Klea® Edge™ 444A

Application Guide and Technical Data Sheet

Introduction

Orbia Fluor & Energy Materials, an experienced designer and producer of refrigerants, is making available R-444A, a refrigerant to exceed the current performance standard, while meeting accepted environmental criteria* with low GWP and minimal TFA. Orbia Fluor & Energy Materials has designed and developed a series of refrigerants that meet and exceed these changing regulatory requirements.

Klea® Edge™ 444A is a mildly flammable, low GWP refrigerant blend, designed by Orbia Fluor & Energy Materials to replace R-1234yf in the global automotive air-conditioning aftermarket. Its favourable environmental and physical properties allow R-444A to establish itself as a safe, high performing, direct-replacement refrigerant in a wide range of applications.

R-444A is a zeotropic refrigerant blend comprising R-32/R-152a/R-1234ze(E), (12.0/5.0/83.0% by weight). It is a low-toxicity and mildly flammable blend, classified as an A2L refrigerant following the ANSI/ASHRAE Standard 34/ISO refrigerant classification. It is a flexible, cost-effective and environmentally friendly alternative to R-1234yf.

Applications

Automotive and transport sectors

Direct replacement for R-1234yf in automotive air conditioning for servicing both new and existing vehicles globally.

*Based on the findings EFCTC Position Paper 08 October 2021 which states 'HFO-1234ze, HFO-1336mzz and HCFO-1233zd are broadly estimated to contribute less than 0.01 µg/L to the average concentration of TFA in European rainwater through to 2050'.

Klea® Edge

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Benefits

R-444A affords the following benefits to the user:

- **A2L Rating:** R-444A has been designated 'A2L' classification rating, by ASHRAE/ISO which means that it is mildly flammable and has low toxicity.[1]
- **Regulatory Compliant:** R-444A with a GWP_{100} <150 meets strict GWP targets (and complies with EPA Technology Transition Rules for many sectors). It has zero ozone depletion potential (ODP).
- **Compatible:** R-444A will work with any system that uses R-1234yf.
- **Easy to Use:** R-444A is a direct replacement for R-1234yf in auto air conditioning. R-1234yf or R-134a service equipment can be re-purposed to service R-444A vehicles. Retrofitting can be completed with common A/C service tools.
- **High Performing:** R-444A offers up to 10% higher cooling/heating capacity[2] in direct replacement scenarios compared to R-1234yf; cooling down the cabin 4 minutes faster than R-1234yf. It may also give higher energy efficiency which will enable internal combustion engine vehicles to see improved fuel economy and extends electric vehicle range. Both leading to an improved passenger experience.
- **Affordable:** R-444A is an economical alternative to R-1234yf.[3] Charge size is the same as R-1234yf.
- **Sustainable:** R-444A has a comparable carbon footprint[4] compared to R-1234yf with minimal TFA derogation in the atmosphere.[5]
- **Stable:** R-444A is chemically stable, its composition remains in specification from charging through to recovery from a/c systems, with no known polymerisation.[6]
- **Service Equipment:** Service tools and equipment are being made available by leading manufacturers. The dedication and use of existing equipment is also an option.

1. See applicable regional regulations codes and product/standards which cover the use of flammable refrigerants, e.g. ASHRAE standard 15.
2. Third party test data from automotive application confirmed R-444A delivered 2-3°C colder air and 4-minute faster pulldown to 22°C than R-1234yf.
3. Based on market conditions as of July 2024.
4. LCCP CO_2 Equivalent Emissions during Vehicle's Lifetime.
5. Based on the findings EFCTC Position Paper 08 October 2021 which states 'HFO-1234ze, HFO-1336mzz and HCFO-1233zd are broadly estimated to contribute less than 0.01 µg/L to the average concentration of TFA in European rainwater through to 2050'.
6. Based on internal laboratory testing'.

R-444A Retrofit

Composite Refrigerant Retrofit Instructions for R-444A

R-1234yf (A2L) to R-444A (A2L)

01	Using certified Refrigerant Recovery Recycling device for the refrigerant to be replaced, remove the refrigerant from the vehicle per proper device operation. Note the amount of oil removed.
02	Adapt low and high side service port to those designed for the new refrigerant.
03	Place label for new refrigerant on the SAE J639 label per local regulations.
04	Add specified oil based upon amount removed during recovery, or as prescribed by the refrigerant manufacturer.
05	Using dedicated equipment (may be repurposed from R-134a or R-1234yf) for the new refrigerant, connect to vehicle and vacuum system for 10 minutes.
06	Vacuum leak test for 5 minutes. Continue to (8) if vacuum drops less than 3 in/Hg, otherwise, repeat step 7.
07	Using the same equipment charge vehicle with new refrigerant by weight • By weight: Set charging scale to the R-1234yf weight indicated on the J639 label or directed by OEM service information. Charge from virgin R-444A cylinder in liquid state. Start vehicle and turn A/C on Max. Observe pressures and ensure center vent temperature meets specification. Close the high side coupler and allow the pressures to stabilize. Close low side coupler and disconnect from the vehicle.

Composite Refrigerant Service Instructions

R-444A (A2L)

01	Assuming R-444A refrigerant is to be removed, connect R-444A Service Station to the vehicle.
02	Set for recovery. The recovery process should remove oil and particulates from the refrigerant, condense the refrigerant and store in a standard recovery tank.
03	Complete A/C system repair and leak check.
04	Using refrigerant specific Service Station, connect to high and low side service ports; set vacuum time to 10 minutes, or until it holds vacuum for 5 minutes dropping less than 3 in Hg/770 mm Hg.
05	Set scale on Service Station to desired charge weight per J639 label or OEM repair information. Open liquid valve on recovery tank to allow the recovered gas to charge first, then if needed, open the virgin tank liquid valve to complete the charge. The use of computer-controlled solenoids is recommended to assure accurate (+/- 15g) charge.
06	Start vehicle and observe high and low side pressure and confirm desired center vent temperature is achieved. Close high side coupler allowing the pressures to stabilize. Close low side and remove couplers.

Leak Detectors

Leak detectors (SAE J2913) designed and qualified to detect R-134a and/or R-1234yf leaks will detect R-444A leaks. R-444A leaks should be treated the same as R-1234yf.

***Special Note:** Best practice is to keep refrigerants separate. However, R444A is compatible with R1234yf, and the lubricants used in R1234yf systems. Vehicle warranties and local regulations should be consulted.

Materials Compatibility

Compatibility testing of R-444A has been conducted with metal, plastics and rubbers as per standard test methods.*

R-444A is compatible with OEM grade of polyalkylene glycol (PAG) oils when used in automotive applications. Automotive OEM Polyolester (POE) oils can also be used with R-444A. The type of lubricant depends on the compressor and requirements of the vehicle manufacturer. R-444A is designed to work with PAG and POE grade R-1234yf lubricants. There is no need to change the oil when converting a system from R-1234yf to R-444A. If the system needs additional lubricant R-1234yf POE oils such as Denso's ND-12, Shrieve's and Sanden's SP-A2 are recommended. We recommend using HFO stabilizing additives with PAG and POE oils. PAG oils and additives used with R-134a should not be used with R-444A.

A wide variety of plastics and rubbers are used in automotive air conditioning systems. Materials include those used in seals, gaskets, hoses, motor fabrication, and insulation. Comparable testing with R-1234yf shows that R-444A is less aggressive to plastics than R-1234yf. R-444A is comparable with a wide range of elastomers as used with R-1234yf with overall permeation rates similar to R-1234yf. Hoses use and recommended for R-1234yf are also compatible with R-444A. For further details on material compatibility consult with your local Orbia Fluor & Energy Materials representative.

Note: performance of elastomers and plastics will vary with formulation and conditions of use. The maximum working temperature of the plastic and maximum application temperature should always be considered prior to selection.

* ASHRAE and ASTM test standards

Physical Properties

A summary of selected property data for R-444A is shown in the Table 1 below. Saturation data and PT tables can be found in Tables 2 and 3 respectively.

Table 1. | R-444A - Basic Refrigerant Property Data

Property	Units	R-444A
Global Warming Potential (GWP)	---	93
Molecular Mass	g/mol	96.7
Normal Boiling Point Temperature (NBP) (101.325 kPa/14.696 psia)	°C	-30
Critical Temperature	°C	102.8
Critical Pressure	kPa	4173.8
Critical Volume	m^3/kg	0.0021
Saturated liquid density (0°C)	kg/m^3	1204
Bubble pressure (-40°C)	kPa	83.62
Bubble pressure (0°C)	kPa	390
Isentropic index (Cp/Cv) (saturated vapour at 0°C)		1.17
Latent heat of vaporisation at 0°C	kJ/kg	233
Safety Classification (ASHRAE/ISO 817)		A2L

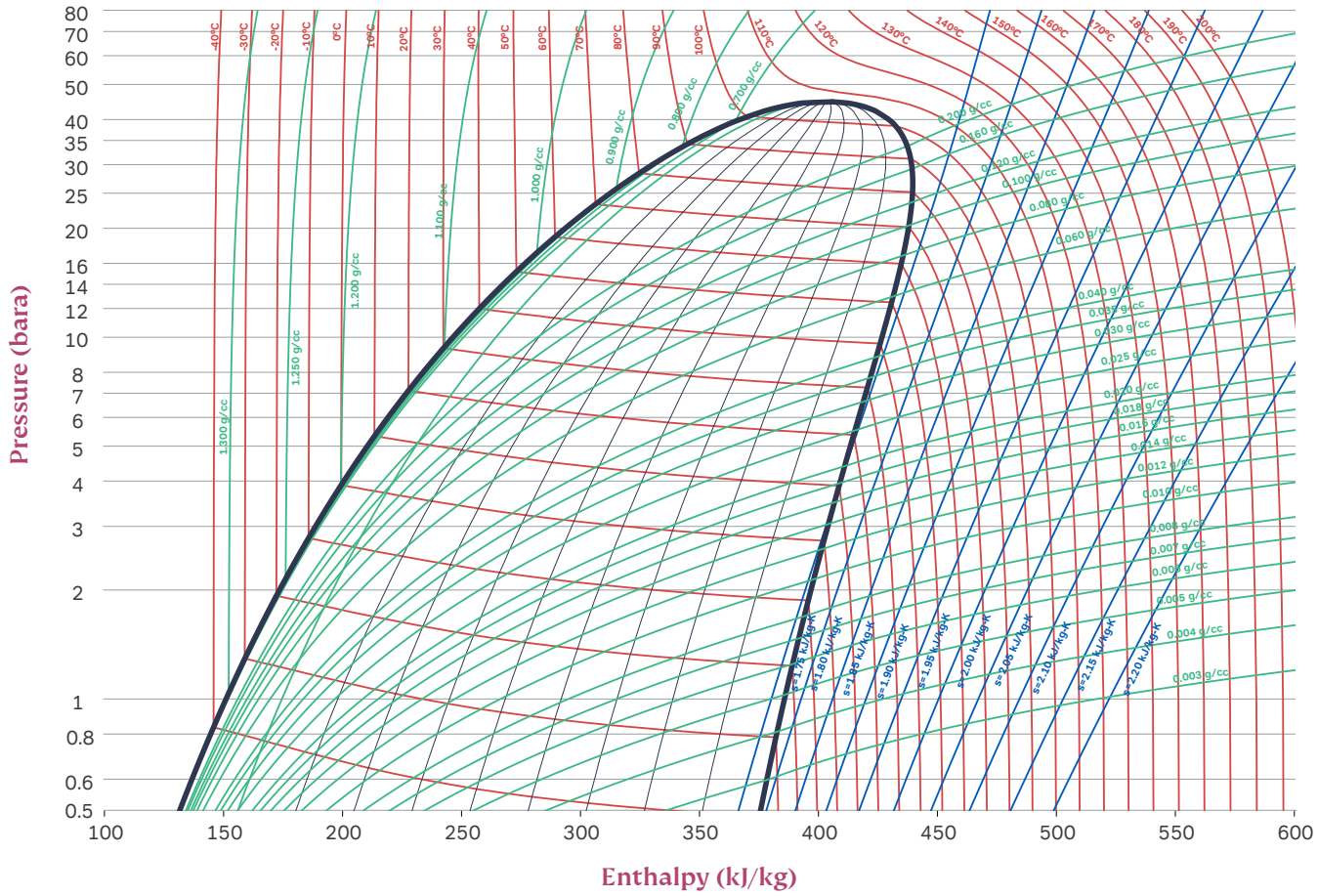
Table 2. | R-444A - Saturation Properties – Temperature Table

Temperature	Pressure		Density		Enthalpy		Entropy	
	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor
(°C)	(bara)	(bara)	(kg/m³)	(kg/m³)	(kJ/kg)	(kJ/kg)	(kJ/kg/K)	(kJ/kg/K)
-40	0.84	0.47	1318	2.4	146.2	376.1	0.79	1.79
-38	0.92	0.52	1312	2.6	148.9	377.5	0.80	1.79
-36	1.00	0.58	1307	2.9	151.5	378.9	0.81	1.79
-34	1.09	0.64	1302	3.2	154.1	380.3	0.82	1.78
-32	1.19	0.70	1296	3.5	156.8	381.7	0.83	1.78
-30	1.29	0.78	1291	3.8	159.4	383.1	0.84	1.78
-28	1.41	0.85	1285	4.2	162.1	384.5	0.85	1.78
-26	1.52	0.94	1280	4.6	164.7	385.8	0.87	1.78
-24	1.65	1.03	1274	5.0	167.4	387.2	0.88	1.77
-22	1.79	1.12	1268	5.4	170.1	388.6	0.89	1.77
-20	1.93	1.23	1263	5.9	172.7	390.0	0.90	1.77
-18	2.08	1.34	1257	6.4	175.4	391.3	0.91	1.77
-16	2.24	1.46	1251	6.9	178.1	392.7	0.92	1.77
-14	2.41	1.58	1246	7.5	180.8	394.0	0.93	1.76
-12	2.59	1.72	1240	8.1	183.5	395.4	0.94	1.76
-10	2.78	1.86	1234	8.7	186.3	396.7	0.95	1.76
-8	2.98	2.01	1228	9.4	189.0	398.0	0.96	1.76
-6	3.20	2.17	1222	10.1	191.7	399.4	0.97	1.76
-4	3.42	2.35	1216	10.9	194.5	400.7	0.98	1.76
-2	3.65	2.53	1210	11.7	197.2	402.0	0.99	1.76
0	3.90	2.72	1204	12.6	200.0	403.3	1.00	1.76
2	4.16	2.93	1198	13.5	202.8	404.6	1.01	1.75
4	4.43	3.14	1192	14.4	205.6	405.9	1.02	1.75
6	4.72	3.37	1186	15.5	208.4	407.2	1.03	1.75
8	5.02	3.61	1179	16.5	211.2	408.4	1.04	1.75
10	5.33	3.87	1173	17.6	214.0	409.7	1.05	1.75
12	5.66	4.14	1166	18.8	216.8	410.9	1.06	1.75
14	6.00	4.42	1160	20.1	219.7	412.2	1.07	1.75
16	6.36	4.71	1153	21.4	222.6	413.4	1.08	1.75
18	6.73	5.02	1147	22.8	225.4	414.6	1.09	1.75
20	7.12	5.35	1140	24.2	228.3	415.8	1.10	1.75
22	7.53	5.69	1133	25.7	231.2	417.0	1.11	1.75
24	7.95	6.05	1126	27.4	234.1	418.2	1.12	1.75
26	8.39	6.43	1120	29.0	237.1	419.3	1.13	1.75
28	8.85	6.82	1112	30.8	240.0	420.5	1.14	1.75
30	9.32	7.23	1105	32.7	243.0	421.6	1.15	1.74

Table 2 continued. | R-444A - Saturation Properties – Temperature Table

Temperature	Pressure		Density		Enthalpy		Entropy	
	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor
(°C)	(bara)	(bara)	(kg/m³)	(kg/m³)	(kJ/kg)	(kJ/kg)	(kJ/kg/K)	(kJ/kg/K)
32	9.82	7.66	1098	34.6	246.0	422.7	1.16	1.74
34	10.33	8.11	1091	36.7	249.0	423.8	1.17	1.74
36	10.86	8.57	1083	38.9	252.0	424.9	1.18	1.74
38	11.42	9.06	1076	41.1	255.0	425.9	1.19	1.74
40	11.99	9.57	1068	43.5	258.1	426.9	1.20	1.74
42	12.58	10.10	1060	46.0	261.1	428.0	1.21	1.74
44	13.20	10.65	1052	48.7	264.2	428.9	1.22	1.74
46	13.83	11.23	1044	51.4	267.4	429.9	1.22	1.74
48	14.49	11.83	1036	54.3	270.5	430.8	1.23	1.74
50	15.17	12.45	1028	57.4	273.7	431.8	1.24	1.74
52	15.88	13.09	1019	60.6	276.9	432.6	1.25	1.74
54	16.61	13.77	1010	64.0	280.1	433.5	1.26	1.74
56	17.36	14.46	1001	67.5	283.3	434.3	1.27	1.74
58	18.13	15.19	992	71.3	286.6	435.1	1.28	1.74
60	18.93	15.94	983	75.2	289.9	435.9	1.29	1.74
62	19.76	16.72	973	79.4	293.2	436.6	1.30	1.73
64	20.61	17.53	963	83.8	296.6	437.2	1.31	1.73
66	21.49	18.36	953	88.5	300.0	437.9	1.32	1.73
68	22.39	19.23	942	93.4	303.5	438.4	1.33	1.73
70	23.32	20.13	932	98.6	307.0	439.0	1.34	1.73
72	24.28	21.07	920	104.1	310.5	439.4	1.35	1.73
74	25.26	22.03	909	110.0	314.1	439.8	1.36	1.73
76	26.28	23.03	897	116.3	317.8	440.2	1.37	1.73
78	27.32	24.07	884	123.0	321.5	440.4	1.38	1.72
80	28.39	25.14	871	130.2	325.3	440.6	1.39	1.72
82	29.49	26.26	858	137.9	329.1	440.7	1.40	1.72
84	30.62	27.41	843	146.2	333.0	440.7	1.41	1.72
86	31.78	28.60	828	155.2	337.1	440.6	1.42	1.72
88	32.96	29.84	812	165.0	341.2	440.3	1.44	1.71

Pressure-Enthalpy Diagram for R-444A



Reference State: IIR
h = 200 kJ/kg, s = 1.0 kJ/kg-K
@ sat. liq at 0 °C

Table 3. | PT Table - Saturation Pressure - Temperature Chart for R-444A

°F	R-444A		°C
	psig	barg	
-42	**16.9**	**16.9**	-41.1
-38	**15.2**	**15.2**	-38.9
-34	**13.5**	**13.5**	-34.4
-30	**11.5**	**11.5**	-34.4
-26	**9.3**	**9.3**	-32.2
-22	**7.0**	**7.0**	-30.0
-18	**4.5**	**4.5**	-27.8
-14	**1.7**	**1.7**	-25.6
-10	0.6	0.0	-23.3
-6	2.2	0.2	-21.1
-2	4.0	0.3	-18.9
2	5.8	0.4	-16.7
6	7.8	0.5	-14.4
10	10.0	0.7	-12.2
14	12.3	0.8	-10.0
18	14.7	1.0	-7.8
22	17.4	1.2	-5.6
26	20.2	1.4	-3.3
30	23.2	1.6	-1.1
34	26.4	1.8	1.1
38	29.8	2.1	3.3
42	33.5	2.3	5.6
46	37.3	2.6	7.8
50	41.4	2.9	10.0
54	**67.9**	**4.7**	12.2
58	**73.5**	**5.1**	14.4

°F	R-444A		°C
	psig	barg	
62	**79.3**	**5.5**	16.7
66	**85.4**	**5.9**	18.9
70	**91.8**	**6.3**	21.1
74	**98.5**	**6.8**	23.3
78	**105.5**	**7.3**	25.6
82	**112.8**	**7.8**	27.8
86	**120.5**	**8.3**	30.0
90	**128.5**	**8.9**	32.2
94	**136.8**	**9.4**	34.4
98	**145.5**	**10.0**	36.7
102	**154.5**	**10.7**	38.9
106	**163.9**	**11.3**	41.1
110	**173.7**	**12.0**	43.3
114	**183.9**	**12.7**	45.6
118	**194.4**	**13.4**	47.8
122	**205.4**	**14.2**	50.0
126	**216.7**	**14.9**	52.2
130	**228.5**	**15.8**	54.4
134	**240.8**	**16.6**	56.7
138	**253.4**	**17.5**	58.9
142	**266.5**	**18.4**	61.1
146	**280.1**	**19.3**	63.3
150	**294.1**	**20.3**	65.6

Black = saturated vapour (dew point) - use to calculate superheat
Bold = saturated liquid (bubble point) - use to calculate subcooling
Red = Inches of Mercury below Atmospheric Pressure

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