RETROFIT GUIDELINES

R-470B (RS-51)

RS-51 is a blend of HFCs and HFOs designed to replace R-404A, R-507A and R-407C and has the lowest GWP on the market. It is a high safety group A1 refrigerant, being therefore non-flammable and non-toxic, and with a cooling capacity and energy efficiency, similar to R-404A substitutes.
Because its GWP is approximately 80% lower than that of R-404A and 45% lower than that of R-448A and R-449A, the F-Gas tax applied to this product is the lowest among the high-safety refrigerants (group A1).

1. INSTALLATIONS WITH R-404A, R-507, R-407C, R-449A, R-448A or R-22

- Medium and low temperature refrigeration equipment.

For commercial refrigeration equipment, industrial refrigeration equipment or water chillers, see the table below to determine the changes involved in converting to RS-51 for each refrigerant:

Conversion	Configure VEE	Change TXV orifice	Lubricant Change	Notes
R-407C – RS-51	⚠ Necessary	☑ Not necessary	☑ No change	Retrofit
R-404A – RS-51	⚠ Necessary	⚠ May be necessary	☑ No change	With thermostatic expansion valve, smaller orifice may be needed
R-507 – RS-51	⚠ Necessary	⚠ May be necessary	☑ No change	With thermostatic expansion valve, smaller orifice may be needed
R-449A – RS-51	⚠ Necessary	⚠ Necessary	☑ No change	With thermostatic expansion valve, smaller orifice required
R-448A – RS-51	⚠ Necessary	⚠ Necessary	☑ No change	With thermostatic expansion valve, smaller orifice required
R-22 – RS-51	⚠ Necessary	☑ Not necessary	⚠ Change needed	Lubricant change from Mineral oil to POE

2. GAS REPLACEMENT

The replacement process with RS-51 basically follows the procedure specified by the equipment manufacturer. Since RS-51 is a zerotropic mixture, it is very important that the charging of the system is carried out in the liquid phase.

1. Ensure that the necessary equipment is available, e.g. pressure gauges, recovery machine, recovery cylinders, oil container, vacuum pump, scales, among others.

2. Before removing the refrigerant, if possible, operate the unit under standard conditions and monitor pressures, temperatures and any other relevant data to establish the working conditions of the equipment. If this is not possible, the appropriate operating conditions are usually specified by the manufacturer.

3. Recover and weigh the refrigerant from the unit. The weight must be within the range indicated by the manufacturer.

4. If possible, check the condition of the lubricant, e.g. (water, acid, solids and uncondensables) and if necessary replace the contaminated oil with the same type of lubricant. If the installation was previously operated with R-404A or R-507, it will definitely contain POE oils. The RS-51 is compatible with polyolester (POE) lubricants and can therefore work with the same type of oil.

   REMARK: If the existing refrigerant was R-22 or its substitutes (R-434A, R-438A, R-453A) it is possible that the installation contains mineral or alkylbenzene oils and therefore should be replaced by POE oils. Note the level of oil removed and check that it is the same as that recommended by the manufacturer. That amount should be the amount replaced by POE oil. The amount of residual mineral oil should be less than 5%. Gas Servei has oil analysis kits for this function.

5. If possible, check the oil level and top up if necessary, as we may have washed out some oil when removing the coolant. If the level is low, do not top up to the maximum, as the level may rise again (after a short period of time the oil level will stabilise).

6. Check the condition of the gaskets and seals of the installation and replace those that are not in good condition.

   REMARK: If the existing refrigerant was R-22 or its substitutes (R-434A, R-438A, R-453A) it is possible that the installation elements have rubber gaskets. In this case, the use of metal-plastic gaskets, such as Klingerit or other fluorinated resins, such as Teflon or similar, compatible with R-404A and R-507, is recommended.

7. Depending on the type of expansion of the installation, the valve must be configured differently. Information on this can be found in sections 2.1 and 2.2.

8. It is recommended to replace the filter and vacuum the system.

9. Test the tightness of the system with dry nitrogen at 25 bar and then evacuate it with a two-stage vacuum pump equipped with a vacuum gauge. If the oil has been replaced, evacuate between 50 and 10 mbar, otherwise 500 mbar is sufficient.

10. Always charge the unit in liquid phase with RS-51. Initially the RS-51 charge should be 90% of the original refrigerant charge, then: $m_{RS\text{-}51} = m_{ORIGINAL} \times 0{,}9$.

    REMARK: RS-51 Pressure/Temperature tables are appropriate.

11. Operate the unit under conditions similar to the original conditions by checking the sight glass, compressor oil level and suction superheat.

12. While continuing to check the aspects in addition to the above operating parameters, add the remaining 10% of RS-51 until the charge is complete. If the system is equipped with a sight glass, gradually charge until only coolant passes through. Do not overload the system.

    Operate the equipment under the same conditions described in step 2 and verify that its operation is comparable.

    To achieve the optimum working conditions with the mid-temperature point, the procedure will vary depending on the type of expansion of the equipment:

    1. Electronic Expansion Valve (EEV).
    2. Thermostatic Expansion Valve (TXV).

3. ADJUSTEMENT OF THE INSTALLATION

3.1 CONFIGURATION WITH EEV (ELECTRONIC EXPANSION VALVE)

There are two possible situations:

1. The EEV controller has different refrigerants preconfigured, and among them is R-470B. In this situation, we must select it so that the equipment adapts its working conditions to operate under optimum conditions with this refrigerant.

2. The EEV controller does not have R-470B in the refrigerant selection list. In this case, it must be configured by entering the RS-51 Antoine constants for the dew point and bubble point:

	Dew point	Bubble point
A (A_1)	10,70	8,99
(*) B (A_2)	2.407,27	1.698,03
C (A_3)	256,64	250,97

$$T_e = \frac{A_2}{\ln(P_e) - A_1} - A_3$$

Remark: Some manufacturers identify the coefficients A, B and C as A_1, A_2 and A_3.

***** As can be seen in the formula above, the constant B (A_2) has a positive sign in the formula, if so, enter the value with a negative sign. To check if the sign is already built into the formula, consult the controller documentation or look at the value of B for any other gas already entered in the system.

3.2 CONFIGURATION WITH TXV (THERMOSTATIC EXPANSION VALVE)

In order to get the equipment to work properly with RS-51, it is necessary to check the expansion valve:

Select the valve and orifice in the same way as for R-407C or R-22. If the equipment was already operating with either of these gases, replacement is not necessary.

When the system is running, check the operating conditions and compare them with those taken at start-up even with the old refrigerant. Adjust the superheat with the expansion valve.

REMARK: If the equipment manufacturer recommends charging the original system with R-404A or R-507 by evaporator superheat or condenser subcooling, use the same values with RS-51.

If the original refrigerant was R-22, even if the compressor suction pressure is similar to that experienced using R-22, the discharge pressure will be higher, requiring adjustment of the high-pressure switches. Check the operating limits of the compressor.

13. Check that the compressor oil level is correct and add or remove if necessary.
You will probably see an improvement in oil return compared to the installation running on R-404A or R-507. It is important to ensure that, in the case of adding polyol ester oil to the system, the oil level (immediately after adding the oil) is kept below the mid-point of the system oil level (e.g. at the middle of the sight glass).

It is also important to keep an accurate record of the amount of oil introduced to avoid overfilling.

14. Disconnect refrigerant containers from the system immediately after completion of filling or draining.

15. Check again the tightness of the installation, looking for possible leaks, any detector suitable for HFC, will be suitable for the RS-51. Ask Gas Servei if you need an HFC detector.

16. Label the installation with the new refrigerant.

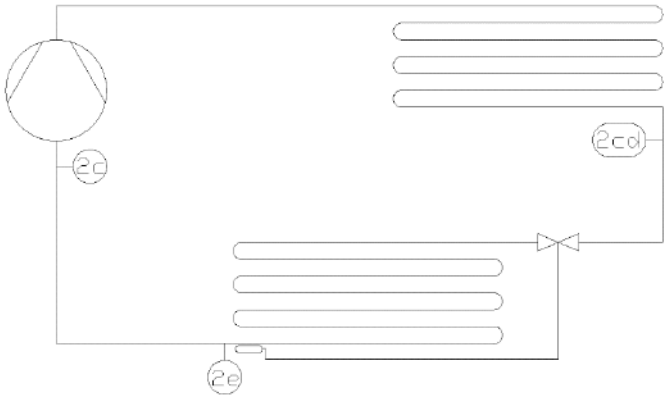
3.2.1. HOW TO SET THE SUPERHEAT (SH) OF THE INSTALLATION

Preliminary considerations:

The total superheat (SH) should ideally be between 7K and 12K.

$$SH_{TOTAL} = SH_{EFFECTIVE} + SH_{SUCTION\ LINE}$$

- $SH_{EFFECTIVE}$: This is the superheat that occurs in the evaporator; therefore, it is the one to be considered when evaluating the system setting. The typical recommended value is between 5K and 8K.
- $SH_{SUCTION\ LINE}$: It is the one between the evaporator outlet and the compressor inlet. Its value should be as low as possible, but ensuring that there is no liquid return. Values are acceptable if they are between 2K and 4K.



Calculation of the effective superheat

- T2e: Take the temperature at point '2e' with a thermometer.
- T1: Look at the pressure on the suction gauge and see which temperature corresponds to the vapour pressure (also known as dew point) in the Pressure/Temperature tables in the RS-51 Technical Data Sheet.

$$SH_{EFFECTIVE}: T2e - (T1)$$

Effective total superheat

- T2c: Take the temperature at point '2c' with a thermometer.
- T1: Look at the pressure on the suction gauge and see which temperature corresponds to the vapour pressure (also known as dew point) in the Pressure/Temperature tables in the RS-51 Technical Data Sheet.

$$SH_{TOTAL} = T2c - (T1)$$

Actual suction line superheat ($SH_{SUCTION\ LINE}$)

$$SH_{SUCTION\ LINE} = SH_{TOTAL} - SH_{EFFECTIVE}$$

3.2.2. SUBCOOLING (SC) OF THE INSTALLATION

Preliminary considerations:

The subcooling (SC) for medium/large installations should ideally be between 8K and 12K.

Calculation of the effective subcooling

- $T_{liquid,\ actuall}$: Take the temperature at point '2c' with a thermometer.
- T_{dew}: Look at the pressure on the high-pressure gauge and see what temperature it corresponds to based on the vapour pressure (also known as dew point) in the Pressure/Temperature tables for the refrigerant.

$$\text{Effective subcooling} = (T_{\text{dew}} - \text{glide}_{\text{effective}}) - T_{\text{liquid, actual}}$$

REMARK: Normally, it would be defined as: $T_{bubble} - T_{liquid,\ actual}$.

In the case of RS-51, the classical calculation of subcooling as $T_{bubble} - T_{liquid}$ can be misleading due to the presence of CO_2 in the mixture, which does not condense at typical system pressures. It is therefore advisable to apply an adjustment with the *effective glide* ratio or to use other more representative variables.

4. HOW TO CALCULATE THE SUPERHEAT (SH) OF THE INSTALLATION FOR THERMODYNAMIC CALCULATION PURPOSES

$$T_{\text{evap}} = T_{\text{dew}} - \frac{\text{Glide}_{\text{effective}}}{2}$$

RS-51's $glide_{effective}$: 4,1K

Disclaimers:

Section 4 explained how to adjust the real superheat of the installation, although for the purposes of performance calculations (COP), analysis of thermodynamic cycles, etc. it is more convenient to take this formula into account for the following reasons:

When the adjustment is carried out, it is not taken into account that the more volatile components of the mixture start to evaporate at a lower temperature. For this reason and for thermodynamic calculations (but not for the adjustment) it is recommended to take the glide into account. For this purpose, it is recommended to take the average evaporation temperature, i.e. the midpoint between the evaporation temperature of the most volatile component and the least volatile component.

In effect, this would mean taking the bubble (or liquid) temperature and the dew (or vapour) temperature for the suction pressure of the installation and calculating the average (sum of the two values divided by two), although this would not be correct for RS-51 either.

En In mixtures with CO_2 such as RS-51, part of the theoretical glide corresponds to the CO_2, which does not condense or evaporate under normal system conditions. Therefore, the thermodynamic calculation should only consider the effective glide, i.e. the temperature difference between the components that actually change phase in the refrigerant circuit.