Technical Reference

Related Formulas

$$\text{MASS FLOW RATE} = \text{VOL FLOW RATE x DENSITY}$$

$$\text{CENTIPOSE} = \text{CENTISTOKES x SPECIFIC GRAVITY}$$

$$\text{SCFM} = \text{FACE AREA (ft}^2\text{) x FACE VELOCITY (sfpm)}$$

$$\text{PRESSURE (psi)} = \frac{\text{FORCE (pounds)}}{\text{AREA (in}^2\text{)}}$$

$$\text{VOL FLOW RATE(gpm)} = \frac{\text{VOLUME (gallons)}}{\text{TIME (minutes)}}$$

$$\text{INPUT POWER (hp)} = \frac{\text{PRESSURE (psig) x FLOW (gpm)}}{1714}$$

$$\text{VEL THROUGH PIPING (ft/s)} = \frac{\text{0.3208 x FLOW RATE (gpm)}}{\text{INTERNAL AREA (in}^2\text{)}}$$

$$\text{SPECIFIC GRAVITY OF A FLUID} = \frac{\text{WT OF ONE CUBIC FT OF FLUID}}{\text{WT OF ONE CUBIC FT OF WATER}}$$

$$\text{PUMP OUTLET FLOW (gpm)} = \frac{\text{RPM x PUMP DISPLACEMENT (in /rev)}}{231}$$

$$\text{PUMP INPUT POWER (hp)} = \frac{\text{FLOW RATE OUTPUT (gpm) x PRESSURE (psig)}}{\text{1714 x OVERALL EFFICIENCY}}$$

$$\text{OVERALL PUMP EFFICIENCY (\%)} = \frac{\text{OUTPUT HORSEPOWER x 100}}{\text{INPUT HORSEPOWER}}$$

$$\text{OVERALL PUMP EFFICIENCY (\%)} = \text{VOL EFF. X MECHANICAL EFF.}$$

$$\text{VOL PUMP EFFICIENCY (\%)} = \frac{\text{ACTUAL FLOW RATE OUTPUT (gpm) x 100}}{\text{THEORETICAL FLOW RATE OUTPUT (gpm)}}$$

$$\text{MECHANICAL PUMP EFFICIENCY (\%)} = \frac{\text{THEORETICAL TORQUE TO DRIVE x 100}}{\text{ACTUAL TORQUE TO DRIVE}}$$

$$\text{PUMP DISPLACEMENT (in}^3\text{/rev)} = \frac{\text{FLOW RATE (gpm) x 231}}{\text{PUMP RPM}}$$

$$\text{PUMP TORQUE (inlbs)} = \frac{\text{HORSEPOWER x 63025}}{\text{RPM}}$$

$$\text{PUMP TORQUE (inlbs)} = \frac{\text{PRESSURE (psig) x PUMP DISPLACEMENT (in /rev)}}{2\pi}$$

$$\text{RESERVOIR COOLING CAPACITY (BTU/HR)} = \text{2 x } \triangle\text{T BETWEEN RESERVOIR WALLS AND AIR (°F) x RESERVOIR AREA (ft}^2\text{)}$$

$$\text{HEAT IN HYDRAULIC SYSTEM DUE TO UNUSED FLOW/PRESSURE (BTU/HR} = \text{FLOW RATE(gpm) x 1.485 x PRESSURE DROP (psig)}$$

Heat Transfer in Fluids

General

Most fluid power systems require a method of heat transfer (dissipation or absorption).

Producing Heat

The energy loss is caused by inefficiencies of the energy process. Some of these losses contribute to the fluid heating. Heat is also produced by passing pressurized fluid through orifices, valves, and piping where a pressure drop occurs. Keeping these pressure drops to a minimum conserves performance and reduces costs. The following table shows the types of systems that will have losses to the fluid and/or the reservoir:

System	% Loss
Simple circuits with minimal valves	25%
Simple circuits with cylinders	28%
Simple circuits with fluid motors	31%
Hydrostatic transmissions	35-40%
Servo based systems	55%
Low pressure fluid transfer systems	15%

These losses are expressed in unites of power, e.g., HP, KW and BTU/HR. Heat problems are usually expressed in HP or KW in terms of the work expanded and losses absorbed. Cooling problems are usually expressed in BTU/HR.

Conversion and Formula Summary

There are many conversions and formulas used in selecting oil coolers. This will be a brief summary of those most commonly used.

Conversions

- HP = (BTU/HR) / 2545 = (BTU/min) / 42.4 = KW/.746, or BTU/HR = HP x 2545; BTU/min = HP x 42.4; KW = HP x .746
- GPM = (L/min) / 3.78 or L/min = GPM x 3.78
- °F = (1.8 x °C) + 32 or °C = (°F - 32) / 1.8
- Mobil Series: Air Velocity SFPM = SCFM/Face Area in FT^2, or SCFM = FT^2 Face Area x Face Velocity SFPM

Methods to Determine Heat Loads

- Hydraulic oil cooling: Assume 30% of the input horsepower will be rejected to heat. If the input horsepower is unknown, this formula may be used: BTU/HR = (System PSI) x (GPM Flow) x 1.8 x .3
- Hydrostatic oil cooling: Assume 25% of the input horsepower will be rejected to heat.
- Automatic transmission: Assume 30% of the engine horsepower will be rejected to heat.
- Engine oil cooling: Assume 10% of the engine horsepower will be rejected to heat.

Heat Loads

- BTU/HR = (Input Horsepower) x (2545) x (.25 – .5)
- BTU/HR = (System GPM Capacity) x (System Pressure) x (1.8) x (.25 –5)
- BTU/HR = (PSI Pressure Drop) x (GPM Oil Flow) x (1.5) x (% Time)
- BTU/HR = (Horsepower to Gearbox) x (2545 x (.05 – .5)
- BTU/HR = (Compressor HP) x (1.1) x (.85) x (2545)
- BTU/HR = (Max Temp. Rise °F/HR) x (Gallons of Oil Changing Temp.) x (3.5)
- BTU/HR = (GPM Oil Flow) x (Oil ΔT) x (210)

Conversions

°F = (1.8 x °C)+32

BAR = PSI ÷ 14.5

BTU/hr = WATTS ÷ .2931

BTU/min = KW ÷ .01757

ft^2 = in^2 ÷ 144

ft^2 = mm^2 ÷ 92900

GPM = L/min ÷ 3.78

HP = BTU/hr ÷ 2545

HP = BTU/min ÷ 42.41

HP = KW ÷ 0.746

in^2 = mm^2 ÷ 645.2

in^3 = GAL ÷ .004329

in^3 = LITERS ÷ .01639

m^3 = GAL ÷ 264.2

m^3 = LITERS ÷ 1000

mm = 25.4 x in

PSIG = PSIA - 14.7

1 ton = 12,000 BTU/HR

$$\frac{KW}{°C} = \frac{HP}{°F} \times 1.343$$

Temperature Changes

- Oil ΔT = (BTU/HR) / (GPM Oil Flow x 210)
- Water ΔT = (BTU/HR) / (GPM Water Flow x 500)
- 50/50 Ethylene Glycol ΔT = (BTU/HR) / (GPM Flow x 432)
- Air ΔT = (BTU/HR) / (SCFM Air Flow x 1.08)

Temperature Changes

Water Cooled: $$\text{HP curve} = \frac{\text{HP Heat x 40 x Correction A}}{\text{(Oil outlet °F - Water inlet °F)}}$$

AO Series: (except AOL) $$\text{HP curve} = \frac{\text{HP Heat x 100}}{\text{(Oil outlet °F - Ambient air °F)}}$$

AOL Series: $$\text{HP curve} = \frac{\text{HP Heat x 100}}{\text{(Oil inlet °F - Ambient air °F)}}$$

Mobile Series: $$\text{BTU/HR curve} = \frac{\text{HP Heat x 2545 x 100}}{\text{(Oil inlet °F - Ambient air °F)}}$$

Centistokes to Saybolt Universal Seconds Conversion