FLUID POWER Design Data Sheet-

Womack

Revised Sheet 1 – Womack Design Data File

COOLING AN OVERHEATED HYDRAULIC SYSTEM

This chart has been prepared for use with an existing hydraulic system which runs at too high a temperature. It may be used to estimate heat exchanger capacity which must be added to reduce the oil temperature to an acceptable level.

Before using the chart, allow the hydraulic system to run for several hours under full load, or until the reservoir oil temperature has stabilized at its highest level. Then, measure the room temperature near the reservoir, and measure the temperature of the metal surface on the side of the reservoir. Also measure the area, in square feet, of all exposed metal surfaces of the reservoir including all four sides, top, and bottom.

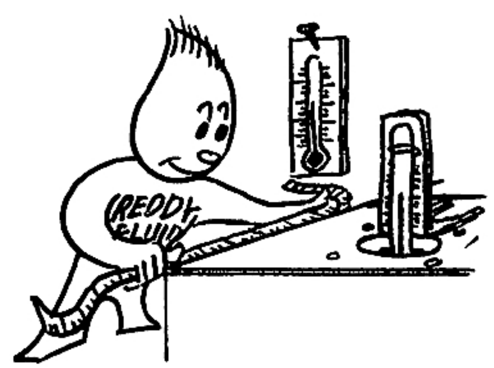
Figures in the body of the chart show heat, in HP, which is now being radiated from the overheated system. HP heat values may be converted, if desired, to BTU per hour with this formula: *1 HP = 2545 BTU per hour.*

Sq. Ft.	Temperature Difference, in Degrees F, Between Oil in Tank & Surrounding Air																		
Surface	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	110	120	130	140
10	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.10	1.20	1.30	1.40
15	0.45	0.53	0.60	0.68	0.75	0.83	0.90	0.98	1.05	1.13	1.20	1.28	1.35	1.43	1.50	1.65	1.80	1.95	2.10
20	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.20	2.40	2.60	2.80
25	0.75	0.88	1.00	1.13	1.25	1.38	1.50	1.63	1.75	1.88	2.00	2.13	2.25	2.38	2.50	2.75	3.00	3.25	3.50
30	0.90	1.05	1.20	1.35	1.50	1.65	1.80	1.95	2.10	2.25	2.40	2.55	2.70	2.85	3.00	3.30	3.60	3.90	4.20
35	1.05	1.23	1.40	1.58	1.75	1.93	2.10	2.28	2.45	2.63	2.80	2.98	3.15	3.33	3.50	3.85	4.20	4.55	4.90
40	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00	4.40	4.80	5.20	5.60
45	1.35	1.58	1.80	2.03	2.25	2.48	2.70	2.93	3.15	3.38	3.60	3.83	4.05	4.28	4.50	4.95	5.40	5.85	6.30
50	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.50	6.00	6.50	7.00
60	1.80	2.10	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00	6.60	7.20	7.80	8.40
70	2.10	2.45	2.80	3.15	3.50	3.85	4.20	4.55	4.90	5.25	5.60	5.95	6.30	6.65	7.00	7.70	8.40	9.10	9.80
80	2.40	2.80	3.20	3.60	4.00	4.40	4.80	5.20	5.60	6.00	6.40	6.80	7.20	7.60	8.00	8.80	9.60	10.4	11.2
90	2.70	3.15	3.60	4.05	4.50	4.95	5.4	5.85	6.30	6.75	7.20	7.65	8.10	8.55	9.00	9.90	10.8	11.7	12.6
100	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.0	11.0	12.0	13.0	14.0
110	3.30	3.85	4.40	4.95	5.50	6.05	6.60	7.15	7.70	8.25	8.80	9.35	9.90	10.5	11.0	12.1	13.2	14.3	15.4
120	3.60	4.20	4.80	5.40	6.00	6.60	7.20	7.80	8.40	9.00	9.60	10.2	10.8	11.4	12.0	13.2	14.4	15.6	16.8
130	3.90	4.55	5.20	5.85	6.50	7.15	7.80	8.45	9.10	9.75	10.4	11.1	11.7	12.4	13.0	14.3	15.6	16.9	18.2
140	4.20	4.90	5.60	6.30	7.00	7.70	8.40	9.10	9.80	10.5	11.6	11.9	12.6	13.3	14.0	15.4	16.8	18.2	19.6
150	4.50	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.5	11.3	12.0	12.8	13.5	14.3	15.0	16.5	18.0	19.5	21.0
175	5.25	6.13	7.00	7.88	8.75	9.63	10.5	11.4	12.3	13.1	14.0	14.9	15.8	16.6	17.5	19.3	21.0	22.8	28.0
200	6.00	7.00	8.00	9.00	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	22.0	24.0	26.0	28.0

INSTRUCTIONS FOR USE OF THE CHART

Take the measured temperature difference between tank surface temperature and room temperature and enter the appropriate column of the chart. At the intersection of this column with the line showing the measured square foot surface of the reservoir, the figure in the chart shows the HP heat which is presently being radiated from the walls of the reservoir.

Next, decide what temperature you would like to maintain. Take the difference between this selected temperature and the room temperature. Enter the chart in the column headed by this new temperature difference, and again using the measured tank surface area find the HP that can be radiated from the reservoir without exceeding the selected maximum temperature. Subtract this value from the heat value previously found in the chart. The difference between these two values is the heat exchanger capacity which must be added to supplement the natural heat radiation capacity of the reservoir.



Measure Air/oil Temperature Difference and Tank Area.

EXAMPLE OF USE OF CHART

Example: Presently a hydraulic system is running at 210°F in a room where the temperature is 80°F, so the T.D. (temperature difference) between air and oil is 130°F. The reservoir has a total surface area of 90 square feet. Desired to reduce system oil temperature to 140°F.

Solution: Enter the chart in the column marked "130". For a tank with 90 square feet of surface, the chart shows the present heat radiation to be 11.7 HP. At the desired oil temperature of 140°F there will be a T. D. of 60°F between air and oil. In the chart column headed "60", a value of 5.4 HP is shown. This is the maximum heat which can be radiated from the tank surface without exceeding 140°F oil temperature. The heat difference (11.7 - 5.4 = 6.3 HP) must be radiated by adding a heat exchanger to the system.

Note: Values in the chart on the opposite side of this sheet have been calculated from the formula:

HP = 0.001 x Area (sq. ft.) x T.D. (in °F)

This formula expresses the approximate amount of heat which can be radiated from a steel surface exposed to air on one side and to hydraulic oil of 0.9 specific gravity, 0.46 specific heat, and 150 SSU (at 100°F) viscosity.

Values in the chart must be considered as approximate since there are several variables such as rate of oil circulation, rate of air circulation, thickness of tank walls, viscosity of the oil, and possibly some others. The chart is presented as a means of estimating the amount of additional cooling capacity needed. The heat exchanger added to the system can be oversized if operating conditions seem unfavorable.

USEFUL FORMULAE FOR HEAT CALCULATIONS

HEAT LOAD FORMULAE:

Heat load on the water side of a shell and tube heat exchanger: *BTU per hour = GPM x 500 x T.D.,* where T.D. is the temperature difference between inlet and outlet water in degrees F.

Heat load on the oil side of a shell and tube heat exchanger: *BTU per hour = GPM x 210 x T.D.* where T.D. is the temperature difference between inlet and outlet oil in degrees F.

HEAT & POWER EQUIVALENTS:

1 HP = 2545 BTU per hour = 42.4 BTU per minute.
1 HP = 746 Watts electrical equivalent.
1 BTU/hr = .000393 HP = .017 BTU/min = .293 Watts.
1 BTU/min = .0167 BTU/hr = .0236 HP = 17.6 Watts.

HEAT RADIATION FROM STEEL RESERVOIRS:

HP (heat) = .001 x T.D. x A, where A is surface area in square feet, T.D. is temperature difference in degrees F between reservoir and surrounding air.

HEAT GENERATED IN A SYSTEM:

Heat goes into the hydraulic oil at every place in the system where there is a PSI pressure loss due to flow of oil without mechanical work being produced. Pressure relief, pressure reducing, and flow control valves are the most common heat generators in the system. Hydraulic pumps and motors have a power loss of about 15% of their input power and most of this goes into heat. Power loss (and heat build-up) caused by valving can be estimated as follows:

HP loss = PSI x GPM ÷ 1714, or
BTU/hr heat loss = 1.5 x PSI x GPM

The PSI for calculating power loss in a flow control valve, for example, is the inlet PSI minus the outlet PSI, or, the PSI pressure drop across the valve while oil is flowing.

Sometimes power loss occurs only intermittently, and to find the amount of heat that will go into the oil, the *average* power loss should be figured. Usually, taking an average over a 1-hour period of operation should be sufficiently accurate.

HEAT EXCHANGER FOR A NEW SYSTEM DESIGN:

The chart on the opposite side of this sheet can be used to estimate whether a heat exchanger will be needed on the design of a new system. Calculate as many of the expected power losses as possible, using 85% efficiency for each hydraulic pump or motor. Calculate power losses across relief, reducing, and flow control valves, and calculate the average losses over a period of 1 hour.

Calculate these average losses in HP (or if in BTU/hr, divide by 2545 to convert to HP). Using square foot surface of the proposed reservoir and desired maximum T.D. between oil and surrounding air, check the chart to see whether the expected HP in heat can be radiated from a reservoir of the proposed size, or whether additional cooling with a heat exchanger should be added.

RULE-OF-THUMB FOR HEAT EXCHANGERS:

Each square foot of tube surface in a shell and tube heat exchanger will transfer approximately 2.16 HP (5500 BTU/hr) under conditions of 50°F temperature difference between oil and water, using oil with viscosity of 150 SSU (measured at 100°F).

ELECTRICAL POWER FOR HEATING OIL:

If a heating element is to be added to the hydraulic oil reservoir to keep the oil warm during periods when the system is shut down and is subjected to cold weather, conditions, use the following rule-of-thumb to estimate the electrical wattage which will probably be needed to maintain the oil at a temperature above the surrounding atmosphere.

For every square foot of exposed metal tank surface, about 7.5 Watts will be needed for every 10°F of oil temperature above ambient temperature.

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