HARP INTERNATIONAL

HARP® 134a
(1,1,1,2-tetrafluoroethane)

HARP® 134a is a zero ozone depletion (ODP) hydrofluorocarbon refrigerant with properties very similar to R-12. It can be used both as a pure refrigerant in a number of traditional R-12 applications, and as a component in alternative refrigerant blends targeted for R-502 and R-22 applications.

Compressor and system manufacturers now supply equipment which has been specifically designed for **HARP® 134a**. In addition, laboratory testing, field trials and applications experience have confirmed that **HARP® 134a** can work in the retrofit of many existing R-12 installations.

NEW SYSTEMS

Industries which are successfully making the transition from R-12 to **HARP® 134a** include automotive air-conditioning, other specialised air-conditioning or climate control applications, positive pressure centrifugal chillers, medium temperature commercial refrigeration, domestic refrigeration appliances, industrial refrigeration plants and transport refrigeration.

RETROFIT

Applications where **HARP® 134a** has been proved reliable in the retrofitting of R-12 systems include centrifugal chillers, semi-hermetic, reciprocating and screw refrigeration applications of all kinds, and industrial refrigeration plants. See later section for specific considerations.

HARP® 134a: BASIC PROPERTY DATA

Chemical Formula:	CH_2FCF_3
Molecular weight:	102.0
Boiling point at 1 atmosphere:	-26.5°C
Density of saturated vapour at boiling point:	0.0053 g/cm^3
Density of saturated liquid at 25°C:	1.21 g/cm^3
Critical temperature:	101°C
Critical pressure:	40.7 bara
Latent heat of vaporisation at boiling point:	210.3 kJ/kg
Specific heat of liquid at 25°C:	1.46 kJ/kg.°C
Specific heat of vapour at 1 atmosphere, 25°C:	0.874 kJ/kg.°C
Flammability limits in air:	none*
Ozone depletion potential (ODP):	0
Halocarbon global warming potential (HGWP):	0.27
Occupational exposure limit:	1000 ppm

***HARP® 134a** does not propagate flame in ASTM E-681-95 at test temperatures up to 100°C.

USE OF HARP® 134a IN NEW REFRIGERATION SYSTEMS

LUBRICATION

For all **HARP® 134a** applications, lubrication is a very important consideration. Miscibility between refrigerant and oil is critical for many equipment designs and is required to ensure adequate oil return to the compressor. R-134a is not miscible with mineral oils traditionally found in R-12 systems. Polyolester and polyalkylene glycol lubricants have been recommended by various equipment manufacturers for use with **HARP® 134a**. Both of these new types of lubricant will absorb moisture quickly. They must be handled carefully to avoid prolonged exposure to air. Generally, new equipment will be shipped by the manufacturer with the compatible lubricant already charged. All of the manufacturers' recommendations should be followed.

SYSTEM PERFORMANCE

CLIMATE CONTROL

Chillers and specially designed air-conditioning systems have been engineered to use **HARP® 134a** while providing energy efficiency comparable to that of R-12. Manufacturers have successfully introduced products for mobile air-conditioning and positive pressure chillers using **HARP® 134a**

REFRIGERATION

LOW TEMPERATURE APPLICATIONS

At lower evaporating temperatures, the pressure ratio of R-134a exceeds that of R-12 and the refrigeration capacity, or duty, may be significantly reduced. Equipment manufacturers should be consulted for specific recommendations regarding the use of equipment with R-134a at lower application temperatures. One alternative for low temperature applications is the use of HFC blends, such as **HARP® 404A**, which have been specifically designed to replace R-502 in low temperature refrigeration.

MEDIUM AND HIGH TEMPERATURE APPLICATIONS

HARP® 134a can be used in most medium and high temperature R-12 applications. An ideal theoretical analysis using the thermodynamic properties of **HARP® 134a** shows a slight decrease in capacity and efficiency. When improvements, such as liquid subcooling, are introduced into the equation, the performance of **HARP® 134a** becomes equal to that of R-12. These improvements are being taken advantage of by equipment manufacturers.

CONSIDERATIONS FOR RETROFITTING R-12 SYSTEMS TO HARP® 134a

Retrofit projects should be included as part of an overall refrigerant management programme. All retrofit applications will require a change in lubricant from that found in R-12 semi-hermetic or open drive systems. The mineral or alkylbenzene oil in the system will need to be replaced with a polyolester lubricant to a residual mineral oil level of less than 5%. This will require several oil flushes with polyolester depending upon system design. Recommendations from equipment manufacturers regarding the compatibility of materials of construction, components and driers with R-134a should be obtained. Replace any materials that are not suitable. Obtain procedures, material specifications, and any other recommendations from equipment, component and lubricant manufacturers, as well as from HRPR. Hermetic units cannot be retrofitted to R-134a. The construction of these systems does not allow the existing lubricant to be adequately drained and replaced with a polyolester.

HARP® 134a: ENGINEERING DATA

Temperature (°C)	Absolute pressure (bara)	Density		Enthalpy (kJ/kg)	
		Liquid (kg/dm³)	Vapour (kg/m³)	Liquid	Vapour
-40	0.5122	1.4148	2.7705	148.57	374.16
-30	0.8436	1.3859	4.4256	161.10	380.45
-26	1.0164	1.3741	5.2740	166.16	382.94
-22	1.2160	1.3622	6.2461	171.26	385.43
-18	1.4454	1.3502	7.3643	176.39	387.89
-14	1.7074	1.3380	8.6133	181.56	390.33
-10	2.0052	1.3256	10.037	186.78	392.75
-6	2.3418	1.3130	11.640	192.03	395.15
-2	2.7206	1.3002	13.441	197.33	397.51
0	2.9269	1.2937	14.420	200.00	398.68
2	3.1450	1.2871	15.456	202.68	399.84
6	3.6186	1.2738	17.705	208.08	402.14
10	4.1449	1.2602	20.210	213.53	404.40
14	4.7276	1.2463	22.999	219.03	406.61
18	5.3706	1.2321	26.089	224.59	408.78
22	6.0777	1.2175	29.516	230.21	410.89
26	6.8531	1.2026	33.300	235.90	412.95
30	7.7008	1.1872	37.495	241.65	414.94
34	8.6250	1.1713	42.123	247.47	416.85
36	9.1172	1.1632	44.623	250.41	417.78
40	10.165	1.1465	50.025	256.35	419.58
44	11.300	1.1292	55.991	262.38	421.28
48	12.527	1.1113	62.578	268.49	422.88
52	13.852	1.0926	69.930	274.71	424.35
56	15.280	1.0730	78.125	281.04	425.68
60	16.815	1.0524	87.260	287.49	426.86
70	21.165	0.9956	115.34	304.29	428.89
80	26.331	0.9274	154.80	322.41	429.02
85	29.259	0.8862	181.82	332.27	427.91
90	32.445	0.8369	216.92	343.01	425.48

To calculate the latent heat of vaporisation, subtract the liquid enthalpy from the vapour enthalpy at the desired temperature.

HARP® 134a: TEMPERATURE-PRESSURE RELATIONSHIP COMPARISON WITH R-12

Temperature (°C)	R-134a pressure (bara)	R-12 pressure (bara)	Temperature (°C)	R-134a pressure (bara)	R-12 pressure (bara)
-30	0.8436	1.0044	8	3.8749	3.9765
-28	0.9268	1.0929	10	4.1449	4.2276
-26	1.0164	1.1872	12	4.4289	4.4903
-24	1.1127	1.2878	14	4.7276	4.7651
-22	1.2160	1.3949	16	5.0413	5.0523
-20	1.3268	1.5088	18	5.3706	5.3521
-18	1.4454	1.6296	20	5.7159	5.6651
-16	1.5721	1.7578	22	6.0777	5.9914
-14	1.7074	1.8937	24	6.4566	6.3315
-12	1.8516	2.0374	26	6.8531	6.6857
-10	2.0052	2.1893	28	7.2676	7.0544
-8	2.1684	2.3498	30	7.7008	7.4379
-6	2.3418	2.5190	32	8.1530	7.8366
-4	2.5257	2.6974	34	8.6250	8.2509
-2	2.7206	2.8851	36	9.1172	8.6811
0	2.9269	3.0827	38	9.6301	9.1277
2	3.1450	3.2902	40	10.165	9.5909
4	3.3755	3.5082	42	10.721	10.071
6	3.6186	3.7368	44	11.300	10.569

THERMODYNAMIC EQUATIONS FOR HARP® 134a

1. VAPOUR PRESSURE

$$\ln P = \frac{a_1}{T} + a_2 + a_3 T + a_4 \ln T$$

where T is in Kelvin and P is in bar

Constants:

a_1	= −3.218946E+03	a_3	= 2.780783E−03
a_2	= 2.73272E+01	a_4	= −2.714900E+01

2. DENSITY OF THE SATURATED LIQUID

$$d = b_o + \sum_{i}^{4} b_i \, (1 - T_r)^{i/3}$$

where d is in kg/m^3 and T is in Kelvin. T_c is the critical temperature and $T_r = T/T_c$.

Constants:

b_0	= 5.119758E+02	b_2	= 1.714503E+02	b_4	= −4.215000E+02
b_1	= 9.475580E+02	b_3	= 6.59154E+02	b_5	= 374.15 K

3. IDEAL GAS HEAT CAPACITY

$$C_v^o = \frac{C_1}{T} + C_2 + C_3 T + C_4 T^2$$

where C_v^o is in J/mol.K and T is in Kelvin.

Constants:

C_1	= 1.582170E+01	C_3	= 3.296570E−03
C_2	= −8.674560E−02	C_4	= −2.017321E−06

4. EQUATION OF STATE

$$P = \frac{RT}{V-b} + \sum_{i=2}^{5} \frac{A_i + B_i T + D_i \exp(-kT)}{(V-b)^i}$$

where T is in Kelvin and P is in bar.

Constants:

R	= 8.148816E−04	B_4	= 0.000000E+00
A_2	= −1.195051E−03	D_4	= 0.000000E+00
B_2	= 1.137590E−06	A_5	= −6.953904E−14
D_2	= −3.531592E−02	B_5	= 1.269806E−15
A_3	= 1.447797E−06	D_5	= −2.051369E−11
B_3	= −8.942552E−10	b	= 3.455467E−04
D_3	= 6.469248E−05	k	= 1.462928E−02
A_4	= −1.049005E−09		

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