

# Index

Previous Ph.D. Thesis Evaluation .....	I
Agradecimientos .....	II
Summary .....	IV
Resumen .....	VI
Resum .....	VIII
Index .....	X
List of Figures .....	XIV
List of Tables .....	XVIII
Nomenclature .....	XX
Chapter 1. Introduction .....	1
1.1. Introduction .....	2
1.1.2. Environmental concern and refrigerant substitution .....	8
1.1.3. Commercial refrigeration .....	29
1.1.4. Working fluids used in PCRRs .....	45
1.2. Motivation .....	50
1.3. Justification .....	51
1.4. Objectives .....	52
1.5. Hypothesis .....	53
1.6. Scope .....	53
1.7. Methodology .....	54

1.8. Document organisation.....	54
1.9. Conclusions Chapter 1.....	56
Chapter 2. State-of-Art.....	57
2.1. Overview of alternatives in commercial refrigeration systems .....	58
2.1.1. Natural refrigerants .....	61
2.1.2. Synthetic refrigerants .....	68
2.1.3. Alternatives to realise a substitution with minor system modifications.....	71
2.2. Recently studies of HFOs .....	72
2.2.1. Thermophysical properties studies.....	72
2.2.2. Flammability studies .....	73
2.2.3. Heat transfer studies.....	74
2.2.4. Performance studies .....	77
2.3. HFC/HFO mixtures .....	80
2.3.1. Thermodynamic properties studies for HFC/HFO mixtures.....	80
2.3.2. Flammability studies for HFC/HFO mixtures.....	82
2.3.3. Heat transfer studies for HFC/HFO mixtures .....	82
2.3.4. AHRI's proposal .....	83
2.3.5. Commercial HFO/HFC mixtures .....	85
2.4. Refrigerants selected .....	88
2.4.1. R134a alternatives properties.....	89
2.4.2. R404A alternatives properties.....	92
2.5. Conclusions Chapter 2.....	94

Analysis of fluoride fluids with low global warming impact in vapour compression systems. Experimental evaluation of different alternatives for commercial refrigeration.

Chapter 3. Theoretical Analysis.....	95
3.1 Basic cycle.....	96
3.2. Methodology of simulation .....	97
3.2.1. Simulation conditions .....	97
3.2.2. Adaptation to the operating ranges .....	99
3.2.3. Assumptions and equations.....	102
3.3. Theoretical results of comparison between R134a and alternatives .....	104
3.3.1. Mass flow rate.....	104
3.3.2. Cooling capacity .....	106
3.3.3. Coefficient of performance .....	107
3.4. Theoretical results of comparison between R404A and alternatives .....	109
3.4.1. Mass flow rate.....	109
3.4.2. Cooling capacity .....	110
3.4.3. Coefficient of performance .....	111
3.5. Conclusions Chapter 3.....	113
Chapter 4. Experimental procedure.....	114
4.1. Experimental setup .....	115
4.1.1. Main circuit.....	116
4.1.2. Secondary circuits.....	120
4.1.3. Sensors .....	121
4.2. Test procedure .....	124
4.2.1. Validation of data collected .....	124

4.2.2. Operating conditions .....	126
4.3. Methodology .....	127
4.4. Conclusions Chapter 4.....	130
Chapter 5. Experimental results .....	131
5.1. R134a and alternatives .....	132
5.1.1. Mass flow rate.....	132
5.1.2. Cooling capacity .....	137
5.1.3. Coefficient of performance .....	140
5.1.4. Compressor discharge temperature .....	143
5.2. Experimental comparison between R404A and alternatives .....	146
5.2.1. Mass flow rate.....	146
5.2.2. Cooling capacity .....	149
5.2.3. Coefficient of performance .....	150
5.2.4. Compressor discharge temperature .....	152
5.3. Conclusions Chapter 5.....	154
Chapter 6. Conclusions and future work.....	156
6.1. Conclusions .....	157
6.2. Future work recommendations .....	162
References.....	164
PhD Activities.....	189