



Unicla
Advanced compressor technology for the world

Compressor and other system component technology for R1234yf systems

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Technical and engineering steps to R1234yf

- Following regulatory pressure, all global MVAC and vehicle manufacturer commenced the Co-operative Research Project (CRP) for an alternative to R134a.
- CRP was engineering and environmentally focussed – administered by SAE International
- After extensive tests of hundreds of alternatives, R1234yf was the clear winner



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Technical and engineering steps to R1234yf

- As a compressor manufacturer, the first challenge is to select and validate the lubricant – minimum 2000 hours of testing
- Next is to check and validate the functionality of the refrigerant and how it operates in the compressor and systems where the compressor is used.
- Compliance to all necessary manufacturing and safety standards



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Lubricant

- Must meet ASHRAE standards for refrigerant suitability.
- Current generation PAG and POE lubricants used in R134a found to have unacceptable chemical stability, and thermal and hydrolytic properties when used with R1234yf.
- Manufacturers were quick to develop suitable double end capped PAGs.
- Di-capped PAG lubricants appear to be the major choice by OEMs for R1234yf, CO2 and electric drive MAC systems.



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Lubricant

Quality evaluation: Typical test is 2000 hrs at 500hr intervals

Compressor					Condenser		Evaporator	
r.p.m	Discharge pressure kg/cm ²	Suction pressure kg/cm ²	Discharge temp. °C	Suction temp. °C	Temp. in °C	Temp. out °C	Temp. in °C	Temp. out °C
800	14.0	3.3	60.1	17.5	61.1	48.8	34.2	20.6
2,000	15.4	2.7	69.6	16.7	69.7	51.4	31.7	19.6
3,000	13.2	1.7	87.0	14.7	87.6	50.8	27.3	7.0
3,500	14.0	1.8	88.4	17.4	91.1	52.5	27.4	8.9
1,500	12.9	2.0	68.0	12.8	70.0	52.0	29.0	9.0



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Lubricant

Unicla compressors use Shrieve ZEROL HD46 due to excellent anti-wear and low hygroscopicity

Shrieve ZEROL HD46	
Typical physical properties	Viscosity at 40°C (cSt)
	44.8
	Viscosity at 100°C (cSt)
	9.70
	Viscosity Index
	215
Flash point (COC)	>230
Specific Gravity (g/cc @ 20°C)	0.9895
Pour point (°C)	<-25



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PRESSURE TEMPERATURE CHART

°C	R134a		HFO1234yf		°C	R134a		HFO1234yf	
	kPa	PSIG	kPa	PSIG		kPa	PSIG	kPa	PSIG
-30	-16.9	-2.5	-8.71	-1.2	24	543.8	78.9	561.3	81.3
-28	-8.6	-1.3	2.79	0.4	26	583.4	84.6	599.4	86.7
-26	0.3	0	14.3	2.1	28	624.8	90.6	639.1	92.6
-24	10	1.4	26.1	3.8	30	668.2	96.9	680.4	98.6
-22	20.3	2.9	38.1	5.5	32	713.4	103.5	723.5	104.9
-20	31.4	4.6	50.6	7.3	34	760.6	110.3	768.3	111.3
-18	43.2	6.3	63.2	9.2	36	809.8	117.4	814.8	118.1
-16	55.9	8.1	76.4	11.1	38	861.2	124.9	863.2	125.1
-14	69.4	10.1	90.6	13.1	40	914.6	132.6	913.5	132.4
-12	83.8	12.2	105.5	15.3	42	970.3	140.7	965.8	140.0
-10	99.1	14.4	121.1	17.6	44	1028.3	149.1	1020.0	147.8
-8	115.4	16.7	138.3	20.0	46	1088.5	157.9	1076.2	156.0
-6	132.7	19.2	156.1	22.6	48	1151.2	167	1134.6	164.4
-4	151.1	21.9	174.7	25.3	50	1216.3	176.4	1195.1	173.2
-2	170.6	24.7	194.5	28.2	52	1283.9	186.2	1257.8	182.3
0	191.2	27.7	215.3	31.2	54	1354.1	196.4	1322.7	191.7
2	213	30.9	237.2	34.4	56	1426.9	206.9	1389.9	201.4
4	236	34.2	260.2	37.7	58	1502.4	217.9	1459.5	211.5
6	260.2	37.7	284.4	41.2	60	1580.7	229.2	1531.6	222.0
8	285.8	41.4	309.9	44.9	62	1661.9	241	1606.1	232.8
10	312.8	45.4	336.5	48.8	65	1789.1	259.5	1723.1	249.7
12	341.2	49.5	364.4	52.8	70	2016.4	292.4	1930.7	279.8
14	371	53.8	393.7	57.1	75	2263.8	328.3	2156.9	312.6
16	402.4	58.4	424.4	61.5	80	2532.6	367.3	2401.6	348.0
18	435.2	63.1	456.4	66.1	85	2824.3	409.6	2668.5	386.6
20	469.7	68.1	489.8	70.1	90	3140.7	455.5	2958.0	428.7
22	505.9	73.4	534.8	77.5	95	3484.5	505.4	3248.6	470.7

*All pressures shown are saturated vapour pressures

Refrigerant operation

Comparing R1234yf to R134a

0°C

- R134a has pressure of 191.2 kpa (27.7 psi)
- R1234yf is **higher** at 215.30 kpa (31.2 psi)

54°C

- R134a has pressure of 1354.1 kpa (196.4 psi)
- R1234yf is **lower** at 1322.7 kpa (191.7 psi)



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Refrigerant operation

A test was carried out to provide a comparison of performance results from a common system operating on R134a refrigerant as compared against a same system converted to operate with OPTEON R1234yf refrigerant. The test comprised of the following components:

Refrigerant	Dupont - R134a	Dupont – OPTEON R1234yf
Condenser	Kysor EC6	Kysor EC6
Compressor	Unicla UP150	Unicla UP150
Expansion valve	Eaton block type 2.0 ton – R134a comp.	Eaton block type 2.0 ton – R134a comp.
Hose	Burgaflex 3090 series	Burgaflex 3090 series
Hose connectors	Burgaclick with R134a service ports	Burgaclick with R1234yf service ports
Evaporator	Carrier EM14	Carrier EM14
Lubricant	Unidap7 – PAG46	Shrieve- Zerol HD- PAG46
Power supply	24 volt	24 volt



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Refrigerant operation

Highlights:

Test condition	Average result over 60 tests
R1234yf system running same refrigerant weight as R134a (1.7 kg) and compressor speed of 1500 rpm	- Lower discharge pressure 0.4 – 1.0 bar - Lower discharge line temperature 2-4K - Higher suction pressure 0.17 -0.47 bar - Different evaporator superheat range $\pm 1.8K$ - Lower sub cooling 4.5 – 4.8K - Lower air TD across evaporator 0.7K



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Refrigerant operation

- R134a and R1234yf, condenser sub-cooling and evaporator super heat table
- Unicla test - 1.7kg refrigerant charge at 1500rpm

Ambient	Refrigerant type	Suction evaporator pressure	Condenser pressure	Suction evaporator temperature	Condenser temperature	Super heat	Sub-cool
25°C	R134a	1.92 bar	10.35 bar	8.70°C	37.10°C	8.70°C	9.90°C
25°C	R134a	1.97 bar	12.37 bar	7.30°C	43.30°C	6.80°C	7.20°C
25°C	R134a	1.94 bar	12.97 bar	6.30°C	45.20°C	6.30°C	7.05°C
35°C	R134a	2.84 bar	15.08 bar	13.10°C	51.60°C	5.10°C	6.10°C
35°C	R134a	2.85 bar	17.52 bar	15.40°C	58.30°C	7.40°C	5.95°C
35°C	R134a	2.87 bar	19.58 bar	15.90°C	63.50°C	7.90°C	5.25°C
25°C	R1234-yf	2.39 bar	10.23 bar	10.90°C	42.60°C	6.90°C	2.40°C
25°C	R1234-yf	2.17 bar	11.87 bar	10.50°C	48.00°C	8.50°C	2.00°C
25°C	R1234-yf	2.35 bar	12.50 bar	10.50°C	47.70°C	6.50°C	4.30°C
35°C	R1234-yf	3.01 bar	13.84 bar	15.90°C	54.10°C	6.90°C	1.90°C
35°C	R1234-yf	3.00 bar	15.50 bar	16.70°C	58.80°C	7.70°C	2.20°C
35°C	R1234-yf	3.09 bar	16.68 bar	16.10°C	61.80°C	6.60°C	2.20°C

Higher on low side

Lower on high side



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Standards

- SAE International always at the forefront of MVAC design and innovation
- Work commenced in 2003 for the search of an alternative to R134a
- Dupont and Honeywell did the chemistry SAE took the lead on system design, component upgrades and risk assessment at the vehicles' level
- Five key standards deal with new low GWP refrigerants R1234yf and R744 (CO₂)



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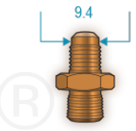
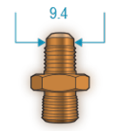
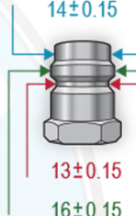
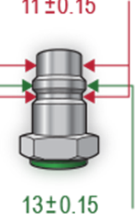
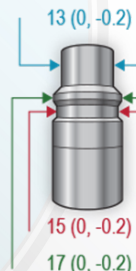
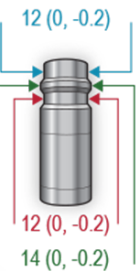
SAE standard J639

- References to 48 SAE standards
- Refers to refrigerants R134a, R1234yf, R-744
- Specifies design of fittings for R12 and R-152a
- Passenger cars only (trucks and buses not included)
- Prohibits use of any refrigerant rated less than A2L
- Provides standards for design, assembly, testing and service to minimise environmental, health and safety impacts



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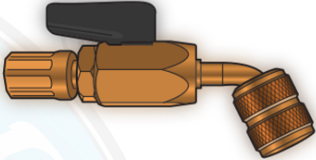
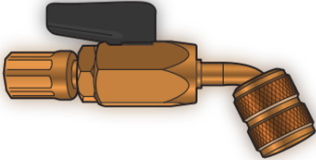
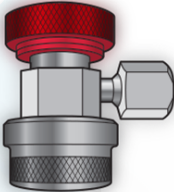
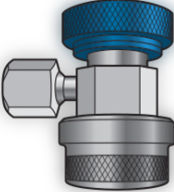
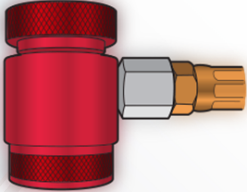
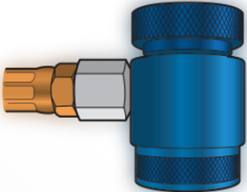
SAE standard J639- Service port fittings

Refrigerant	High	Low
R12	 9.4	 9.4
R134a	 14$\pm$0.15 13$\pm$0.15 16$\pm$0.15	 11$\pm$0.15 13$\pm$0.15
R1234yf	 13 (0, -0.2) 15 (0, -0.2) 17 (0, -0.2)	 12 (0, -0.2) 12 (0, -0.2) 14 (0, -0.2)



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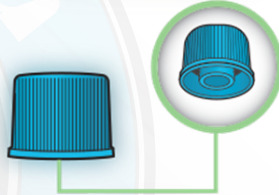
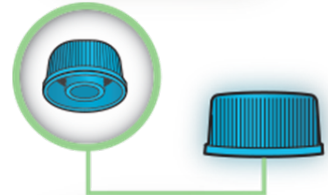
SAE standard J639- Service charge couplings

Refrigerant	High	Low
R12		
R134a		
R1234yf		



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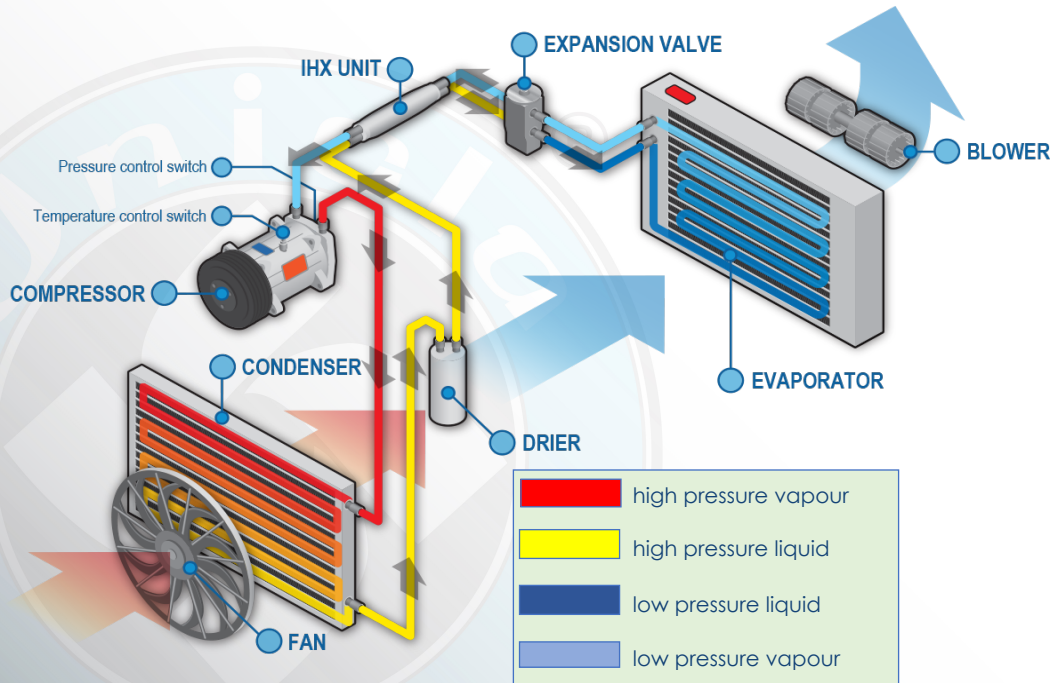
SAE standard J639- Service fitting caps

Refrigerant	High	Low
R12		
R134a		
R1234yf		



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SAE standard J639 - R1234yf maximum working pressure



High side:

- must not exceed 4.14 mPa (600 psig) gauge pressure during operation
- must not exceed limit of any system component
- pressure must be limited by compressor operation before relief valve on burst disc

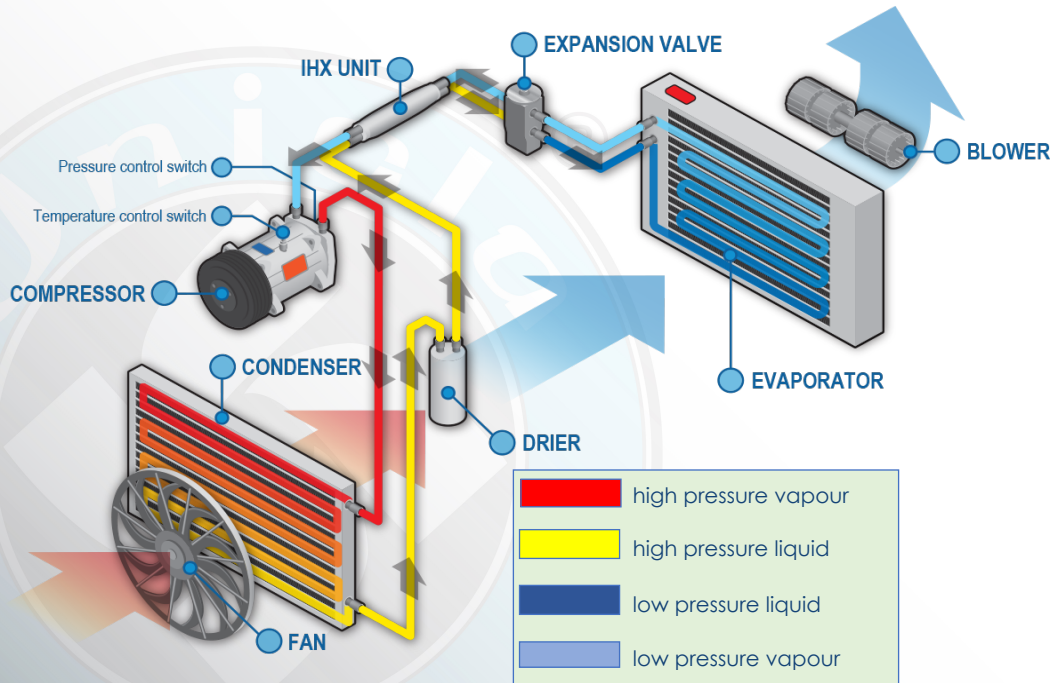
Low side:

- must not exceed 1.46 mPa (according to saturation pressure of R1234yf at 56°C) with system on or off



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SAE standard J639 - R1234yf maximum system burst pressure



High side:

- new components must not be less than two times the working pressure of 8.24 mPa (1200 psig)

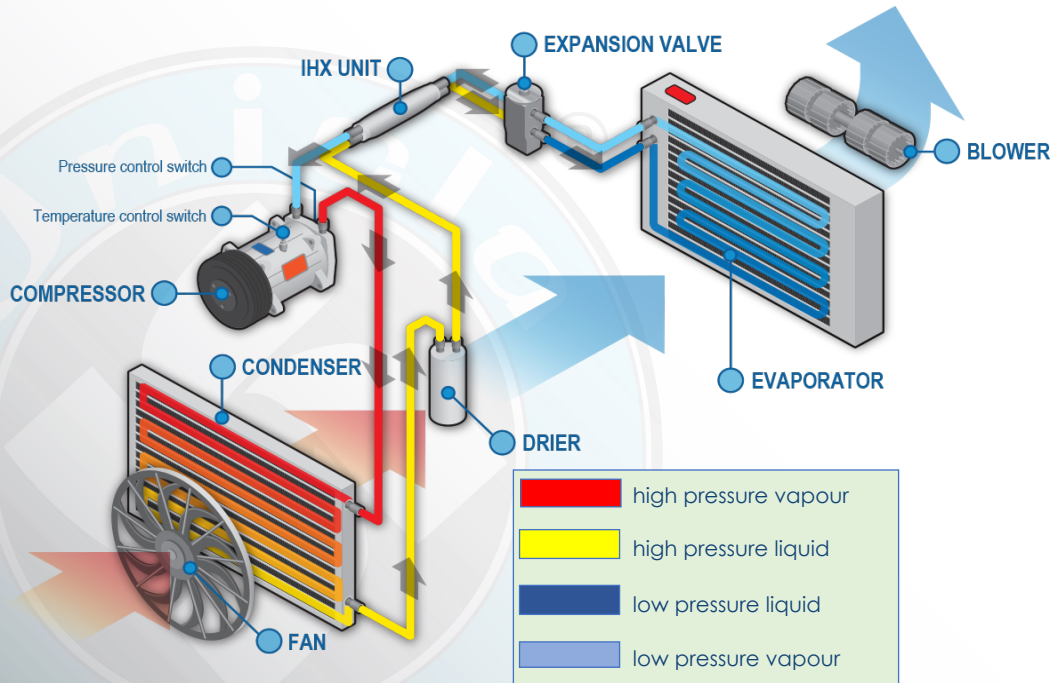
Low side:

- new components must not be less than two times allowable pressure with system on or off – 2.92 (423psig) mPa



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SAE standard J639 - R1234yf maximum working temperature



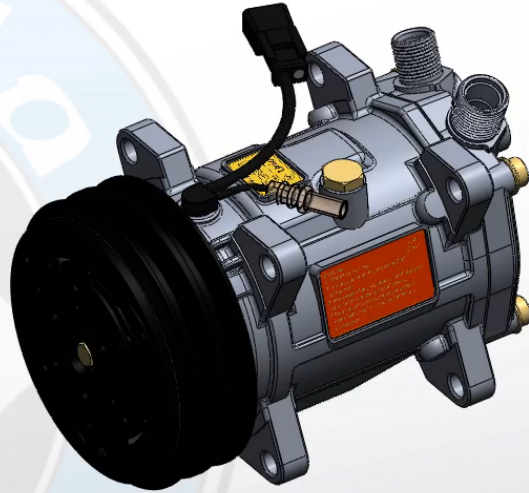
High side:

- discharge outlet at compressor and line must not exceed 150°C during continuous operation
- discharge outlet must not exceed 160°C during intermittent (5 minute intervals) during operation

Low side:

- must not exceed 56°C with system on or off

SAE standard J639 - compressor design and requirements



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SAE standard J639 -

R1234yf maximum burst pressure of
compressor and adjacent cavities

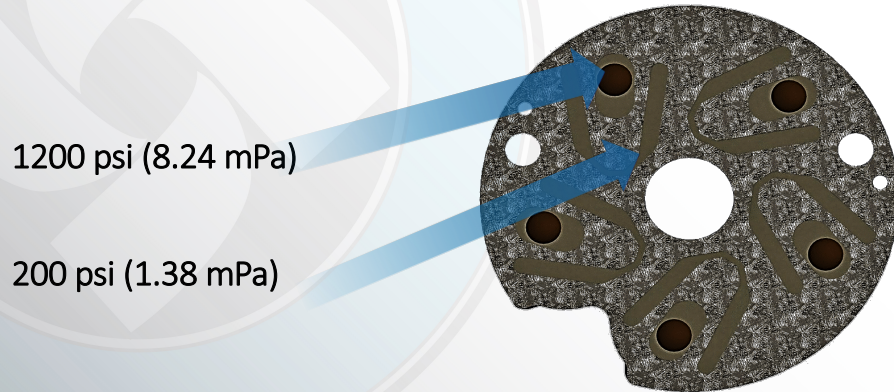
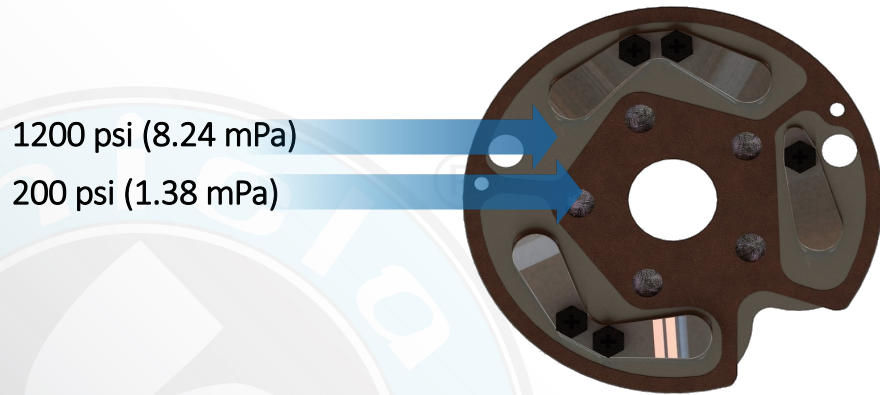
Suction valve plate

Gasket



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SAE standard J639 - R1234yf maximum burst pressure of compressor and adjacent cavities



- adjacent cavities (low side next to high side) shall be burst tested at maximum pressures
- high side must be tested at twice the maximum high side working pressure which is 1200 psi (8.24 mPa) while the low side is maintained at 1.38 mPa



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SAE standard J639 - R1234yf compressor design requirements



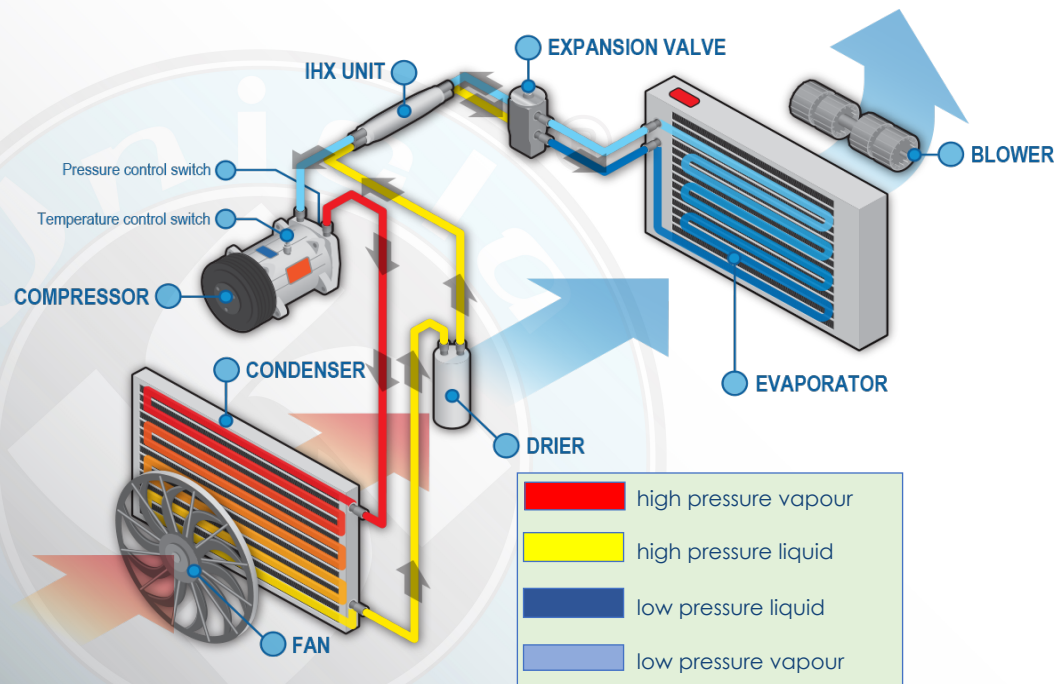
- must be inoperative with no power transmission or power if failed on drawing excessive torque
- managed by lock sensor or permanent clutch cutout (designed to eliminate catastrophic failure of compressor components causing refrigerant leakage)
- must have pressure relief < 4.14 mPa (600 psig) and self sealing



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SAE standard J639 -

R1234yf refrigerant line routing
and connections

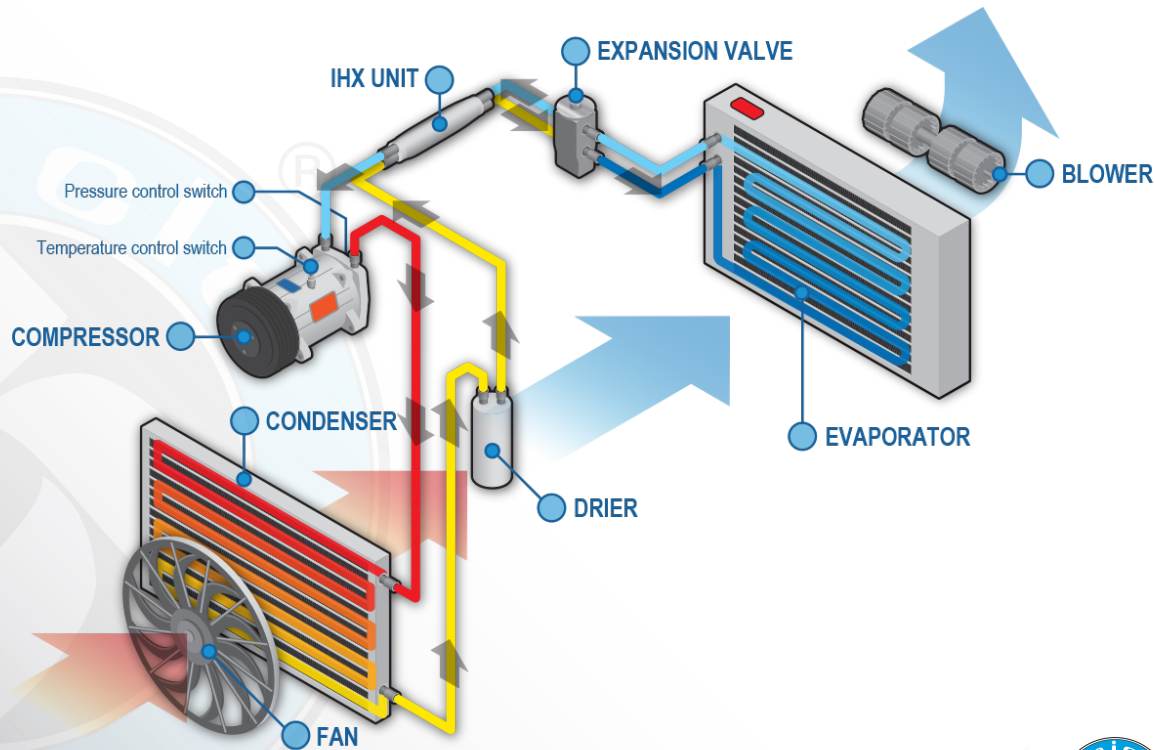


- must be located outside the passenger compartment and outside the cabin airflow path (plenum) – or –
- design to sufficiently present no leakage if inside the cabin or cabin air flow path
- service manual must state a process to prevent any leakage into cabin or plenum
- service fittings must have ease of access for technicians
- piping must be sufficiently robust to withstand connect/disconnect procedures



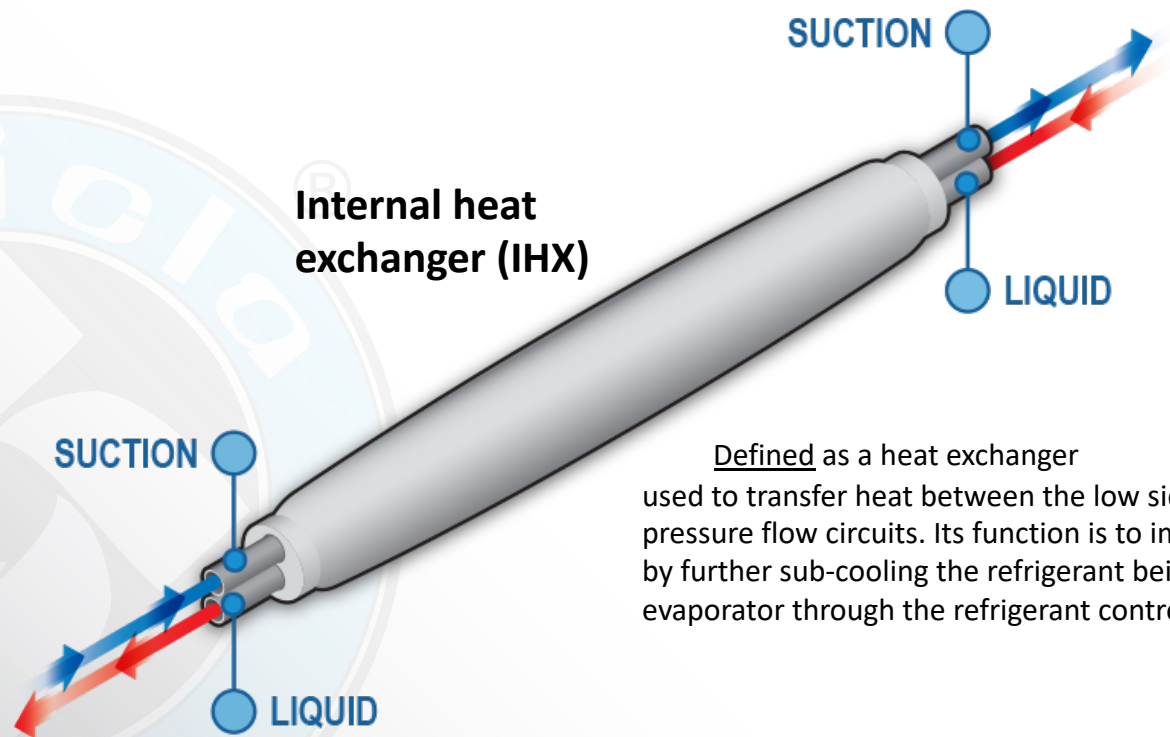
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SAE standard J639 - R1234yf compressor design requirements



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SAE standard J639 - Internal heat exchanger



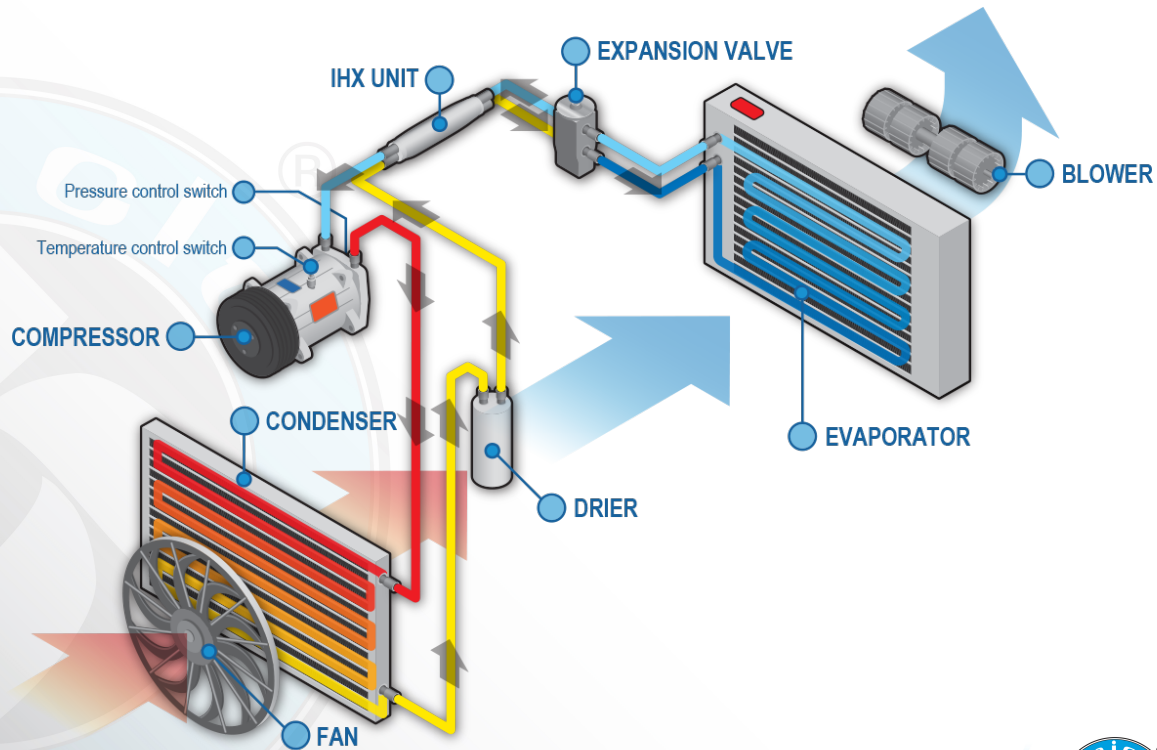
Defined as a heat exchanger

used to transfer heat between the low side pressure and high pressure flow circuits. Its function is to improve system capacity by further sub-cooling the refrigerant being supplied to the evaporator through the refrigerant control device.



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SAE standard J639 - internal heat exchanger (IHX)

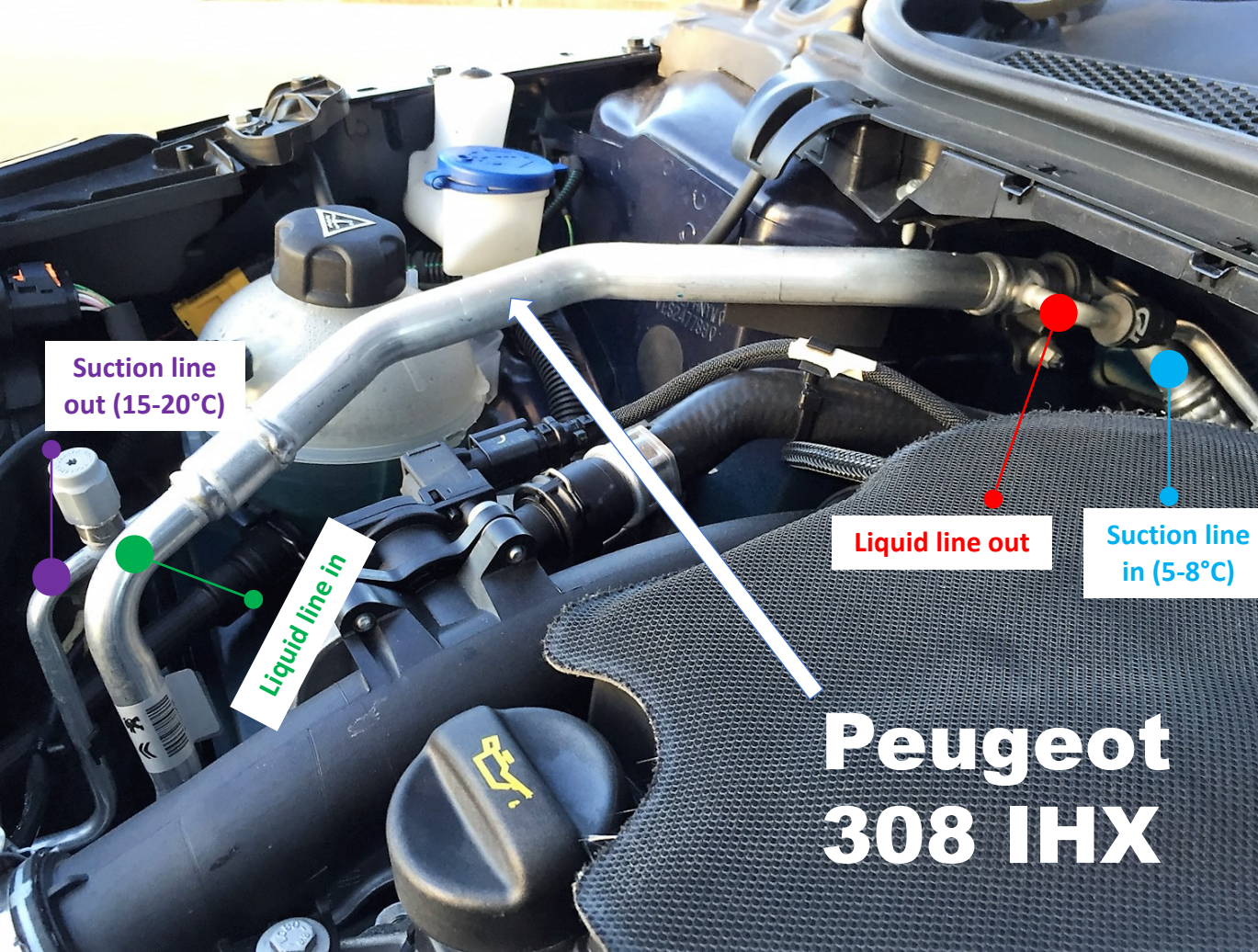


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SAE standard J639

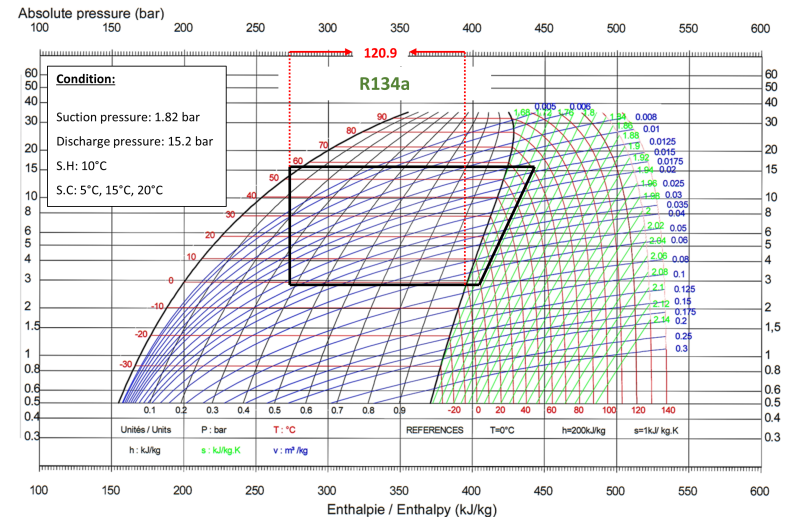
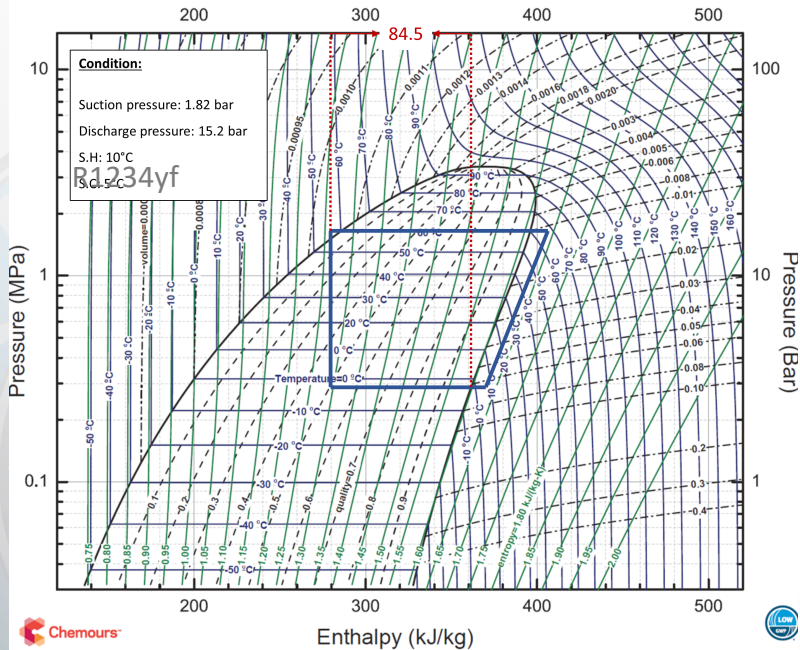
internal heat exchanger (IHX)

IHX- not insulated due to no sweating (the temperature never reaches the dew point)



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SAE standard J639 - internal heat exchanger (IHX)

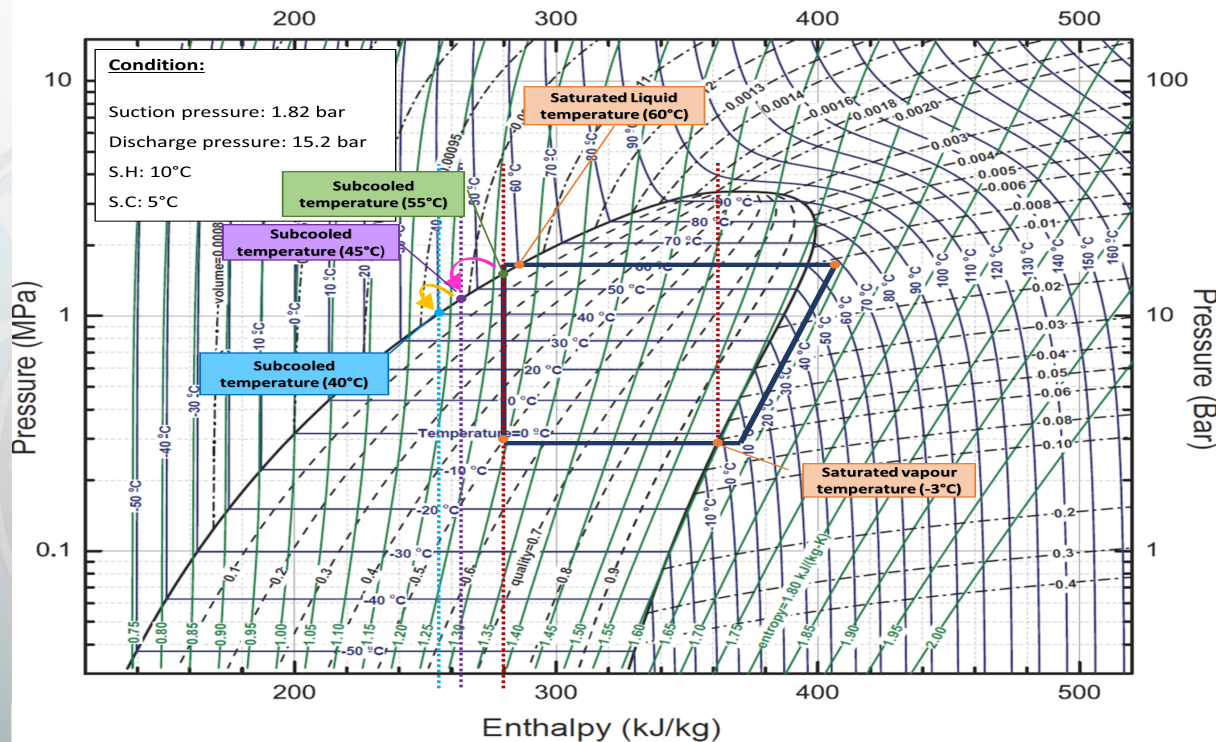


- R1234yf absorbs slightly less energy per unit of flow in a refrigerant cycle.
- R134a absorbs 120.9 kJ/kg
- R1234yf absorbs 84.5 kJ/kg



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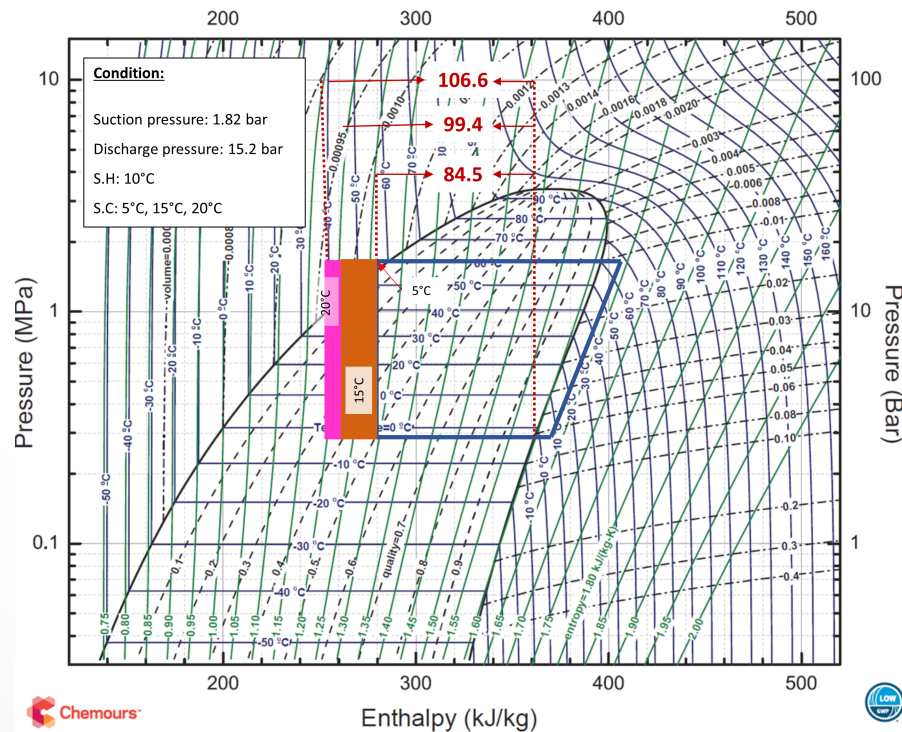
SAE standard J639 - internal heat exchanger (IHX)



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SAE standard J639 - internal heat exchanger (IHX)

- With extra subcooling of 10 – R1234yf absorbs 99.4 kJ/kg
- With extra subcooling of 15 – R1234yf absorbs 106.6 kJ/kg



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SAE J2842

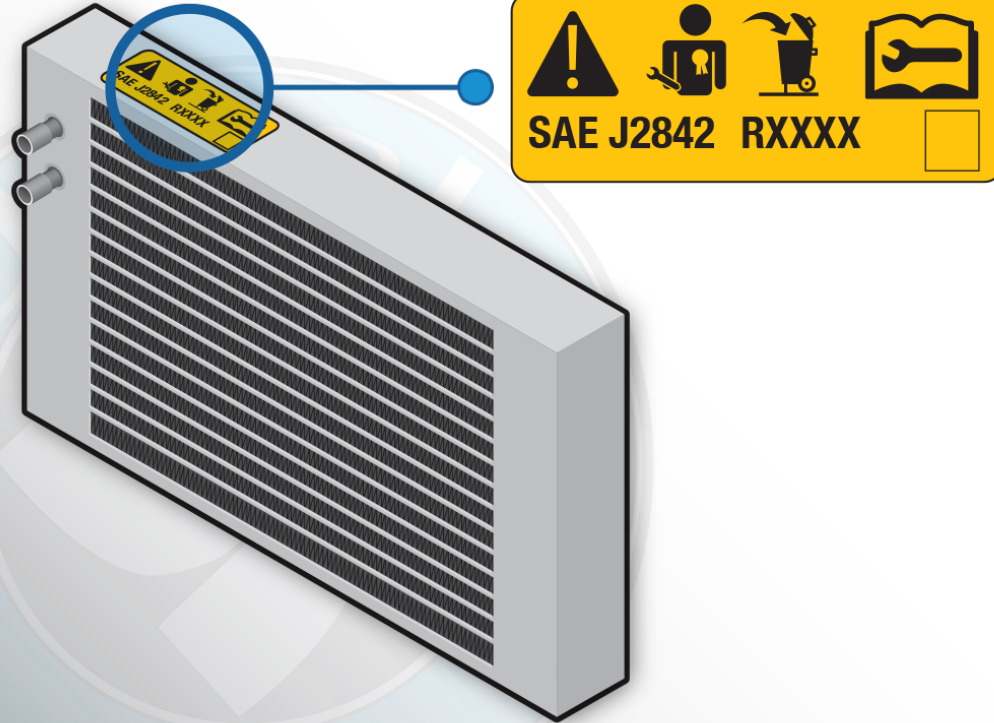
R1234yf and R744 design criteria and certification for OE mobile air conditioning evaporator and service replacements:

- provides a testing framework for evaporator manufacturers to meet J639
- describes labelling requirements
- demands that all evaporator manufacturers build and test to this standard



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SAE J2842



- requirements include standards for strength, corrosion, durability, fatigue resistance, burst pressure and design (2.92 mPa – 423psig)
- must be labelled
- must meet J639 as one of the MAC components
- must never be repaired, re-worked or re-used
- must have permanent label, stamp or etching
- label must be two colour Pantone orange (151) and black



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