



GUIDELINES FOR THE UTILIZATION OF

R-404A

R-452A



GUIDELINES FOR THE UTILIZATION OF R-404A AND R-452A

For many years, R-404A has emerged as the industry's major choice as an alternative refrigerant for R-502. Due to the changing environmental landscape refrigerant manufacturers have introduced HFO blends with a much lower Global Warming Potential (GWP). To accommodate the industry R-452A has been tested and approved by Tecumseh as a suitable replacement for R-404A.

While R-452A is a viable option for new and existing equipment, it is not a "drop-in" replacement for R-502 or R-404A. There are significant differences between R-502, R-404A, and R-452A, which must be considered when handling, processing, applying, or retrofitting with these refrigerants. These guidelines are offered to help understand the differences.

NOTE: R-404A is a near azeotrope and therefore needs to be charged in the liquid phase. R-452A is an azeotrope and must also be charged in the liquid phase. Any Tecumseh compressor with the letter "Z" as the refrigerant designation code in the model number can be used with either R-404A or R-452A.

REFRIGERANT PROPERTIES

- A. Pressure/temperature table for R-502, R-404A, and R-452A is shown in *Figure 1*.
- B. R-404A and R-452A possess similar energy efficiency and capacity characteristics to R-502.
- C. *Figure 2* shows the comparison of some properties of R-502, R-404A, and R-452A.
- D. For the same amount of subcooling, R-404A and R-452A produce a greater refrigerating effect than R-502.

Temperature		Pressure					
°F	°C	PSIG			KPa		
		R-502	R-404A	R-452A	R-502	R-404A	R-452A
-40	-40	4.1	4.5	2.4	129.6	132.4	117.8
-30	-34	9.2	9.9	7.3	164.8	169.7	151.6
-20	-28	15.3	16.3	13.2	206.9	213.8	192.3
-10	-23	22.6	23.9	20.4	257.2	266.2	241.9
0	-18	31.1	32.9	28.9	315.8	328.2	300.5
10	-12.2	41	43.3	38.8	384.1	400	368.8
20	-9	52.5	55.5	50.5	463.3	484.1	449.5
30	-1	65.6	69.5	63.9	553.7	580.6	541.8
40	4.4	80.5	85.5	79.5	656.4	690.9	649.4
50	10	97.4	103.7	97.2	773	816.4	771.4
60	15.6	116.4	124.4	117.3	904	959.1	910
70	21.1	137.6	147.5	140	1050	1118	1065
80	26.7	161.2	173.5	165.6	1212	1297	1243
90	32.2	187.4	202.5	194.3	1393	1497	1440
100	37.8	216.2	234.7	226.4	1592	1719	1662
110	43.3	247.9	270.4	262.1	1810	1965	1908
120	48.9	282.7	309.7	301.8	2050	2236	2182
130	54.4	320.8	353	345.9	2313	2535	2486
140	60	362.6	400.5	395	2601	2862	2824
150	65.6	408.4	452.5	449.8	2917	3221	3202

Figure 1



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Reference Document RD-0007-E

- E. The solubility of water in R-404A and R-452A is comparable to that of water in R-502. It is necessary to keep the system dry. See Section B.
- F. Extensive investigation and testing have been conducted to determine that R-404A, and R-452A are compatible with all materials used in Tecumseh Products' hermetic compressors and condensing units.

Refrigerant Comparison	R-502	R-404A	R-452A
Refrigerant Type	CFC	HFC	HFO-BLEND
ASHRAE Safety Designation	A1	A1	A1
GWP	4657	3922	1397
Approved Oil	MINERAL/AB	POE	POE
Temperature Glide (°C / °F)	-17.6 / 0.3	-16.6 / 2	-13.7 / 7.2
Boiling point at 1 bar (°C / °F)	-45.2 / -49.5	-46.5 / -51.7	-47 / -52.6
Critical temperature (°C / °F)	80.7 / 177.3	72.1 / 161.8	74.9 / 166.8
Critical pressure (bar abs / PSIG)	318.4 / 605.2	37.3 / 541	40.0 / 580.2

Figure 2

1. R-404A, and R-452A are non-flammable. They have been assigned an A1 safety classification under ASHRAE 34 and EN 378 standards. A1 means that the substance is classified “non-dangerous” with the following nomenclature.

A = Low toxicity

1 = No flame propagation at 18°C / 64.4°F, 101300 Pa / 14.7 psi.

2. However, because R-452A contain R-32 and R-1234yf which are mildly flammable, it should not be mixed with air to check for system leaks. This type of mixture can become combustible. See Figure 3.

Composition	R-502	R-404A	R-452A
R134a	0%	4%	0%
R125	0%	44%	59%
R143a	0%	52%	0%
R32	0%	0%	11%
R1234yf	0%	0%	30%
R115	51.2	0%	0%
R22	48.8	0%	0%

Figure 3

G. Chemical Stability

When decomposed, refrigerants generate fluoride ions and organic acids, causing POE oil degradation (PVE is less a concern), leading to corrosion of expansion valves, capillary tube plugging, and compressor bearing wear.



H. Refrigerant Glide

Blend refrigerants such as R-404A, and R-452A boil and condense at varying temperatures for a given pressure. The range over which the temperature varies is referred to as “temperature glide”.

I. Bubble and Dew Point

For blend refrigerants such as R-404A, and R-452A use the “dew” (vapor) pressure to calculate superheat. To calculate subcooling use the “bubble” (liquid) pressure.

LUBRICANTS - POLYOL ESTERS (POE's)

A. Miscibility

1. Miscibility is the ability of the lubricant and the refrigerant to mix. This miscibility is a very important factor in the returning of the lubricant to the compressor in a refrigeration system over its range of operating temperatures.
2. R-404A / R-452A and mineral oils are **not miscible**.
3. Polyol ester oils and R-404A / R-452A **are miscible**.

B. Moisture

1. Polyol ester oils, while not as hygroscopic (ability to absorb moisture) as earlier considered PAG's (polyalkylene glycols), are **100 times** more hygroscopic than mineral oils. This moisture is difficult to remove even with heat and vacuum.
2. **Utmost care must be taken to prevent moisture from getting into the refrigeration system.** Do not leave the compressor or system open to the atmosphere for longer than 15 minutes maximum. The preferred method of assembly would be to remove system component plugs and caps just prior to brazing. The maximum system moisture content after completing system processing should be 80 PPM.

After running the system with the appropriate drier installed, the system moisture level should be 10 PPM or less. These levels are based on measuring moisture in liquid refrigerant samples taken from the system.

3. **Always** use an appropriate drier in the system when using R-404A and R-452A. (See section on DRIERS.)

C. Compatibility

1. Extensive investigation and testing have been conducted by Tecumseh Products Company to determine that the polyol ester lubricants **approved by Tecumseh** are compatible with all materials used in Tecumseh hermetic compressors. Contact your Tecumseh sales representative for the latest list of approved oils. (Policy Bulletin No. 105.)
2. All polyol ester oils approved by Tecumseh Products are compatible with each other.
3. While polyol ester oils are compatible with mineral oils, they should not be indiscriminately mixed with mineral oils in R-404A and R-452A refrigerant systems. This practice could result in the inability of the oil to return to the compressor and/or reduce heat transfer performance in the evaporator. However, small amounts, up to 5% of mineral oil are acceptable in field retrofit situations (1% or less is preferred)



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SYSTEM DESIGN

- A. **Compressor selection:** Tecumseh is continuing to design R-404A and R-452A compressors with the compatibility of oil, refrigerant and materials in mind. These compressors will have the letter "Z" as the refrigerant designator, e.g. **AVA2490ZXN**. It will be necessary to test each compressor selection in the applications to determine its suitability, since system operating conditions vary greatly from one application to another.
- B. **Capillary tube selection:** In general, Capillary tubes selected for R-502 applications should be adequate for a preliminary selection for R-404A and R-452A. As with any capillary tube selection, system testing is necessary to determine the proper final selection.
- C. **Expansion valve selection:** The expansion valve manufacturers have designed product specifically for use with R-404A and R-452A. Consult them for their recommendations.
- D. **Driers:** Tecumseh requires that an appropriate drier be used on every R-404A and R-452A system. See section on DRIERS.
- E. **Return gas/discharge temperatures:** The theoretical discharge temperature for R-404A is slightly lower than that of R-502 at similar conditions. Therefore, existing compressor guidelines regarding return gas and discharge temperatures for R-502 should apply to R-404A and R-452A compressors as well. In general, keeping the return gas cool without flooding liquid refrigerant back to the compressor is beneficial in limiting compressor discharge and motor temperatures to acceptable levels.
- F. **Refrigerant quantity:** The refrigerant quantity will depend on the system components. In general, based on limited application data, 5% to 20% less R-404A will be needed compared to R-502 and 5% to 10% more R-452A compared to R-404A.

DRIERS

- A. The polyol ester oils, which are used with R-404A and R-452A, are prone to hydrolyze with moisture, resulting in the formation of acids. Therefore, Tecumseh requires that an appropriate drier be used in every R-404A application.
- B. The types of driers, which should be used, are the molecular sieve types, which are presently compatible with R-404A and R-452A. The XH-6 (**bonded core**), XH-7 and XH-9 types are recommended. The XH-6 (loose fill) type is not recommended due to its somewhat higher attrition rate.
- C. Solid core driers if made with bauxite would have the tendency to absorb both polyol ester oil and moisture. The ester could hydrolyze and form acidic materials. If the drier were to be overloaded due to excessive moisture in the system, it could release the acidic materials back into the system. Clearly this would **not** be healthy for the compressor. **For this reason, Tecumseh does not recommend the use of solid core driers made with bauxite for systems containing polyol ester oils.**
- D. For specific drier selection, contact your drier supplier.

SYSTEM PROCESSING

A. Compatibility

1. Polyol ester oils are good solvents and have a tendency to wash system processing materials such as



drawing components, rust inhibitors and cleaning compounds from system surfaces. Care must be taken to remove such processing materials from all the system components.

2. Residual chlorinated materials **should** be considered as system contamination and eliminated from all internal surfaces of the refrigeration system.

B. Evacuation

1. The evacuation levels for R-404A and R-452A systems should be the same as for R-502 systems (minimum of 200 microns at the system and pulled from both the low and high-pressure sides of the system. If care is not taken to prevent moisture from entering the system components prior to assembly, evacuation could be expected to take longer to achieve acceptable limits of system moisture and non-condensibles. Tecumseh recommends a maximum of 2% non-condensibles and 80 PPM moisture. The completed system should have a moisture level of 10 PPM or less after running with an appropriate drier installed. These levels are based on measuring moisture in liquid refrigerant samples taken from the system.
2. Polyol ester oils vaporize much less than mineral oils for the same level of heat and vacuum. Therefore, if oil vaporization was not a problem with the R-502 system processing, it should not be a problem with the R-404A and R-452A system processing.
3. Consult your vacuum pump manufacturer to learn if your existing equipment may need to be converted for use on R-404A and R-452A polyol ester systems.

C. Leak Testing

1. Use equipment, which is designed for R-404A and R-452A leak detection or approved for use with R-404A/R-452A by the manufacturer. Many leak detector manufacturers have R-404A and R-452A detectors on the market, consult these manufacturers for their recommendations on their equipment.
2. **CAUTION: Do not** attempt to use R-404A or R-452A as a mixture with air to pressure test for leaks.

D. Refrigerant Charging

1. In general, refrigerant charging equipment such as charging boards, valves, and hoses, which are compatible with R-502 should be compatible with R-404A/R-452A. This equipment would need to be recalibrated for use with R-404A and R-452A. **Once designated for R-404A/R-452A use, it should be used specifically for that refrigerant only.** Converted R-502 equipment should be clean of all residual R-502. Pulling a deep vacuum (25 to 50 microns) and repeated flushing with R-404A or R-452A should be sufficient. Consult your equipment and component manufacturer for specific recommendations for converting R-502 equipment for use with R-404A/R-452A.
2. R-404A is a "near azeotrope" and therefore must be charged as a liquid. R-452A is an "azeotrope" and also needs to be charged as a liquid. When refrigerant charging is done in the liquid state, it should be done into the liquid line or receiver. Liquid charging can be done into the suction line while the compressor is running if the refrigerant is SLOWLY metered through a liquid charge adaptor or similar device. (The preferred method of charging any refrigerant is to charge liquid into the liquid line or receiver.) **CAUTION: Always break the vacuum with refrigerant vapor or liquid before applying power to the compressor.**



RETROFITTING

The ideal situation regarding the use of R-404A and R-452A would be that it be limited to new equipment only. In this way, the system components would all be selected and tested by a system designer with the necessary concerns regarding R-404A and R-452A and polyol ester oils in mind. However, in the real world of today with millions of existing R-502 systems in the field, this would not be possible.

Therefore, we offer some **general** guidelines to those who must retrofit existing R-502 units in the field with R-404A or R-452A. Specific procedures can only be determined after an in-depth evaluation of the existing equipment. Contact the equipment OEM for specific details.

A. Replacing an R-502 compressor with an R-404A/R-452A ("Z") compressor: Use generally accepted system changeout procedures, taking special effort not to leave the system or the R-404A or R-452A compressor open to the atmosphere for more than a few minutes (15 minutes maximum).

1. Recover the R-502 refrigerant in the system using proper recovery equipment. Take special effort to remove any residual mineral oil left in the system. The remaining mineral oil should be 5% or less.
2. Refit the system with the proper capillary tube, expansion valve, or other appropriate expansion device.
3. Install a drier suitable for R-404/R-452A of suitable size for the system being retrofitted.
4. Install the proper Tecumseh R-404/R-452A ("Z") compressor containing polyol ester oil. **Be sure to use the correct electrical components: they could differ from those used with the R-502 compressor.**
5. Evacuate the system thoroughly. Break the system vacuum with R-404A (liquid), or R-452A (liquid) into the liquid line.
6. Charge the system using industry acceptable charging methods with the proper amount of R-404A or R-452A.
7. Check the system for proper operation.
8. After retrofitting an -R502 system with R-404A or R-452A, always identify the system as being charged with that refrigerant and containing a polyol ester oil. Indicate on the unit the amount of refrigerant used.
9. Tecumseh compressors, which have refrigerant designation codes other than "Z", are **NOT** approved for use with R-404A and R-452A.

B. Refrigerant Change Out Only (Existing R-404A System):

1. Establish baseline performance with R-404A.
2. Disconnect power.



3. Recover R-404A refrigerant from the system using proper recovery equipment. Weigh and record the amount.
4. Replace liquid line filter drier with a drier that is compatible with the replacement refrigerant.
5. R-452A has similar mass flow rates to R-404A so, TXV settings may be retained with minor adjustments.
6. Leak test using nitrogen (refer to Tecumseh's Service Handbook for proper leak test procedure). When pressure testing confirms that the system is free of leaks, evacuate the system thoroughly. Air, moisture and non-condensables must be removed to ensure long term compressor reliability. Evacuate to a minimum of 500 microns. Always use a vacuum gauge to measure vacuum levels.
7. Recharge with R-452A refrigerant in the liquid state to 80% of the original R404A name plate charge or weighed amount. Depending on the application and system design, refrigerant charge may vary. The final R-452A charge amount will be 5% to 10% higher compared to R-404A.
8. Label Equipment indicating charged with R-452A.

C. Performance Comparison

Reference Figures 4 and 5 below for an estimated compressor capacity and efficiency comparison to R-404A. The information is based on calorimeter data at AHRI (LBP/MBP) rating points. The results may vary depending on the compressor platform.

Capacity Relative to R-404A		
Refrigerant	Evaporator Temperature	
	Low	Medium
R-452A	99%	100%

Figure 4

COP Relative to R-404A		
Refrigerant	Evaporator Temperature	
	Low	Medium
R-452A	104%	102%

Figure 5

COMPRESSOR OPERATING WINDOW

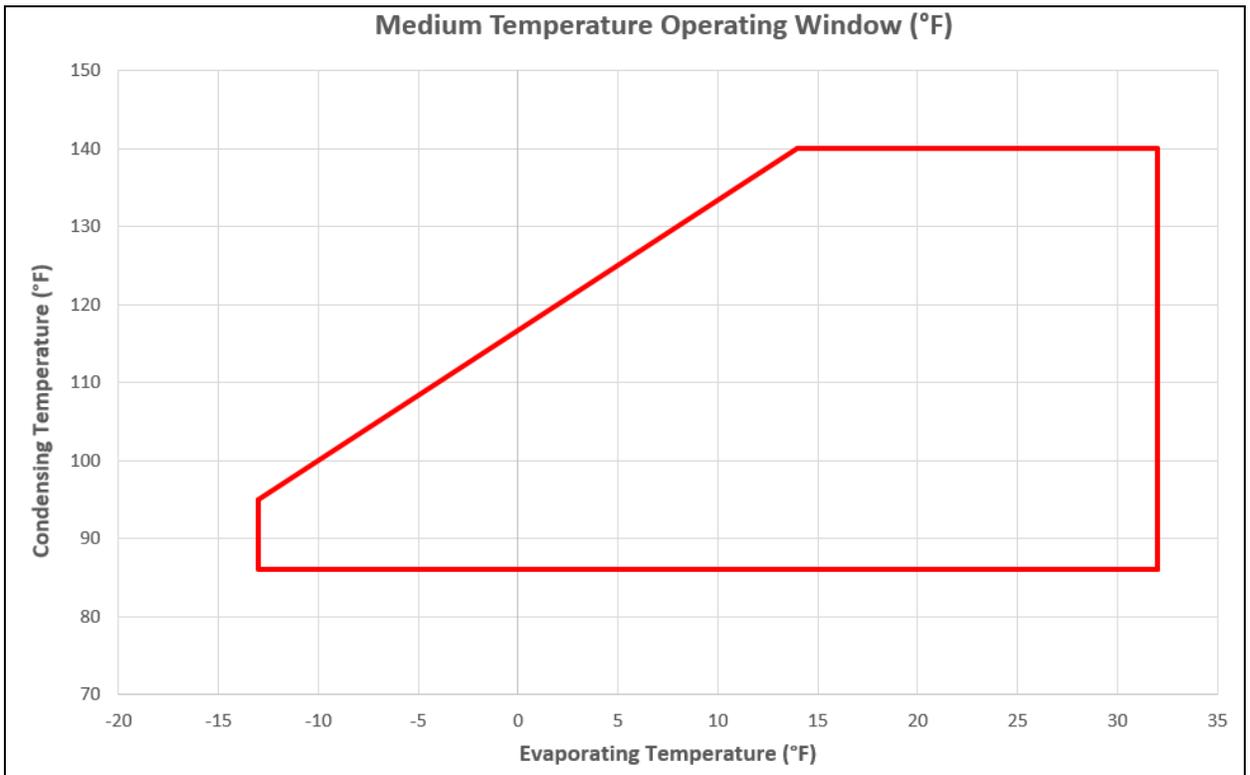
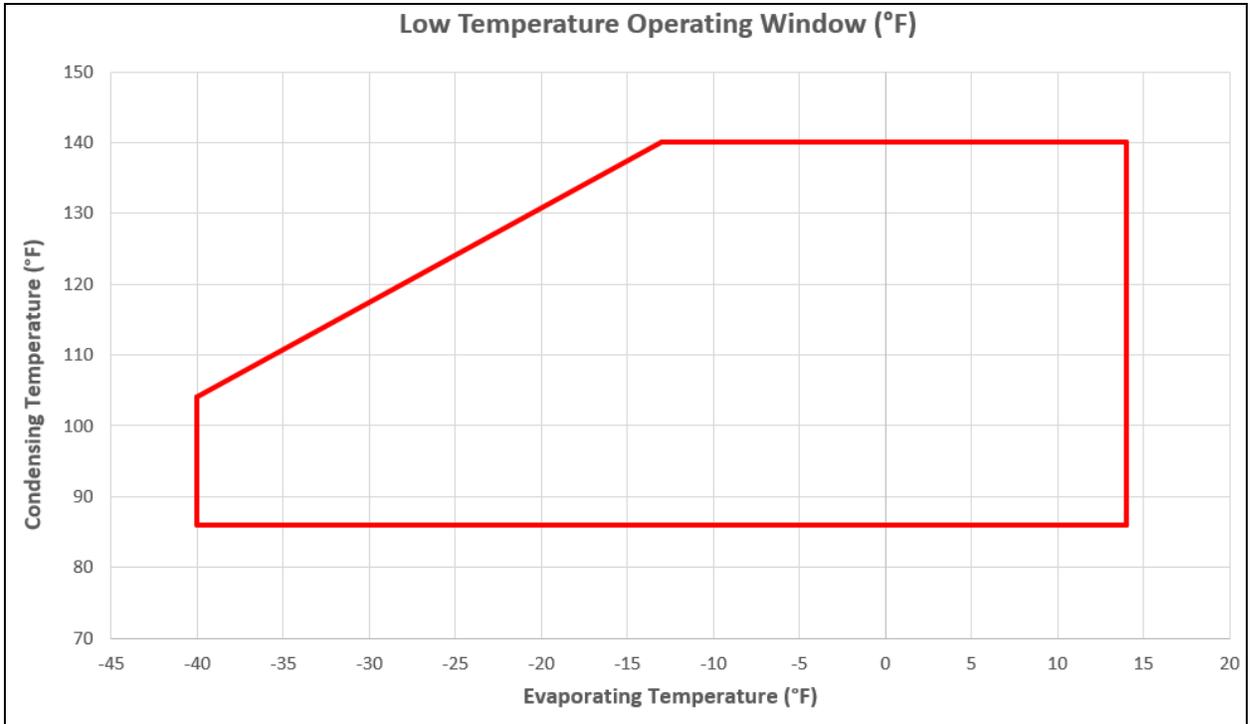
A. Application Boundaries

The operating windows shown on pages 8-9 are provided as guidelines only and need to be adjusted based on the specific compressor applied and the overall design of the refrigeration system.



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R-404A / R-452A APPLICATION BOUNDARIES (°F)





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R404A / R452A APPLICATION BOUNDARIES (°C)

