Freon™ MO99™ (R-438A) and Freon™ NU-22B™ (R-422B)

Refrigerants

Retrofit Guidelines

Introduction

Freon™ MO99™ and Freon™ NU-22B™ refrigerants have proven to be reliable and cost-effective, non-ozone depleting retrofit refrigerants. In many cases, systems converted to these refrigerants are operating with the same mineral oil or alkylbenzene lubricant that was used with the previous chlorofluorocarbon (CFC) or hydrochlorofluorocarbon (HCFC) refrigerant. Freon™ MO99™ and Freon™ NU-22B™ refrigerants have shown to provide similar system performance as when operating with the previous refrigerant. Using these retrofit guidelines, direct expansion (DX) residential and commercial air conditioning (AC) containing R-22 can be easily and economically converted to Freon™ MO99™ or Freon™ NU-22B™. This allows existing equipment to continue operating safely and effectively for the remainder of its useful life.

Retrofit Choice for R-22 Direct Expansion Systems in Residential and Commercial Air Conditioning

Freon™ MO99™ and Freon™ NU-22B™ are non-ozone depleting HFC refrigerants designed to replace R-22 in existing DX residential and commercial AC. Freon™ MO99™ and Freon™ NU-22B™ are compatible with traditional and new lubricants; in most cases, no change of lubricant type during retrofit is required.

Oil return is determined by a number of operating and design conditions; in some complex systems, polyol ester lubricant (POE) may need to be added. Minor equipment modifications (e.g., seal replacement) or expansion device adjustments may be required in some applications.

Field experience has shown that Freon™ MO99™ and Freon™ NU-22B™ provide performance that meets customer requirements in most properly retrofitted systems. Freon™ MO99™ and Freon™ NU-22B™ provide similar cooling capacity and energy efficiency to R-22 in most systems, while operating at a lower compressor discharge temperature. Actual performance depends on system design and operating conditions.

Systems using Freon™ MO99™ or Freon™ NU-22B™ are easy to service. Freon™ MO99™ or Freon™ NU-22B™ can be topped off during service, without the need to remove the entire refrigerant charge. The cause of any refrigerant loss should be investigated and corrected as soon as possible.

Note: When servicing critically charged systems, all of the refrigerant charge should be removed. This is the same practice recommended for R-22.

In general, Freon™ MO99™ or Freon™ NU-22B™ refrigerant is not recommended for use in centrifugal compressor systems or chillers with flooded evaporators. For system-specific guidance on working with HFC blends in "semi-flooded" operations with low-pressure receivers, contact Chemours or consult the OEM.

DO NOT mix Freon™ MO99™ and Freon™ NU-22B™ in the same system.

Chemours™

Easy Steps to Retrofit

The following provides a summary of the basic retrofit steps for Freon™ MO99™ or Freon™ NU-22B™. (Detailed discussion of each step is provided in this bulletin.)

1. Establish baseline performance with existing refrigerant (see Retrofit Checklist).
2. Remove existing refrigerant (R-22 or other) from the system into a recovery cylinder. Weigh the amount removed.
3. Replace the filter drier and critical elastomeric seals/gaskets.*
4. Evacuate system and check for leaks.
5. Charge with Freon™ MO99™ or Freon™ NU-22B™.
    - Remove as a liquid only from charging cylinder.
    - The initial charge amount should be approximately 85% of the standard charge for R-22. The final charge amount will vary by system, but will be approximately the same weight as with R-22.
6. Start up system, monitor, and adjust TXV and/or charge size to achieve optimum superheat.
7. Monitor oil levels in compressor. Add oil as required to maintain proper levels.
8. Label system for the refrigerant and lubricant used.

*Critical seals are ones that are difficult to isolate and/or service while operating or require removal of the entire refrigerant charge, i.e., liquid receiver level gauge, in order to replace.

Important Safety Information

Like CFCs and HCFCs, Freon™ refrigerants are safe to use when handled properly. However, any refrigerant can cause injury or even death when mishandled. Please review the following guidelines and consult the product Safety Data Sheet (SDS), including proper personal protective equipment recommendations, before using any refrigerant. At a minimum, appropriate hand (gloves) and eye (safety glasses) protection should be used.

- Do not work in high concentrations of refrigerant vapors. Always maintain adequate ventilation in the work area. Do not breathe vapors. Do not breathe lubricant mists from leaking systems. Ventilate the area well after any leak before attempting to repair equipment.
- Do not use hand-held leak detectors to check for breathable air in enclosed working spaces. These detectors are not designed to determine if the air is safe to breathe. Use oxygen monitors to ensure adequate oxygen is available to sustain life.
- Do not use flames or halide torches to search for leaks. Open flames (e.g., halide detection or brazing torches) can release large quantities of acidic compounds in the presence of all refrigerants, which can be hazardous. Halide torches are not effective as leak detectors for HFC refrigerants; they detect the presence of chlorine, which is not present in Freon™ MO99™ or Freon™ NU-22B™, and, consequently, these detectors will not detect the presence of this refrigerant. Use an electronic leak detector designed to find the refrigerants you are using.

If you detect a visible change in the size or color of a flame when using brazing torches to repair equipment, stop work immediately and leave the area. Ventilate the work area well and stop any refrigerant leaks before resuming work. These flame effects may be an indication of very high refrigerant concentrations, and continuing to work without adequate ventilation may result in injury or death.

Note: Any refrigerant can be hazardous if used improperly. Hazards include liquid or vapor under pressure and frostbite from the escaping liquid.

Overexposure to high concentrations of refrigerant vapor can cause asphyxiation and cardiac arrest. Please read all safety information before handling any refrigerant.

Refer to the Freon™ MO99™ or Freon™ NU-22B™ SDS for more specific safety information. Chemours Safety Bulletin AS-1 also gives additional information for safe handling of refrigerants.

Flammability

Freon™ MO99™ and Freon™ NU-22B™ are nonflammable in air under normal conditions and have an ASHRAE A1 safety classification (nonflammable and low toxicity). When mixed with high concentrations of air or oxygen under elevated pressure, however, this product, like other A1 classified HFC refrigerants, can become combustible in the presence of an ignition source. This product should not be mixed with air to check for system leaks.

Filter Drier and Elastomeric Seal Information

Filter Drier

Change the filter drier during the retrofit. This is a routine system maintenance practice after the system has been open to air. There are two types of filter driers commonly used, solid core and loose filled. Replace the drier with the same type currently in use in the system. The drier label will show which refrigerants can be used with that drier. Select a drier specified to work with HFC refrigerants. (Many driers sold today are "universal"; they will work with most fluorocarbon refrigerants.) Check with your Chemours distributor for the correct drier to use in your system.

Elastomeric Seals

R-22 and, to a lesser extent, R-22-containing refrigerant blends, interact relatively strongly with many elastomers, causing significant swelling and, often, over time, a measurable increase in hardness. Freon™ MO99™ or Freon™ NU-22B™, like other HFC refrigerants, does not have as strong of an effect on elastomers commonly used as seals in refrigeration systems. As a result, when performing an R-22 retrofit to an HFC alternative, it is possible for leaks to occur at elastomeric seals that have been previously exposed to R-22 refrigerant. This is not a problem attributable specifically to the use of Freon™ MO99™ or Freon™ NU-22B™. Such seal leaks have been reported when replacing R-22 with other HFC refrigerants, such as R-407C or R-404A. Components commonly affected are Schrader core seals, liquid level receiver gaskets, solenoid valves, ball valves, flange seals, and some shaft seals on open drive compressors. Leaks do not occur in every system retrofitted, and, in practice, it is difficult to predict whether such leaks will occur. (As a rule of thumb: the older the system, the higher the probability that leaks will be observed after a retrofit.)

As a consequence, it is recommended to change elastomeric seals and gaskets as a matter of course during a retrofit, particularly any system-critical seals (those which would require removal of the refrigerant charge to allow seal replacement, e.g., liquid receiver, refrigerant high-pressure side, etc.). It is also recommended to have spare seals for other components available during restart of the system. The same type of seal can be used; it should just be a new one that has not previously been in R-22 service. A rigorous leak check regime pre- and post-retrofit will minimize any refrigerant losses. Obviously, any seals found to be leaking before the retrofit takes place should be replaced during the retrofit.

General Retrofit Information

System Modifications

The composition of Freon™ MO99™ and Freon™ NU-22B™ refrigerants have been designed to provide performance comparable to R-22, in terms of both capacity and energy efficiency. As a result, minimal system modifications are anticipated when retrofitting.

Retrofits of R-22 systems with other non-ozone depleting alternative refrigerants, such as R-407A or R-407C, will require multiple oil changes and possibly more extensive modifications to the existing equipment. For some systems, the cost of conversion may be high. Freon™ MO99™ and Freon™ NU-22B™ provide the service contractor and equipment owner with a cost-effective way to retrofit an existing system without oil changes.

Note: Freon™ MO99™ or Freon™ NU-22B™ should not be mixed with other refrigerants or additives that have not been clearly specified by Chemours or the system equipment manufacturer. Mixing these refrigerants with CFC or HCFC refrigerants, or mixing two different alternative refrigerants, may have an adverse effect on system performance. "Topping off" a CFC or HCFC refrigerant with any Freon™ refrigerant is not recommended.

Lubricants and System Oil Management

Lubricant selection is based on many factors, including compressor wear characteristics, material compatibility, and lubricant/refrigerant solubility (which can affect oil return to the compressor). Freon™ MO99™ and Freon™ NU-22B™ are compatible with traditional and new lubricants.

Field experience has shown that Freon™ MO99™ and Freon™ NU-22B™ will work successfully with the existing mineral (or alkylbenzene) oil in most systems. In some poorly designed, maintained, or operated R-22 systems, or in split systems with complex piping or component arrangements where the evaporator is positioned substantially lower than the condensing unit, the oil may not consistently return to the compressor. If oil return issues exist with R-22 operation, it is recommended that corrective actions be taken prior to converting to Freon™ MO99™ or Freon™ NU-22B™.

When oil level sight glasses are present in the compressor, oil levels should be monitored during initial operation with Freon™ MO99™ or Freon™ NU-22B™. If the oil level falls below the minimum allowed, top off the oil to the minimum level with the existing oil type. Do not fill to maximum, as the level may rise again.

Should the oil level fall continuously, or suffer large oscillations during an operating cycle, addition of POE lubricant has proven effective in restoring adequate oil return rates. An addition of POE lubricant (approximately 20% of the total oil charge) should be made. This can be followed, if necessary, by further small increments of POE, until the oil level returns to normal.

When adding POE oil to the system, it is important to ensure that the oil level (immediately after addition) is kept below the system mid-point (e.g., mid-sight glass) oil level. In most cases, the process of recovering R-22 at the start of the retrofit also removes some of the existing lubricant from the system. As a result, there should be sufficient space for the addition of POE, if deemed necessary. If there is concern about overfilling the oil sump, some of the existing mineral oil or alkylbenzene can be drained prior to the equivalent addition of POE.

Systems with Liquid Receivers

When converting an AC system with a liquid receiver from R-22 to Freon™ MO99™ or Freon™ NU-22B™, there is a possibility of trapping oil in the receiver by formation of a separate layer, if the oil discharge rate of the compressor is high, for example, when there is no oil separator system. Because it is impossible to know at any given time what the oil discharge rate of any compressor is, and it may change over time, it is recommended for systems with liquid receivers and no oil separators, that an addition of some POE (approximately 20% of the total oil charge) be made during the conversion. The addition of the appropriate POE for the system will assist in maintaining adequate oil solubility in the receiver in the event of a high discharge of oil from the compressor. There is no need to perform multiple system flushes or remove all of the mineral oil or alkylbenzene when converting to Freon™ MO99™ or Freon™ NU-22B™.

Systems that have oil separators, such as supermarket parallel racks, when converted to Freon™ MO99™ or Freon™ NU-22B™, have typically maintained lower oil circulation rates and have not required the addition of POE to maintain solubility in liquid receivers.

Enhanced Surface Tubing

In systems containing enhanced tube surfaces in heat exchangers, large amounts of oil in circulation could potentially inhibit heat transfer and negatively impact system performance. If a specific system with enhanced heat transfer tubes is suspected or known to have high oil circulation rates, a partial charge (approximately 20%) of POE in the existing mineral oil will provide increased solubility of the lubricant in the refrigerant.

Refrigerant Migration and Oil Miscibility

Refrigerant migration, the movement of refrigerant (vapor and/or liquid) to the compressor during off-cycles, usually occurs when the compressor becomes colder than the rest of the system, creating a driving force. This typically happens during cold weather; however, refrigerant migration can occur under other conditions.

Systems operating with highly miscible refrigerant oil pairs (R-22/mineral oil or R-404A/POE) can dissolve a large amount of refrigerant into the oil in the compressor oil sump due to refrigerant migration during off-cycles. Upon start-up, the dissolved refrigerant will rapidly flash from the oil, resulting in foaming, a drop in oil pressure, and reduced lubricity.

Concerns over refrigeration migration issues extend as well to converted systems with limited miscibility refrigerant/oil combinations, such as Freon™/mineral oil, because, in these cases, the potential exists to form separate oil and refrigerant layers in the compressor, with the refrigerant at the bottom. This potential can be reduced by the use of properly functioning crankcase heaters. However, in compressors designed to lubricate the bearings by drawing oil specifically from the bottom of the oil sump, ***such as Trane 3-D and Danfoss SM scroll compressors,*** the refrigerant/oil combination in use should be highly miscible as an added precautionary measure to avoid the potential formation of a refrigerant layer at the bottom of the compressor oil sump. Because Freon™ MO99™ or Freon™ NU-22B™ refrigerant has the highest miscibility with POE lubricant, ***a single oil change in the compressor oil sump from mineral oil to an OEM-approved POE lubricant is recommended in these select cases to address potential refrigerant migration concerns.*** The impact of refrigerant migration and recommendations for converting systems from R-22 to Freon™ MO99™ or Freon™ NU-22B™ can be very equipment-specific. Consult the OEM or Chemours for specific questions.

Direct Expansion Systems with Screw Compressors

The complex lubrication and oil management system associated with screw compressors requires special consideration and evaluation when retrofitting to any alternate refrigerant. Depending on the system design, oil circulation rates vary and may far exceed typical rates seen with common reciprocating and scroll compressors, even when oil separation systems are installed.

So that the periods of high oil circulation rates do not lead to oil logging and performance concerns, for these systems, the use of OEM-approved POE lubricant is recommended when retrofitting an R-22 system to an HFC alternative, such as Freon™ MO99™ or Freon™ NU-22B™. In order to ensure adequate oil return through these complex screw systems, the change from the existing lubricant to POE should take place while the system is still operating with R-22. Once the system has been converted to POE, the retrofit from R-22 to Freon™ MO99™ or Freon™ NU-22B™ should proceed as outlined in these guidelines.

Consultation with the chiller and screw compressor OEMs on topics beyond oil management is also recommended for these systems. There may be additional system-specific elastomeric seals in the compressor that may need to be replaced during the retrofit or programmed control settings related to pressure and temperature readings that would require involvement of the OEM for slight set point changes.

Liquid Refrigerant Control

The potential problems that poor liquid refrigerant control can cause in a refrigeration or air conditioning system can be severe and difficult to predict with certainty. Where flooding, slugging, or refrigerant migration can occur, corrective action should be taken. The proper course of action is normally dependent on the compressor type, system design, type of problem, and the refrigerant/lubricant combination. Compressor or equipment manufacturers should be consulted for detailed guidance on liquid control for a specific system.

While undesirable for reasons previously described and often dependent on system design, management of liquid refrigerant in general may be accomplished by a variety of equipment or control strategies:

- **Minimize Refrigerant Charge**—Charge system with minimum amount of refrigerant required for proper operation. Keep the tubes in condensers, evaporators, and connecting lines to smallest practical size.
- **Pumpdown Cycle (Continuous or One-Time)**—Isolates the refrigerant when compressor is not in operation, preventing refrigerant migration (see, for example, Copeland Application Engineering Bulletin AE-1182-R24).
- **Crank Case Heaters**—Maintains oil in the compressor at a temperature higher than coldest part of the system, driving refrigerant out of the compressor.
- **Suction Line Accumulators**—Provides a temporary storage vessel to trap liquid refrigerant that has flooded back; especially important for heat pump systems.

Flood Back, Superheat, and Temperature Glide

Flood back (incomplete evaporation of liquid refrigerant in the evaporator), due to inadequate superheat, may be caused by an oversized or improperly adjusted TXV and can lead to liquid slugging and/or bearing washout in the compressor.

For air conditioning systems being converted from R-22 to Freon™ MO99™ or Freon™ NU-22B™ refrigerant, the mass flow rates are fairly similar, such that a TXV (valve body, power-head, or nozzle/orifice) properly sized and operating well for R-22 should not need replacement when switching to Freon™ MO99™ or Freon™ NU-22B™.

However, it may be necessary to slightly adjust the TXV due to the temperature glide effect and small suction pressure differences of the new refrigerant. The need for adjustment will depend on current valve set points and amount of superheat desired to achieve appropriate system performance. Detailed guidelines on measuring and setting superheat for Freon™ MO99™ and Freon™ NU-22B™ are included in a separate section in this document. Because the mass flow rates and pressure-temperature curves for R-22 and Freon™ MO99™ and Freon™ NU-22B™ are very close, only minor adjustments should be required for properly sized components. Conversion kits are available to convert some older non-adjustable TXVs into adjustable types, without replacing the valve, if need be.

Freon™ MO99™ and Freon™ NU-22B™ will also work well in systems designed with fixed expansion devices, such as capillary tubes, pistons, or other fixed orifices; in most cases, a change in expansion device is not required.

In these non-adjustable systems, the refrigerant charge size is critical, and extra care should be used when weighing and charging the refrigerant. As stated in the retrofit steps, when charging Freon™ MO99™ or Freon™ NU-22B™ to these critically charged systems, begin with approximately 85% of the original R-22 charge weight. Once conditions stabilize, additional refrigerant can be added in small increments as needed to achieve the desired superheat for the system.

During any refrigerant charging process, as system pressures are being monitored, if the condenser (head) pressure rises significantly above typical levels expected with R-22, and necessary refrigerant charge weight has not been reached, STOP CHARGING and ensure there is not a restriction in the flow. Fixed expansion devices are designed with small diameters to properly meter flow; a restriction in the path can lead to high condenser pressures and/or starving of the evaporator.

If condenser pressures remain high after verifying the system has no line restriction and is not overcharged, the suction superheat should be checked. If the suction superheat is higher than typically observed with R-22, it is possible that the existing fixed expansion device is undersized. The replacement option for each type of device and system will vary based on design. However, in general, fixed pistons and orifices can be replaced with an orifice of a larger size or with a TXV designed for use with R-22. Capillary tubes, if undersized for Freon™ MO99™ or Freon™ NU-22B™, can also be replaced with a shorter or wider tube or with a TXV designed for use with R-22.

Refrigerant Recovery Information

Most recovery or recycle equipment used for R-22 can be used for Freon™ MO99™ or Freon™ NU-22B™. Use standard procedures to avoid cross-contamination when switching from one refrigerant to another. Most recovery or recycle machines can use the same compressor oil that was used for the HCFC refrigerant. However, some modifications may be necessary, such as a different kind of drier or a different moisture indicator. Consult the equipment manufacturer for specific recommendations.

Expected Performance After Retrofit

Operational Set Points

Freon™ MO99™ and Freon™ NU-22B™ have been designed to closely match the pressure, temperature, enthalpy, and mass flow properties of R-22. Therefore, in most cases, the operational set points currently used for evaporator pressures, thermal expansion valves, condenser head pressure control, etc., will be adequate for Freon™ MO99™ or Freon™ NU-22B™. After replacing R-22 with Freon™ MO99™ or Freon™ NU-22B™, start up the system and allow it to stabilize using the existing R-22 set points. If desired, after the system has stabilized, operating controls can be fine-tuned to optimize system performance. Detailed instructions for measuring and setting suction pressure, superheat, and subcooling can be found at the end of this bulletin.

Cooling capacity and energy efficiency depend greatly on system design, operating conditions, and the actual condition of the equipment. Freon™ MO99™ or Freon™ NU-22B™ provides similar cooling capacity and energy efficiency to R-22 in most systems. Actual performance depends on system design and operating conditions.

Detailed Retrofit Procedure for R-22 in Direct Expansion Residential

(Refer to the Retrofit Checklist at the back of this bulletin.)

1. **Establish baseline performance with existing refrigerant.** Collect system performance data while the old refrigerant is in the system. Check for correct refrigerant charge and operating conditions. The baseline data of temperatures and pressures at various points in the system (evaporator, condenser, compressor suction and discharge, superheat, and subcool) at normal operating conditions will be useful when optimizing operation of the system with Freon™ MO99™ or Freon™ NU-22B™. A System Data Sheet is included at the back of this bulletin to record baseline data.
2. **Remove refrigerant from the system into a recovery cylinder.** The existing charge should be removed from the system and collected in a recovery cylinder using a recovery device capable of pulling 10–15 in Hg vacuum (50–67 kPa absolute). If the recommended charge size for the system is not known, weigh the amount of refrigerant removed. The initial quantity of Freon™ MO99™ or Freon™ NU-22B™ to charge to the system can be estimated from this amount (see Step 5). Ensure that any residual refrigerant dissolved in the compressor oil is removed by holding the system under vacuum. Break the vacuum with dry nitrogen.

3. **Replace the filter drier/elastomeric seals/gaskets.** It is routine practice to replace the filter drier during system maintenance. Replacement filter driers are available that are compatible with Freon™ MO99™ or Freon™ NU-22B™. While the system is empty, check and replace any elastomeric seals that may be near the end of their serviceable life. Even if they were not previously leaking, the change of swell characteristics when changing to any new refrigerant (e.g., R-22 to any HFC refrigerant) and the general disturbance to the system may cause worn seals to leak after retrofit. Components commonly affected are Schrader core seals, liquid level receiver gaskets, solenoid valves, ball valves, flange seals, and some shaft seals on open drive compressors; but, all external seals in contact with the refrigerant should be viewed as a potential leak source post-retrofit. Field experience has shown that the older the system, the greater the likelihood of seal and gasket leaks. It is recommended to change any system-critical seals (e.g., those that require removal of the refrigerant charge to allow seal replacement: liquid receiver, condenser system) as a matter of course and have spare seals for other components available during the retrofit, should any seal failure occur. A rigorous leak check regime pre- and post-retrofit will minimize any refrigerant losses.
4. **Evacuate system and check for leaks.** Use normal service practices. To remove air or other non-condensable gases and any residual moisture from the system, evacuate the system to near full vacuum (29.9 in Hg vacuum [500 microns] or less than 10 kPa), isolate the vacuum pump from the system, and observe the vacuum reading. If the system does not maintain vacuum, it is an indication that there might be a leak. Pressurize the system with nitrogen, taking care not to exceed the system design maximum pressure, and check for leaks. Do not use mixtures of air and refrigerant under pressure to check for leaks; these mixtures can be combustible. After leak checking with nitrogen, remove residual nitrogen using a vacuum pump.
5. **Charge with Freon™ MO99™ or Freon™ NU-22B™.** Because Freon™ MO99™ or Freon™ NU-22B™ is a near-azeotrope, the vapor composition in the refrigerant cylinder is different from the liquid composition. For this reason, Freon™ MO99™ or Freon™ NU-22B™ should be transferred from the container in the liquid phase during system charging. (If the cylinder does not have a valve with a dip tube, invert the cylinder so that the valve is underneath the cylinder.) The proper cylinder position for liquid removal is often indicated by arrows on the cylinder and cylinder box. Once liquid is removed from the cylinder, the refrigerant can be allowed to enter the refrigeration system as liquid or vapor, as desired. Use the manifold gauges or a throttling valve to flash the liquid to vapor, if required.

   WARNING: Do not charge liquid refrigerant into the compressor. This will cause serious irreversible damage.

   In general, refrigeration systems will require about the same weight of Freon™ MO99™ or Freon™ NU-22B™ refrigerant as the original R-22 charge. The optimum charge will vary, depending on the system design and operating conditions. The initial charge should be approximately 85% of the standard charge for R-22. After start-up and adjustment, the final charge amount will usually be 95% of the original R-22 charge. Consult the system OEM guidelines for specific directions.

   Note: These values apply, provided no changes to mechanical components of the system (which could significantly affect the system's internal volumetric capacity) will be made during the retrofit. For systems with a liquid refrigerant receiver, charge the system to the normal refrigerant level in the receiver.
6. **Start up system and adjust charge size** (for systems without a liquid receiver). Start the system and let conditions stabilize. If the system is undercharged (as indicated by the level of superheat at the evaporator exit or the amount of subcool at the condenser exit), add more Freon™ MO99™ or Freon™ NU-22B™ in small amounts (still by transferring as liquid from the charging cylinder), until the system conditions reach the desired level. See the pressure-temperature charts (Appendix B) in this bulletin to compare pressures and temperatures in order to calculate superheat or subcooling for the refrigerant.

If present, sight glasses in the liquid line can be used in most cases as a guide to system charge; but, correct system charge must be determined by measuring system operating conditions (discharge and suction pressures, suction line temperature, compressor motor amps, superheat, etc.). Attempting to charge until the sight glass is "full" (bubble-free) may result in overcharging the refrigerant. Please read the section on "How to Determine Suction Pressure, Superheat, and Subcool" for details on estimating when a system is full, without relying solely on sight glass observations.

For any of the 400-series refrigerant blends, like Freon™ MO99™ or Freon™ NU-22B™, it is reasonable to expect to see some bubbles in the sight glass that are entrained in the liquid, not flashing off, even once the system is properly filled. It is also possible to have a "milky" or cloudy sight glass; this observation alone should not be cause for concern, as it is generally a result of a light scattering effect of the partially miscible oil in liquid refrigerant and typically will clear up over time. If the cloudy sight glass persists for an extended period of time, it may be an indication of higher oil discharge from the compressor. Details on managing systems with higher oil circulation rates can be found in the Lubricants and System Oil Management section.

Ensuring that the correct evaporator exit and compressor suction superheat is set is very important for reliable system operation with Freon™ MO99™ or Freon™ NU-22B™. Experience has shown that superheat (at the compressor inlet) for Freon™ MO99™ or Freon™ NU-22B™ should be the same as for the refrigerant being replaced.

WARNING: Liquid refrigerant entering the compressor at any time during system operation can lead to compressor oil level problems and rapid compressor failure.

7. **Monitor oil levels.** When compressor sight glasses are present, during initial operation of the system, monitor the level of oil in the compressor (or compressor oil management system) to verify that oil is returning to the compressor in an adequate manner.
    - If the oil level falls below the minimum allowed level, top off to the minimum level with the existing oil type. Do not fill to the maximum level, as the level may rise again.
    - Should the oil return appear to be erratic, as evidenced by large swings in oil level during the refrigeration system cycle, an addition of POE lubricant (approximately 20% of the total oil charge) should be made. This can be followed, if necessary, by the addition of further small increments of POE, until the oil level returns to normal. The exact amount of POE needed will depend on the specific system (evaporating temperatures, physical geometry, etc.).
    - It is important to ensure that, when adding POE oil to the system, the oil level (immediately after addition) is kept below the system midpoint (e.g., mid-sight glass) oil level. It is also important to keep accurate records of how much oil is added to avoid overfilling. If concerned about overfilling with oil, a portion of the existing mineral oil or alkylbenzene can be drained prior to the equivalent addition of POE.
8. **Thoroughly leak check the system.** As mentioned in Step 3, it is possible that refrigerant leakage can occur during or immediately after a retrofit. Experience has shown that some leaks will not appear until after the new refrigerant has been charged to the system. Pay particular attention to Schrader valve core seals, solenoid valves, and ball valve stems on the liquid high pressure side.
9. **Label the system** to clearly and permanently show the refrigerant and oil(s) present in the system.

Pressure-Temperature Charts (Appendix B)

How to Read the Pressure-Temperature Chart

The following pages contain pressure-temperature charts for the refrigerants discussed in this bulletin. Two temperatures are shown for Freon™ MO99™ and Freon™ NU-22B™ at a given pressure:

- Saturated Liquid Temperature (Bubble Point)—In the condenser, this is the point at which the last bit of vapor has condensed. This pressure-temperature should be used when determining the system subcooling as well as the pressure-temperature value of product stored in a refrigerant cylinder.
- Saturated Vapor Temperature (Dew Point)—In the evaporator, this is the temperature at which the last drop of liquid has just boiled. Above this temperature, the refrigerant will be superheated vapor. This pressure-temperature should be used in determining the system superheat.

How to Determine Suction Pressure, Superheat, and Subcool

Suction Pressure

In many cases, the evaporator pressure setting used for R-22 will provide adequate performance when using Freon™ MO99™ or Freon™ NU-22B™. However, if it is determined some adjustment is needed, refer to Appendix A (Average Evaporator Set Points [Table 4] and Average Condenser Set Points [Table 3]) and proceed as follows: Determine the expected average evaporator temperature using R-22 (from the baseline data you collected prior to the retrofit). Find the same expected evaporator temperature in the Saturated Vapor Temperature (Dew Point) column for Freon™ MO99™ or Freon™ NU-22B™. Note the corresponding pressure for this temperature. This is the approximate suction pressure at which the system should operate.

Superheat

In many cases, the superheat settings used for R-22 will provide adequate performance when using Freon™ MO99™ or Freon™ NU-22B™. However, if it is determined an adjustment is needed, refer to the P-T chart (Appendix B) and proceed as follows: First, measure the suction pressure, and using the saturated vapor temperature (dew point) table for Freon™ MO99™ or Freon™ NU-22B™, determine the saturated vapor temperature corresponding to that measured pressure. Next, measure the suction temperature at the evaporator exit (for evaporator superheat) or compressor inlet (for suction superheat), and subtract the previously determined dew point temperature for Freon™ MO99™ or Freon™ NU-22B™ to give the amount of vapor superheat. Adjust TXV, if necessary, to increase or decrease superheat. In general, the superheat for Freon™ MO99™ or Freon™ NU-22B™ operation should be similar to that used previously during R-22 operation.

Subcool

Using the saturated liquid temperature (bubble point) tables in P-T chart (Appendix B), for Freon™ MO99™ or Freon™ NU-22B™, determine the saturated liquid temperature for the measured condensing pressure (usually the high-side pressure). Measure the refrigerant liquid line temperature and subtract it from the previously determined bubble point temperature for Freon™ MO99™ or Freon™ NU-22B™ to give the amount of liquid subcool.

Retrofit Checklist for Converting CFC or HCFC Systems to Freon™ MO99™ or Freon™ NU-22B™

- ☐ Establish baseline performance with existing refrigerant.
  - Use the System Data Sheet provided in this bulletin.
  - Note the oil type in use and system operating data (if system is operating properly).
  - Check for existing leaks and repair.

- ☐ Remove existing refrigerant charge from system. (Need 10–15 in Hg vacuum [50–67 kPa absolute] to remove charge.)
  - Use recovery cylinder. (DO NOT vent to atmosphere.)
  - Weigh amount removed (if possible).: __________
  - Break the vacuum with dry nitrogen.

- ☐ Replace the filter drier and elastomeric seals/gaskets ; check oil/add POE lubricant where applicable (see below):
  - Check and replace elastomeric seals and gaskets that cannot be replaced without removal of refrigerant.
    — Components commonly affected are Schrader core seals, liquid level receiver gaskets, solenoid valves, ball valves, flange seals, or shaft seals on open drive compressors; but, all external seals in contact with the refrigerant should be viewed as a potential post-retrofit leak source.
  - Check that oil is in good condition; replace if necessary. ***(Note: Add 20% POE lubricant to R-22 systems with liquid receivers or with known or potential oil return issues.)***
    — One time change to POE lubricant in compressor oil sump is recommended for R-22 systems with Trane 3-D or Danfoss SM scroll compressors.

- ☐ Evacuate system and check for leaks.
  - Does the system hold a vacuum?
  - Break vacuum with dry nitrogen; pressurize to below the system design pressure.
  - Does the system hold pressure?
  - Check for any leaks, and make repairs as necessary.

- ☐ Charge system with Freon™ MO99™ or Freon™ NU-22B™ refrigerant.
  - Remove liquid only from cylinder.
  - The initial charge amount should be approximately 85% of the standard charge for R-22. The final charge amount will vary by system, but will be approximately the same weight as with R-22.
  - Particular attention should be given to critically charged systems (with fixed orifices/capillary tubes) to ensure equipment is not overcharged. (Monitor discharge pressure.)

    Note: Do not charge liquid refrigerant into the compressor. This will cause serious irreversible damage.

- ☐ Adjust TXV and/or refrigerant charge in small increments to achieve the same superheat as the original system. If adjustment is not possible or adequate, replace expansion device.

- ☐ Monitor oil levels in compressor.
  - If the oil level falls below the minimum, top off to the minimum level with the existing oil type.
  - If the oil level continuously falls or large oscillations occur during operation, add approximately 20% of an equivalent POE, or more if needed, until oil return becomes normal.
  - If a sudden surge in oil level occurs (e.g., during/just after defrost), or if there is concern about overfilling, a portion (approximately 20%) of the existing mineral oil or alkylbenzene can be drained prior to the equivalent addition of POE.

- ☐ Label system clearly. Ensure System Data Sheet is completed and filed securely.

System Data Sheet

Type of System/Location: ____________________

Equipment Mfg.: ____________________

Model No.: ____________________

Serial No.: ____________________

Date of Manufacture: ____________________

Original Charge Size: ____________________

Lubricant Charge Size: ____________________

Drier Type: ____________________

Compressor Mfg.: ____________________

Model No.: ____________________

Serial No.: ____________________

Date of Manufacture: ____________________

Lubricant Type: ____________________

Drier Mfg.: ____________________

Condenser Cooling Medium: ____________________

Expansion Device (check one):

☐ Capillary Tube: ____________________

☐ Expansion Valve: ____________________

If Expansion Valve:

Manufacturer: ____________________

Model No.: ____________________

Control/Set Point: ____________________

Location of Sensor: ____________________

Other System Controls (e.g., Head Pressure Control): ____________________

____

Date/Time				
Refrigerant				
Charge Size (lb)				
Ambient Temperature (°F)				
Compressor				
Suction Temperature (°F)				
Suction Pressure (psig)				
Discharge Temperature (°F)				
Discharge Pressure (psig)				
Evaporator				
Coil Air/H_2O In T (°F)				
Coil Air/H_2O Out T (°F)				
Operating Service Temperature (°F)				
Condenser				
Coil Air/H_2O In T (°F)				
Coil Air/H_2O Out T (°F)				
Superheat and Subcool (derived values)				
Refrigerant T at Superheat Ctl. Pt. (°F)				
Calculated Superheat (°F)				
Expansion Device Inlet T (°F)				
Calculated Subcool (°F)				
Motor Amps (If Rack: Total)				

Appendix A

Table 1. Physical Properties of Freon™ MO99™ and Freon™ NU-22B™ (Properties Calculated Using REFPROP Version 9.0, NIST 2010)

Physical Property	Unit	Freon™ MO99™	Freon™ NU-22B™	R-22
Boiling Point (1 atm)	°F	–44.2	-42.4	–41.4
Vapor Pressure at 77 °F	psia	142.2	139.5	151.4
Liquid Density at 77 °F	lb/ft^3	71.6	72	74.3
Density, Satd. Vapor at 77 °F	lb/ft^3	3.03	3.27	2.76
Ozone Depletion Potential	CFC-11 = 1.0	0	0	0.05
Global Warming Potential, AR5 Values	CO_2 = 1	2059	2289	1760

Table 2. Composition of Freon™ MO99™ and Freon™ NU-22B™ (wt%)

	HFC-32	HFC-125	HFC-134a	n-butane (R-600)	i-pentane (R-601a)	iso-butane (R-600A)
Freon™ MO99™	8.5	45	44.2	1.7	0.6	—
Freon™ NU-22B™	—	55	42	—	—	3

Table 3. Condenser Pressure (Set Points Based on 20 °F Evaporator, 10 °F Subcooling)

R-22, psig	Avg. Condenser Temp., °F	Freon™ MO99™, psig	Freon™ NU-22B™, psig
143.4	80	143.9	138.5
145.7	81	146.3	140.8
148.0	82	148.7	143.2
150.4	83	151.1	145.6
152.8	84	153.6	148.0
155.3	85	156.1	150.4
157.8	86	158.6	152.9
160.3	87	161.2	155.4
162.8	88	163.8	157.9
165.4	89	166.4	160.5
168.0	90	169.1	163.1
170.6	91	171.8	165.7
173.2	92	174.6	168.4
175.9	93	177.3	171.0
178.7	94	180.1	173.7
181.4	95	183.0	176.5
184.2	96	185.8	179.2
187.0	97	188.7	182.0
189.8	98	191.7	184.8
192.7	99	194.6	187.7
195.6	100	197.6	190.6
198.6	101	200.6	193.5
201.5	102	203.7	196.4
204.5	103	206.8	199.4
207.5	104	209.9	202.4
210.6	105	213.1	205.5
213.7	106	216.3	208.5
216.8	107	219.5	211.6
220.0	108	222.8	214.8
223.2	109	226.1	217.9
226.4	110	229.4	221.1

R-22, psig	Avg. Condenser Temp., °F	Freon™ MO99™, psig	Freon™ NU-22B™, psig
229.6	111	232.7	224.4
232.9	112	236.1	227.6
236.2	113	239.5	230.9
239.5	114	243.0	234.3
242.9	115	246.5	237.6
246.3	116	250.0	241.0
249.7	117	253.6	244.5
253.2	118	257.1	247.9
256.7	119	260.8	251.5
260.2	120	264.4	255.0
263.7	121	268.1	258.6
267.3	122	271.8	262.2
270.9	123	275.5	265.8
274.6	124	279.3	269.5
278.3	125	283.1	273.2
282.0	126	287.0	277.0
285.7	127	290.9	280.8
289.5	128	294.8	284.6
293.3	129	298.7	288.5
297.1	130	302.7	292.4
300.9	131	306.7	296.4
304.8	132	310.7	300.4
308.8	133	314.8	304.4
312.7	134	318.9	308.5
316.7	135	323.0	312.6
320.7	136	327.2	316.7
324.8	137	331.4	320.9
328.8	138	335.7	325.1
332.9	139	339.9	329.4
337.1	140	344.2	333.7

After converting from R-22, the condensing pressure can be determined by locating the desired average condenser temperature (or R-22 pressure setting) in Table 3 and determining the new set point required for equivalent operation with Freon™ MO99™ or Freon™ NU-22B™.

Table 4. Evaporator Suction Pressure (Set Points Based on 105 °F Condenser, 95 °F Subcooling)

R-22, psig	Avg. Condenser Temp., °F	Freon™ MO99™, psig	Freon™ NU-22B™, psig
7.6	-25	5.2	5.6
8.1	-24	5.7	6.1
8.6	-23	6.1	6.6
9.1	-22	6.6	7.1
9.6	-21	7.1	7.6
10.1	-20	7.6	8.2
10.7	-19	8.1	8.7
11.2	-18	8.6	9.3
11.8	-17	9.2	9.9
12.4	-16	9.7	10.5
13.0	-15	10.3	11.1
13.6	-14	10.9	11.7
14.2	-13	11.5	12.3
14.9	-12	12.1	12.9
15.5	-11	12.8	13.5
16.2	-10	13.4	14.2
16.9	-9	14.1	14.9
17.6	-8	14.8	15.5
18.3	-7	15.5	16.2
19.1	-6	16.2	16.9
19.8	-5	16.9	17.6
20.6	-4	17.7	18.4
21.4	-3	18.4	19.1
22.2	-2	19.2	19.8
23.0	-1	20.0	20.6
23.8	0	20.8	21.4
24.6	1	21.6	22.2
25.5	2	22.5	23.0
26.4	3	23.3	23.8
27.2	4	24.2	24.6
28.1	5	25.1	25.4
29.0	6	26.0	26.3
30.0	7	26.9	27.1
30.9	8	27.8	28.0
31.9	9	28.7	28.9
32.8	10	29.7	29.8
33.8	11	30.7	30.8
34.8	12	31.7	31.7
35.8	13	32.7	32.6
36.9	14	33.7	33.6
37.9	15	34.7	34.6
39.0	16	35.8	35.6
40.0	17	36.9	36.6
41.1	18	37.9	37.6
42.2	19	39.0	38.7
43.3	20	40.2	39.7
44.5	21	41.3	40.8
45.6	22	42.4	41.9
46.8	23	43.6	43.0
47.9	24	44.8	44.1
49.1	25	46.0	45.3
50.3	26	47.2	46.4
51.5	27	48.4	47.6
52.8	28	49.6	48.8
54.0	29	50.9	50.0
55.3	30	52.2	51.2
56.6	31	53.4	52.5
57.9	32	54.7	53.7
59.2	33	56.1	55.0
60.5	34	57.4	56.3
61.8	35	58.7	57.6
63.2	36	60.1	59.0
64.5	37	61.5	60.3
65.9	38	62.9	61.7
67.3	39	64.3	63.1
68.7	40	65.7	64.5
70.1	41	67.1	65.9
71.6	42	68.9	67.4
73.0	43	70.0	68.8
74.5	44	71.5	70.3
76.0	45	73.0	71.8

After converting from R-22, the evaporator temperature can be set by locating the desired average evaporator temperature (or R-22 evaporator pressure) in Table 4 and determining the new set point required for Freon™ MO99™ or Freon™ NU-22B™, in order to achieve an equivalent average evaporator temperature.

Appendix B. Freon™ MO99™ and Freon™ NU-22B™ Pressure-Temperature Data (ENG)

Pressure, psig	R-22	Freon™ MO99™		Freon™ NU-22B™	
	Saturated Temp.,°F	Saturated Liquid Temp. (Bubble Point),°F	Saturated Vapor Temp. (Dew Point), °F	Saturated Liquid Temp. (Bubble Point),°F	Saturated Vapor Temp. (Dew Point), °F
-6	-60.5	-63.0	-51.5	-61.5	-51.1
-5	-56.7	-59.3	-47.8	-57.7	-47.4
-4	-53.3	-55.8	-44.5	-54.2	-44.0
-3	-50.0	-52.6	-41.3	-50.9	-40.9
-2	-47.0	-49.6	-38.4	-47.9	-38.0
-1	-44.1	-46.8	-35.6	-45.1	-35.2
0	-41.4	-44.2	-33.0	-42.4	-32.6
1	-38.9	-41.7	-30.6	-39.8	-30.1
2	-36.5	-39.3	-28.2	-37.4	-27.8
3	-34.2	-37.0	-26.0	-35.1	-25.5
4	-32.0	-34.8	-23.9	-32.9	-23.4
5	-29.8	-32.7	-21.8	-30.7	-21.3
6	-27.8	-30.7	-19.8	-28.7	-19.4
7	-25.8	-28.8	-18.0	-26.7	-17.5
8	-24.0	-26.9	-16.1	-24.8	-15.6
9	-22.1	-25.1	-14.4	-23.0	-13.9
10	-20.4	-23.4	-12.6	-21.2	-12.1
12	-17.0	-20.1	-9.4	-17.8	-8.9
14	-13.8	-16.9	-6.3	-14.6	-5.8
16	-10.8	-13.9	-3.4	-11.6	-2.8
18	-7.9	-11.1	-0.6	-8.7	-0.1
20	-5.2	-8.4	2.0	-6.0	2.6
22	-2.5	-5.8	4.6	-3.4	5.1
24	0.0	-3.4	7.0	-0.8	7.6
26	2.4	-1.0	9.3	1.6	9.9
28	4.7	1.3	11.6	3.9	12.2
30	6.9	3.5	13.7	6.1	14.4
32	9.1	5.7	15.8	8.3	16.5
34	11.2	7.7	17.8	10.4	18.5
36	13.2	9.7	19.8	12.5	20.5
38	15.2	11.7	21.7	14.4	22.4
40	17.1	13.6	23.5	16.4	24.2
42	19.0	15.4	25.3	18.2	26.0
44	20.8	17.2	27.1	20.0	27.8
46	22.6	18.9	28.8	21.8	29.5
48	24.3	20.6	30.4	23.5	31.2
50	26.0	22.3	32.1	25.2	32.8
52	27.6	23.9	33.7	26.9	34.4
54	29.2	25.5	35.2	28.5	36.0
56	30.8	27.0	36.7	30.1	37.5
58	32.4	28.6	38.2	31.6	39.0
60	33.9	30.1	39.6	33.1	40.5
62	35.3	31.5	41.1	34.6	41.9
64	36.8	32.9	42.5	36.1	43.3
66	38.2	34.3	43.8	37.5	44.7
68	39.6	35.7	45.2	38.9	46.0
70	41.0	37.1	46.5	40.2	47.4
75	44.3	40.3	49.7	43.6	50.6
80	47.5	43.5	52.7	46.8	53.7
85	50.6	46.5	55.7	49.8	56.7
90	53.5	49.4	58.5	52.8	59.5

Appendix B. Freon™ MO99™ and Freon™ NU-22B™ Pressure-Temperature Data (ENG)—Cont'd

Pressure, psig	R-22	Freon™ MO99™		Freon™ NU-22B™	
	Saturated Temp.,°F	Saturated Liquid Temp. (Bubble Point),°F	Saturated Vapor Temp. (Dew Point), °F	Saturated Liquid Temp. (Bubble Point),°F	Saturated Vapor Temp. (Dew Point), °F
95	56.4	52.2	61.2	55.6	62.3
100	59.1	54.9	63.9	58.4	64.9
105	61.8	57.5	66.4	61.1	67.5
110	64.4	60.1	68.9	63.6	70.0
115	66.9	62.6	71.3	66.1	72.4
120	69.3	65.0	73.6	68.6	74.8
125	71.7	67.3	75.9	71.0	77.1
130	74.0	69.6	78.1	73.3	79.3
135	76.2	71.8	80.3	75.5	81.5
140	78.4	73.9	82.4	77.7	83.6
145	80.6	76.0	84.4	79.8	85.7
150	82.7	78.1	86.4	81.9	87.7
155	84.7	80.1	88.4	84.0	89.7
160	86.7	82.1	90.3	86.0	91.6
165	88.7	84.0	92.1	87.9	93.5
170	90.6	85.9	94.0	89.9	95.4
175	92.5	87.8	95.8	91.7	97.2
180	94.3	89.6	97.5	93.6	99.0
185	96.2	91.4	99.2	95.4	100.7
190	97.9	93.1	100.9	97.2	102.4
195	99.7	94.8	102.6	98.9	104.1
200	101.4	96.5	104.2	100.6	105.8
205	103.1	98.2	105.8	102.3	107.4
210	104.8	99.8	107.4	103.9	109.0
215	106.4	101.4	108.9	105.6	110.6
220	108.0	103.0	110.5	107.2	112.1
225	109.6	104.6	112.0	108.8	113.6
230	111.1	106.1	113.4	110.3	115.1
235	112.7	107.6	114.9	111.8	116.6
240	114.2	109.1	116.3	113.3	118.0
245	115.7	110.5	117.7	114.8	119.5
250	117.1	112.0	119.1	116.3	120.9
255	118.6	113.4	120.5	117.7	122.3
260	120.0	114.8	121.8	119.1	123.6
265	121.4	116.2	123.1	120.5	125.0
270	122.8	117.6	124.4	121.9	126.3
275	124.2	118.9	125.7	123.3	127.6
280	125.5	120.3	127.0	124.6	128.9
285	126.9	121.6	128.3	126.0	130.2
290	128.2	122.9	129.5	127.3	131.5
295	129.5	124.2	130.7	128.6	132.7
300	130.8	125.4	131.9	129.9	133.9
310	133.3	127.9	134.3	132.4	136.4
320	135.8	130.4	136.6	134.8	138.7
330	138.2	132.7	138.9	137.2	141.0
340	140.6	135.1	141.1	139.6	143.3
350	142.9	137.4	143.3	141.9	145.5
360	145.2	139.6	145.4	144.1	147.6
370	147.5	141.8	147.5	146.3	149.7
380	149.6	143.9	149.5	148.5	151.8
390	151.8	146.1	151.5	150.6	153.8
400	153.9	148.1	153.4	152.7	155.8

For more information on Freon™ refrigerants, visit freon.com

Replaces: K-22217-2
C-10862 (3/19)