.10	50.20	40.40	38.70	
	70	10.55	0.15	33000	11.70	0.17	29757	52.10	41.55	52.20	52.30	41.30	39.80	
	80	11.65	0.15	34153	12.95	0.16	30725	54.30	42.65	54.40	54.40	42.20	40.70	
	90	12.70	0.14	35246	14.05	0.16	31859	56.00	43.30	56.20	55.90	42.70	41.30	
	100	15.75	0.16	31578	16.95	0.17	29343	59.75	44.00	60.00	59.70	43.20	42.60	
	110	17.10	0.16	31994	18.60	0.17	29414	62.20	45.10	62.50	62.30	43.90	43.70	
	120	18.95	0.16	31495	20.00	0.17	29842	64.50	45.55	64.70	64.60	44.60	44.70	
130	19.75	0.15	32738	21.45	0.17	30143	66.75	47.00	66.90	67.00	45.30	45.70		
60	20	5.15	0.26	19315	5.60	0.28	17763	42.10	36.95	42.00	42.00	37.10	35.70	
	30	6.25	0.21	23873	6.80	0.23	21942	44.00	37.75	43.90	44.00	37.90	36.40	
	40	7.30	0.18	27253	8.10	0.20	24561	46.00	38.70	46.00	46.10	38.80	37.10	
	50	8.35	0.17	29782	9.15	0.18	27178	48.00	39.65	47.90	48.00	39.60	38.00	
	60	9.55	0.16	31248	10.60	0.18	28152	50.15	40.60	50.20	50.20	40.40	38.80	
	70	10.65	0.15	32690	11.75	0.17	29630	52.15	41.50	52.20	52.20	41.10	39.80	
	80	11.85	0.15	33577	13.05	0.16	30489	54.35	42.50	54.50	54.30	41.90	40.80	
	90	13.05	0.15	34301	14.70	0.16	30451	56.60	43.55	56.80	56.60	42.30	41.70	
	100	14.10	0.14	35274	16.20	0.16	30701	58.75	44.65	59.20	58.90	43.00	42.70	
	110	15.15	0.14	36112	17.45	0.16	31352	60.70	45.55	61.10	61.00	43.60	43.60	
	120	16.20	0.14	36841	18.65	0.16	32002	62.75	46.55	63.10	63.10	44.40	44.50	
	130	17.30	0.13	37374	20.00	0.15	32328	64.75	47.45	65.10	65.30	45.00	45.40	
140	18.75	0.13	37136	21.30	0.15	32690	67.20	48.45	67.60	67.30	45.90	46.40		
30	20	5.40	0.27	18421	5.90	0.30	16860	42.35	36.95	42.20	42.30	37.10	35.60	
	30	6.45	0.22	23133	7.05	0.24	21164	44.30	37.85	44.20	44.20	38.00	36.30	
	40	7.50	0.19	26526	8.10	0.20	24561	46.15	38.65	46.10	46.00	38.80	37.10	
	50	8.45	0.17	29430	9.30	0.19	26740	48.05	39.60	48.10	48.00	39.60	37.90	

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	60	9.75	0.16	30607	10.80	0.18	27631	50.40	40.65	50.50	50.30	40.40	38.80
	70	11.70	0.17	29757	12.80	0.18	27199	53.45	41.75	53.70	53.40	41.20	40.30
	80	13.05	0.16	30489	14.50	0.18	27441	55.80	42.75	56.10	55.90	41.60	41.40
	90	14.25	0.16	31412	15.85	0.18	28241	58.05	43.80	58.30	58.20	42.30	42.50
	100	14.90	0.15	33380	2.10	0.02	236838	59.65	44.75	60.40	60.30	73.10	43.40
	110	15.35	0.14	35641	17.35	0.16	31533	60.90	45.55	61.10	60.90	43.70	43.60
	120	16.35	0.14	36503	18.60	0.16	32088	62.80	46.45	63.00	62.90	44.50	44.20
	130	17.60	0.14	36737	19.95	0.15	32409	65.00	47.40	65.30	65.10	45.30	45.20
	140	19.00	0.14	36648	21.30	0.15	32690	67.30	48.30	67.50	67.50	46.10	46.30
0	20	5.35	0.27	18593	5.85	0.29	17004	42.35	37.00	42.30	42.30	37.20	35.70
	30	6.45	0.22	23133	7.05	0.24	21164	44.30	37.85	44.30	44.20	38.10	36.30
	40	7.55	0.19	26350	8.25	0.21	24114	46.25	38.70	46.30	46.20	38.90	37.10
	50	9.30	0.19	26740	9.45	0.19	26315	49.00	39.70	48.30	48.10	39.70	37.80
	60	14.35	0.24	20796	15.30	0.26	19504	55.25	40.90	56.50	53.60	41.00	38.50
-30	20	5.60	0.28	17763	6.10	0.31	16307	42.65	37.05	42.60	42.60	37.30	35.70
	30	6.80	0.23	21942	7.50	0.25	19894	44.75	37.95	44.80	44.70	38.20	36.30
	40	13.65	0.34	14575	14.75	0.37	13488	52.65	39.00	54.80	50.90	39.30	36.90
-60	20	17.20	0.86	5783	18.25	0.91	5451	54.40	37.20	55.90	53.60	37.40	35.60
-90	20	18.20	0.91	5465	20.20	1.01	4924	55.50	37.30	57.00	56.60	37.60	35.60

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

Heat pipe tested: 8mm x 300mm groove / powder metal + water

