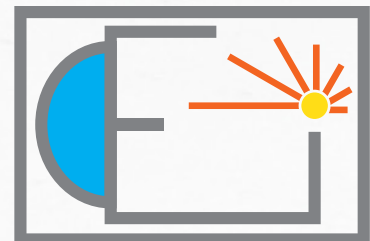
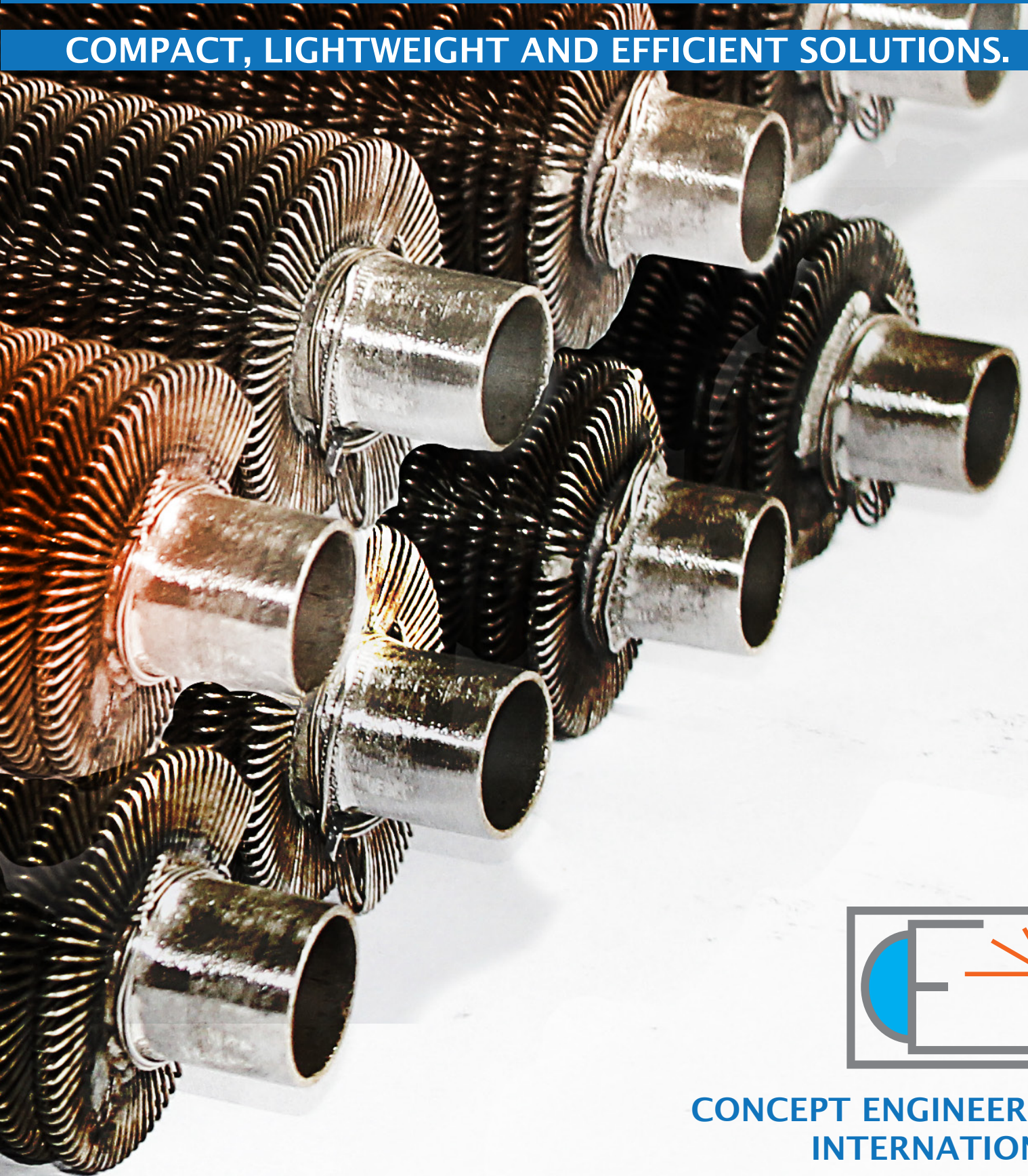


BUILDING SUPERIOR

STEAM AIR HEATERS

COMPACT, LIGHTWEIGHT AND EFFICIENT SOLUTIONS.



CONCEPT ENGINEERING
INTERNATIONAL

Saturated steam condensing in tubes has a very high heat transfer coefficient. To harness its true potential you need a very efficient fin tube as the airside is the limiting factor.

Our PIN Fin tube fits the bill. It consists of wire loops fastened to the tube with a flattened wire soldered to the tube. The soldering (lead free solder is an option) gives 100% bonding and strength and the wire loops provide very high airside turbulence. The result is an extremely high airside coefficient enhancing significantly the overall heat transfer coefficient.

These fin tubes can be provided with carbon steel, stainless steel or copper wire fins on steel, stainless steel or copper/copper alloy tubes. To demonstrate the performance of these tubes against helical fin tubes we have done the following:

1. Designed a 1 meter by 1 meter 3 row panel using $\frac{3}{4}$ " OD steel tubes with 10 FPI L type Aluminum fins. We have used 57 tubes in this panel. (19 tubes/row) The fin thickness was 0.5 mm and the fin height was 13 mm giving a heat transfer area of 3.51 ft²/ft. The transverse pitch was 50.8 mm and the longitudinal pitch was 38 mmv
2. Using HTRI software, we calculated the heat transfer and pressure drop of this panel under different air flow rate conditions, 25 deg C ambient air temperature and saturated steam at 3 kg/cm²g pressure in the tubes. We calculated all the parameters like air outlet temperature, LMTD, linear heat transfer coefficient, heat load and airside pressure drop. We also isolated the airside heat transfer coefficient.
3. We then repeated this exercise using the same tube size but substituting the L type fins with our Pin fins in 5 different wire-winding configurations. The design was done using our in house design data proven over 2 decades of use. Since Aluminum cannot be used in wire wound fin tubes, we have considered stainless steel wire fins.
4. We also used panels with the same 1 meter by one meter 3 row configuration but changed the tube OD. We have adjusted the number of tubes to fit this configuration. We have selected the most commonly used winding configuration for each tube OD selected. We thus had panels with 1" OD at 51 tubes per panel, 5/8" tubes at 60 tubes per panel and 3/8" tubes at 77 tubes per panel.
5. We thus arrived at 9 panels, One of $\frac{3}{4}$ " L type fin tubes, five of different windings of $\frac{3}{4}$ " wire wound fin tubes and one each of 3/8", 5/8" & 1" tubes. The idea of comparing one meter by one-meter panels was to be able to compare the performance of similarly sized heat exchangers across the tube options.
6. When comparing coefficients we have decided to use a linear coefficient (Per length of tube) instead of the generally used surface area. This gives a more straightforward comparison between tubes and is easier to use. One must keep in mind that with lower OD tubes a larger number of tubes can be fitted in a panel which will give a higher panel coefficient. (Linear coefficient x length of tube in panel).
7. Due to its fin geometry and efficiency the weight of the wire fin tube is very low both in absolute per meter terms and more so when the total length is adjusted for higher performance. To compare, S1 and the higher efficiency S2 and S3 stainless steel fin tubes are lower in weight than the 10 FPI Aluminum fin steel tube combination. The S4 & S5 are only slightly higher. When comparing against the stainless steel L fin tube, the S1 is 40% of the weight. The S5 stainless steel is only 2.9 kgs vs. 4.7 kgs for the stainless steel fin L tube. When you consider that the S1 is 30% more efficient and the S5 is 3 times the efficiency of the L tube great new possibilities open up. The weight chart that follows is worth studying.

Weight of different fin configurations of fintubes

| Winding | Code | Tube OD | Weight per meter (kg/mtr) | | | | Total weight Kg/mtr |
|-----------|----------|---------|---------------------------|------|--------------|-------------|------------------------|
| | | | Tube | Fins | Tension wire | Solder wire | |
| S1 | A | ¾" | 1.01 | 0.91 | 0.062 | 0.09 | 2.072 |
| S2 | B | ¾" | 1.01 | 1.1 | 0.07 | 0.093 | 2.273 |
| S3 | C | ¾" | 1.01 | 1.25 | 0.08 | 0.11 | 2.45 |
| S4 | D | ¾" | 1.01 | 1.38 | 0.083 | 0.12 | 2.593 |
| S5 | E | ¾" | 1.01 | 1.68 | 0.083 | 0.12 | 2.893 |
| P4 | F | 3/8" | 0.16 | 0.45 | 0.05 | 0.06 | 0.72 |
| R2 | G | 5/8" | 0.34 | 0.88 | 0.08 | 0.09 | 1.39 |
| T5 | H | 1" | 0.75 | 1.63 | 0.12 | 0.14 | 2.64 |
| L fins SS | L 10 FPI | ¾" | 1.01 | 3.71 | - | - | 4.72 |
| L fins AL | L 10 FPI | ¾" | 1.01 | 1.41 | - | - | 2.42 |

Design Parameter

| Model No | Units | L 10, S1,S2,S3,S4,S5 | T5 | R2 | P4 |
|---------------------------|---------------------------|-------------------------|--------|--------|--------|
| Air inlet temperature | deg C | 25 | 25 | 25 | 25 |
| Steam Pressure | kg/cm ² g | 3 | 3 | 3 | 3 |
| Dirt factor outside (Rdo) | hr. ft ² F/btu | 0.002 | 0.002 | 0.002 | 0.002 |
| Dirt factor inside (Rdi) | hr. ft ² F/btu | 0.0005 | 0.0005 | 0.0005 | 0.0005 |
| Face Area | M ² | 1 | 1 | 1 | 1 |

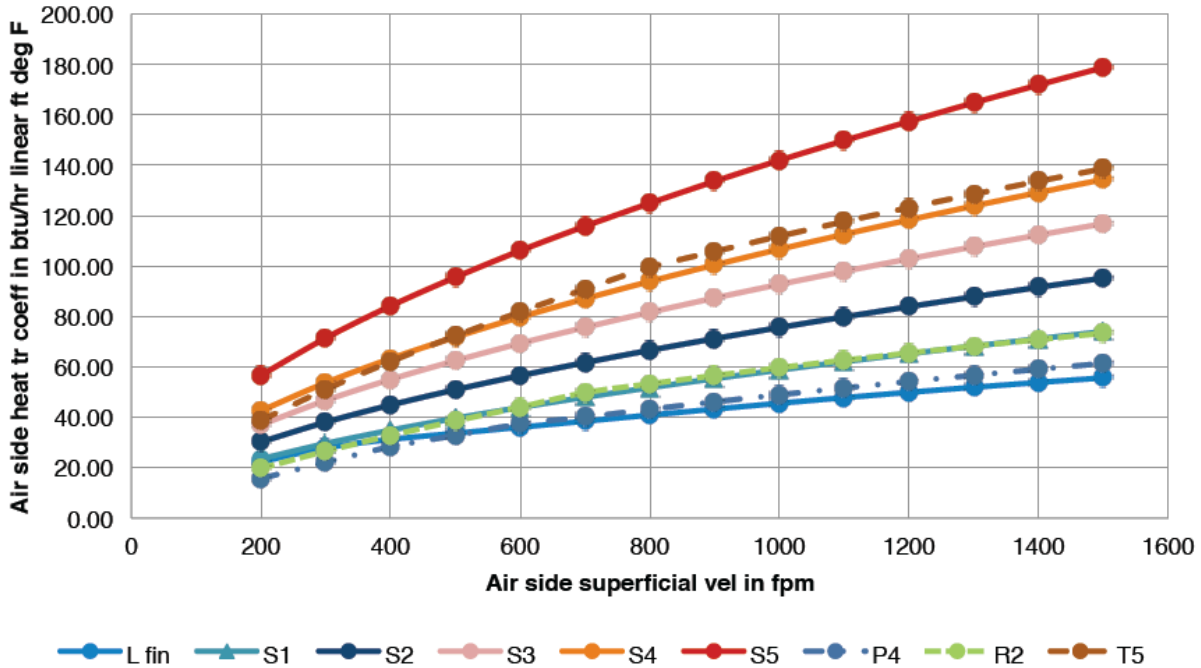
Heat Transfer Coefficient

| | | | | | |
|-----------------------------------|---------------------------|--------|--------|--------|-------|
| Tube side (hi) | btu/hr. ft ² F | 1500 | 1500 | 1500 | 1500 |
| When referred to tube ID/OD (hio) | btu/hr. ft ² F | 1180 | - | - | - |
| with dirt factor (hiod) | btu/hr. ft ² F | 742 | 742 | 742 | 742 |
| linear heat transfer coefficient | btu/hr. ft F | 145.64 | 202.27 | 122.20 | 70.29 |

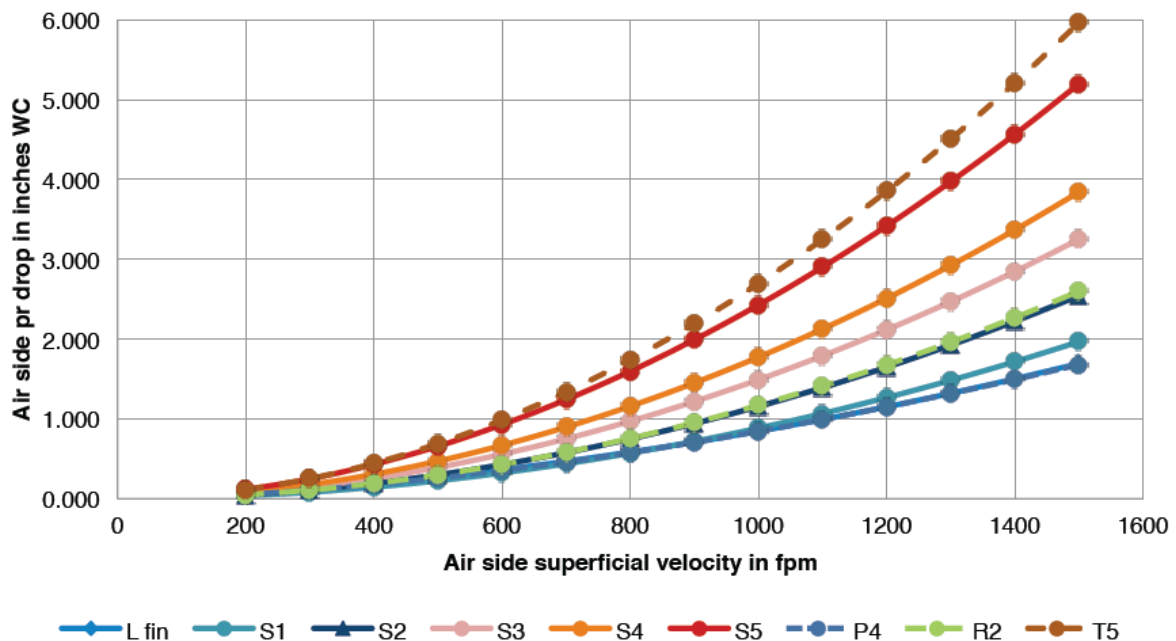
Tube

| | | | | | |
|--------------------|----|------|------|-------|-------|
| OD | in | 0.75 | 1 | 0.625 | 0.375 |
| thk | in | 0.08 | 0.08 | 0.064 | 0.048 |
| ID | in | 0.59 | 0.84 | 0.497 | 0.279 |
| No.of rows | | 3 | 3 | 3 | 3 |
| No. of tubes | | 57 | 51 | 60 | 77 |
| Pitch in row (pir) | mm | 50.8 | 57.2 | 48 | 38 |
| row pitch (Rp) | mm | 38 | 44 | 36 | 28 |

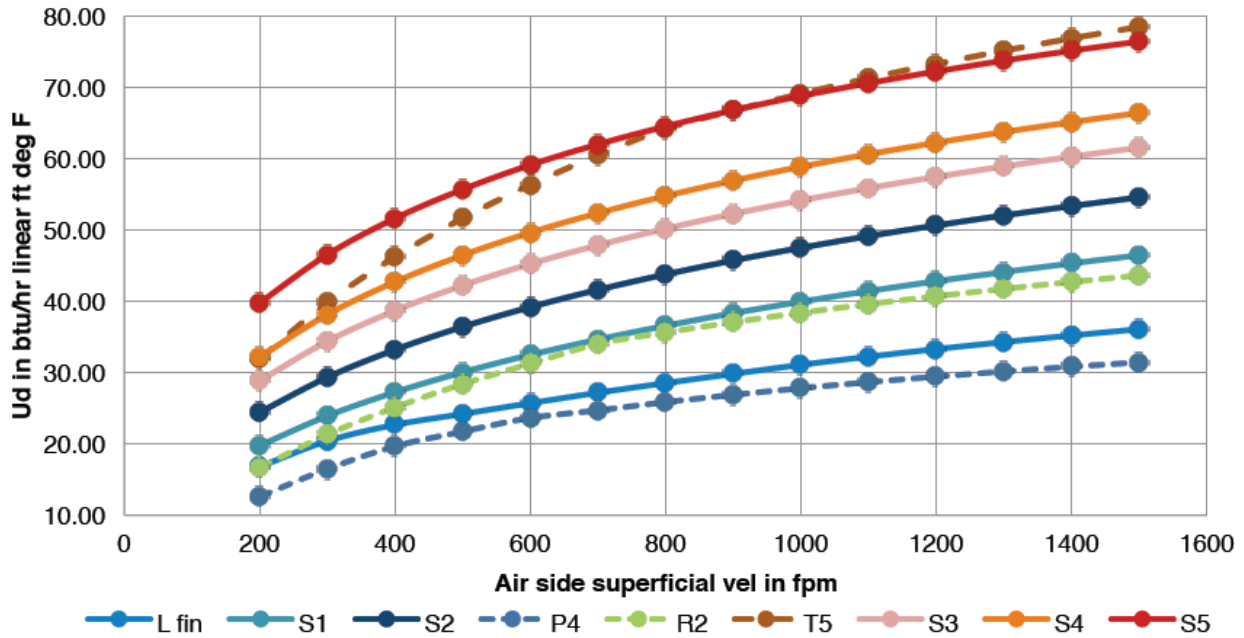
Air side heat transfer coeff linear basis at diff air velocities for diff windings



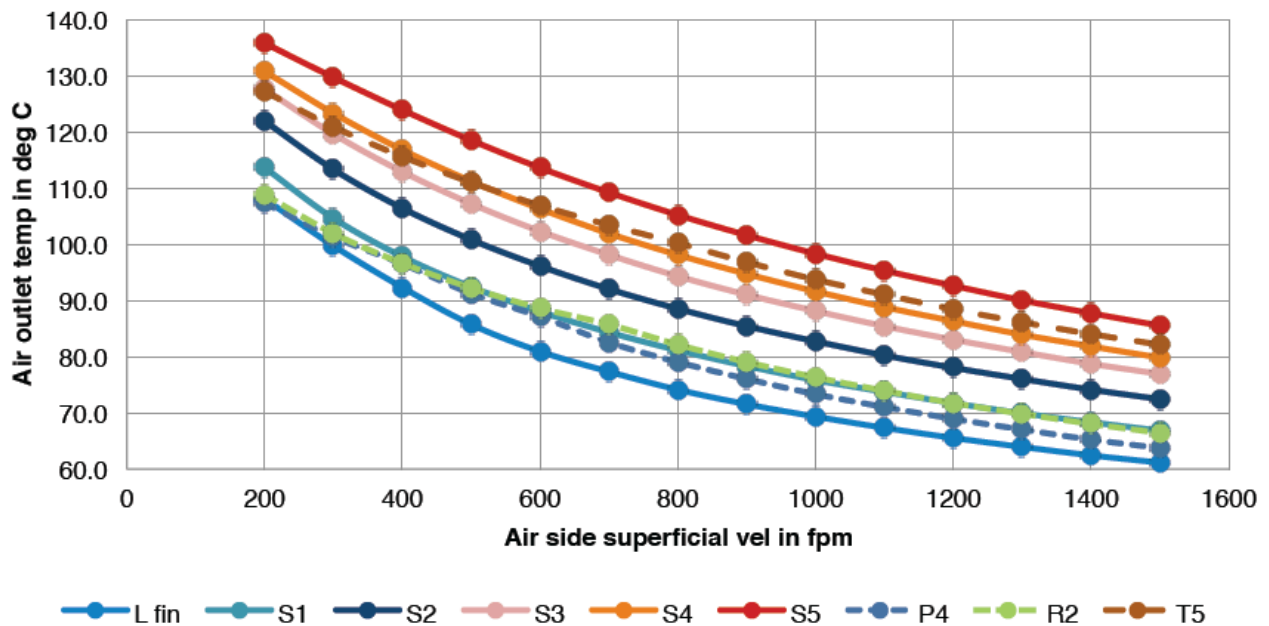
Air side pr drop in inches of WC at diff air vels for diff windings



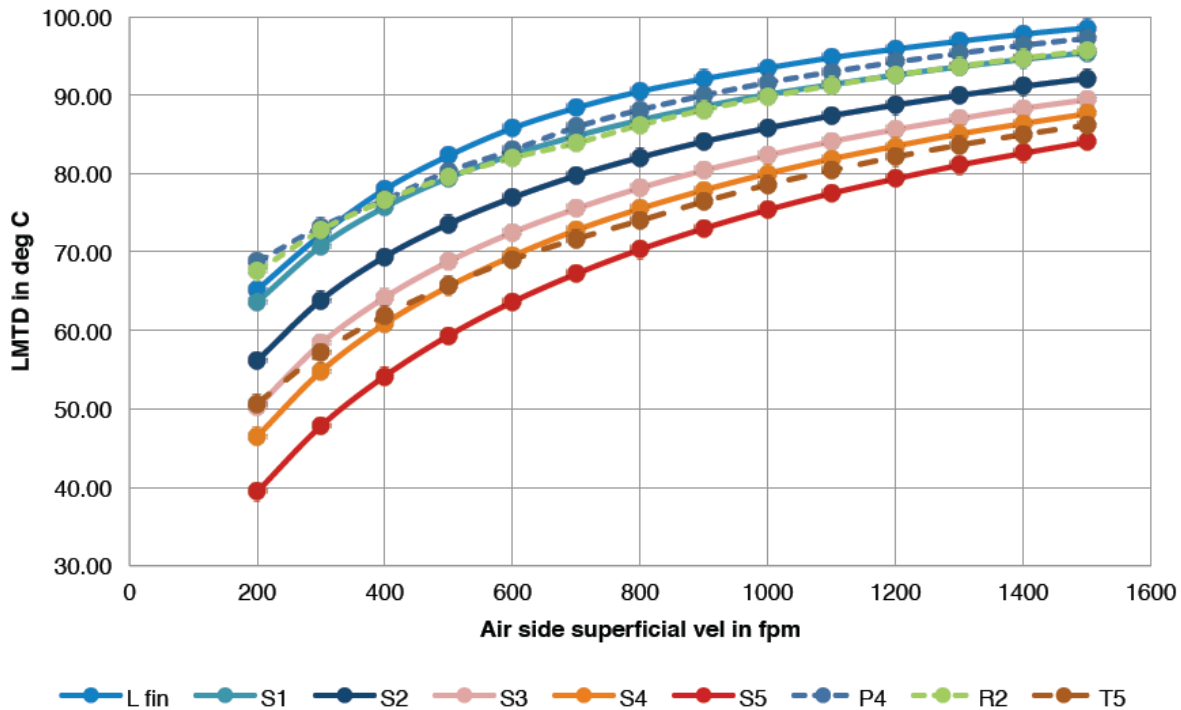
Ud linear basis at diff air vels for diff windings



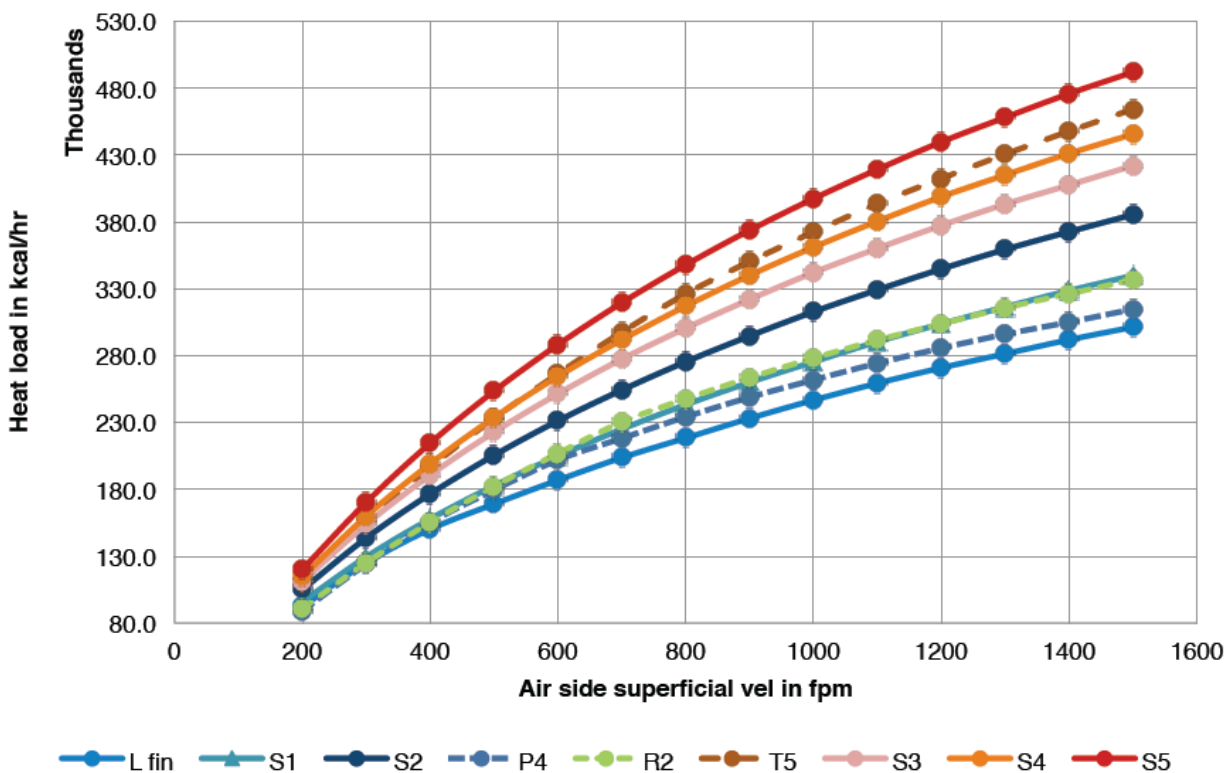
Air outlet temperature in deg C at diff air vels for diff windings



LMTD in deg C at different air velocities for different windings



Heat load in kcal/hr at diff air vels for diff windings



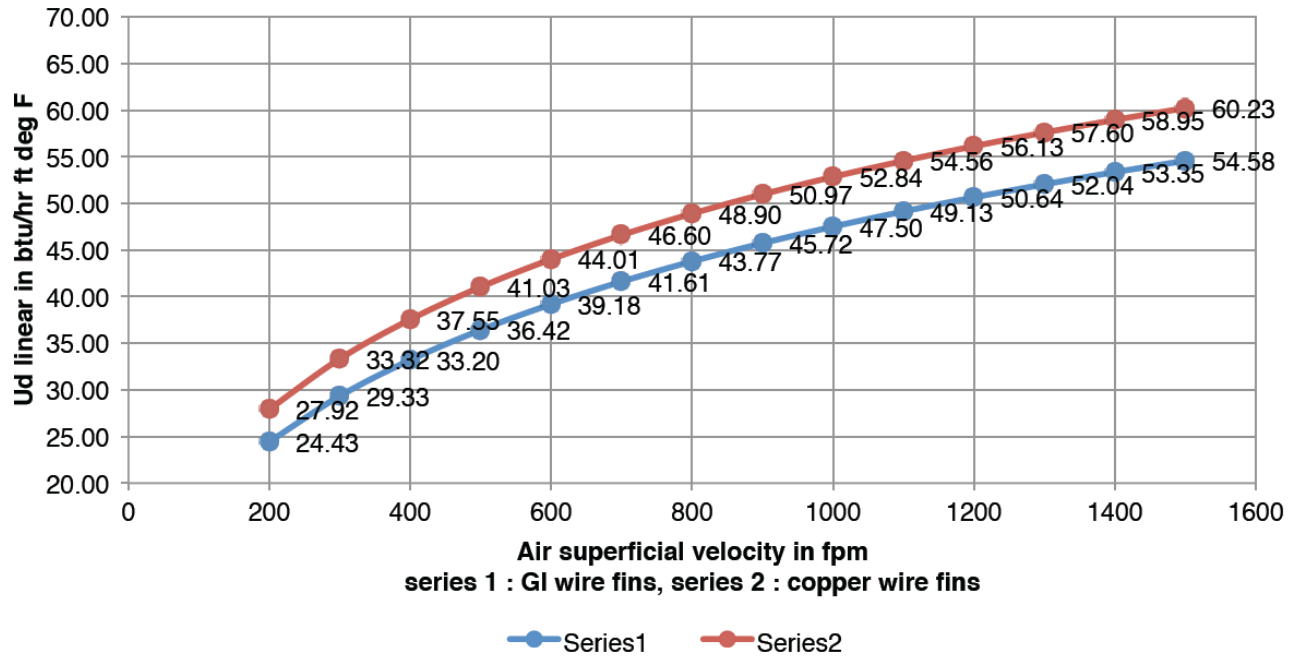
| Air sup velocity fpm | Udlinear | | | | | | | | | | | | | | | Air coefficient | | | | |
|-------------------------|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|-----------------|--------|--------|--|--|
| | btu/hr. ft F | | | | | | | | | | | | | | | btu/hr. ft | | | | |
| | P4 | R2 | L fin | S1 | S2 | S3 | S4 | S5 | T5 | P4 | R2 | L fin | S1 | S2 | S3 | S4 | S5 | T5 | | |
| 200 | 12.61 | 16.69 | 16.80 | 19.76 | 24.43 | 28.86 | 32.19 | 39.79 | 31.92 | 15.68 | 19.75 | 22.32 | 23.48 | 30.21 | 37.05 | 42.61 | 56.70 | 38.76 | | |
| 300 | 16.47 | 21.30 | 20.40 | 23.91 | 29.33 | 34.38 | 38.13 | 46.53 | 39.82 | 22.13 | 26.55 | 27.86 | 29.58 | 38.07 | 46.68 | 53.69 | 71.44 | 51.06 | | |
| 400 | 19.65 | 25.11 | 22.67 | 27.24 | 33.20 | 38.68 | 42.71 | 51.61 | 46.22 | 28.26 | 32.75 | 31.22 | 34.85 | 44.85 | 55.00 | 63.26 | 84.17 | 62.09 | | |
| 500 | 21.73 | 28.38 | 24.20 | 30.04 | 36.42 | 42.21 | 46.45 | 55.68 | 51.64 | 32.79 | 38.55 | 33.63 | 39.59 | 50.93 | 62.45 | 71.83 | 95.55 | 72.27 | | |
| 600 | 23.63 | 31.25 | 25.71 | 32.48 | 39.18 | 45.24 | 49.62 | 59.11 | 56.33 | 37.32 | 44.04 | 36.04 | 43.90 | 56.51 | 69.31 | 79.73 | 106.12 | 81.81 | | |
| 700 | 24.70 | 34.01 | 27.17 | 34.63 | 41.61 | 47.86 | 52.35 | 62.01 | 60.47 | 40.06 | 49.73 | 38.45 | 47.95 | 61.70 | 75.67 | 87.04 | 115.82 | 90.85 | | |
| 800 | 25.85 | 35.62 | 28.53 | 36.57 | 43.77 | 50.17 | 54.76 | 64.53 | 64.18 | 43.17 | 53.25 | 40.85 | 51.74 | 66.58 | 81.65 | 93.91 | 124.94 | 99.48 | | |
| 900 | 26.88 | 37.07 | 29.82 | 38.33 | 45.72 | 52.26 | 56.92 | 66.77 | 66.74 | 46.12 | 56.55 | 43.23 | 55.33 | 71.20 | 87.32 | 100.44 | 133.64 | 105.78 | | |
| 1000 | 27.81 | 38.38 | 31.09 | 39.94 | 47.50 | 54.15 | 58.86 | 68.79 | 69.11 | 48.92 | 59.67 | 45.56 | 58.75 | 75.61 | 92.73 | 106.68 | 141.96 | 111.85 | | |
| 1100 | 28.65 | 39.59 | 32.23 | 41.43 | 49.13 | 55.86 | 60.62 | 70.58 | 71.28 | 51.60 | 62.64 | 47.78 | 62.04 | 79.83 | 97.89 | 112.60 | 149.81 | 117.65 | | |
| 1200 | 29.43 | 40.71 | 33.29 | 42.81 | 50.64 | 57.45 | 62.24 | 72.23 | 73.28 | 54.18 | 65.48 | 49.89 | 65.20 | 83.89 | 102.87 | 118.32 | 157.42 | 123.20 | | |
| 1300 | 30.15 | 41.75 | 34.28 | 44.10 | 52.04 | 58.91 | 63.74 | 73.75 | 75.14 | 56.66 | 68.21 | 51.90 | 68.23 | 87.81 | 107.68 | 123.86 | 164.81 | 128.54 | | |
| 1400 | 30.82 | 42.72 | 35.20 | 45.31 | 53.35 | 60.27 | 65.12 | 75.13 | 76.87 | 59.06 | 70.84 | 53.82 | 71.18 | 91.60 | 112.32 | 129.20 | 171.90 | 133.69 | | |
| 1500 | 31.44 | 43.63 | 36.09 | 46.45 | 54.58 | 61.55 | 66.41 | 76.43 | 78.49 | 61.39 | 73.38 | 55.65 | 74.02 | 95.27 | 116.84 | 134.41 | 178.86 | 138.67 | | |

| Air sup velocity fpm | Air outlet temp | | | | | | | | | | | | | | | Heat load | | | | |
|-------------------------|-----------------|-------|-------|-------|-------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|-----------|--------|--------|--|--|
| | deg C | | | | | | | | | | | | | | | kcal/hr. | | | | |
| | P4 | R2 | L fin | S1 | S2 | S3 | S4 | S5 | T5 | P4 | R2 | L fin | S1 | S2 | S3 | S4 | S5 | T5 | | |
| 200 | 107.3 | 108.8 | 108.1 | 113.6 | 121.9 | 127.60 | 130.80 | 135.80 | 127.2 | 89234. | 90860. | 92400. | 96065. | 105064 | 111245 | 114714 | 120135 | 110811 | | |
| 300 | 101.3 | 101.9 | 99.7 | 104.6 | 113.3 | 119.60 | 123.30 | 129.70 | 120.9 | 124093 | 125069 | 124950 | 129460 | 143610 | 153856 | 159874 | 170282 | 155970 | | |
| 400 | 96.5 | 96.6 | 92.3 | 97.8 | 106.4 | 112.90 | 116.80 | 123.90 | 115.6 | 155049 | 155265 | 150150 | 157868 | 176517 | 190612 | 199070 | 21446 | 19646 | | |
| 500 | 91.2 | 92.2 | 85.7 | 92.4 | 100.8 | 107.20 | 111.20 | 118.50 | 111.0 | 179444 | 182155 | 169050 | 182697 | 205467 | 22281 | 23365 | 253445 | 233115 | | |
| 600 | 87.1 | 88.6 | 80.9 | 88.0 | 96.1 | 102.30 | 106.30 | 113.60 | 106.9 | 201997 | 20687 | 186900 | 204925 | 23127 | 251439 | 264450 | 28819 | 26640 | | |
| 700 | 82.5 | 85.7 | 77.3 | 84.3 | 92.0 | 98.10 | 101.90 | 109.20 | 103.4 | 21820 | 230350 | 20370 | 22503 | 254258 | 277407 | 29182 | 319531 | 29752 | | |
| 800 | 79.0 | 82.1 | 74.1 | 81.1 | 88.5 | 94.30 | 98.10 | 105.20 | 100.2 | 234200 | 247644 | 218400 | 243307 | 275401 | 30055 | 317037 | 34783 | 326145 | | |
| 900 | 76.0 | 79.0 | 71.5 | 78.3 | 85.4 | 91.00 | 94.70 | 101.60 | 96.8 | 248837 | 26347 | 233100 | 260059 | 29470 | 322025 | 34007 | 37374 | 35032 | | |
| 1000 | 73.3 | 76.3 | 69.3 | 75.8 | 82.7 | 88.10 | 91.60 | 98.30 | 93.7 | 261848 | 278112 | 246750 | 275401 | 312808 | 34208 | 361058 | 397381 | 372443 | | |
| 1100 | 71.0 | 73.9 | 67.3 | 73.7 | 80.2 | 85.40 | 88.80 | 95.30 | 91.0 | 27431 | 29161 | 25935 | 29041 | 32918 | 360191 | 38046 | 419228 | 393586 | | |
| 1200 | 68.9 | 71.7 | 65.5 | 71.7 | 78.0 | 83.00 | 86.30 | 92.60 | 88.4 | 285593 | 303809 | 270900 | 303809 | 344794 | 37732 | 398790 | 439775 | 412452 | | |
| 1300 | 67.0 | 69.8 | 63.9 | 69.9 | 76.0 | 80.80 | 83.90 | 90.00 | 86.1 | 296002 | 31573 | 281400 | 31644 | 35943 | 393260 | 415108 | 458099 | 430613 | | |
| 1400 | 65.2 | 68 | 62.4 | 68.3 | 74.1 | 78.70 | 81.80 | 87.70 | 84.0 | 30511 | 326362 | 29190 | 328639 | 372660 | 407573 | 431101 | 475881 | 447799 | | |
| 1500 | 63.7 | 66.4 | 61.1 | 66.8 | 72.4 | 76.90 | 79.80 | 85.50 | 82.1 | 314706 | 336662 | 301350 | 33991 | 385454 | 422048 | 445630 | 491982 | 464334 | | |

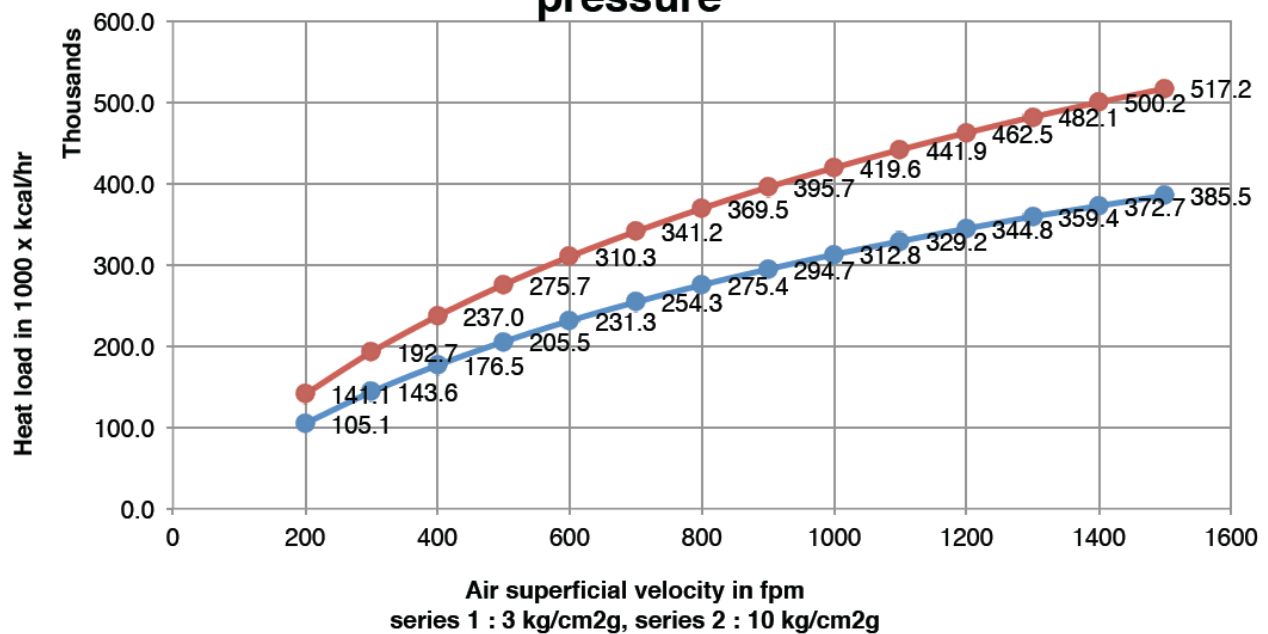
| Air sup velocity fpm | LMTD | | | | | | | | | | | | | | | Air side pr drop in wc | | | | |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------------------------------|-------|-------|--|--|
| | deg C | | | | | | | | | | | | | | | | | | | |
| | P4 | R2 | L fin | S1 | S2 | S3 | S4 | S5 | T5 | P4 | R2 | L fin | S1 | S2 | S3 | S4 | S5 | T5 | | |
| 200 | 68.71 | 67.54 | 65.2 | 63.63 | 56.15 | 50.24 | 46.46 | 39.43 | 50.68 | 0.055 | 0.049 | 0.07 | 0.038 | 0.051 | 0.067 | 0.081 | 0.115 | 0.113 | | |
| 300 | 73.23 | 72.79 | 72.2 | 70.78 | 63.88 | 58.33 | 54.77 | 47.81 | 57.11 | 0.11 | 0.11 | 0.128 | 0.083 | 0.112 | 0.147 | 0.178 | 0.25 | 0.253 | | |
| 400 | 76.66 | 76.59 | 78 | 75.74 | 69.41 | 64.21 | 60.87 | 54.17 | 61.92 | 0.18 | 0.194 | 0.194 | 0.147 | 0.196 | 0.257 | 0.309 | 0.432 | 0.446 | | |
| 500 | 80.29 | 79.61 | 82.3 | 79.48 | 73.59 | 68.79 | 65.61 | 59.34 | 65.78 | 0.262 | 0.301 | 0.273 | 0.227 | 0.302 | 0.394 | 0.473 | 0.66 | 0.692 | | |
| 600 | 83 | 82.02 | 85.8 | 82.41 | 76.94 | 72.5 | 69.49 | 63.63 | 69.02 | 0.357 | 0.43 | 0.368 | 0.325 | 0.43 | 0.56 | 0.671 | 0.93 | 0.99 | | |
| 700 | 85.95 | 83.91 | 88.4 | 84.81 | 79.75 | 75.53 | 72.79 | 67.22 | 71.68 | 0.463 | 0.583 | 0.471 | 0.44 | 0.58 | 0.753 | 0.9 | 1.243 | 1.341 | | |
| 800 | 88.14 | 86.21 | 90.5 | 86.84 | 82.08 | 78.18 | 75.53 | 70.33 | 74.03 | 0.58 | 0.758 | 0.587 | 0.572 | 0.751 | 0.973 | 1.161 | 1.598 | 1.743 | | |
| 900 | 89.99 | 88.14 | 92.1 | 88.58 | 84.1 | 80.42 | 77.91 | 73.01 | 76.45 | 0.708 | 0.954 | 0.711 | 0.721 | 0.944 | 1.22 | 1.453 | 1.994 | 2.195 | | |
| 1000 | 91.62 | 89.81 | 93.5 | 90.11 | 85.83 | 82.35 | 80.02 | 75.39 | 78.6 | 0.846 | 1.173 | 0.847 | 0.887 | 1.158 | 1.493 | 1.775 | 2.429 | 2.697 | | |
| 1100 | 93 | 91.26 | 94.8 | 91.38 | 87.4 | 84.1 | 81.88 | 77.49 | 80.42 | 0.994 | 1.414 | 0.996 | 1.07 | 1.393 | 1.792 | 2.128 | 2.904 | 3.25 | | |
| 1200 | 94.24 | 92.58 | 95.9 | 92.58 | 88.76 | 85.64 | 83.52 | 79.34 | 82.15 | 1.152 | 1.678 | 1.153 | 1.269 | 1.649 | 2.118 | 2.511 | 3.419 | 3.853 | | |
| 1300 | 95.35 | 93.71 | 96.9 | 93.65 | 89.99 | 87.02 | 85.06 | 81.09 | 83.65 | 1.319 | 1.963 | 1.323 | 1.485 | 1.927 | 2.47 | 2.926 | 3.974 | 4.506 | | |
| 1400 | 96.39 | 94.76 | 97.8 | 94.59 | 91.14 | 88.33 | 86.4 | 82.61 | 85 | 1.495 | 2.27 | 1.505 | 1.718 | 2.225 | 2.847 | 3.368 | 4.565 | 5.209 | | |
| 1500 | 97.25 | 95.7 | 98.6 | 95.46 | 92.16 | 89.44 | 87.65 | 84.04 | 86.21 | 1.681 | 2.6 | 1.695 | 1.968 | 2.544 | 3.25 | 3.842 | 5.196 | 5.963 | | |

| Air sup Velocity fpm | ud/panel | | | | | | | | | | | | | | | Air Coefficient | | | | |
|-------------------------|--------------------|------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------|-------|-------|--|--|
| | btu/hr panel deg C | | | | | | | | | | | | | | | btu/hr panel deg C | | | | |
| | P4 | R2 | L fin | S1 | S2 | S3 | S4 | S5 | T5 | P4 | R2 | L fin | S1 | S2 | S3 | S4 | S5 | T5 | | |
| 200 | 3185 | 3284 | 3141 | 3694 | 4568 | 5396 | 6019 | 7438 | 5339 | 3960 | 3886 | 4173 | 4390 | 5648 | 6926 | 7967 | 10600 | 6483 | | |
| 300 | 4161 | 4191 | 3814 | 4470 | 5483 | 6427 | 7129 | 8699 | 6661 | 5590 | 5225 | 5208 | 5531 | 7117 | 8728 | 10039 | 13357 | 8541 | | |
| 400 | 4962 | 4942 | 4239 | 5093 | 6207 | 7231 | 7985 | 9649 | 7732 | 7138 | 6446 | 5837 | 6516 | 8385 | 10283 | 11827 | 15737 | 10387 | | |
| 500 | 5489 | 5585 | 4524 | 5617 | 6808 | 7892 | 8684 | 10410 | 8638 | 8282 | 7586 | 6288 | 7401 | 9522 | 11676 | 13429 | 17864 | 12089 | | |
| 600 | 5969 | 6150 | 4806 | 6072 | 7325 | 8457 | 9278 | 11051 | 9423 | 9426 | 8666 | 6738 | 8208 | 10565 | 12958 | 14907 | 19839 | 13685 | | |
| 700 | 6239 | 6693 | 5080 | 6475 | 7779 | 8947 | 9788 | 11592 | 10116 | 10118 | 9787 | 7189 | 8964 | 11536 | 14147 | 16273 | 21653 | 15197 | | |
| 800 | 6529 | 7010 | 5333 | 6836 | 8184 | 9381 | 10238 | 12064 | 10736 | 10904 | 10480 | 7638 | 9674 | 12448 | 15264 | 17557 | 23360 | 16641 | | |
| 900 | 6789 | 7295 | 5575 | 7165 | 8548 | 9770 | 10641 | 12484 | 11165 | 11647 | 11129 | 8082 | 10345 | 13312 | 16325 | 18778 | 24986 | 17694 | | |
| 1000 | 7023 | 7554 | 5812 | 7467 | 8881 | 10123 | 11005 | 12861 | 11561 | 12355 | 11743 | 8518 | 10984 | 14136 | 17338 | 19944 | 26541 | 18711 | | |
| 1100 | 7237 | 7792 | 6026 | 7745 | 9186 | 10444 | 11333 | 13196 | 11924 | 13033 | 12328 | 8933 | 11599 | 14925 | 18302 | 21051 | 28008 | 19680 | | |
| 1200 | 7433 | 8012 | 6225 | 8004 | 9468 | 10740 | 11636 | 13504 | 12258 | 13683 | 12887 | 9327 | 12189 | 15684 | 19233 | 22121 | 29430 | 20609 | | |
| 1300 | 7614 | 8216 | 6409 | 8245 | 9730 | 11014 | 11916 | 13788 | 12569 | 14311 | 13424 | 9704 | 12757 | 16417 | 20132 | 23158 | 30814 | 21502 | | |
| 1400 | 7783 | 8407 | 6581 | 8472 | 9974 | 11269 | 12175 | 14047 | 12859 | 14917 | 13941 | 10061 | 13308 | 17125 | 21000 | 24155 | 32139 | 22363 | | |
| 1500 | 7940 | 8586 | 6748 | 8685 | 10204 | 11507 | 12417 | 14290 | 13130 | 15505 | 14441 | 10404 | 13840 | 17812 | 21845 | 25129 | 33440 | 23196 | | |

Overall heat transfer coefficient SS fins vs Copper fins



Heat loads 3 kg/cm2g vs 10 kg/cm2g steam pressure



Tables giving maximum air velocity and performance for various tubes at different pressure drop points. (Measured in inches of water column.)

We have after analysis generated the following tables where we have generated the maximum airflow rate possible for every panel given a pressure drop limit. We have set the limit at .5”, 1”, 1.5” and 2” of water column. For this maximum airflow, we have given the corresponding heat transfer parameters. These tables allow us to optimize the tubes and airflow rates to get the desired results.

| 0.5” Water Column | | | | | | | |
|-------------------|--------------|------------------|------------------|----------|-------|-----------|-------------|
| Tube | Air Velocity | Air side Pr Drop | Air Co efficient | Udlinear | LMTD | Heat Load | Outlet temp |
| P4 | 700 | 0.463 | 40.06 | 24.70 | 85.95 | 218207.2 | 82.5 |
| R2 | 600 | 0.430 | 44.04 | 31.25 | 82.02 | 206876.7 | 88.6 |
| L fin | 700 | 0.471 | 38.45 | 27.17 | 88.40 | 203700.0 | 77.3 |
| S1 | 700 | 0.440 | 47.95 | 34.63 | 84.81 | 225038.0 | 84.3 |
| S2 | 600 | 0.430 | 56.51 | 39.18 | 76.94 | 231272.5 | 96.1 |
| S3 | 500 | 0.394 | 62.45 | 42.21 | 68.79 | 222815.3 | 107.20 |
| S4 | 500 | 0.473 | 71.83 | 46.45 | 65.61 | 233657.9 | 111.20 |
| S5 | 400 | 0.432 | 84.17 | 51.61 | 54.17 | 214466.5 | 123.90 |
| T5 | 400 | 0.446 | 62.09 | 46.22 | 61.92 | 196467.8 | 115.60 |
| 1” Water Column | | | | | | | |
| Tube | Air Velocity | Air side Pr Drop | Air Co efficient | Udlinear | LMTD | Heat Load | Outlet temp |
| P4 | 1100 | 0.994 | 51.60 | 28.65 | 93.00 | 274317.6 | 71.0 |
| R2 | 900 | 0.954 | 56.55 | 37.07 | 88.14 | 263475.0 | 79.0 |
| L fin | 1100 | 0.996 | 47.78 | 32.23 | 94.80 | 259350.0 | 67.3 |
| S1 | 1100 | 1.070 | 62.04 | 41.43 | 91.38 | 290418.9 | 73.7 |
| S2 | 900 | 0.944 | 71.20 | 45.72 | 84.10 | 294701.7 | 85.4 |
| S3 | 800 | 0.973 | 81.65 | 50.17 | 78.18 | 300556.7 | 94.30 |
| S4 | 700 | 0.900 | 87.04 | 52.35 | 72.79 | 291828.4 | 101.90 |
| S5 | 600 | 0.930 | 106.12 | 59.11 | 63.63 | 288196.1 | 113.60 |
| T5 | 600 | 0.990 | 81.81 | 56.33 | 69.02 | 266402.5 | 106.90 |
| 1.5” Water Column | | | | | | | |
| Tube | Air Velocity | Air side Pr Drop | Air Co efficient | Udlinear | LMTD | Heat Load | Outlet temp |
| P4 | 1400 | 1.495 | 59.06 | 30.82 | 96.39 | 305110.6 | 65.2 |
| R2 | 1100 | 1.414 | 62.64 | 39.59 | 91.26 | 291611.6 | 73.9 |
| L fin | 1400 | 1.505 | 53.82 | 35.20 | 97.80 | 291900.0 | 62.4 |
| S1 | 1300 | 1.485 | 68.23 | 44.10 | 93.65 | 316441.1 | 69.9 |
| S2 | 1100 | 1.393 | 79.83 | 49.13 | 87.40 | 329181.2 | 80.2 |
| S3 | 1000 | 1.493 | 92.73 | 54.15 | 82.35 | 342083.8 | 88.10 |
| S4 | 900 | 1.453 | 100.44 | 56.92 | 77.91 | 340078.0 | 94.70 |
| S5 | 800 | 1.598 | 124.94 | 64.53 | 70.33 | 347830.4 | 105.20 |
| T5 | 700 | 1.341 | 90.85 | 60.47 | 71.68 | 297520.8 | 103.40 |
| 2” Water Column | | | | | | | |
| Tube | Air Velocity | Air side Pr Drop | Air Co efficient | Udlinear | LMTD | Heat Load | Outlet temp |
| P4 | 1500 | 1.681 | 61.39 | 31.44 | 97.25 | 314706.3 | 63.7 |
| R2 | 1300 | 1.963 | 68.21 | 41.75 | 93.71 | 315736.3 | 69.8 |
| L fin | 1500 | 1.695 | 55.65 | 36.09 | 98.60 | 301350.0 | 61.1 |
| S1 | 1500 | 1.968 | 74.02 | 46.45 | 95.46 | 339915.3 | 66.8 |
| S2 | 1300 | 1.927 | 87.81 | 52.04 | 89.99 | 359432.0 | 76.0 |
| S3 | 1200 | 2.118 | 102.87 | 57.45 | 85.64 | 377322.3 | 83.0 |
| S4 | 1100 | 2.128 | 112.60 | 60.62 | 81.88 | 380466.6 | 88.80 |
| S5 | 900 | 1.994 | 133.64 | 66.77 | 73.01 | 373744.2 | 101.60 |
| T5 | 900 | 2.195 | 105.78 | 66.74 | 76.45 | 350324.2 | 96.80 |

Analysis of the Data generated:

Performance of any Fin tube cooler is a combination of its Air side Coefficient and tubeside coefficient as given by the general formula:

$$U_d = \frac{h'_{fi} \cdot h'_i}{h'_{fi} + h'_i}$$

Where:

U_d = overall heat transfer Coefficient

h'_{fi} = Heat transfer coefficient on fin side of the tube.

h'_i = Heat transfer coefficient inside the tube

From this formula we can see that any increase of the coefficient on one side (Air or tube) will lead to a less than proportional increase in the overall coefficient.

So to get a fair idea of the performance of a fin tube we have to look at both the Airside performance as well as the overall performance to see its individual impact as well as composite impact. We have accordingly in the interest of transparency given both the airside coefficient as well as the overall coefficient.

The lower material consumption per meter of tube offsets in part its greater labor cost giving a surprisingly economical tube. When the lower length of tube required in any equipment is factored in it becomes definitely very cost effective.

Now the findings:

1. In the general Airflow velocity range of 800 to 1200 the pressure drop of S1 pin fin tube is almost identical to the 10 FPI L fin tube. However the airside coefficient is higher by 26-30% similarly the overall coefficient is higher by 28% in the case of 3-bar steam in the tubes.
2. For S5 the overall coefficient is 220% and airside coefficient is 300% of the coefficient of the 10 FPI L fin tube. This implies a reduction to 40% in panel size for the same performance.
3. The wire fin tube hits the pressure drop limit at a lower airflow rate as compared to the L fin tube. However at this lower air flow it has a much higher coefficient than the L fin tube operating at the higher airflow rate giving a higher total heat load. This translates into significant power saving.
4. The outlet Air temperature achieved at different flow rates is higher for the S5 Panel by about 25 degrees centigrade. Again this implies that one can achieve the desired air temperature with a lower number of fin tube rows.
5. Again with the log mean temperature difference we are able to achieve an improvement of about 18-24 degrees between the 10 FPI L fin tube and S5. A tighter LMTD means a much more efficient heat exchanger.
6. Notwithstanding the tight LMTD achieved, the heat load for S5 is higher by 60-61% for S5 compared to the 10 FPI L panel.
7. While the difference is very large for S5 and 10 FPI L fin, it is also substantial when compared with S1, the lowest configuration.
8. Copper fins give a 15% higher airside coefficient and an 8-10% higher overall coefficient as compared to stainless steel or steel fins.

In a nutshell, we can achieve a reduction in number of rows of the steam air heater, by approximately 50%. We can achieve a further reduction in weight as the wire fin tube is much lighter than the L fin tube. (If the same metal is used by over 50%, In case the L fin is made of aluminum the weight may be about the same.) A significant reduction in power consumption is also achieved. We are able to substitute aluminum fins with stainless steel without an increase in cost or weight.

Designing your own exchangers

We have made it easy to design your own exchangers by providing extensive data. Also by presenting the data in the form of 1x1 meter 3 row Panels, and expressing the coefficient in linear terms we have made it easy to predict performance by scaling up these panels in face area or number of rows. We have tried to make it intuitive.

For easy reference we have also given a graph comparing the same panel 3 kgs with 10 kgs steam.

By isolating the airside coefficient, we have made it possible for designers to use the data for any other type of heat exchanger like oil coolers, water coolers or any other air-cooled heat exchangers.

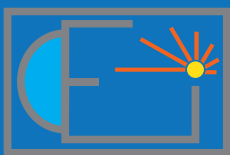
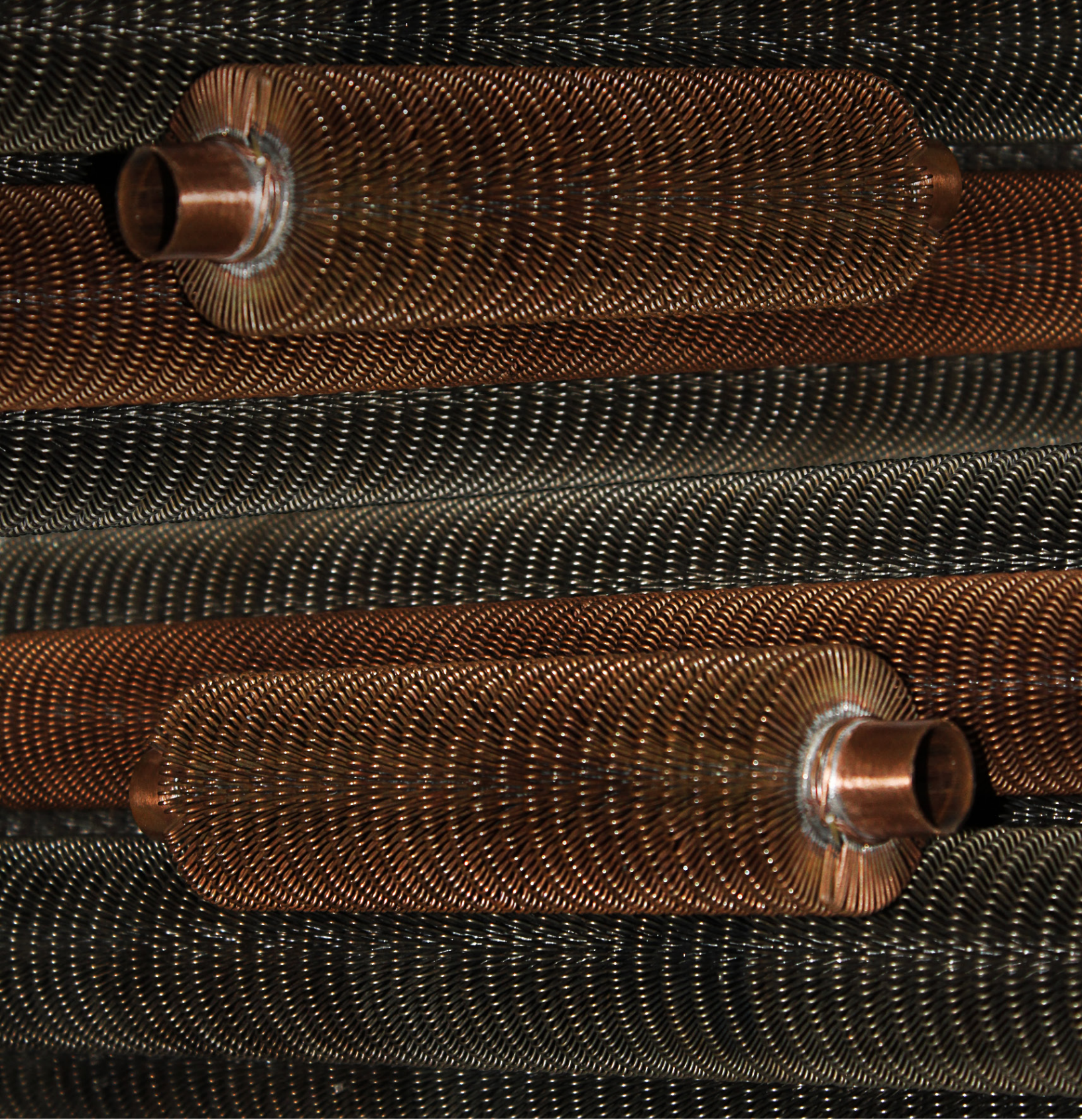
The Data tables have given a color code to values where the typical allowable pressure drops are reached. (.5, 1, 1.5 & 2) inches of water column. This allows you to select the most appropriate tube and airflow rate for a given allowable pressure drop. This allows you to easily optimize your tube type and panel sizing.

Assistance with design

We are willing to work together with you to design your equipment. We charge a very nominal design fee, which we are willing to rebate at the time of order conclusion. Our design capability covers all types of heat exchangers and fin tubes. We generally limit ourselves to process design but can also assist in mechanical design.

Partnership

Concept engineering wishes to work with local companies in all countries. We encourage our local partners to fabricate the heaters themselves using our fin tubes, turbulators, components and design capability. This makes it possible for companies with Fabrication capacity but limited heat exchanger design capability to partner with us to successfully make and market heat exchangers. Of course we are looking at sustained partnerships with a win win perspective.



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