COLMAC COIL MANUFACTURING, INC

"The Heat Transfer Experts"

Who We Are

Founded in 1971, Colmac Coil Manufacturing initially supplied heating and cooling coils to OEM customers and the HVAC industry. By the early 1980's Colmac Coil had expanded their refrigeration product line to include industrial air coolers and condensers for the ammonia refrigeration industry, developing a reputation for high quality products and the ability to engineer a wide range of heating and cooling solutions using their in-house developed heat and mass transfer modeling software.

Our Mission

The mission of Colmac Coil is to provide heat transfer markets worldwide with innovative, cost effective products that are configured, manufactured, and shipped with the shortest lead times in the industry, with fast, friendly service, for the mutual benefit of our employees, customers, and shareholders.

Our Products

- Refrigeration Evaporators
- Fluid Coolers & Condensers
- Heating & Cooling Coils
- Heat Pipes
- Hygienic Air Handlers

Our Customers

Colmac Coil serves a wide variety of markets and customers with an emphasis in the following industries:

- Industrial Refrigeration
- HVAC
- Power Generation
- Process Cooling

COLMAC'S ENGINEERING TOOLBOX CALCULATORS AND DESIGN TOOLS

Access Colmac's Engineering Toolbox by signing up at:
www.colmaccoil.com

SCAN ME

The suite of powerful engineering calculators includes:

- Air Properties
- Air Throw
- ASHRAE Weather Data Viewer
- Baker Map
- Brine Properties
- Fan Calculator
- Fan Power Calculator
- Frost Melt Calculator
- Graduated Orifices Calculator
- MAWP Calculator
- Orifice Calculator
- Climate Data
- Refrigerant Charge Calculator
- Refrigerant Properties
- Sensible and Latent Heat Load Calculator
- Single Phase Pressure Drop
- Sound Calculator
- Plate Fin Surface Area
- Two Phase Pressure Drop
- Vertical Riser Calculator

QUALITY PRODUCTS FROM COLMAC COIL

COLMAC COIL Manufacturing Inc.

www.colmaccoil.com

"The Heat Transfer Experts"
Since 1971

North American Headquarters
Colmac Coil Manufacturing, Inc.
370 N. Lincoln St. | P.O. Box 571
Colville, WA 99114 | USA
+1.509.684.2595 | +1.800.845.6778

Midwest US Manufacturing
Colmac Coil Midwest
350 Baltimore Dr.
Paxton, IL 60957 | USA

CRN

ASME Sec. VIII, Canadian Registration Number, UL508, UL207

CO_2 REFRIGERATION REFERENCE GUIDE

COLMAC COIL Manufacturing Inc.

REFRIGERANT COMPARISON

Refrigerant	Natural R-744	Natural Ammonia	HFC R-404A	HFC R-134a	HFC R-407A	HFC R-407F	HCFC R-22	HFO R-1234yf
Temperature at atmospheric pressure	-109.3°F (Temp. of the dry ice)	-28.01°F	-50.8°F (Saturation temp.)	-14.9°F (Saturation temp.)	-41.8°F (Mid point saturation temp.)	-45.4°F (Mid point saturation temp.)	-41.8°F (Saturation temp.)	-22°F (Saturation temp.)
Critical Temperature	87.8°F	271°F	161.7°F	213.9°F	177.8°F	180.9°F	205.1°F	202.5°F
Critical Pressure	1070 psia	1657 psia	548 psia	588.8 psia	659 psia	688.75 psia	723.7 psia	493 psia
Triple-Point Pressure	75.1 psia	0.88 psia	3.2 psia	0.06 psia	1.5 psia	1.5 psia	<0.073 psia	TBC
Pressure at a saturated temperature of 68°F	826.7 psia	124.3 psia	158.1 psia	82.7 psia	136.3 psia	143.3 psia	131.9 psia	68.0 psia
Global Warming Potential	1	0	3922	1430	2170	1824	1790	4

A REFRIGERANT FOR THE FUTURE R744

CO2 as a refrigerant is becoming an increasingly popular option for a wide range of industrial refrigeration applications. Colmac Coil has developed tools and a comprehensive product offering to provide the market with the evaporators needed for any type of CO2 industrial refrigeration system being installed today.

CO2 Refrigeration System Types

- Trans-critical
- CO_2 Cascade With Lowside Compression
- CO_2 Cascade Volatile Brine

CO2 AS A REFRIGERANT

- Low toxicity and non-flammable
- Future proof: A1 classification and unregulated status
- Equipment is becoming more available and cost effective
- Removes ammonia from the space
- Natural refrigerant with a low global warming potential (GWP) and ozone depletion potential (ODP)
- Highly efficient at low temperature applications

HELPFUL EQUATIONS

Sensible heating and cooling:

$$Q = M * Cp * \Delta T$$

Where: Q = The amount of heat transferred to or from the fluid (BTU/hr)

M = Mass flow rate of the fluid (lb/hr)
Cp = Specific heat of the fluid (BTU/lb-°F)
ΔT = The change in temperature of the fluid (°F)

Qair = 1.085 * SCFM * (Entering Air Temperature - Leaving Air Temperature)

Heat loss by conduction:

$$Q = \frac{k \times A \times \Delta T}{t}$$

Where:
k = Thermal conductivity of materials (Btu-in/h ft² °F) or (Btu-ft/h ft² °F);
A = Area, ft²;
ΔT = Average temperature difference across the material, (F°);
t = Thickness of a wall of some material (in).

Total heating and cooling (including latent heat)

$$Q = M * \Delta H$$

Where: Q = The amount of heat transferred to or from the fluid (BTU/hr)

M = Mass flow rate of the fluid (lb/hr)
ΔH = The change in enthalpy of the fluid (BTU/lb)

Latent heat transfer

$$Q_{latent} = Q_{tot} - Q_{sens}$$

Sensible heat ratio (SHR)

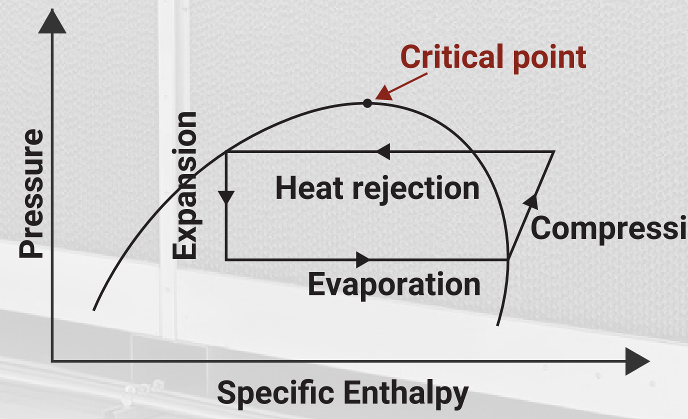
$$SHR = \frac{Q_{sens}}{Q_{tot}}$$

Q_{sens} = Sensible heat transfer
Q_{tot} = Total heat transfer

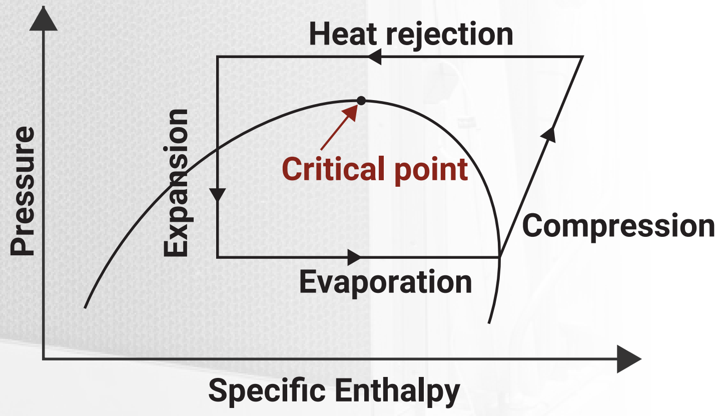
COP:

COP (coefficient of performance) = Desired Output (cooling) / Required Input (work done)

Subcritical



Trans-critical

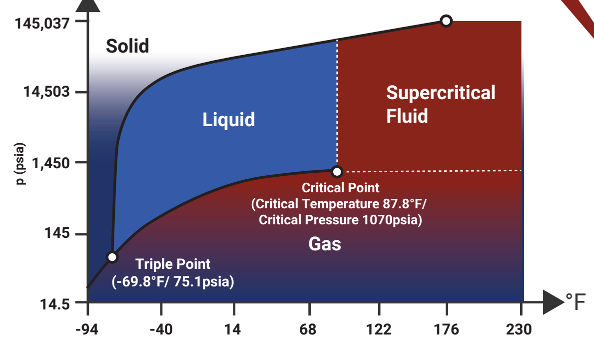


CO_2 SATURATION PRESSURE TEMPERATURE DATA

Temp °F	CO2 (R-744) Pressure psi (g)	CO2 (R-744) Pressure bar (g)	Temp °C	Temp °F	CO2 (R-744) Pressure psi (g)	CO2 (R-744) Pressure bar (g)	Temp °C
-39	134.2	9.3	-39.4	25	440.9	30.4	-3.9
-38	137.2	9.5	-38.9	26	447.8	30.9	-3.3
-37	140.3	9.7	-38.3	27	454.8	31.4	-2.8
-36	143.5	9.9	-37.8	28	461.9	31.8	-2.2
-35	146.7	10.1	-37.2	29	469.0	32.3	-1.7
-34	149.9	10.3	-36.7	30	476.3	32.8	-1.1
-33	153.2	10.6	-36.1	31	483.6	33.3	-0.6
-32	156.5	10.8	-35.6	32	491.0	33.9	0
-31	159.9	11.0	-35.0	33	498.5	34.4	0.6
-30	163.3	11.3	-34.4	34	506.0	34.9	1.1
-29	166.8	11.5	-33.9	35	513.6	35.4	1.7
-28	170.3	11.7	-33.3	36	521.4	35.9	2.2
-27	173.9	12.0	-32.8	37	529.2	36.5	2.8
-26	177.5	12.2	-32.2	38	537.1	37.0	3.3
-25	181.2	12.5	-31.7	39	545.0	37.6	3.9
-24	185.0	12.8	-31.1	40	553.1	38.1	4.4
-23	188.7	13.0	-30.6	41	561.2	38.7	5.0
-22	192.6	13.3	-30.0	42	569.5	39.3	5.6
-21	196.5	13.5	-29.4	43	577.8	39.8	6.1
-20	200.4	13.8	-28.9	44	586.2	40.4	6.7
-19	204.4	14.1	-28.3	45	594.7	41.0	7.2
-18	208.5	14.4	-27.8	46	603.2	41.6	7.8
-17	212.6	14.7	-27.2	47	611.9	42.2	8.3
-16	216.7	14.9	-26.7	48	620.7	42.8	8.9
-15	221.0	15.2	-26.1	49	629.5	43.4	9.4
-14	225.2	15.5	-25.6	50	638.5	44.0	10.0
-13	229.6	15.8	-25.0	51	647.5	44.6	10.6
-12	234.0	16.1	-24.4	52	656.7	45.3	11.1
-11	238.4	16.4	-23.9	53	665.9	45.9	11.7
-10	242.9	16.7	-23.3	54	675.2	46.6	12.2
-9	247.5	17.1	-22.8	55	684.6	47.2	12.8
-8	252.1	17.4	-22.2	56	694.2	47.9	13.3
-7	256.8	17.7	-21.7	57	703.8	48.5	13.9
-6	261.5	18.0	-21.1	58	713.5	49.2	14.4
-5	266.3	18.4	-20.6	59	723.3	49.9	15.0
-4	271.2	18.7	-20.0	60	733.3	50.6	15.6
-3	276.1	19.0	-19.4	61	743.3	51.2	16.1
-2	281.1	19.4	-18.9	62	753.4	51.9	16.7
-1	286.1	19.7	-18.3	63	763.6	52.7	17.2
0	291.2	20.1	-17.8	64	774.0	53.4	17.8
1	296.4	20.4	-17.2	65	784.4	54.1	18.3
2	301.7	20.8	-16.7	66	795.0	54.8	18.9
3	307.0	21.2	-16.1	67	805.7	55.5	19.4
4	312.3	21.5	-15.6	68	816.4	56.3	20.0
5	317.8	21.9	-15.0	69	827.3	57.0	20.6
6	323.2	22.3	-14.4	70	838.3	57.8	21.1
7	328.8	22.7	-13.9	71	849.4	58.6	21.7
8	334.4	23.1	-13.3	72	860.7	59.3	22.2
9	340.1	23.5	-12.8	73	872.0	60.1	22.8
10	345.9	23.8	-12.2	74	883.5	60.9	23.3
11	351.7	24.3	-11.7	75	895.1	61.7	23.9
12	357.6	24.7	-11.1	76	906.9	62.5	24.4
13	363.6	25.1	-10.6	77	918.7	63.3	25.0
14	369.7	25.5	-10.0	78	930.7	64.2	25.6
15	375.8	25.9	-9.4	79	942.8	65.0	26.1
16	382.0	26.3	-8.9	80	955.1	65.9	26.7
17	388.2	26.8	-8.3	81	967.5	66.7	27.2
18	394.5	27.2	-7.8	82	980.0	67.6	27.8
19	400.9	27.6	-7.2	83	992.7	68.4	28.3
20	407.4	28.1	-6.7	84	1005.6	69.3	28.9
21	414.0	28.5	-6.1	85	1018.6	70.2	29.4
22	420.6	29.0	-5.6	86	1031.8	71.1	30.0
23	427.3	29.5	-5.0	87	1045.1	72.1	30.6
24	434.0	29.9	-4.4	87.8	1055.5	72.8	31

Low Temp Suction Typical
Critical Point

CO_2 Phase Diagram



Helpful Definitions:

Saturation pressure (vapor pressure): Pressure at which a phase change will take place at a given temperature.

Saturation temperature: Temperature at which a phase change will take place at a given pressure.

Subcooled liquid: Liquid at a temperature below its saturation temperature.

Superheated vapor: Vapor at a temperature above its saturation temperature.

Critical point: The condition at which the liquid and gas densities are the same. Above this point distinct liquid and gas phases do not exist.

Triple point: The condition at which solid, liquid and gas are in equilibrium.

Subcritical refrigeration cycle: Heat rejection occurs below the critical point and the refrigerant can be condensed.

Trans-critical refrigeration cycle: Heat rejection occurs above the critical point and the refrigerant is cooled but not condensed.

Latent heat: Heat, that when added to or removed from a substance, results in a change of state with no change in temperature of that substance.

Sensible heat: Heat which, when added or removed from a substance, results in a temperature change.

Enthalpy: The total heat content of a substance.

Entropy: The quantity of unavailable energy in a system.

Isothermal: Constant temperature.

Isochoric: Constant volume.

Adiabatic: No heat transfer.

Isentropic: Constant entropy.

Isobaric: Constant pressure.

Isotropic: No change with direction.