

Heat Pipe Test Report

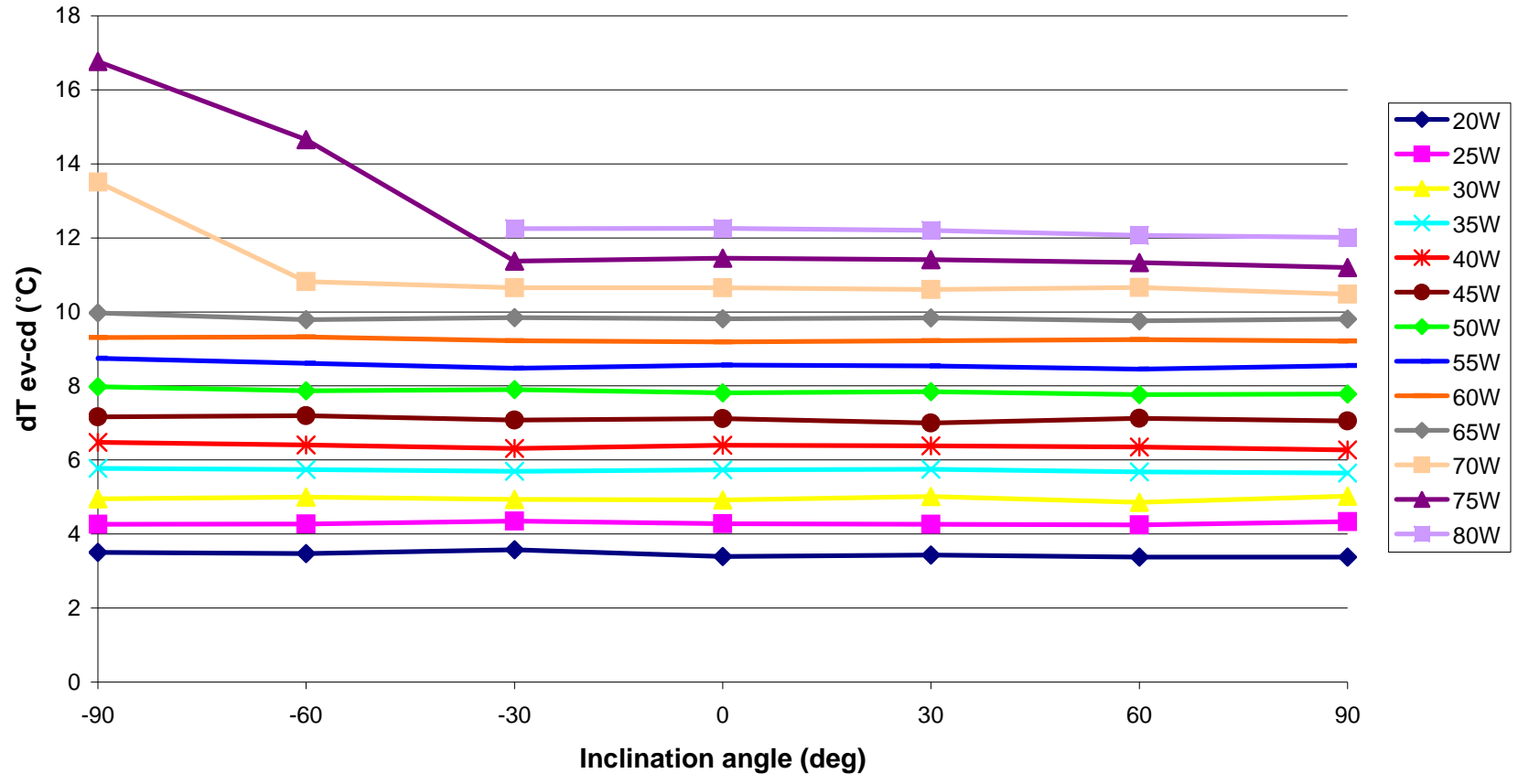
| Manufacturer | | Enertron | | | | Test conditions | | | | Test date | 8/25/2011 | | | | | | |
|-------------------------------|---------------|----------------------------------|---------------------------------|-----------------------------------|---------------|--|-----------------------------------|-----------------------------|-------|---|-----------|-------|-------|--|--|--|--|
| 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 | 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 | 20 | 3.38 | 0.17 | 11772 | 5.78 | 0.29 | 6887 | 41.27 | 37.89 | 42.96 | 43.27 | 37.14 | 37.53 | | | | |
| | 25 | 4.33 | 0.17 | 11486 | 7.32 | 0.29 | 6796 | 43.30 | 38.97 | 45.50 | 45.63 | 38.07 | 38.43 | | | | |
| | 30 | 5.02 | 0.17 | 11891 | 8.71 | 0.29 | 6854 | 44.81 | 39.79 | 47.40 | 47.68 | 38.58 | 39.08 | | | | |
| | 35 | 5.65 | 0.16 | 12326 | 10.03 | 0.29 | 6940 | 46.41 | 40.76 | 49.45 | 49.70 | 39.29 | 39.79 | | | | |
| | 40 | 6.27 | 0.16 | 12684 | 11.35 | 0.28 | 7014 | 47.91 | 41.64 | 51.34 | 51.65 | 39.88 | 40.41 | | | | |
| | 45 | 7.06 | 0.16 | 12688 | 12.76 | 0.28 | 7014 | 49.50 | 42.45 | 53.35 | 53.73 | 40.47 | 41.08 | | | | |
| | 50 | 7.79 | 0.16 | 12777 | 14.18 | 0.28 | 7016 | 50.86 | 43.08 | 55.08 | 55.59 | 40.78 | 41.53 | | | | |
| | 55 | 8.55 | 0.16 | 12795 | 15.56 | 0.28 | 7033 | 52.49 | 43.94 | 57.10 | 57.72 | 41.50 | 42.20 | | | | |
| | 60 | 9.21 | 0.15 | 12955 | 16.73 | 0.28 | 7133 | 53.84 | 44.63 | 58.81 | 59.51 | 42.06 | 42.79 | | | | |
| | 65 | 9.80 | 0.15 | 13191 | 18.04 | 0.28 | 7167 | 55.08 | 45.28 | 60.60 | 61.25 | 42.53 | 43.24 | | | | |
| | 70 | 10.48 | 0.15 | 13289 | 19.22 | 0.27 | 7245 | 56.52 | 46.04 | 62.25 | 63.12 | 43.11 | 43.82 | | | | |
| | 75 | 11.20 | 0.15 | 13325 | 20.71 | 0.28 | 7205 | 58.00 | 46.80 | 64.29 | 65.20 | 43.65 | 44.43 | | | | |
| 80 | 12.02 | 0.15 | 13246 | 22.31 | 0.28 | 7133 | 59.75 | 47.73 | 66.53 | 67.45 | 44.31 | 45.05 | | | | | |
| 60 | 20 | 3.37 | 0.17 | 11793 | 5.71 | 0.29 | 6965 | 41.33 | 37.96 | 43.09 | 43.13 | 37.20 | 37.60 | | | | |
| | 25 | 4.24 | 0.17 | 11722 | 7.36 | 0.29 | 6762 | 43.27 | 39.03 | 45.50 | 45.63 | 38.02 | 38.40 | | | | |
| | 30 | 4.85 | 0.16 | 12301 | 8.58 | 0.29 | 6955 | 44.71 | 39.86 | 47.34 | 47.52 | 38.63 | 39.07 | | | | |
| | 35 | 5.68 | 0.16 | 12270 | 10.07 | 0.29 | 6913 | 46.47 | 40.80 | 49.48 | 49.75 | 39.29 | 39.80 | | | | |
| | 40 | 6.35 | 0.16 | 12534 | 11.35 | 0.28 | 7010 | 47.92 | 41.57 | 51.33 | 51.69 | 39.91 | 40.40 | | | | |
| | 45 | 7.13 | 0.16 | 12565 | 12.81 | 0.28 | 6988 | 49.56 | 42.44 | 53.43 | 53.79 | 40.52 | 41.08 | | | | |
| | 50 | 7.77 | 0.16 | 12809 | 14.11 | 0.28 | 7049 | 50.86 | 43.09 | 55.09 | 55.56 | 40.81 | 41.62 | | | | |
| | 55 | 8.45 | 0.15 | 12943 | 15.47 | 0.28 | 7075 | 52.46 | 44.00 | 57.08 | 57.65 | 41.54 | 42.26 | | | | |
| | 60 | 9.26 | 0.15 | 12896 | 16.84 | 0.28 | 7087 | 53.95 | 44.69 | 59.00 | 59.62 | 42.06 | 42.87 | | | | |
| | 65 | 9.76 | 0.15 | 13252 | 18.02 | 0.28 | 7175 | 55.13 | 45.38 | 60.63 | 61.21 | 42.56 | 43.23 | | | | |
| | 70 | 10.66 | 0.15 | 13068 | 19.54 | 0.28 | 7128 | 56.87 | 46.22 | 62.74 | 63.56 | 43.23 | 44.00 | | | | |
| | 75 | 11.33 | 0.15 | 13165 | 20.91 | 0.28 | 7136 | 58.29 | 46.96 | 64.67 | 65.54 | 43.80 | 44.59 | | | | |
| 80 | 12.07 | 0.15 | 13187 | 22.46 | 0.28 | 7085 | 59.93 | 47.87 | 66.75 | 67.65 | 44.38 | 45.09 | | | | | |
| 30 | 20 | 3.43 | 0.17 | 11587 | 5.78 | 0.29 | 6890 | 41.42 | 37.99 | 43.20 | 43.27 | 37.29 | 37.63 | | | | |
| | 25 | 4.26 | 0.17 | 11675 | 7.24 | 0.29 | 6868 | 43.30 | 39.04 | 45.53 | 45.60 | 38.11 | 38.54 | | | | |
| | 30 | 5.02 | 0.17 | 11899 | 8.57 | 0.29 | 6967 | 44.79 | 39.77 | 47.35 | 47.52 | 38.69 | 39.05 | | | | |
| | 35 | 5.75 | 0.16 | 12105 | 10.13 | 0.29 | 6875 | 46.53 | 40.77 | 49.50 | 49.81 | 39.31 | 39.75 | | | | |

| 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 | 40 | 6.39 | 0.16 | 12461 | 11.42 | 0.29 | 6969 | 47.99 | 41.60 | 51.39 | 51.74 | 39.85 | 40.44 |
| | 45 | 7.00 | 0.16 | 12789 | 12.83 | 0.29 | 6977 | 49.54 | 42.54 | 53.39 | 53.74 | 40.46 | 41.00 |
| | 50 | 7.85 | 0.16 | 12673 | 14.09 | 0.28 | 7061 | 50.97 | 43.13 | 55.16 | 55.64 | 40.98 | 41.64 |
| | 55 | 8.54 | 0.16 | 12814 | 15.46 | 0.28 | 7076 | 52.46 | 43.92 | 57.06 | 57.67 | 41.54 | 42.26 |
| | 60 | 9.22 | 0.15 | 12945 | 16.78 | 0.28 | 7113 | 53.95 | 44.73 | 58.97 | 59.61 | 42.14 | 42.87 |
| | 65 | 9.84 | 0.15 | 13144 | 18.02 | 0.28 | 7175 | 55.21 | 45.37 | 60.59 | 61.28 | 42.53 | 43.30 |
| | 70 | 10.60 | 0.15 | 13134 | 19.58 | 0.28 | 7113 | 56.88 | 46.28 | 62.75 | 63.57 | 43.26 | 43.90 |
| | 75 | 11.41 | 0.15 | 13076 | 21.01 | 0.28 | 7101 | 58.41 | 47.00 | 64.79 | 65.67 | 43.79 | 44.64 |
| 0 | 80 | 12.20 | 0.15 | 13045 | 22.47 | 0.28 | 7085 | 60.00 | 47.80 | 66.80 | 67.66 | 44.48 | 45.05 |
| | 20 | 3.39 | 0.17 | 11723 | 5.82 | 0.29 | 6832 | 41.51 | 38.12 | 43.26 | 43.40 | 37.34 | 37.68 |
| | 25 | 4.28 | 0.17 | 11631 | 7.32 | 0.29 | 6796 | 43.29 | 39.01 | 45.50 | 45.58 | 38.01 | 38.44 |
| | 30 | 4.92 | 0.16 | 12126 | 8.55 | 0.29 | 6980 | 44.76 | 39.84 | 47.33 | 47.54 | 38.63 | 39.14 |
| | 35 | 5.74 | 0.16 | 12139 | 10.11 | 0.29 | 6889 | 46.48 | 40.75 | 49.52 | 49.77 | 39.29 | 39.78 |
| | 40 | 6.40 | 0.16 | 12444 | 11.42 | 0.29 | 6967 | 48.01 | 41.62 | 51.40 | 51.80 | 39.93 | 40.43 |
| | 45 | 7.12 | 0.16 | 12583 | 12.78 | 0.28 | 7003 | 49.57 | 42.46 | 53.39 | 53.85 | 40.53 | 41.13 |
| | 50 | 7.81 | 0.16 | 12733 | 14.13 | 0.28 | 7042 | 50.94 | 43.13 | 55.11 | 55.63 | 40.92 | 41.57 |
| | 55 | 8.57 | 0.16 | 12775 | 15.45 | 0.28 | 7081 | 52.48 | 43.91 | 57.07 | 57.63 | 41.54 | 42.26 |
| | 60 | 9.19 | 0.15 | 12993 | 16.79 | 0.28 | 7108 | 53.96 | 44.77 | 59.03 | 59.58 | 42.14 | 42.89 |
| | 65 | 9.81 | 0.15 | 13180 | 18.06 | 0.28 | 7162 | 55.21 | 45.39 | 60.59 | 61.33 | 42.56 | 43.25 |
| | 70 | 10.65 | 0.15 | 13072 | 19.63 | 0.28 | 7093 | 56.93 | 46.28 | 62.81 | 63.63 | 43.23 | 43.95 |
| -30 | 75 | 11.45 | 0.15 | 13030 | 21.06 | 0.28 | 7085 | 58.44 | 46.99 | 64.77 | 65.69 | 43.77 | 44.57 |
| | 80 | 12.26 | 0.15 | 12985 | 22.36 | 0.28 | 7117 | 59.97 | 47.71 | 66.62 | 67.52 | 44.37 | 45.05 |
| | 20 | 3.57 | 0.18 | 11133 | 5.85 | 0.29 | 6806 | 41.64 | 38.06 | 43.35 | 43.44 | 37.35 | 37.75 |
| | 25 | 4.35 | 0.17 | 11434 | 7.38 | 0.30 | 6740 | 43.30 | 38.95 | 45.54 | 45.63 | 37.97 | 38.44 |
| | 30 | 4.93 | 0.16 | 12096 | 8.61 | 0.29 | 6936 | 44.83 | 39.89 | 47.36 | 47.61 | 38.66 | 39.10 |
| | 35 | 5.69 | 0.16 | 12233 | 10.13 | 0.29 | 6871 | 46.51 | 40.82 | 49.53 | 49.79 | 39.29 | 39.77 |
| | 40 | 6.31 | 0.16 | 12603 | 11.42 | 0.29 | 6968 | 48.00 | 41.68 | 51.41 | 51.75 | 39.88 | 40.45 |
| | 45 | 7.08 | 0.16 | 12648 | 12.85 | 0.29 | 6966 | 49.57 | 42.49 | 53.41 | 53.81 | 40.51 | 41.01 |
| | 50 | 7.90 | 0.16 | 12585 | 14.11 | 0.28 | 7051 | 50.99 | 43.08 | 55.10 | 55.68 | 40.98 | 41.58 |
| | 55 | 8.48 | 0.15 | 12911 | 15.51 | 0.28 | 7056 | 52.49 | 44.01 | 57.08 | 57.72 | 41.53 | 42.25 |
| | 60 | 9.22 | 0.15 | 12946 | 16.83 | 0.28 | 7092 | 53.91 | 44.69 | 58.88 | 59.48 | 42.02 | 42.68 |
| | 65 | 9.85 | 0.15 | 13132 | 18.21 | 0.28 | 7102 | 55.35 | 45.51 | 60.77 | 61.50 | 42.52 | 43.33 |
| -60 | 70 | 10.65 | 0.15 | 13071 | 19.61 | 0.28 | 7100 | 56.92 | 46.27 | 62.75 | 63.63 | 43.18 | 43.97 |
| | 75 | 11.37 | 0.15 | 13121 | 21.01 | 0.28 | 7101 | 58.38 | 47.01 | 64.66 | 65.59 | 43.73 | 44.49 |
| | 80 | 12.25 | 0.15 | 12993 | 22.28 | 0.28 | 7143 | 59.94 | 47.69 | 66.55 | 67.47 | 44.36 | 45.09 |
| | 20 | 3.47 | 0.17 | 11473 | 5.92 | 0.30 | 6717 | 41.60 | 38.13 | 43.38 | 43.52 | 37.34 | 37.71 |
| | 25 | 4.27 | 0.17 | 11642 | 7.33 | 0.29 | 6782 | 43.33 | 39.06 | 45.57 | 45.70 | 38.10 | 38.49 |
| | 30 | 5.00 | 0.17 | 11939 | 8.71 | 0.29 | 6853 | 44.86 | 39.86 | 47.55 | 47.65 | 38.61 | 39.17 |

| 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 |
| -60 | 35 | 5.74 | 0.16 | 12135 | 10.19 | 0.29 | 6835 | 46.55 | 40.82 | 49.57 | 49.86 | 39.27 | 39.79 |
| | 40 | 6.41 | 0.16 | 12424 | 11.46 | 0.29 | 6946 | 48.07 | 41.66 | 51.48 | 51.80 | 39.86 | 40.51 |
| | 45 | 7.20 | 0.16 | 12439 | 12.85 | 0.29 | 6970 | 49.63 | 42.44 | 53.48 | 53.87 | 40.53 | 41.12 |
| | 50 | 7.87 | 0.16 | 12644 | 14.23 | 0.28 | 6990 | 51.03 | 43.16 | 55.29 | 55.75 | 40.92 | 41.66 |
| | 55 | 8.61 | 0.16 | 12707 | 15.60 | 0.28 | 7014 | 52.56 | 43.95 | 57.21 | 57.79 | 41.59 | 42.22 |
| | 60 | 9.32 | 0.16 | 12806 | 16.89 | 0.28 | 7069 | 53.97 | 44.65 | 58.92 | 59.64 | 42.09 | 42.70 |
| | 65 | 9.79 | 0.15 | 13203 | 18.13 | 0.28 | 7135 | 55.29 | 45.49 | 60.68 | 61.36 | 42.51 | 43.28 |
| | 70 | 10.82 | 0.15 | 12868 | 19.73 | 0.28 | 7059 | 56.98 | 46.15 | 62.94 | 63.68 | 43.14 | 44.03 |
| | 75 | 14.66 | 0.20 | 10181 | 22.17 | 0.30 | 6731 | 61.38 | 46.73 | 65.69 | 66.91 | 43.68 | 44.59 |
| -90 | 20 | 3.50 | 0.18 | 11358 | 6.00 | 0.30 | 6630 | 41.66 | 38.15 | 43.55 | 43.62 | 37.40 | 37.77 |
| | 25 | 4.26 | 0.17 | 11678 | 7.40 | 0.30 | 6719 | 43.27 | 39.01 | 45.52 | 45.71 | 38.10 | 38.33 |
| | 30 | 4.95 | 0.17 | 12050 | 8.62 | 0.29 | 6928 | 44.87 | 39.92 | 47.45 | 47.66 | 38.73 | 39.16 |
| | 35 | 5.78 | 0.17 | 12055 | 10.17 | 0.29 | 6845 | 46.51 | 40.73 | 49.54 | 49.84 | 39.24 | 39.79 |
| | 40 | 6.48 | 0.16 | 12282 | 11.52 | 0.29 | 6907 | 48.04 | 41.56 | 51.45 | 51.86 | 39.86 | 40.41 |
| | 45 | 7.16 | 0.16 | 12498 | 12.83 | 0.29 | 6977 | 49.62 | 42.46 | 53.44 | 53.88 | 40.50 | 41.15 |
| | 50 | 7.98 | 0.16 | 12464 | 14.29 | 0.29 | 6963 | 51.08 | 43.10 | 55.30 | 55.87 | 40.94 | 41.66 |
| | 55 | 8.74 | 0.16 | 12515 | 15.63 | 0.28 | 7001 | 52.69 | 43.94 | 57.28 | 57.84 | 41.57 | 42.29 |
| | 60 | 9.31 | 0.16 | 12828 | 16.98 | 0.28 | 7029 | 53.93 | 44.62 | 59.04 | 59.67 | 42.00 | 42.74 |
| | 65 | 9.97 | 0.15 | 12965 | 18.20 | 0.28 | 7104 | 55.39 | 45.41 | 60.85 | 61.58 | 42.64 | 43.39 |
| | 70 | 13.51 | 0.19 | 10308 | 20.59 | 0.29 | 6764 | 59.55 | 46.04 | 63.65 | 64.84 | 43.26 | 44.05 |
| 75 | 16.77 | 0.22 | 8897 | 23.06 | 0.31 | 6472 | 63.28 | 46.51 | 66.38 | 67.91 | 43.57 | 44.61 | |

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

Heat pipe tested: $\phi 8\text{mm} \times 150\text{mm}$ sintered powder metal/ water



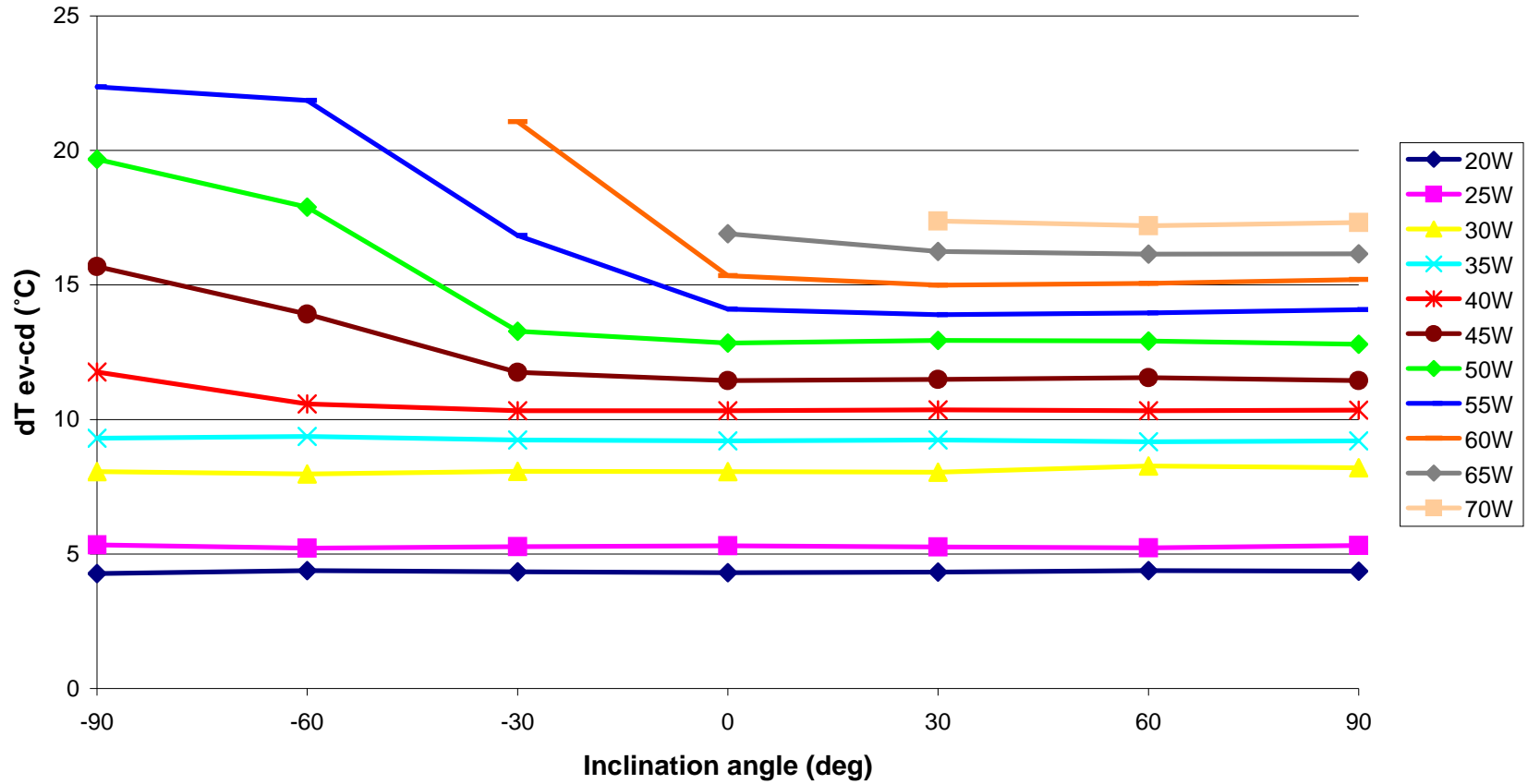
Heat Pipe Test Report

| Manufacturer | | Enertron | | | | Test conditions | | | | Test date | 8/26/2011 | | |
|-------------------------------|---------------|----------------------------------|---------------------------------|-----------------------------------|---------------|--|-----------------------------------|-----------------------------|-------|---|-----------|-------|-------|
| 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 | 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 | 20 | 4.36 | 0.22 | 11405 | 8.24 | 0.41 | 6034 | 43.00 | 38.63 | 46.18 | 45.97 | 37.65 | 38.02 |
| | 25 | 5.32 | 0.21 | 11697 | 10.32 | 0.41 | 6025 | 44.89 | 39.58 | 48.84 | 48.54 | 38.16 | 38.59 |
| | 30 | 8.20 | 0.27 | 9095 | 11.21 | 0.37 | 6657 | 47.92 | 39.71 | 50.38 | 50.05 | 38.84 | 39.18 |
| | 35 | 9.20 | 0.26 | 9458 | 12.61 | 0.36 | 6901 | 49.69 | 40.49 | 52.39 | 52.12 | 39.43 | 39.85 |
| | 40 | 10.35 | 0.26 | 9614 | 14.24 | 0.36 | 6984 | 51.62 | 41.27 | 54.62 | 54.43 | 40.06 | 40.50 |
| | 45 | 11.45 | 0.25 | 9773 | 15.87 | 0.35 | 7050 | 53.52 | 42.07 | 56.85 | 56.60 | 40.65 | 41.05 |
| | 50 | 12.80 | 0.26 | 9716 | 17.65 | 0.35 | 7043 | 55.60 | 42.80 | 59.37 | 58.98 | 41.34 | 41.71 |
| | 55 | 14.09 | 0.26 | 9709 | 19.35 | 0.35 | 7070 | 57.47 | 43.39 | 61.57 | 61.20 | 41.82 | 42.26 |
| | 60 | 15.20 | 0.25 | 9818 | 20.96 | 0.35 | 7120 | 59.39 | 44.19 | 63.92 | 63.44 | 42.53 | 42.92 |
| | 65 | 16.16 | 0.25 | 10005 | 22.53 | 0.35 | 7175 | 61.07 | 44.91 | 66.06 | 65.41 | 42.97 | 43.43 |
| 60 | 20 | 4.38 | 0.22 | 11355 | 8.23 | 0.41 | 6047 | 43.05 | 38.67 | 46.20 | 45.97 | 37.63 | 38.09 |
| | 25 | 5.22 | 0.21 | 11901 | 10.83 | 0.43 | 5742 | 44.89 | 39.66 | 48.75 | 48.48 | 38.37 | 37.21 |
| | 30 | 8.27 | 0.28 | 9022 | 11.20 | 0.37 | 6663 | 48.03 | 39.76 | 50.45 | 50.17 | 38.87 | 39.36 |
| | 35 | 9.17 | 0.26 | 9488 | 12.58 | 0.36 | 6921 | 49.66 | 40.49 | 52.36 | 52.12 | 39.51 | 39.83 |
| | 40 | 10.33 | 0.26 | 9631 | 14.19 | 0.35 | 7010 | 51.53 | 41.20 | 54.55 | 54.37 | 40.06 | 40.49 |
| | 45 | 11.56 | 0.26 | 9680 | 15.96 | 0.35 | 7013 | 53.67 | 42.11 | 57.06 | 56.69 | 40.72 | 41.12 |
| | 50 | 12.92 | 0.26 | 9625 | 17.74 | 0.35 | 7008 | 55.73 | 42.81 | 59.43 | 59.03 | 41.28 | 41.70 |
| | 55 | 13.96 | 0.25 | 9798 | 19.24 | 0.35 | 7109 | 57.47 | 43.52 | 61.60 | 61.11 | 41.88 | 42.35 |
| | 60 | 15.06 | 0.25 | 9911 | 20.81 | 0.35 | 7170 | 59.28 | 44.22 | 63.76 | 63.22 | 42.48 | 42.88 |
| | 65 | 16.15 | 0.25 | 10010 | 22.48 | 0.35 | 7192 | 61.05 | 44.91 | 65.99 | 65.40 | 42.97 | 43.46 |
| 30 | 20 | 4.33 | 0.22 | 11481 | 8.22 | 0.41 | 6049 | 43.06 | 38.72 | 46.14 | 45.97 | 37.64 | 38.02 |
| | 25 | 5.26 | 0.21 | 11826 | 10.73 | 0.43 | 5797 | 44.92 | 39.67 | 48.74 | 48.50 | 38.39 | 37.40 |
| | 30 | 8.04 | 0.27 | 9278 | 10.98 | 0.37 | 6793 | 47.76 | 39.71 | 50.15 | 49.84 | 38.80 | 39.23 |
| | 35 | 9.24 | 0.26 | 9423 | 12.52 | 0.36 | 6950 | 49.74 | 40.50 | 52.34 | 52.13 | 39.50 | 39.93 |
| | 40 | 10.36 | 0.26 | 9601 | 14.16 | 0.35 | 7026 | 51.59 | 41.23 | 54.56 | 54.32 | 40.05 | 40.52 |
| | 45 | 11.49 | 0.26 | 9743 | 15.92 | 0.35 | 7028 | 53.58 | 42.09 | 56.97 | 56.59 | 40.61 | 41.12 |
| | 50 | 12.94 | 0.26 | 9607 | 17.68 | 0.35 | 7032 | 55.73 | 42.79 | 59.38 | 59.05 | 41.28 | 41.80 |
| | 55 | 13.90 | 0.25 | 9840 | 19.23 | 0.35 | 7114 | 57.43 | 43.53 | 61.54 | 61.01 | 41.80 | 42.29 |

| 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 | 15.00 | 0.25 | 9951 | 20.88 | 0.35 | 7145 | 59.25 | 44.25 | 63.82 | 63.31 | 42.37 | 43.00 |
| | 65 | 16.25 | 0.25 | 9947 | 22.57 | 0.35 | 7163 | 61.20 | 44.95 | 66.09 | 65.50 | 42.93 | 43.53 |
| | 70 | 17.38 | 0.25 | 10016 | 24.31 | 0.35 | 7162 | 63.14 | 45.76 | 68.46 | 67.83 | 43.50 | 44.17 |
| 0 | 20 | 4.31 | 0.22 | 11537 | 8.13 | 0.41 | 6121 | 43.11 | 38.80 | 46.11 | 45.92 | 37.67 | 38.11 |
| | 25 | 5.31 | 0.21 | 11710 | 10.79 | 0.43 | 5764 | 45.01 | 39.70 | 48.83 | 48.49 | 38.37 | 37.39 |
| | 30 | 8.06 | 0.27 | 9255 | 10.87 | 0.36 | 6863 | 47.79 | 39.73 | 50.09 | 49.83 | 38.90 | 39.28 |
| | 35 | 9.20 | 0.26 | 9457 | 12.54 | 0.36 | 6941 | 49.67 | 40.47 | 52.33 | 52.11 | 39.47 | 39.89 |
| | 40 | 10.32 | 0.26 | 9635 | 14.12 | 0.35 | 7044 | 51.57 | 41.25 | 54.59 | 54.27 | 40.06 | 40.57 |
| | 45 | 11.45 | 0.25 | 9773 | 15.84 | 0.35 | 7066 | 53.52 | 42.07 | 56.96 | 56.54 | 40.65 | 41.18 |
| | 50 | 12.85 | 0.26 | 9679 | 17.74 | 0.35 | 7011 | 55.74 | 42.90 | 59.47 | 59.04 | 41.24 | 41.79 |
| | 55 | 14.10 | 0.26 | 9701 | 19.44 | 0.35 | 7037 | 57.55 | 43.45 | 61.67 | 61.19 | 41.68 | 42.32 |
| | 60 | 15.34 | 0.26 | 9725 | 21.06 | 0.35 | 7085 | 59.51 | 44.16 | 64.00 | 63.41 | 42.33 | 42.96 |
| | 65 | 16.91 | 0.26 | 9561 | 22.90 | 0.35 | 7059 | 61.60 | 44.69 | 66.43 | 65.79 | 42.74 | 43.69 |
| -30 | 20 | 4.34 | 0.22 | 11473 | 8.17 | 0.41 | 6085 | 43.09 | 38.75 | 46.15 | 45.95 | 37.68 | 38.07 |
| | 25 | 5.28 | 0.21 | 11784 | 10.74 | 0.43 | 5790 | 44.94 | 39.67 | 48.73 | 48.44 | 38.38 | 37.31 |
| | 30 | 8.07 | 0.27 | 9241 | 10.93 | 0.36 | 6829 | 47.81 | 39.74 | 50.16 | 49.90 | 38.87 | 39.34 |
| | 35 | 9.24 | 0.26 | 9418 | 12.61 | 0.36 | 6905 | 49.75 | 40.51 | 52.41 | 52.15 | 39.41 | 39.94 |
| | 40 | 10.33 | 0.26 | 9634 | 14.25 | 0.36 | 6982 | 51.61 | 41.28 | 54.67 | 54.40 | 40.08 | 40.50 |
| | 45 | 11.75 | 0.26 | 9522 | 16.05 | 0.36 | 6973 | 53.72 | 41.97 | 57.13 | 56.73 | 40.57 | 41.19 |
| | 50 | 13.28 | 0.27 | 9364 | 17.87 | 0.36 | 6959 | 55.79 | 42.52 | 59.53 | 59.08 | 41.09 | 41.79 |
| | 55 | 16.84 | 0.31 | 8122 | 21.26 | 0.39 | 6433 | 59.95 | 43.11 | 63.21 | 63.38 | 41.53 | 42.54 |
| | 60 | 21.07 | 0.35 | 7082 | 25.71 | 0.43 | 5804 | 64.82 | 43.75 | 67.82 | 68.71 | 41.91 | 43.21 |
| -60 | 20 | 4.39 | 0.22 | 11342 | 8.21 | 0.41 | 6061 | 43.11 | 38.73 | 46.26 | 45.94 | 37.72 | 38.06 |
| | 25 | 5.21 | 0.21 | 11924 | 10.69 | 0.43 | 5818 | 44.98 | 39.77 | 48.65 | 48.44 | 38.35 | 37.37 |
| | 30 | 7.98 | 0.27 | 9349 | 10.82 | 0.36 | 6898 | 47.75 | 39.77 | 50.01 | 49.86 | 38.92 | 39.32 |
| | 35 | 9.37 | 0.27 | 9294 | 12.73 | 0.36 | 6837 | 49.89 | 40.52 | 52.61 | 52.40 | 39.50 | 40.06 |
| | 40 | 10.58 | 0.26 | 9403 | 14.41 | 0.36 | 6904 | 51.82 | 41.24 | 54.87 | 54.65 | 40.05 | 40.66 |
| | 45 | 13.92 | 0.31 | 8039 | 17.60 | 0.39 | 6360 | 55.69 | 41.77 | 58.39 | 58.57 | 40.47 | 41.30 |
| | 50 | 17.90 | 0.36 | 6948 | 21.90 | 0.44 | 5678 | 60.34 | 42.45 | 62.89 | 63.78 | 40.93 | 41.95 |
| | 55 | 21.85 | 0.40 | 6259 | 26.37 | 0.48 | 5187 | 64.90 | 43.04 | 67.79 | 68.99 | 41.33 | 42.72 |
| -90 | 20 | 4.27 | 0.21 | 11650 | 8.17 | 0.41 | 6090 | 43.23 | 38.96 | 46.35 | 46.10 | 37.86 | 38.26 |
| | 25 | 5.34 | 0.21 | 11653 | 10.72 | 0.43 | 5798 | 45.06 | 39.73 | 48.76 | 48.56 | 38.49 | 37.39 |
| | 30 | 8.06 | 0.27 | 9251 | 10.83 | 0.36 | 6887 | 47.76 | 39.70 | 50.02 | 49.88 | 38.92 | 39.32 |
| | 35 | 9.30 | 0.27 | 9356 | 12.60 | 0.36 | 6907 | 49.73 | 40.43 | 52.36 | 52.18 | 39.40 | 39.94 |
| | 40 | 11.76 | 0.29 | 8456 | 15.18 | 0.38 | 6553 | 52.78 | 41.02 | 55.38 | 55.49 | 39.90 | 40.61 |
| | 45 | 15.68 | 0.35 | 7135 | 19.32 | 0.43 | 5794 | 57.42 | 41.73 | 59.88 | 60.45 | 40.41 | 41.29 |
| | 50 | 19.67 | 0.39 | 6321 | 23.92 | 0.48 | 5199 | 61.97 | 42.30 | 64.65 | 65.79 | 40.75 | 41.85 |
| | 55 | 22.36 | 0.41 | 6117 | 27.03 | 0.49 | 5060 | 65.16 | 42.80 | 68.11 | 69.51 | 41.14 | 42.42 |

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

Heat pipe tested: $\phi 8\text{mm} \times 175\text{mm}$ sintered powder metal/ water



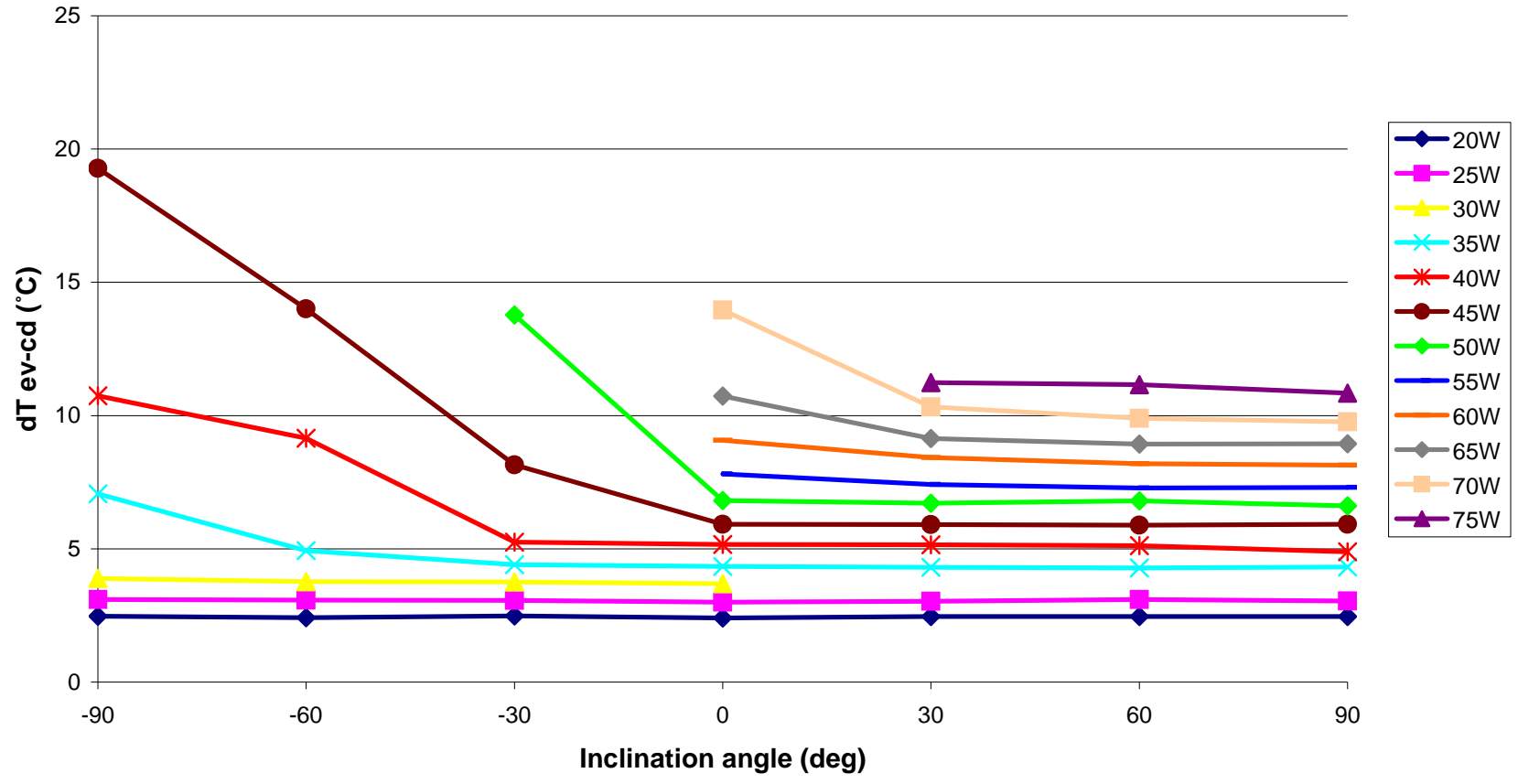
Heat Pipe Test Report

| Manufacturer | | Enertron | | | | Test conditions | | | | Test date | 8/24/2011 | | | | | | |
|-------------------------------|---------------|----------------------------------|---------------------------------|-----------------------------------|---------------|--|-----------------------------------|-----------------------------|-------|---|-----------|-------|-------|--|--|--|--|
| 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 | 2.47 | 0.12 | 24212 | 5.82 | 0.29 | 10248 | 41.59 | 39.13 | 43.76 | 42.93 | 37.58 | 37.45 | | | | |
| | 25 | 3.04 | 0.12 | 24557 | 7.22 | 0.29 | 10339 | 43.44 | 40.40 | 46.22 | 45.07 | 38.50 | 38.36 | | | | |
| | 35 | 4.31 | 0.12 | 24211 | 10.07 | 0.29 | 10374 | 46.67 | 42.35 | 50.43 | 48.97 | 39.70 | 39.57 | | | | |
| | 40 | 4.88 | 0.12 | 24445 | 11.48 | 0.29 | 10398 | 48.27 | 43.39 | 52.57 | 50.93 | 40.36 | 40.18 | | | | |
| | 45 | 5.92 | 0.13 | 22676 | 12.90 | 0.29 | 10411 | 50.30 | 44.38 | 54.74 | 52.83 | 41.00 | 40.77 | | | | |
| | 50 | 6.62 | 0.13 | 22549 | 14.50 | 0.29 | 10292 | 52.03 | 45.41 | 56.65 | 54.72 | 41.19 | 41.19 | | | | |
| | 55 | 7.30 | 0.13 | 22477 | 15.93 | 0.29 | 10301 | 54.02 | 46.72 | 59.05 | 56.70 | 41.98 | 41.91 | | | | |
| | 60 | 8.14 | 0.14 | 22007 | 17.51 | 0.29 | 10224 | 56.05 | 47.92 | 61.39 | 58.88 | 42.65 | 42.59 | | | | |
| | 65 | 8.94 | 0.14 | 21690 | 19.12 | 0.29 | 10143 | 57.99 | 49.04 | 63.70 | 61.02 | 43.24 | 43.24 | | | | |
| | 70 | 9.77 | 0.14 | 21390 | 21.08 | 0.30 | 9911 | 60.07 | 50.31 | 66.13 | 63.34 | 43.68 | 43.64 | | | | |
| 60 | 20 | 2.47 | 0.12 | 24212 | 5.80 | 0.29 | 10292 | 41.79 | 39.32 | 43.95 | 43.12 | 37.77 | 37.70 | | | | |
| | 25 | 3.09 | 0.12 | 24112 | 7.20 | 0.29 | 10366 | 43.37 | 40.28 | 46.15 | 45.06 | 38.43 | 38.39 | | | | |
| | 35 | 4.28 | 0.12 | 24409 | 9.99 | 0.29 | 10452 | 46.65 | 42.37 | 50.45 | 48.93 | 39.79 | 39.60 | | | | |
| | 40 | 5.12 | 0.13 | 23337 | 11.47 | 0.29 | 10404 | 48.45 | 43.33 | 52.55 | 50.90 | 40.31 | 40.19 | | | | |
| | 45 | 5.89 | 0.13 | 22803 | 12.91 | 0.29 | 10404 | 50.24 | 44.35 | 54.79 | 52.88 | 41.07 | 40.79 | | | | |
| | 50 | 6.80 | 0.14 | 21942 | 14.63 | 0.29 | 10196 | 52.45 | 45.65 | 57.02 | 55.10 | 41.45 | 41.40 | | | | |
| | 55 | 7.28 | 0.13 | 22548 | 15.81 | 0.29 | 10383 | 54.00 | 46.72 | 58.91 | 56.61 | 41.97 | 41.94 | | | | |
| | 60 | 8.20 | 0.14 | 21849 | 17.46 | 0.29 | 10254 | 55.99 | 47.79 | 61.29 | 58.80 | 42.63 | 42.54 | | | | |
| | 65 | 8.93 | 0.14 | 21719 | 19.08 | 0.29 | 10169 | 57.94 | 49.01 | 63.62 | 60.92 | 43.18 | 43.20 | | | | |
| | 75 | 9.90 | 0.14 | 21106 | 21.20 | 0.30 | 9853 | 60.36 | 50.46 | 66.42 | 63.60 | 43.84 | 43.78 | | | | |
| 30 | 20 | 2.46 | 0.12 | 24291 | 5.74 | 0.29 | 10401 | 41.80 | 39.34 | 43.90 | 43.06 | 37.83 | 37.66 | | | | |
| | 25 | 3.04 | 0.12 | 24565 | 7.17 | 0.29 | 10408 | 43.40 | 40.36 | 46.13 | 45.09 | 38.55 | 38.34 | | | | |
| | 35 | 4.31 | 0.12 | 24261 | 10.00 | 0.29 | 10441 | 46.66 | 42.36 | 50.39 | 48.96 | 39.79 | 39.56 | | | | |
| | 40 | 5.15 | 0.13 | 23191 | 11.47 | 0.29 | 10410 | 48.55 | 43.40 | 52.56 | 50.88 | 40.35 | 40.15 | | | | |
| | 45 | 5.91 | 0.13 | 22741 | 12.93 | 0.29 | 10385 | 50.36 | 44.45 | 54.77 | 52.89 | 41.00 | 40.80 | | | | |
| | 50 | 6.71 | 0.13 | 22250 | 14.53 | 0.29 | 10266 | 52.42 | 45.71 | 56.94 | 54.93 | 41.43 | 41.38 | | | | |
| | 55 | 7.41 | 0.13 | 22150 | 15.97 | 0.29 | 10275 | 54.17 | 46.76 | 59.07 | 56.80 | 41.92 | 42.00 | | | | |
| | 60 | 8.43 | 0.14 | 21252 | 17.89 | 0.30 | 10011 | 56.55 | 48.13 | 61.75 | 59.30 | 42.61 | 42.67 | | | | |

| 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 | 65 | 9.13 | 0.14 | 21236 | 19.59 | 0.30 | 9899 | 58.45 | 49.32 | 64.10 | 61.46 | 43.20 | 43.17 |
| | 70 | 10.33 | 0.15 | 20222 | 21.41 | 0.31 | 9759 | 60.64 | 50.31 | 66.69 | 63.83 | 43.93 | 43.78 |
| | 75 | 11.24 | 0.15 | 19912 | 23.06 | 0.31 | 9706 | 62.50 | 51.26 | 69.00 | 65.94 | 44.48 | 44.35 |
| 0 | 20 | 2.41 | 0.12 | 24755 | 5.80 | 0.29 | 10297 | 41.76 | 39.35 | 43.86 | 43.08 | 37.71 | 37.64 |
| | 25 | 3.00 | 0.12 | 24843 | 7.16 | 0.29 | 10417 | 43.33 | 40.33 | 46.09 | 45.02 | 38.41 | 38.38 |
| | 30 | 3.69 | 0.12 | 24255 | 8.56 | 0.29 | 10463 | 44.99 | 41.30 | 48.12 | 46.91 | 39.01 | 38.91 |
| | 35 | 4.34 | 0.12 | 24049 | 10.06 | 0.29 | 10387 | 46.69 | 42.35 | 50.41 | 48.91 | 39.66 | 39.55 |
| | 40 | 5.16 | 0.13 | 23133 | 11.45 | 0.29 | 10423 | 48.56 | 43.40 | 52.54 | 50.93 | 40.31 | 40.25 |
| | 45 | 5.93 | 0.13 | 22664 | 13.01 | 0.29 | 10324 | 50.33 | 44.40 | 54.76 | 52.95 | 40.92 | 40.78 |
| | 50 | 6.81 | 0.14 | 21907 | 14.63 | 0.29 | 10198 | 52.52 | 45.71 | 57.00 | 54.97 | 41.28 | 41.43 |
| | 55 | 7.81 | 0.14 | 21012 | 16.42 | 0.30 | 9998 | 54.63 | 46.81 | 59.40 | 57.17 | 41.73 | 42.01 |
| | 60 | 9.08 | 0.15 | 19730 | 18.71 | 0.31 | 9569 | 57.26 | 48.19 | 62.43 | 60.05 | 42.48 | 42.58 |
| | 65 | 10.73 | 0.17 | 18077 | 21.26 | 0.33 | 9123 | 59.79 | 49.06 | 65.43 | 63.16 | 43.01 | 43.06 |
| | 70 | 13.96 | 0.20 | 14960 | 24.54 | 0.35 | 8513 | 63.60 | 49.63 | 69.09 | 67.14 | 43.55 | 43.61 |
| -30 | 20 | 2.48 | 0.12 | 24095 | 5.73 | 0.29 | 10410 | 41.80 | 39.32 | 43.89 | 43.08 | 37.82 | 37.68 |
| | 25 | 3.07 | 0.12 | 24333 | 7.19 | 0.29 | 10379 | 43.37 | 40.30 | 46.09 | 45.06 | 38.44 | 38.33 |
| | 30 | 3.76 | 0.13 | 23841 | 8.64 | 0.29 | 10366 | 45.03 | 41.28 | 48.25 | 46.99 | 39.04 | 38.93 |
| | 35 | 4.40 | 0.13 | 23716 | 10.10 | 0.29 | 10337 | 46.85 | 42.44 | 50.51 | 49.04 | 39.76 | 39.57 |
| | 40 | 5.25 | 0.13 | 22741 | 11.52 | 0.29 | 10365 | 48.62 | 43.37 | 52.59 | 50.93 | 40.30 | 40.20 |
| | 45 | 8.15 | 0.18 | 16481 | 14.62 | 0.32 | 9187 | 52.61 | 44.46 | 56.05 | 54.92 | 40.82 | 40.92 |
| | 50 | 13.77 | 0.28 | 10836 | 20.96 | 0.42 | 7119 | 58.37 | 44.60 | 62.16 | 62.31 | 40.99 | 41.56 |
| -60 | 20 | 2.42 | 0.12 | 24652 | 5.85 | 0.29 | 10206 | 41.86 | 39.43 | 44.15 | 43.21 | 37.88 | 37.78 |
| | 25 | 3.07 | 0.12 | 24277 | 7.27 | 0.29 | 10259 | 43.48 | 40.41 | 46.20 | 45.13 | 38.44 | 38.35 |
| | 30 | 3.77 | 0.13 | 23734 | 8.72 | 0.29 | 10262 | 45.24 | 41.47 | 48.40 | 47.19 | 39.12 | 39.03 |
| | 35 | 4.94 | 0.14 | 21164 | 10.70 | 0.31 | 9764 | 47.41 | 42.48 | 50.98 | 49.76 | 39.70 | 39.65 |
| | 40 | 9.15 | 0.23 | 13048 | 14.94 | 0.37 | 7988 | 52.50 | 43.35 | 55.43 | 55.02 | 40.24 | 40.32 |
| | 45 | 14.01 | 0.31 | 9588 | 21.02 | 0.47 | 6389 | 57.93 | 43.93 | 61.77 | 61.96 | 40.70 | 40.98 |
| -90 | 20 | 2.47 | 0.12 | 24183 | 5.82 | 0.29 | 10264 | 41.87 | 39.40 | 44.05 | 43.19 | 37.91 | 37.70 |
| | 25 | 3.09 | 0.12 | 24112 | 7.26 | 0.29 | 10280 | 43.52 | 40.43 | 46.21 | 45.09 | 38.47 | 38.32 |
| | 30 | 3.89 | 0.13 | 23044 | 8.67 | 0.29 | 10326 | 45.27 | 41.39 | 48.35 | 47.10 | 39.08 | 39.03 |
| | 35 | 7.06 | 0.20 | 14796 | 12.16 | 0.35 | 8591 | 49.55 | 42.49 | 52.07 | 51.55 | 39.61 | 39.69 |
| | 40 | 10.74 | 0.27 | 11114 | 16.67 | 0.42 | 7161 | 53.83 | 43.09 | 56.97 | 56.90 | 40.14 | 40.38 |
| | 45 | 19.28 | 0.43 | 6966 | 27.81 | 0.62 | 4829 | 62.99 | 43.71 | 68.27 | 68.93 | 40.49 | 41.09 |

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

Heat pipe tested: $\phi 8\text{mm} \times 200\text{mm}$ sintered powder metal/ water



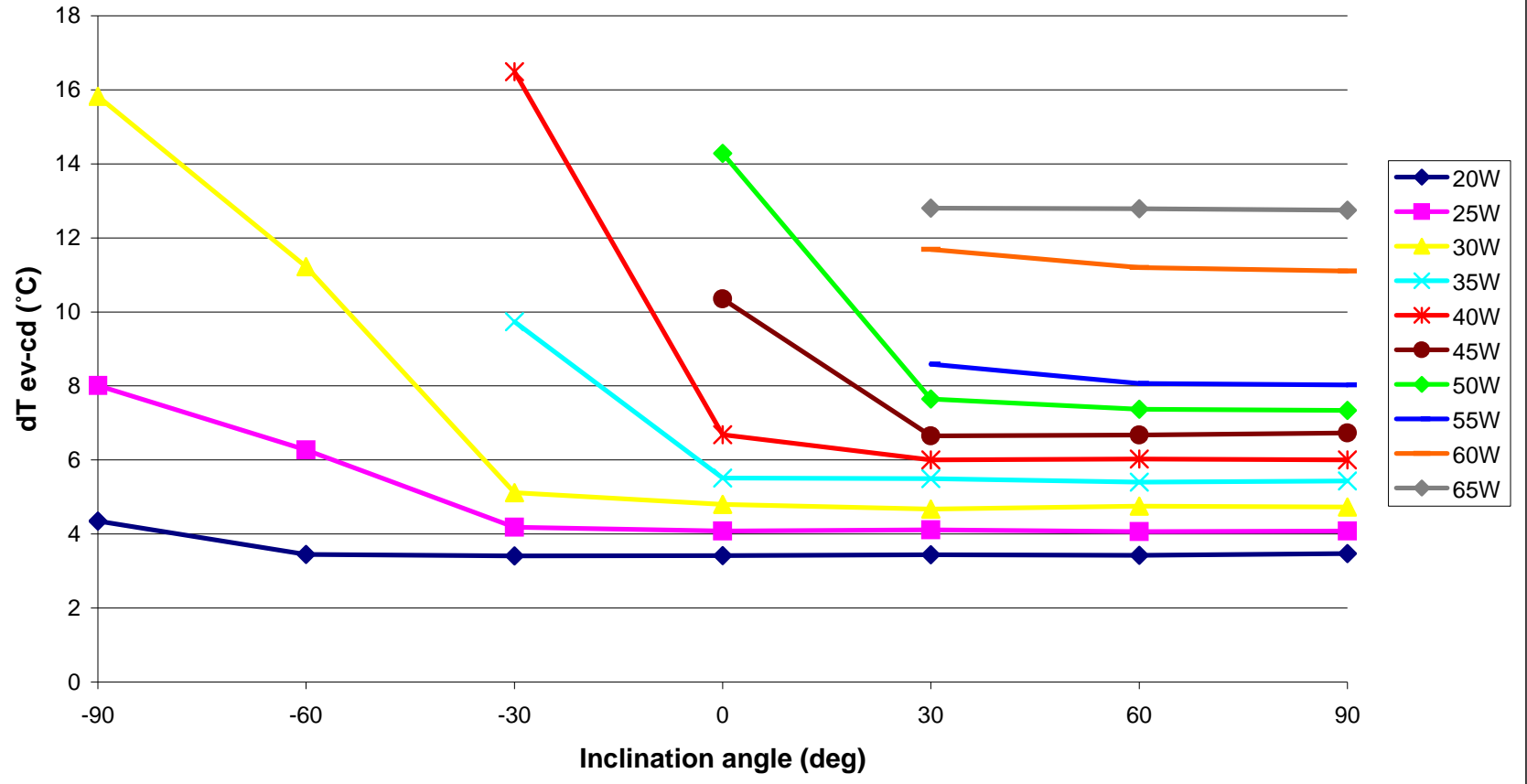
Heat Pipe Test Report

| Manufacturer | | Enertron | | | | Test conditions | | | | Test date | 8/23/2011 | | | |
|-------------------------------|---------------|----------------------------------|---------------------------------|-----------------------------------|---------------|--|-----------------------------------|-----------------------------|----------|---|-----------|-------|-------|--|
| 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 | 3.47 | 0.17 | 20066 | 6.44 | 0.32 | 10817 | 42.12 | 38.65 | 44.14 | 43.59 | 37.28 | 37.57 | |
| | 25 | 4.08 | 0.16 | 21322 | 7.91 | 0.32 | 11010 | 43.82 | 39.74 | 46.32 | 45.80 | 38.07 | 38.24 | |
| | 30 | 4.73 | 0.16 | 22100 | 9.32 | 0.31 | 11207 | 45.53 | 40.80 | 48.50 | 47.80 | 38.75 | 38.91 | |
| | 35 | 5.43 | 0.16 | 22424 | 10.84 | 0.31 | 11239 | 47.37 | 41.94 | 50.80 | 49.95 | 39.43 | 39.64 | |
| | 40 | 6.00 | 0.15 | 23210 | 12.32 | 0.31 | 11307 | 49.08 | 43.08 | 53.03 | 52.02 | 40.19 | 40.23 | |
| | 45 | 6.73 | 0.15 | 23286 | 13.82 | 0.31 | 11334 | 50.61 | 43.89 | 55.13 | 54.00 | 40.65 | 40.84 | |
| | 50 | 7.34 | 0.15 | 23713 | 15.40 | 0.31 | 11307 | 52.22 | 44.88 | 57.35 | 56.03 | 41.19 | 41.40 | |
| | 55 | 8.02 | 0.15 | 23864 | 16.99 | 0.31 | 11268 | 53.87 | 45.84 | 59.63 | 58.18 | 41.84 | 41.98 | |
| | 60 | 11.11 | 0.19 | 18809 | 19.80 | 0.33 | 10551 | 58.08 | 46.98 | 62.99 | 61.66 | 42.47 | 42.59 | |
| 60 | 20 | 3.42 | 0.17 | 20354 | 6.33 | 0.32 | 11005 | 41.99 | 38.57 | 44.01 | 43.50 | 37.37 | 37.48 | |
| | 25 | 4.07 | 0.16 | 21401 | 7.84 | 0.31 | 11107 | 43.82 | 39.76 | 46.32 | 45.70 | 38.09 | 38.26 | |
| | 30 | 4.75 | 0.16 | 21989 | 9.25 | 0.31 | 11293 | 45.56 | 40.81 | 48.51 | 47.74 | 38.78 | 38.97 | |
| | 35 | 5.40 | 0.15 | 22570 | 10.79 | 0.31 | 11292 | 47.31 | 41.91 | 50.74 | 49.86 | 39.38 | 39.65 | |
| | 40 | 6.03 | 0.15 | 23110 | 12.20 | 0.31 | 11413 | 48.97 | 42.94 | 52.90 | 51.79 | 40.05 | 40.25 | |
| | 45 | 6.68 | 0.15 | 23471 | 13.79 | 0.31 | 11360 | 50.60 | 43.93 | 55.15 | 53.93 | 40.62 | 40.88 | |
| | 50 | 7.37 | 0.15 | 23629 | 15.61 | 0.31 | 11153 | 52.44 | 45.08 | 57.64 | 56.33 | 41.27 | 41.48 | |
| | 55 | 8.07 | 0.15 | 23734 | 17.00 | 0.31 | 11264 | 53.94 | 45.87 | 59.70 | 58.22 | 41.85 | 42.06 | |
| | 60 | 11.20 | 0.19 | 18659 | 19.85 | 0.33 | 10523 | 58.09 | 46.89 | 63.08 | 61.72 | 42.44 | 42.66 | |
| 30 | 20 | 3.44 | 0.17 | 20235 | 6.29 | 0.31 | 11075 | 42.04 | 38.60 | 43.97 | 43.45 | 37.35 | 37.51 | |
| | 25 | 4.11 | 0.16 | 21182 | 7.83 | 0.31 | 11116 | 43.81 | 39.70 | 46.26 | 45.68 | 38.03 | 38.25 | |
| | 30 | 4.67 | 0.16 | 22356 | 9.25 | 0.31 | 11288 | 45.48 | 40.81 | 48.42 | 47.72 | 38.72 | 38.92 | |
| | 35 | 5.50 | 0.16 | 22167 | 10.83 | 0.31 | 11254 | 47.31 | 41.82 | 50.74 | 49.79 | 39.31 | 39.57 | |
| | 40 | 6.00 | 0.15 | 23210 | 12.22 | 0.31 | 11401 | 48.90 | 42.90 | 52.87 | 51.78 | 39.96 | 40.25 | |
| | 45 | 6.65 | 0.15 | 23545 | 13.87 | 0.31 | 11292 | 50.57 | 43.92 | 55.17 | 54.00 | 40.55 | 40.88 | |
| | 50 | 7.65 | 0.15 | 22764 | 15.83 | 0.32 | 11000 | 52.69 | 45.04 | 57.85 | 56.57 | 41.21 | 41.56 | |
| | 55 | 8.59 | 0.16 | 22289 | 17.77 | 0.32 | 10779 | 54.66 | 46.07 | 60.36 | 58.94 | 41.72 | 42.04 | |
| | 60 | 11.69 | 0.19 | 17877 | 20.09 | 0.33 | 10400 | 58.35 | 46.67 | 63.15 | 61.85 | 42.33 | 42.51 | |
| 65 | 12.81 | 0.20 | 17670 | 22.21 | 0.34 | 10188 | 60.32 | 47.51 | 65.75 | 64.38 | 42.78 | 42.92 | | |

| 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 | 20 | 3.41 | 0.17 | 20396 | 6.24 | 0.31 | 11153 | 42.03 | 38.61 | 43.94 | 43.48 | 37.40 | 37.53 |
| | 25 | 4.08 | 0.16 | 21328 | 7.82 | 0.31 | 11132 | 43.86 | 39.78 | 46.32 | 45.69 | 38.09 | 38.28 |
| | 30 | 4.80 | 0.16 | 21769 | 9.24 | 0.31 | 11309 | 45.52 | 40.73 | 48.41 | 47.67 | 38.72 | 38.89 |
| | 35 | 5.51 | 0.16 | 22119 | 10.79 | 0.31 | 11289 | 47.38 | 41.87 | 50.78 | 49.83 | 39.35 | 39.67 |
| | 40 | 6.68 | 0.17 | 20841 | 12.60 | 0.31 | 11056 | 49.24 | 42.55 | 53.17 | 52.17 | 39.82 | 40.32 |
| | 45 | 10.35 | 0.23 | 15138 | 15.76 | 0.35 | 9940 | 53.53 | 43.18 | 56.75 | 56.14 | 40.42 | 40.95 |
| | 50 | 14.29 | 0.29 | 12186 | 20.72 | 0.41 | 8400 | 58.15 | 43.86 | 61.79 | 62.06 | 40.82 | 41.59 |
| -30 | 20 | 3.41 | 0.17 | 20407 | 6.31 | 0.32 | 11037 | 42.05 | 38.64 | 44.01 | 43.50 | 37.32 | 37.57 |
| | 25 | 4.19 | 0.17 | 20793 | 7.83 | 0.31 | 11110 | 43.94 | 39.76 | 46.41 | 45.79 | 38.18 | 38.35 |
| | 30 | 5.12 | 0.17 | 20407 | 9.48 | 0.32 | 11021 | 45.77 | 40.66 | 48.63 | 47.94 | 38.63 | 38.99 |
| | 35 | 9.74 | 0.28 | 12513 | 13.85 | 0.40 | 8799 | 51.00 | 41.27 | 53.14 | 53.42 | 39.18 | 39.68 |
| | 40 | 16.49 | 0.41 | 8446 | 22.77 | 0.57 | 6117 | 58.42 | 41.93 | 62.16 | 63.28 | 39.60 | 40.31 |
| -60 | 20 | 3.45 | 0.17 | 20200 | 6.42 | 0.32 | 10849 | 42.21 | 38.76 | 44.23 | 43.70 | 37.46 | 37.63 |
| | 25 | 6.27 | 0.25 | 13877 | 9.03 | 0.36 | 9640 | 45.82 | 39.55 | 47.37 | 47.16 | 38.07 | 38.40 |
| | 30 | 11.22 | 0.37 | 9306 | 15.28 | 0.51 | 6835 | 51.55 | 40.33 | 53.66 | 54.54 | 38.53 | 39.12 |
| -90 | 20 | 4.35 | 0.22 | 16000 | 6.78 | 0.34 | 10276 | 43.02 | 38.67 | 44.62 | 44.16 | 37.51 | 37.72 |
| | 25 | 8.01 | 0.32 | 10865 | 10.99 | 0.44 | 7918 | 47.44 | 39.43 | 49.00 | 49.40 | 37.95 | 38.47 |
| | 30 | 15.83 | 0.53 | 6600 | 21.13 | 0.70 | 4942 | 56.07 | 40.24 | 59.39 | 60.51 | 38.50 | 39.14 |

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

Heat pipe tested: $\phi 8\text{mm} \times 225\text{mm}$ sintered powder metal/ water

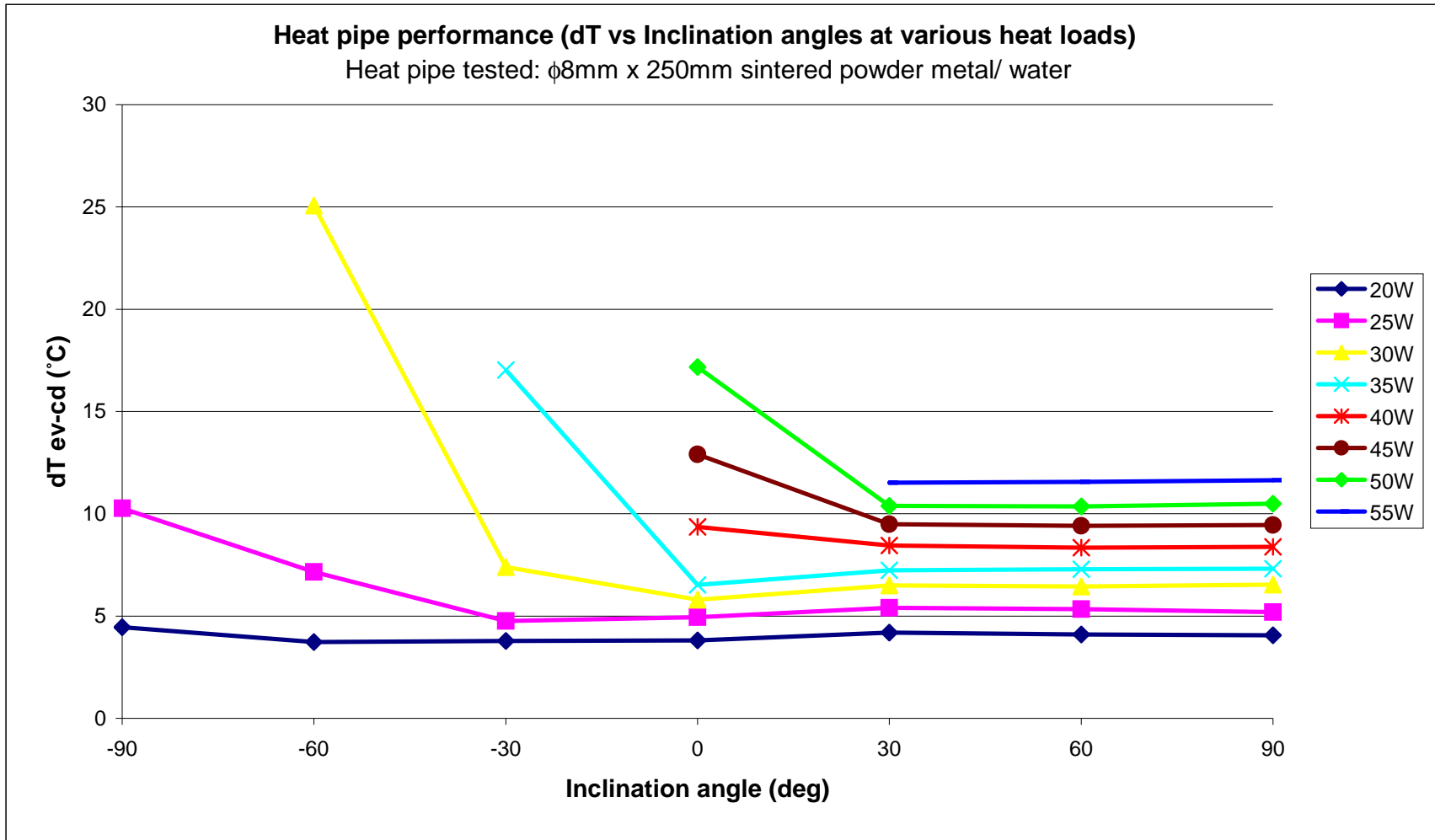


Heat Pipe Test Report

| | | | | | | | | |
|-------------------------------|----------|----------------------------------|--|--|--|----------|---|-----------|
| Manufacturer | | Enertron | | Test conditions | | | Test date | 8/29/2011 |
| 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 | 4.06 | 0.20 | 19615 | 5.51 | 0.28 | 14442 | 41.76 | 37.71 | 42.64 | 43.11 | 37.21 | 37.53 |
| | 25 | 5.20 | 0.21 | 19144 | 7.10 | 0.28 | 14018 | 43.75 | 38.55 | 45.06 | 45.42 | 38.01 | 38.28 |
| | 30 | 6.54 | 0.22 | 18252 | 5.55 | 0.19 | 21492 | 45.89 | 39.35 | 40.88 | 47.91 | 38.69 | 38.99 |
| | 35 | 7.32 | 0.21 | 19022 | 10.40 | 0.30 | 13394 | 47.54 | 40.22 | 49.79 | 50.11 | 39.37 | 39.73 |
| | 40 | 8.38 | 0.21 | 18995 | 11.79 | 0.29 | 13495 | 49.29 | 40.91 | 51.85 | 52.17 | 40.02 | 40.40 |
| | 45 | 9.46 | 0.21 | 18933 | 13.45 | 0.30 | 13311 | 51.09 | 41.64 | 54.00 | 54.43 | 40.63 | 40.90 |
| | 50 | 10.49 | 0.21 | 18972 | 14.79 | 0.30 | 13449 | 52.60 | 42.12 | 55.73 | 56.18 | 40.93 | 41.39 |
| | 55 | 11.64 | 0.21 | 18809 | 16.33 | 0.30 | 13405 | 54.29 | 42.65 | 57.66 | 58.22 | 41.39 | 41.84 |
| 60 | 20 | 4.10 | 0.20 | 19423 | 5.58 | 0.28 | 14266 | 41.73 | 37.63 | 42.59 | 43.10 | 37.11 | 37.43 |
| | 25 | 5.34 | 0.21 | 18635 | 7.21 | 0.29 | 13791 | 43.92 | 38.58 | 45.12 | 45.52 | 37.94 | 38.27 |
| | 30 | 6.45 | 0.21 | 18518 | 5.33 | 0.18 | 22395 | 45.83 | 39.38 | 40.64 | 47.85 | 38.75 | 39.08 |
| | 35 | 7.29 | 0.21 | 19095 | 10.19 | 0.29 | 13673 | 47.36 | 40.07 | 49.57 | 49.90 | 39.38 | 39.72 |
| | 40 | 8.34 | 0.21 | 19079 | 11.75 | 0.29 | 13543 | 49.20 | 40.86 | 51.76 | 52.10 | 39.96 | 40.40 |
| | 45 | 9.42 | 0.21 | 19017 | 13.22 | 0.29 | 13548 | 50.99 | 41.58 | 53.88 | 54.21 | 40.56 | 41.09 |
| | 50 | 10.36 | 0.21 | 19201 | 14.53 | 0.29 | 13690 | 52.32 | 41.96 | 55.37 | 55.91 | 40.80 | 41.42 |
| | 55 | 11.56 | 0.21 | 18927 | 16.10 | 0.29 | 13589 | 54.14 | 42.58 | 57.47 | 58.04 | 41.39 | 41.91 |
| 30 | 20 | 4.20 | 0.21 | 18970 | 5.66 | 0.28 | 14067 | 41.74 | 37.55 | 42.61 | 43.04 | 37.04 | 37.30 |
| | 25 | 5.41 | 0.22 | 18404 | 7.34 | 0.29 | 13556 | 43.98 | 38.58 | 45.32 | 45.60 | 38.00 | 38.25 |
| | 30 | 6.49 | 0.22 | 18387 | 5.22 | 0.17 | 22850 | 45.80 | 39.31 | 40.33 | 47.79 | 38.65 | 39.03 |
| | 35 | 7.23 | 0.21 | 19254 | 10.14 | 0.29 | 13730 | 47.32 | 40.09 | 49.50 | 49.77 | 39.27 | 39.71 |
| | 40 | 8.45 | 0.21 | 18846 | 11.74 | 0.29 | 13553 | 49.21 | 40.76 | 51.72 | 52.01 | 39.87 | 40.38 |
| | 45 | 9.49 | 0.21 | 18861 | 13.23 | 0.29 | 13529 | 50.97 | 41.48 | 53.79 | 54.18 | 40.46 | 41.04 |
| | 50 | 10.38 | 0.21 | 19161 | 14.43 | 0.29 | 13789 | 52.22 | 41.84 | 55.25 | 55.70 | 40.75 | 41.34 |
| | 55 | 11.51 | 0.21 | 19006 | 15.97 | 0.29 | 13705 | 53.92 | 42.41 | 57.24 | 57.81 | 41.28 | 41.83 |
| 0 | 20 | 3.80 | 0.19 | 20925 | 5.34 | 0.27 | 14899 | 41.44 | 37.63 | 42.35 | 42.72 | 36.97 | 37.43 |
| | 25 | 4.94 | 0.20 | 20148 | 6.82 | 0.27 | 14577 | 43.56 | 38.62 | 44.84 | 45.15 | 37.97 | 38.37 |
| | 30 | 5.80 | 0.19 | 20580 | 4.69 | 0.16 | 25451 | 45.23 | 39.43 | 39.93 | 47.19 | 38.55 | 39.19 |
| | 35 | 6.52 | 0.19 | 21356 | 9.48 | 0.27 | 14698 | 46.66 | 40.14 | 48.84 | 49.09 | 39.04 | 39.94 |
| | 40 | 9.36 | 0.23 | 17006 | 12.19 | 0.30 | 13056 | 50.19 | 40.84 | 51.98 | 52.70 | 39.55 | 40.74 |
| | 45 | 12.90 | 0.29 | 13882 | 15.82 | 0.35 | 11321 | 53.90 | 41.01 | 55.54 | 56.98 | 39.99 | 40.90 |
| | 50 | 17.18 | 0.34 | 11579 | 21.00 | 0.42 | 9473 | 58.46 | 41.27 | 60.37 | 63.00 | 40.19 | 41.17 |

| 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 | 3.78 | 0.19 | 21058 | 5.23 | 0.26 | 15230 | 41.50 | 37.72 | 42.46 | 42.65 | 37.17 | 37.49 |
| | 25 | 4.75 | 0.19 | 20933 | 6.60 | 0.26 | 15067 | 43.42 | 38.66 | 44.67 | 44.99 | 37.98 | 38.47 |
| | 30 | 7.39 | 0.25 | 16148 | 9.34 | 0.31 | 12776 | 46.63 | 39.24 | 47.61 | 48.50 | 38.18 | 39.25 |
| | 35 | 17.03 | 0.49 | 8179 | 22.38 | 0.64 | 6223 | 57.02 | 40.00 | 60.61 | 62.82 | 38.59 | 40.08 |
| -60 | 20 | 3.73 | 0.19 | 21312 | 5.33 | 0.27 | 14936 | 41.50 | 37.76 | 42.58 | 42.85 | 37.21 | 37.56 |
| | 25 | 7.16 | 0.29 | 13895 | 9.02 | 0.36 | 11028 | 45.77 | 38.61 | 46.51 | 47.81 | 37.69 | 38.60 |
| | 30 | 25.08 | 0.84 | 4760 | 29.70 | 0.99 | 4019 | 64.31 | 39.24 | 67.42 | 69.26 | 37.99 | 39.29 |
| -90 | 20 | 4.45 | 0.22 | 17887 | 5.81 | 0.29 | 13699 | 42.26 | 37.81 | 43.06 | 43.45 | 37.13 | 37.76 |
| | 25 | 10.27 | 0.41 | 9682 | 13.20 | 0.53 | 7538 | 48.94 | 38.67 | 50.44 | 52.32 | 37.60 | 38.76 |



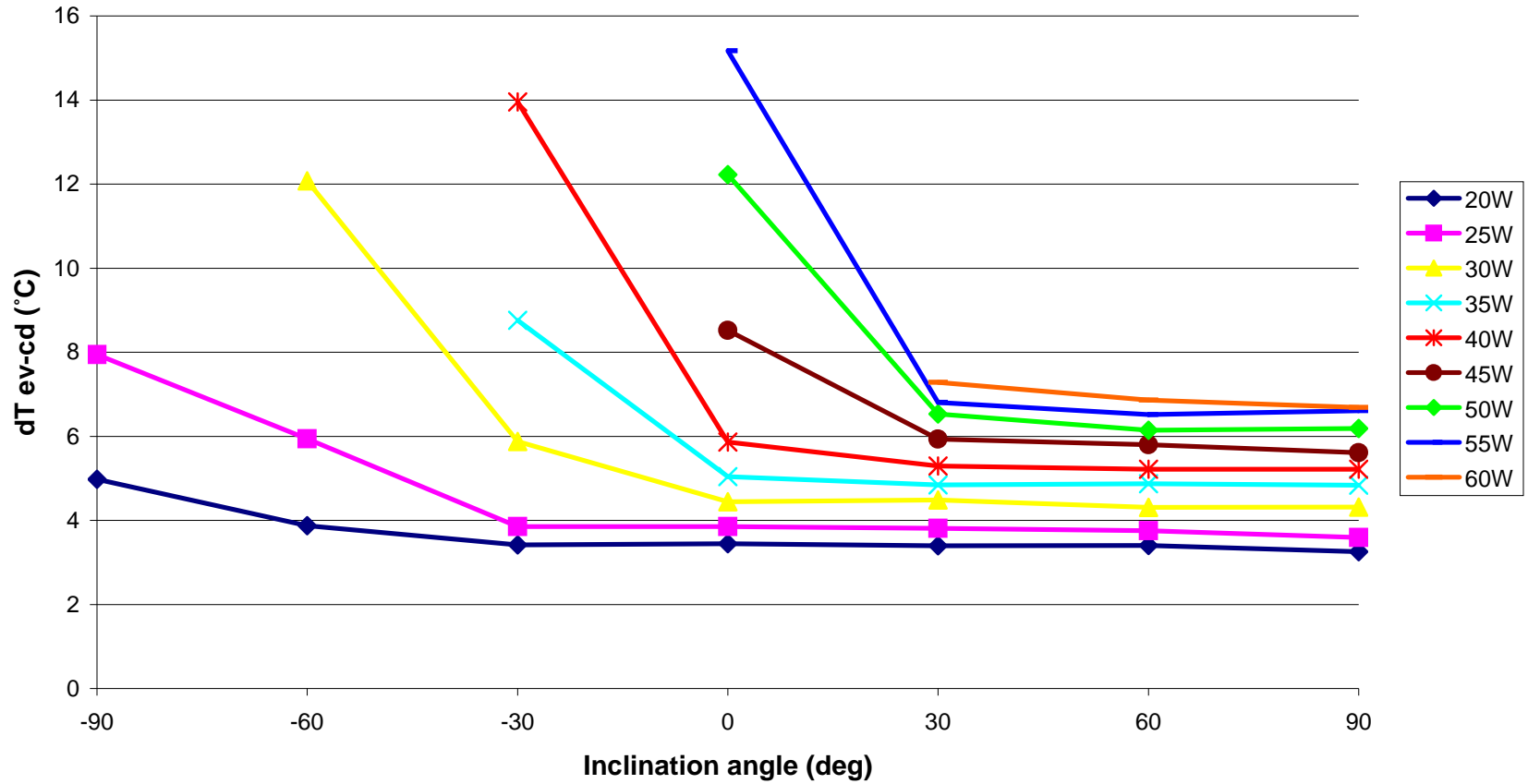
Heat Pipe Test Report

| Manufacturer | | Enertron | | | | Test conditions | | | Test date | 8/10/2011 | | | | |
|-------------------------------|---------------|----------------------------------|---------------------------------|-----------------------------------|---------------|--|-----------------------------------|-----------------------------|---|-----------|-------|-------|-------|--|
| 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 | 3.25 | 0.16 | 27529 | 4.83 | 0.24 | 18535 | 41.25 | 37.99 | 42.18 | 42.04 | 37.03 | 37.53 | |
| | 25 | 3.59 | 0.14 | 31154 | 5.55 | 0.22 | 20149 | 42.33 | 38.74 | 43.45 | 43.28 | 37.48 | 38.14 | |
| | 30 | 4.31 | 0.14 | 31135 | 6.64 | 0.22 | 20230 | 44.05 | 39.74 | 45.31 | 45.09 | 38.25 | 38.87 | |
| | 35 | 4.84 | 0.14 | 32369 | 7.86 | 0.22 | 19935 | 45.64 | 40.80 | 47.19 | 46.84 | 38.91 | 39.40 | |
| | 40 | 5.21 | 0.13 | 34347 | 8.90 | 0.22 | 20118 | 47.09 | 41.87 | 49.01 | 48.63 | 39.67 | 40.18 | |
| | 45 | 5.61 | 0.12 | 35918 | 9.57 | 0.21 | 21046 | 48.16 | 42.55 | 50.18 | 49.68 | 40.12 | 40.59 | |
| | 50 | 6.18 | 0.12 | 36198 | 10.66 | 0.21 | 20999 | 49.79 | 43.60 | 51.93 | 51.46 | 40.89 | 41.18 | |
| | 55 | 6.61 | 0.12 | 37274 | 11.80 | 0.21 | 20871 | 51.15 | 44.55 | 53.60 | 53.10 | 41.40 | 41.71 | |
| 60 | 20 | 3.40 | 0.17 | 26308 | 5.10 | 0.26 | 17540 | 41.56 | 38.16 | 42.61 | 42.44 | 37.16 | 37.68 | |
| | 25 | 3.75 | 0.15 | 29826 | 5.83 | 0.23 | 19211 | 42.68 | 38.93 | 43.89 | 43.68 | 37.69 | 38.23 | |
| | 30 | 4.31 | 0.14 | 31172 | 6.96 | 0.23 | 19286 | 44.41 | 40.10 | 45.80 | 45.55 | 38.37 | 39.05 | |
| | 35 | 4.87 | 0.14 | 32150 | 7.91 | 0.23 | 19799 | 45.66 | 40.79 | 47.18 | 46.93 | 38.86 | 39.42 | |
| | 40 | 5.22 | 0.13 | 34327 | 8.97 | 0.22 | 19972 | 47.05 | 41.83 | 49.01 | 48.65 | 39.56 | 40.16 | |
| | 45 | 5.80 | 0.13 | 34735 | 9.92 | 0.22 | 20301 | 48.72 | 42.92 | 50.76 | 50.29 | 40.36 | 40.84 | |
| | 50 | 6.14 | 0.12 | 36440 | 10.68 | 0.21 | 20966 | 49.80 | 43.66 | 51.95 | 51.46 | 40.81 | 41.24 | |
| | 55 | 6.52 | 0.12 | 37783 | 11.72 | 0.21 | 20999 | 51.11 | 44.60 | 53.60 | 53.11 | 41.42 | 41.84 | |
| 30 | 20 | 3.39 | 0.17 | 26393 | 5.08 | 0.25 | 17619 | 41.60 | 38.21 | 42.57 | 42.39 | 37.10 | 37.70 | |
| | 25 | 3.81 | 0.15 | 29379 | 5.84 | 0.23 | 19165 | 42.69 | 38.88 | 43.85 | 43.61 | 37.56 | 38.22 | |
| | 30 | 4.49 | 0.15 | 29935 | 6.90 | 0.23 | 19462 | 44.41 | 39.93 | 45.72 | 45.48 | 38.38 | 39.03 | |
| | 35 | 4.85 | 0.14 | 32323 | 7.93 | 0.23 | 19761 | 45.69 | 40.84 | 47.25 | 46.99 | 38.88 | 39.50 | |
| | 40 | 5.29 | 0.13 | 33840 | 8.95 | 0.22 | 20012 | 47.15 | 41.86 | 48.99 | 48.63 | 39.58 | 40.15 | |
| | 45 | 5.94 | 0.13 | 33934 | 10.02 | 0.22 | 20107 | 48.83 | 42.90 | 50.78 | 50.36 | 40.33 | 40.78 | |
| | 50 | 6.53 | 0.13 | 34285 | 10.95 | 0.22 | 20445 | 50.16 | 43.63 | 52.18 | 51.75 | 40.76 | 41.28 | |
| | 55 | 6.81 | 0.12 | 36173 | 11.82 | 0.21 | 20827 | 51.40 | 44.59 | 53.65 | 53.14 | 41.36 | 41.78 | |
| 0 | 20 | 3.44 | 0.17 | 25994 | 5.07 | 0.25 | 17647 | 41.63 | 38.19 | 42.53 | 42.42 | 37.07 | 37.73 | |
| | 25 | 3.85 | 0.15 | 29074 | 5.81 | 0.23 | 19261 | 42.77 | 38.92 | 43.80 | 43.63 | 37.58 | 38.23 | |
| | 30 | 4.44 | 0.15 | 30224 | 6.89 | 0.23 | 19484 | 44.42 | 39.98 | 45.72 | 45.55 | 38.37 | 39.12 | |

| 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 | 35 | 5.04 | 0.14 | 31066 | 7.99 | 0.23 | 19608 | 45.85 | 40.80 | 47.32 | 47.04 | 38.84 | 39.54 |
| | 40 | 5.87 | 0.15 | 30523 | 9.38 | 0.23 | 19082 | 47.80 | 41.93 | 49.34 | 49.12 | 39.51 | 40.18 |
| | 45 | 8.52 | 0.19 | 23642 | 12.04 | 0.27 | 16734 | 51.23 | 42.71 | 52.07 | 52.89 | 40.00 | 40.88 |
| | 50 | 12.23 | 0.24 | 18305 | 16.56 | 0.33 | 13515 | 55.59 | 43.37 | 56.51 | 58.40 | 40.32 | 41.48 |
| | 55 | 15.17 | 0.28 | 16226 | 20.11 | 0.37 | 12242 | 58.82 | 43.65 | 59.94 | 62.56 | 40.45 | 41.83 |
| -30 | 20 | 3.42 | 0.17 | 26177 | 5.00 | 0.25 | 17912 | 41.67 | 38.25 | 42.64 | 42.34 | 37.18 | 37.80 |
| | 25 | 3.85 | 0.15 | 29044 | 5.89 | 0.24 | 19009 | 42.84 | 38.98 | 43.94 | 43.72 | 37.62 | 38.27 |
| | 30 | 5.88 | 0.20 | 22850 | 8.09 | 0.27 | 16591 | 45.79 | 39.91 | 46.66 | 46.85 | 38.22 | 39.10 |
| | 35 | 8.76 | 0.25 | 17887 | 11.87 | 0.34 | 13199 | 49.53 | 40.77 | 50.30 | 51.68 | 38.61 | 39.62 |
| | 40 | 13.95 | 0.35 | 12834 | 18.60 | 0.46 | 9627 | 55.27 | 41.32 | 57.10 | 59.15 | 38.91 | 40.15 |
| -60 | 20 | 3.87 | 0.19 | 23115 | 5.38 | 0.27 | 16656 | 42.09 | 38.21 | 42.91 | 42.71 | 37.10 | 37.78 |
| | 25 | 5.94 | 0.24 | 18836 | 7.87 | 0.31 | 14221 | 44.84 | 38.89 | 45.38 | 46.03 | 37.43 | 38.24 |
| | 30 | 12.08 | 0.40 | 11121 | 16.02 | 0.53 | 8381 | 51.73 | 39.66 | 53.55 | 55.16 | 37.79 | 38.87 |
| -90 | 20 | 4.98 | 0.25 | 17977 | 6.57 | 0.33 | 13637 | 43.34 | 38.36 | 43.74 | 44.26 | 37.04 | 37.83 |
| | 25 | 7.95 | 0.32 | 14083 | 10.46 | 0.42 | 10695 | 46.87 | 38.93 | 47.64 | 48.92 | 37.37 | 38.26 |

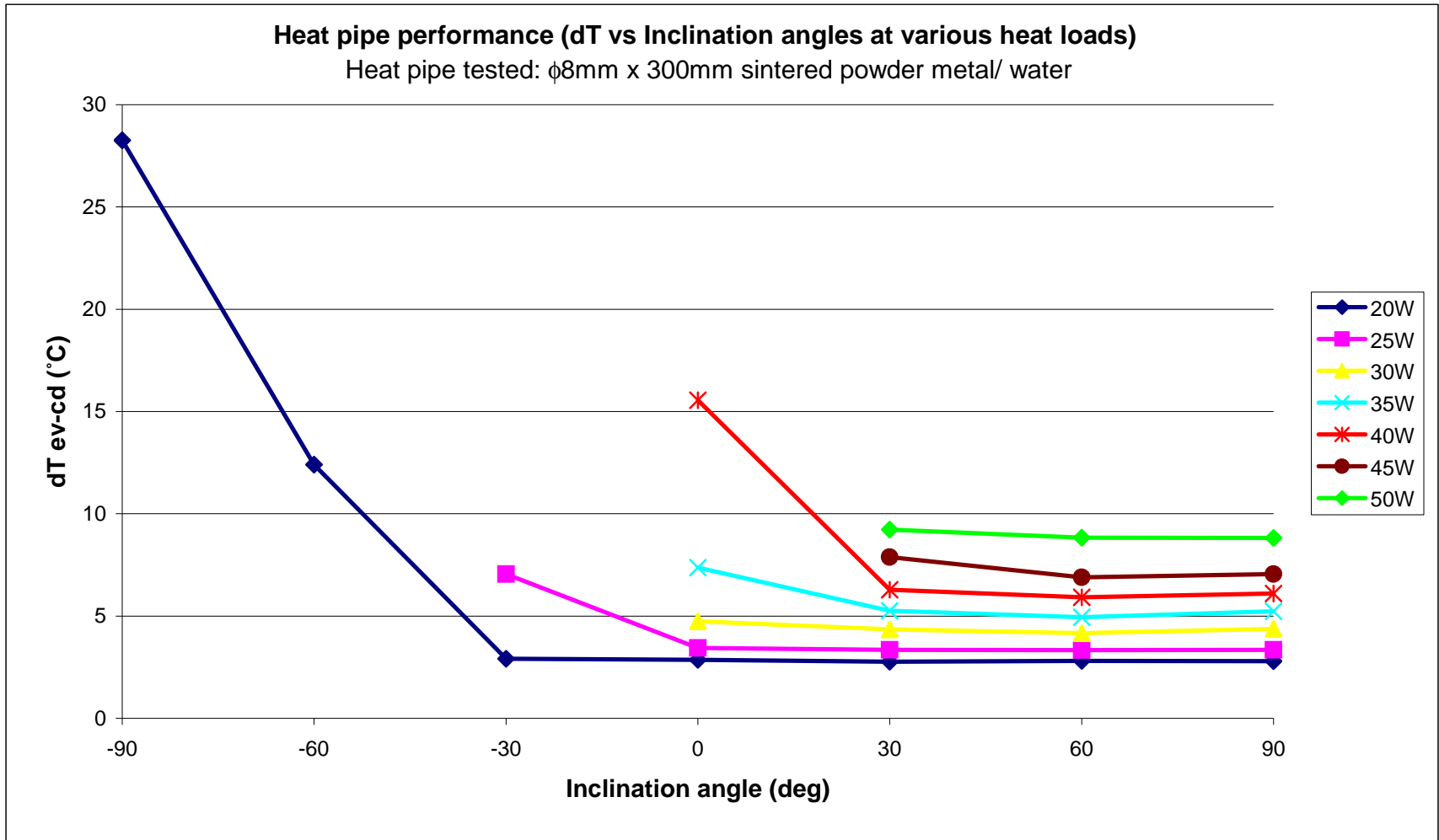
Heat pipe performance (dT vs Inclination angles at various heat loads)

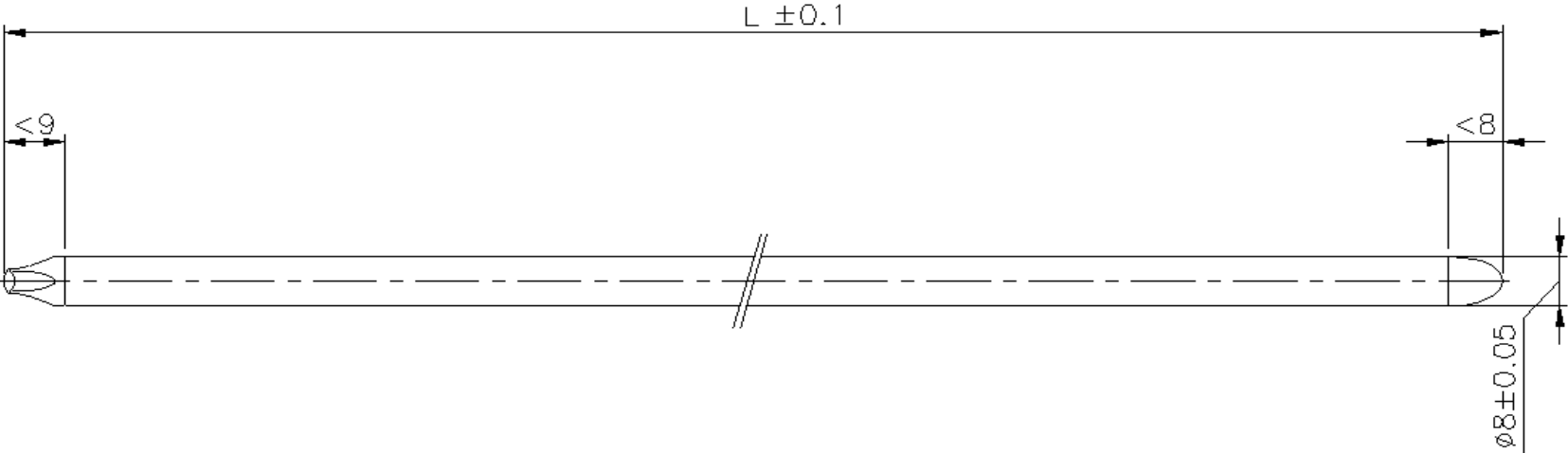
Heat pipe tested: $\phi 8\text{mm} \times 275\text{mm}$ sintered powder metal/ water



Heat Pipe Test Report

| Manufacturer | | Enertron | | | | Test conditions | | | Test date | 8/22/2011 | | | | |
|-------------------------------|---------------|----------------------------------|---------------------------------|-----------------------------------|---------------|--|-----------------------------------|-----------------------------|---|-----------|-------|-------|-------|--|
| 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 | 2.80 | 0.14 | 35551 | 4.59 | 0.23 | 21671 | 41.03 | 38.23 | 41.92 | 42.28 | 37.37 | 37.64 | |
| | 25 | 3.35 | 0.13 | 37072 | 5.70 | 0.23 | 21814 | 42.62 | 39.27 | 43.70 | 44.06 | 38.02 | 38.33 | |
| | 30 | 4.37 | 0.15 | 34128 | 7.17 | 0.24 | 20816 | 44.93 | 40.56 | 45.93 | 46.51 | 38.92 | 39.18 | |
| | 35 | 5.24 | 0.15 | 33252 | 8.41 | 0.24 | 20704 | 46.72 | 41.48 | 47.70 | 48.46 | 39.49 | 39.86 | |
| | 40 | 6.11 | 0.15 | 32571 | 9.59 | 0.24 | 20736 | 48.44 | 42.33 | 49.34 | 50.37 | 40.10 | 40.43 | |
| | 45 | 7.05 | 0.16 | 31737 | 11.11 | 0.25 | 20149 | 50.38 | 43.33 | 51.33 | 52.65 | 40.69 | 41.07 | |
| | 50 | 8.81 | 0.18 | 28214 | 13.74 | 0.27 | 18106 | 53.35 | 44.54 | 54.33 | 56.01 | 41.37 | 41.51 | |
| 60 | 20 | 2.80 | 0.14 | 35513 | 4.59 | 0.23 | 21676 | 41.06 | 38.26 | 41.89 | 42.12 | 37.32 | 37.52 | |
| | 25 | 3.33 | 0.13 | 37306 | 5.51 | 0.22 | 22587 | 42.68 | 39.34 | 43.61 | 43.94 | 38.09 | 38.45 | |
| | 30 | 4.16 | 0.14 | 35841 | 6.75 | 0.23 | 22092 | 44.51 | 40.35 | 45.44 | 45.90 | 38.74 | 39.10 | |
| | 35 | 4.94 | 0.14 | 35217 | 8.01 | 0.23 | 21746 | 46.18 | 41.24 | 47.18 | 47.86 | 39.37 | 39.65 | |
| | 40 | 5.92 | 0.15 | 33594 | 9.46 | 0.24 | 21030 | 48.20 | 42.28 | 49.21 | 50.11 | 40.00 | 40.40 | |
| | 45 | 6.89 | 0.15 | 32479 | 10.88 | 0.24 | 20578 | 50.06 | 43.17 | 51.05 | 52.26 | 40.57 | 40.99 | |
| | 50 | 8.83 | 0.18 | 28176 | 13.25 | 0.27 | 18765 | 52.87 | 44.04 | 53.78 | 55.34 | 41.28 | 41.35 | |
| 30 | 20 | 2.77 | 0.14 | 35949 | 4.49 | 0.22 | 22159 | 41.15 | 38.39 | 41.88 | 42.16 | 37.43 | 37.64 | |
| | 25 | 3.35 | 0.13 | 37127 | 5.56 | 0.22 | 22359 | 42.63 | 39.28 | 43.62 | 43.95 | 38.07 | 38.39 | |
| | 30 | 4.35 | 0.15 | 34285 | 6.81 | 0.23 | 21920 | 44.68 | 40.33 | 45.50 | 45.97 | 38.74 | 39.12 | |
| | 35 | 5.26 | 0.15 | 33101 | 8.08 | 0.23 | 21547 | 46.48 | 41.22 | 47.27 | 47.97 | 39.34 | 39.74 | |
| | 40 | 6.29 | 0.16 | 31639 | 9.82 | 0.25 | 20257 | 48.57 | 42.28 | 49.47 | 50.46 | 39.93 | 40.35 | |
| | 45 | 7.88 | 0.18 | 28392 | 11.77 | 0.26 | 19011 | 50.93 | 43.05 | 51.83 | 53.05 | 40.56 | 40.78 | |
| | 50 | 9.23 | 0.18 | 26943 | 13.50 | 0.27 | 18422 | 53.16 | 43.93 | 53.92 | 55.54 | 41.17 | 41.30 | |
| 0 | 20 | 2.87 | 0.14 | 34708 | 4.54 | 0.23 | 21915 | 41.16 | 38.29 | 41.92 | 42.18 | 37.42 | 37.60 | |
| | 25 | 3.44 | 0.14 | 36145 | 5.63 | 0.23 | 22070 | 42.89 | 39.45 | 43.70 | 44.07 | 38.13 | 38.38 | |
| | 30 | 4.75 | 0.16 | 31432 | 7.18 | 0.24 | 20784 | 44.99 | 40.25 | 45.73 | 46.31 | 38.64 | 39.04 | |
| | 35 | 7.37 | 0.21 | 23607 | 9.67 | 0.28 | 17994 | 48.11 | 40.73 | 48.45 | 49.76 | 39.14 | 39.72 | |
| | 40 | 15.56 | 0.39 | 12790 | 18.96 | 0.47 | 10491 | 56.71 | 41.16 | 57.43 | 60.22 | 39.37 | 40.35 | |
| -30 | 20 | 2.91 | 0.15 | 34206 | 4.60 | 0.23 | 21610 | 41.31 | 38.40 | 42.05 | 42.32 | 37.43 | 37.73 | |
| | 25 | 7.05 | 0.28 | 17632 | 8.90 | 0.36 | 13979 | 46.08 | 39.03 | 46.45 | 47.76 | 37.91 | 38.51 | |
| -60 | 20 | 12.40 | 0.62 | 8020 | 15.12 | 0.76 | 6580 | 50.48 | 38.08 | 52.00 | 53.30 | 37.21 | 37.85 | |
| -90 | 20 | 28.27 | 1.41 | 3519 | 30.92 | 1.55 | 3217 | 66.12 | 37.85 | 67.61 | 68.83 | 36.96 | 37.64 | |





unit: mm