TECUMSEH PRODUCTS COMPANY

GUIDELINES FOR
UTILIZATION OF

R404A  R507
GUIDELINES FOR UTILIZATION OF R404A and R507

After many years of investigation and testing, R404A and R507 have emerged as the industry's major choices as alternative refrigerant for R502. Both R404A and R507 have ozone depletion potential (ODP) factor of zero (0.0) and a fraction of the global warming potential of R502. Both are non-flammable and have acceptable toxicity levels.

Neither of these refrigerants are "drop-in" replacements for R502. There are significant differences between R502, and R404A and R507, which must be considered when handling, processing, applying, or retrofitting with these new refrigerants. These guidelines are offered to help understand these differences.

NOTE: R404A and R507 are very similar, but not exactly the same. R404A is a near azeotrope and therefore needs to be charged in the liquid phase, while R507 is an azeotrope and does not need to be charged in the liquid phase. In these guidelines we will treat them as the same, except as specifically noted. Any Tecumseh compressor with the letter "Z" as the refrigerant designation code in the model number can be used with either R404A or R507.

I REFRIGERANT PROPERTIES

A. Pressure/temperature table of R502 vs. R404A and R507 is shown in Figure 1. Both are higher than R502 from -40°F (-40°C) to +150°F (65.6°C).

B. R404A and R507 possess similar energy efficiency and capacity characteristics to R502.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Pressure PSIG (kPa Abs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R502</td>
</tr>
<tr>
<td>-40 (-40)</td>
<td>4.1 (129.6)</td>
</tr>
<tr>
<td>-30 (-34.4)</td>
<td>9.2 (164.8)</td>
</tr>
<tr>
<td>-20 (-28.9)</td>
<td>15.3 (206.9)</td>
</tr>
<tr>
<td>-10 (-23.3)</td>
<td>22.6 (257.2)</td>
</tr>
<tr>
<td>0 (-17.8)</td>
<td>31.1 (315.8)</td>
</tr>
<tr>
<td>+10 (-12.2)</td>
<td>41.0 (384.1)</td>
</tr>
<tr>
<td>20 (-6.7)</td>
<td>52.5 (463.3)</td>
</tr>
<tr>
<td>30 (-1.1)</td>
<td>66.6 (553.7)</td>
</tr>
<tr>
<td>40 (+4.4)</td>
<td>80.5 (656.4)</td>
</tr>
<tr>
<td>50 (+10.0)</td>
<td>97.4 (773.0)</td>
</tr>
<tr>
<td>60 (+15.6)</td>
<td>116.4 (904.0)</td>
</tr>
<tr>
<td>70 (+21.1)</td>
<td>137.6 (1050)</td>
</tr>
<tr>
<td>80 (+26.7)</td>
<td>161.2 (1212)</td>
</tr>
<tr>
<td>90 (+32.2)</td>
<td>187.4 (1393)</td>
</tr>
<tr>
<td>100 (+37.8)</td>
<td>216.2 (1592)</td>
</tr>
<tr>
<td>110 (+43.3)</td>
<td>247.9 (1810)</td>
</tr>
<tr>
<td>120 (+48.9)</td>
<td>282.7 (2050)</td>
</tr>
<tr>
<td>130 (+54.4)</td>
<td>320.8 (2313)</td>
</tr>
<tr>
<td>140 (+60.0)</td>
<td>362.6 (2601)</td>
</tr>
<tr>
<td>150 (+65.6)</td>
<td>408.4 (2917)</td>
</tr>
</tbody>
</table>

*) Dew Point Pressures

Sources of Data: R502 - ASHRAE, R404A - DuPont, R507 - Allied

Figure 1
E. The solubility of water in R404A and R507 is comparable to that of water in R502. It is necessary to keep the system dry. See Section II. B.

F. Extensive investigation and testing have been conducted to determine that R404A and R507 are compatible with all materials used in Tecumseh Products’ hermetic compressors and condensing units.

<table>
<thead>
<tr>
<th>DATA</th>
<th>R502</th>
<th>R404A (*)</th>
<th>R507</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Formula</td>
<td>CHCLF₂ / CCLF₂CF₃</td>
<td>CHF₂CF₃ / CH₂CF₃ / CH₂FCF₃</td>
<td>CHF₂CF₃ / CH₃CF₃</td>
</tr>
<tr>
<td>Evaporating Pressure PSIG (kPa Abs.)</td>
<td>35.9 (348.6)</td>
<td>37.9 (362.5)</td>
<td>40.5 (380.4)</td>
</tr>
<tr>
<td>Condensing Pressure PSIG (kPa Abs.)</td>
<td>176.6 (1319)</td>
<td>190.5 (1415)</td>
<td>197.8 (1465)</td>
</tr>
<tr>
<td>Sat. Vapor Density @ 5°F (+30°C) Lbs./cu. ft. (Kg/m³)</td>
<td>1.250 (20.0)</td>
<td>1.136 (18.18)</td>
<td>1.220 (19.52)</td>
</tr>
<tr>
<td>Sat. Liquid Density @ 86°F (+30°C) Lbs./cu. ft. (Kg/m³)</td>
<td>74.45 (1191)</td>
<td>63.87 (1022)</td>
<td>63.80 (1021)</td>
</tr>
<tr>
<td>Latent Heat of Vaporization @ 5°F (-15°C) BTU/Lb. (KJ/Kg)</td>
<td>67.3 (156.5)</td>
<td>77.5 (180.3)</td>
<td>75.4 (175.3)</td>
</tr>
</tbody>
</table>

(*) Dew Point Data

II 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. R404A/R507 and mineral oils are not miscible.
3. Polyol ester oils and R404A/R507 are miscible. The miscibility of polyol ester (POE) oils and R404A/R507 is similar to that of current refrigerant oils and R22.

Some types of POE's are fully miscible with R404A/R507 (as are synthetic alkylate and R22), while some POE's are partially miscible with R404A/R507 (as are mineral oils and R22).

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 R404A/R507. (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 R404A/R507 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).
III SYSTEM DESIGN

A. **Compressor selection:** Tecumseh is continuing to design R404A/R507 compressors with the compatibility of oil, refrigerant and materials in mind. These compressors will have the letter "Z" as the refrigerant designator, e.g. AH2490Z. These compressors are designed to closely match the capacity of their corresponding R502 compressors at their individual rating point. In many cases, the same displacement is used. 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, R404A/R507 has a greater refrigerating effect than R502, thus reducing the required mass flow for a given capacity. However, capillary tubes selected for R502 applications should be adequate for a preliminary selection. 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 R404A/R507. Consult them for their recommendations.

D. **Driers:** Tecumseh requires that an appropriate drier be used on every R404A/R507 system. See section on DRIERS.

E. **Return gas/discharge temperatures:** The theoretical discharge temperature for R404A and R507 is slightly lower than that of R502 at similar conditions. Therefore existing compressor guidelines regarding return gas and discharge temperatures for R502 should apply to R404A/R507 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 R404A/R507 will be needed compared to R502.

IV DRIERS

A. The polyol ester oils, which are used with R404A/R507, are prone to hydrolyze with moisture, resulting in the formation of acids. Therefore, Tecumseh requires that an appropriate drier be used in every R404A/R507 application.

B. The types of driers, which should be used, are the molecular sieve types, which are presently compatible with R22. 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.

V 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 R404A/R507 systems should be the same as for R502 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 R502 system processing, it should not be a problem with the R404A/R507 system processing.

3. Consult your vacuum pump manufacturer to learn if your existing equipment may need to be converted for use on R404A/R507 polyol ester systems.

C. Leak Testing

1. Use equipment, which is designed for R404A/R507 detection or approved for R404A/R507 use by its manufacturer. Many leak detector manufacturers have R404A/R507 detectors on the market, and more are in development. Consult these manufacturers for their recommendations on their equipment.

2. CAUTION: Both DuPont and Allied Signal warn not to attempt to use R404A/R507 as a mixture with air to pressure test for leaks. Contact DuPont or Allied Signal for more information.

D. Refrigerant Charging

1. In general, refrigerant charging equipment such as charging boards, valves, and hoses, which are compatible with R502 should be compatible with R404A/R507. This equipment would need to be recalibrated for use with R404A or R507. Once designated for R404A or R507 use, it should be used specifically for that refrigerant only. Converted R502 equipment should be clean of all residual R502. Pulling a deep vacuum (25 to 50 microns) and repeated flushing with R404A or R507 should be sufficient. Consult your equipment and component manufacturer for specific recommendations for converting R502 equipment for use with R404A or R507.

2. R507 can be charged in either the liquid or vapor state. R404A is a “near azeotrope” and therefore should be charged in the liquid phase. If refrigerant charging is done in the liquid state, it should be done into the liquid line. Vapor charging can be done into the suction line while the compressor is running. (The preferred method of charging any refrigerant is to charge liquid into the liquid line.) CAUTION: Always break the vacuum with refrigerant vapor or liquid before applying power to the compressor.

V I RETROFITTING

The ideal situation regarding the use of R404A/R507 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 R404A/R507 and polyol ester oils in mind. However, in the real world of today with millions of existing R502 systems in the field, and the supply of R502 rapidly declining as the CFC phaseout date approaches, this would not be possible.

Therefore we offer some general guidelines to those who must retrofit existing R502 units in the field with R404A/R507. 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 R502 compressor with an R404A/ R507 (“Z”) compressor: Use generally accepted system changeout procedures, taking special effort not to leave the system nor the R404A1R507 compressor open to the atmosphere for more than a few minutes (15 minutes maximum).

1. Recover the R502 refrigerant in the system using proper recovery equipment. Take special effort to remove any residual mineral oil left in the system. The remaining amount of 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 R404/R507 of suitable size for the system being retrofitted.

4. Install the proper Tecumseh R404/R507 ("Z") compressor containing polyol ester oil. This compressor displays an orange and teal label stating it uses R404/R507 refrigerant and polyol ester oil. *(See Figure 3.)* Be sure to use the correct electrical components; they could differ from those used with the R502 compressor.

5. Evacuate the system thoroughly. *(Ref. V.B.1.)*

6. Break the system vacuum with R404A (liquid) or R507 (liquid or vapor) into the liquid line.

7. Charge the system using industry acceptable charging methods with the proper amount of R404A/R507. Generally, the system will use less than it used with R502.

8. Check the system for proper operation.

After retrofitting an R502 system with R404A or R507, 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.

B. Tecumseh compressors, which have refrigerant designation codes other than “Z”, are **NOT** approved for use with R404A or R507.

C. Tecumseh R404A/R507 ("Z") compressors can be used with R502, although the preferred refrigerant for these compressors is R404A or R507.

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The transition from the familiar R502 refrigerant to the new unfamiliar R404A/R507 refrigerant will present many challenges to our industry. Tecumseh Products Company is working diligently to meet these challenges. For information regarding the new Tecumseh R404A/R507 "Z" compressors, contact your Tecumseh sales representative.