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Conversion Evaluation

R-22 to R-434A (R 45)

Butadiene Refrigeration Units

AM-1908 & AM-3908

For
Advanced Refrigerant Technologies (ART)
1613 Highway 3, South
League City, TX 77573

For

INEOS Olefins & Polymers USA
Chocolate Bayou Plant
FM 2004
Alvin, TX

Project No. 201638

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Texas Engineering Firm F-2055

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1.0 Introduction:

Two refrigeration units, AM-1908 and AM-3908, installed for butadiene cooling for storage tanks and spheres at INEOS Olefins & Polymers in Alvin, TX, were evaluated to determine the feasibility of converting the units to operation on Refrigerant R-434A (trade name RS 45) from present operation on R-22. The units are used to cool butadiene for storage in Day Tanks and Storage Spheres. Refrigeration (heat) loads are absorbed by heat exchangers for the Day Tanks, Storage Spheres, and Rundown. AM-1908 serves 2 day tank heat exchangers, 3 sphere heat exchangers, and 1 rundown heat exchanger. The two refrigeration units are essentially identical in design and operation, except that AM-1908 serves 3 storage sphere heat exchangers and AM-3908 serves only 2 storage sphere heat exchangers.

The evaluation was done to identify any performance differences (capacity gain or loss and power increase or loss) for the system, to determine any capacity deficiencies for the components and piping, and to determine the need for modification or changing system components. The evaluation was done for AM-1908 (the largest design heat load) with the results applicable to AM-3908 except minus the heat load for one sphere.

The refrigeration systems are packaged (skidded) industrial refrigeration systems, each with two Carrier 5H80 reciprocating compressors, a water-cooled refrigerant condenser, a high-pressure refrigerant receiver, a suction accumulator, suction/liquid heat exchangers, valves and control valves, and interconnecting piping. Six, refrigerant flooded heat exchangers are installed near each refrigeration skid for cooling butadiene. Refer to 201638-PFD-1 (Appendix) showing the process flow diagram prepared for the evaluation. Details of both systems are shown on INEOS P&IDs D-A-XE-1128-SH-1, D-A-XE-1129-SH-1 for the refrigeration units; and D-A-XE-1120-SH2, D-A-XE-1122-SH-1, D-A-XE-1123-SH-2, D-A-XE-1123-SH-2, and D-A-XE-1124-SH-2 for the butadiene heat exchangers.

The maximum design refrigeration loads (loads if all exchangers simultaneously operate at design) are shown on 201638-PFD-1 with the evaluation shown on 201638-Htbal-1 (Appendix) The refrigeration design loads were taken from INEOS data sheets provided for the evaluation. The total refrigeration is 88 tons (AM-1908) and 65.6 tons (AM-3908 less one sphere) at the normal operating conditions (on R-22) of 32°F and 110°F condensing temperature

Compressor capacities for the Carrier 5H80s for R-434A were estimated by comparison of displacements with compressors that have published ratings for R434A. Published ratings for R-434A are not available for the 5AH80s. R-22 ratings were taken from Carrier rating tables.

Section 2.0 is an executive summary of the results of the evaluation of the systems converted to operation on R-434A. Section 3.0 provides a discussion of the evaluation's findings and any recommended changes that were found to be necessary. The Appendix contains the PFD for the evaluation and Spreadsheet 201638-Htbal-1 showing the evaluation calculations. The spreadsheet contains the detailed findings supporting the conversion.

2.0 Executive Summary:

The results of the evaluation show that the R-22 refrigeration systems are good candidates for conversion to R-434A (RS 45). Refrigeration capacity is estimated to be 61.1 tons per compressor, requiring 93.3 bhp each at design operating conditions (32°F evaporating and 110°F condensing), compared to 65.5 tons and 88 bhp for R-22. The spreadsheet evaluation shows that compressor capacity will be reduced by about 7% and the power required increased by about by about 6%. However, note that if both compressors are operated, total capacity at 123.2 tons will provide 34.5 tons of excess capacity with AM1908 at maximum design loads. According to INEOS, two compressors rarely need to be operated, therefore, capacity of the converted systems should be adequate. Note also that AM-3908 with one compressor is only 4.0 tons short of the maximum design load (with two spheres).

Operation on R-434A will require operating the compressors at 67.7 psig compared to 57.5 psig for R-22, to maintain the average 32°F evaporating temperature due to the refrigerant glide for R-434A. This accounts for the higher bhp requirement. The average temperature due to glide is an estimate and some additional capacity may be available if the evaporating pressure can be adjusted a bit higher and still provide the required evaporating temperatures..

R-434A requires a higher mass flow rate, about 43% higher than for R-22. The total mass flow fort R-434A is 17,573 lb/hr compared to 12,300 lb/hr for R-22. Although there is higher mass flow, a check of the existing pipe sizes indicates the existing piping will be adequate.

The evaluation also showed that other components: BD heat exchangers, condenser, receiver, and suction accumulator should be adequate (the suction accumulator is significantly oversized for R-22 and will be adequate for R-434A).

Be aware that changes in system set points will be required and some adjustments will need to be made to achieve best performance from the system.

It should be noted that the mineral oil used in the existing systems should be changed to a POE type oil. It is recommended that Carrier be consulted regarding the oil to ensure the proper oil is used for the 5H80s.

It should be understood that R-434A is a blend and is subject to composition change due to leakage. Therefore, judicious leak checking and repair will be a necessary requirement to ensure good performance from R-434A. Also, regular analysis of the blend composition, with the potential replenishment of individual component addition, if available, will minimize the concern for composition variation due to leaks.

Conversion will require recovery of the R-22 in compliance with 40CFR, Part 82, Subpart F, and any repairs or other maintenance requirements should be considered for completion during the conversion. It is also recommended that the system is evacuated to at least 1,000 microns Hg absolute pressure and checked for moisture before adding new R-434A.

It is also recommended that if conversion is done, time should be allowed to do a thorough maintenance check and make any repairs or upgrades before adding the new refrigerant.

Because this is an existing system, and because there appears to be minimum experience with R-434A in larger systems, there can be no guarantee of adequate performance of the system on R-434A.

3.0 Evaluation Details

The details and results of the conversion evaluation are provided on the spreadsheet 201638-Htbal-1 in the Appendix. The spreadsheet provides the details of the evaluation and any recommendations, but the following provides some explanation of the results.

The flow rates for R-434A are lower than for R-22, based on the Carrier R-22 ratings. The flow rates are based on operation of the system at maximum design loads for all heat exchangers (and for 3 spheres in operation. See 201638-PFD-1 process flow diagram, copy in the Appendix, for the stated loads. Flows were determined from the capacity estimates for the compressors using 32°F average evaporating temperature and 110°F average condensing temperature.

The compressor capacity results are included in Section II with the total heat rejection shown for the condenser. Section III shows the available condenser capacity compared to the total heat rejection from the system. Capacity available is 1,850 MBH for a heat rejection from one compressor of 977 MBH. Note that the condenser is not adequate if both compressors operate at 100% capacity. But with 3 spheres and at simultaneous maximum process heat loads, the second compressor would operate at 25% capacity maximum to satisfy maximum design loads. At that condition, hear rejection would be 1,222 MBH with 1,850 MBH available capacity. Therefore, the condenser is adequate.

Section IV A provides a discussion of the adequacy of the Fisher EZ level control valves. The valves appear adequate but it is recommended to record the serial numbers of the installed valves and, with the refrigerant data, have the valves checked by Fisher to ensure that the 1" valves with ¼" ports, are adequate for each heat exchanger.

Section IV B discusses the Fisher Level-Trol 2500 series displacers. The density of R-434A is lower than for R-22 at 32°F, therefore, the displacers should be ok. However, the actual controllers should be checked, with Fisher, for correct displacers.

Section V shows the pipe size evaluation for the systems. Note that the existing pipe sizes are adequate for R-434A.

In conclusion, it appears that conversion to R-434A should provide adequate performance for the system based of the results of this evaluation.

Appendix

201638-PFD-1 Process Flow Diagram

201638 Htbal-1 Evaluation Spreadsheet