

## HFC-HC Performance Comparisons - Literature Review

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References that are preceded by (\*) indicates that a copy of the paper is on file at ARI.  
References that are in **bold** type contain HFC to HC performance comparisons.

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### HEAD-TO-HEAD TESTING UNDER CONTROLLED CONDITIONS

- \*Agarwal, R. S., 1996  
“Hydrocarbon Blends - A Simple Alternative Technology to CFC-12 for Domestic Refrigeration,”  
*Proceedings of the 1996 International Conference on Ozone Protection Technologies*,  
Washington, DC, USA, 1996. Pages 357 - 366.  
Referenced in Colbourne & Suen, 2000.  
Compares capacity and energy consumption for R-12 & several compositions of R-290/600a.  
The performance of modified domestic refrigerators suited to operate with hydrocarbon blends  
was experimentally evaluated under controlled environment conditions.  
Head-to-head testing under controlled conditions.
- \* Agarwal, R. S., Ramaswamy, M., Kant, A., Agarwal, V., Srivastava, V. K., 1995  
“Evaluation of Hydrocarbon Refrigerants in Single Evaporator Domestic Refrigerator-Freezers”  
*Proceedings of the 1995 International CFC and Halon Alternatives Conference*,  
Washington, DC, USA, 1995. Pages 248 - 257.  
Comparison of capacity and COP for R-12, R-134a, R-152a, R-22/124/152a, & R-290/600a  
One domestic refrigerator was used to compare performance of R-12 and an R-290/600a blend.  
The refrigerator system was optimized for use with the HC blend. Other comparisons are based on  
simulations.  
Simulation & Head-to-head testing under controlled conditions.
- \*Agarwal, R. S., Ramaswamy, M., Agarwal, V., Srivastava, V. K., 1996  
“Comparative Study of Hydrocarbon Mixtures and MP-39 as Refrigerants to Retrofit CFC-12 Based  
Domestic Refrigerator-Freezers,”  
*Proceedings of the 1996 International Refrigeration Conference at Purdue*,  
Purdue University, West Lafayette, IN, USA, 1996. Pages 471 - 476.  
Referenced in Colbourne & Suen, 2000.  
Comparisons of R-12, MP-39 (R-401A), MP-66 (R-401B), MP-52 (R-401C) with 3 compositions  
of R-290/600a blends.  
Two refrigerators were simultaneously charged with the same refrigerant and tested. The  
refrigerant was then replaced with another refrigerant until data for each refrigerant was taken.  
Simulation & Head-to-head testing under controlled conditions.
- \* Agarwal, R. S., 1998  
“Hydrocarbon Refrigerants for Domestic and Commercial Refrigeration Appliances”  
*Proceedings of Emerging Trends in Refrigeration and Air-Conditioning*  
IIR/IIF Conference, New Delhi, India, March 1998. Pages 270 - 284.  
Performance tests were conducted in a laboratory setting using modified domestic CFC-12  
compressors to compare energy consumption, temperature pull down, and ice making for R-12, R-  
600a and several HC blends.  
Simulation and Head-to-head testing under controlled conditions.
- \* Agarwal, R. S., 2000  
“Hydrocarbon Blend as Retrofit Refrigerant for Domestic Refrigerators”  
*Preliminary Proceedings of the 4<sup>th</sup> IIR-Gustav Lorentzen Conference on Natural Working Fluids at  
Purdue*.

Purdue University, West Lafayette, IN, USA, 2000. Pages 379 - 386.

Twenty CFC-12 refrigerators are retrofitted with a blend of HC-290/HC-600a (CARE-30), the average energy consumption is than compare to CFC-12.

Simulation & Head-to-head testing under controlled conditions.

\*Baskin, E., Perry, R. B., 1994

“The Performance of Hydrocarbons in a Household Refrigerator/Freezer,”  
*Proceedings of the 1994 International Refrigeration Conference at Purdue,*  
Purdue University, 1994. Pages 237-244.

Referenced in Colbourne & Suen, 2000.

Compares capacity and COP for R-12 and various compositions of R-290/600a.

The researchers tested a domestic refrigerator in controlled conditions. The capillary tube length was increased for the use of HCs.

Head-to-head testing under controlled conditions.

\* Camporese, R., Bobbo, S., Rozza, F., 1994

“Hydrocarbons as Substitutes for Halogenated Refrigerants in Refrigerating Systems,”  
*Proceedings of the 1994 International Refrigeration Conference at Purdue,*  
Purdue University, West Lafayette, IN, USA, 1994. Pages 231 - 236

Referenced in Colbourne & Suen, 2000.

Comparison of capacity and EER for R-12, R-134a, R-600a & R-290/600a (50/50%)

Several hermetic compressors with different displacements were tested using the secondary refrigerant calorimeter method. The tests were performed with R-12 and three substitutes, R-134a, R-290/600A, and R-600a.

Simulation & Head-to-head testing under controlled conditions.

\* Choi, D. K., Domanski, P. A., Didion, D., 1996

“Evaluation of Flammable Refrigerants for Use in a Water-to-Water Residential Heat Pump,”  
*Proceedings of the Natural Working Fluids Conference,*  
IIR/IIF, Arahus, Denmark, 1996. Pages 467 - 476.

Referenced in Colbourne & Suen, 2000.

Comparison of COP for R-22, R-290, R-290/600a (70/30%), & R-32/152a (50/50%).

Head-to-head testing under controlled conditions.

\* Corberan, J. M., Urchueguia, J. F., Nararro, I., Gonzalvez, J., Calas, A. 2000

“Performance of a Reciprocating Hermetic Refrigerant Compressor Using Propane as Working Fluid”  
*Preliminary Proceedings of the 4<sup>th</sup> IIR-Gustav Lorentzen Conference on Natural Working Fluids at Purdue*

Purdue University, West Lafayette, IN, USA, 2000. Pages 225 - 232,

Compares capacity of COP of R-290 with R-22.

R-290 was tested in a standard 6kW R-22 unit, a positive displacement hermetic refrigerant piston compressor. A secondary fluid calorimeter was used in the compressor test rig. The compressor rating procedure was performed in accordance with ASHRAE 23.

Head-to-head testing under controlled conditions.

\* Deeg, W., Johnson, R., Hayslett, M., Hortin, K., 1998

“Influence of Blowing Agent Selection and Foam Aging on Energy Consumption and TEWI of Refrigerators”

*Proceedings of the Earth Technologies Forum*

Washington, DC, USA, 1998. Pages 270 - 278.

Comparison of long term energy consumption for different foam blowing agents, R-141b, R-245fa, R-134a, HFC-365mfc, and Cyclopentane.

Head-to-head testing under controlled conditions.

- \* **Devotta, S., Kulkarni, S. M., Lele, M., 1997**  
**“Performance of Refrigerators Fitted with HFC-134a and HC Blend,”**  
*Proceedings of the 1997 International Conference on Ozone Protection Technologies*  
 Baltimore, USA, 1997. Pages 66 - 73.  
 Referenced in Colbourne & Suen, 2000.  
 Comparison of energy consumption for R-134a and R-290/600a (50/50%)  
 A domestic R-12 refrigerator was retrofitted with R-134a and R-290/600a (50/50%) for  
 comparison. All testing was performed in a refrigerator performance test room.  
**Head-to-head testing under controlled conditions.**
  
- \* Devotta, S., Murthy, M., Sawant, N., 1998  
 “Performance of Two Door Refrigerators Retrofitted with a HC Blend”  
*Proceedings of Emerging Trends in Refrigeration and Air-Conditioning*  
 IIR Conference, New Delhi, India, March 1998. Pages 210 - 218.  
 The performance characteristics of an Indian two door direct cooled refrigerator, retrofitted with a  
 HC blend (CARE-30) refrigerant were studied and compared with CFC-12 baseline data.  
 Head-to-head testing under controlled conditions.
  
- \* Driessen, J. L., Pereira, R. H., Thiessen, M. R., Lunardi, M. A., 1994  
 “Hydrocarbon Refrigerants as Substitutes for CFC-12 in Domestic Refrigeration Systems,”  
*Proceedings of the Natural Working Fluids Conference,*  
 IIR/IIF, Hanover, Germany, 1994. Pages 561-569  
 Referenced in Colbourne & Suen, 2000.  
 Comparison of energy consumption for R-12, R-600a, and R-290/600a (60/40%)  
 Head-to-head testing under controlled conditions.
  
- \* Ellis, C., 1992  
 AREP Report #3, “Compressor Calorimeter and Drop-in Tests of Refrigerant R-290 (Propane)  
 Lennox International, Inc., Dallas, TX, 1992  
 A direct comparison between R-22 and R-290 was made for an off-the-shelf, three ton, split-  
 system, single speed, heat pump. A specially built compressor with 14.5% greater volumetric  
 displacement was used when the system was retrofitted.  
 Head-to-head under controlled conditions.
  
- \* **Engler, T., Mobner, F., Oellrich, L. R., 1995**  
**“Experimental Results and Theoretical Investigations with Alternative Refrigerants,”**  
*Proceedings of the 19<sup>th</sup> International Congress on Refrigeration,*  
 IIR/IIF, The Hague, Netherlands, 1995. Volume IV-b, Pages 774 - 781.  
 Referenced in Colbourne & Suen, 2000.  
 Comparison of COP and TEWI for R-22, R-502, several HFC and HFC blends, R-290, and  
 R-1270.  
 Experimental investigations were carried out on a vapor compression test stand equipped  
 with a semi-hermetic compressor.  
**Head-to-head testing under controlled conditions.**
  
- \* ETL Testing Laboratory, Inc., 1992  
 AREP Report #33, “Drop-in Test of Refrigerant R-290 (Propane)”  
 ETL Testing Laboratory, Inc., Cortland, NY, December 1992.  
 This report gives the results of performance tests of a 3 ton unitary heat pump using R-22 and R-  
 290. The tests were conducted in accordance with ARI 210/240 and ASHRAE 37.  
 Head-to-head testing under controlled conditions.
  
- \* **Fine, H. A., Xiaozhuang, L., Radermacher, R., Hailer, I., Fridley, D. G., Phillips, R., Briskin, J.,**  
**1996**  
**“The Sino-US CFC-Free Super-Efficient Refrigerator Project: Part 1 - Prototype Development;**  
**Part 2 - Field Tests,”**

*Proceedings of the 1996 International Conference on Ozone Protection Technologies*

Washington, DC, USA, 1996. Pages 322 - 339.

Referenced in Colbourne & Suen, 2000.

Comparison of energy consumption for R-12, R-134a, R-152a, R-600a, R-290/600, R-290/600a & several HCFC/HFC/HC blends.

While starting with a Chinese domestic refrigerator and using that as a baseline many modifications were made to the baseline system including the use of various refrigerants.

Head-to-head testing under controlled conditions.

\* Firth, A., Carrington, G., 1999

“Performance of Care 50 as an R22 Replacement in a Domestic HPAC System,”

*Proceedings of the 20<sup>th</sup> International Congress on Refrigeration,*

IIR/IIF, Sidney, Australia, 1999. Volume V, Paper 549.

Referenced in Colbourne & Suen, 2000.

Comparison of capacity and COP of R-22 and Care 50 (HC blend mostly R-290) in a split system heat pump.

Head-to-head testing under controlled conditions.

\* Granryd, E., Tengblad, N., Nowacki, J. E., 1994

“Propane as Refrigerant in a Small Heat Pump. Safety Considerations and Performance Comparisons,”

*Proceedings of the Natural Working Fluids Conference,*

IIR/IIF, Hanover, Germany, 1994. Pages 355 - 364.

Referenced in Colbourne & Suen, 2000.

Comparison of capacity and COP of R-22, R-290 and gasol (95% R-290, 2.5% of butanes, 1.5% ethane, & 0.5% butene).

Head-to-head testing under controlled conditions.

\* Gorenflo, D., Hesse, F.-J., Heilmann, G., 1994

“Energy Efficiency of Domestic Refrigerators and Deep Freezers,”

*Proceedings of the Natural Working Fluids Conference,*

IIR/IIF, Hanover, Germany, 1994. Pages 595 - 606.

Referenced in Colbourne & Suen, 2000.

Comparison of energy consumption of R-134a, R-600a, & R-290/600a blend.

Head-to-head testing conducted under controlled conditions.

\* Hammad, M., Tarawnah, R., 2000

“Hydro Carbon Refrigerants Performance in An Air Conditioning Unit”

*Preliminary Proceedings of the 4<sup>th</sup> IIR-Gustav Lorentzen Conference on Natural Working Fluids at Purdue*

Purdue University, West Lafayette, IN, USA. Pages 167 - 176.

Compares COP of R-290/600a mixtures with R-134a.

Head-to-head testing under controlled conditions.

\* Kim, M. S., Chang, Y. S., Ro, S. T., 1996

“Performance and Heat Transfer of Hydrocarbon Refrigerants and their Mixtures in a Heat Pump System,”

*Proceedings of the Applications for Natural Refrigerants,*

IIR, Aarhus, Denmark, 1996. Pages 477-486.

Referenced in Colbourne & Suen, 2000.

Comparison of capacity and COP for R-22, R-290, R-600, R-600a, R-1270, R-290/600 (50/50%) blend, & R-290/600a (50/50%) blend.

Head-to-head testing under controlled conditions.

- \* **Kruse, H., 1994**  
 “Evaluation of Zeotropic Hydrocarbon Mixtures in a Lorenz-Meutzner-Cycle Refrigerator-Freezer”  
*Proceedings of the New Applications of Natural Working Fluids in Refrigeration and Air Conditioning*  
 Hanover, Germany, 1994. Pages 607 - 620.  
 Comparisons of R-134a and several mixtures of R-290/600 and R-290/600a.  
 Head-to-head testing under controlled conditions and some simulations.
  
- \* **Kuijpers, L. J. M., de Witt, J. A., Janssen, M. J. P., 1988**  
 “Possibilities for the Replacement of CFC 12 in Domestic Equipment”  
*IIR/IFF 1988-2, Refrigeration Science and Technology Proceedings*  
*Status of CFCs - Refrigeration Systems and Refrigerant Properties*  
 Purdue University, 1988.  
 Comparative energy consumption for R-12, HC-270 (cyclopropane), R-290, R-152a, and DME and several HCFC/HFC blends.  
 Head-to-head testing under controlled conditions.
  
- \* **La Rocca, V., Morale, M., 1999**  
 “Use of Propane and Butane as Working Fluids in Home Refrigerators”  
*Proceedings of the 20<sup>th</sup> International Congress of Refrigeration*  
 IIR/IFF, Sydney, Australia, 1999, Volume II, Paper 529.  
 Compares 24-hour energy use for R-12, R-290, and several R-290/600 mixture concentrations.  
 Head-to-head testing under controlled conditions.
  
- \* **Liu, B. Y., Radermacher, R., Tomasek, M. L., 1994**  
 “Tests with R290/R600 Mixtures in a Domestic Refrigerator/Freezer,”  
*Proceedings of the Natural Working Fluids Conference,*  
 IIR/IFF, Hanover, Germany, 1994. Pages 579 - 588.  
 Referenced in Colbourne & Suen, 2000.  
 COP of R-12 and various compositions of R-290/600 blends.  
 Head-to-head testing under controlled conditions.
  
- \* **Melin, P., Vamling, L., 1995**  
 “Heat Transfer and Pressure Drop Measurements for Hydrocarbons in a Direct-Expansion-Evaporator Tube”  
*Proceedings of the 19<sup>th</sup> International Congress on Refrigeration,*  
 IIR/IFF, The Hague, Netherlands, 1995. Volume IVa, Pages 404 - 411.  
 Compares R-22 and propane.  
 This paper reports on heat transfer and pressure drop during evaporation for R-22 and propane.  
 This project simply concerns refrigerant flow boiling in a straight tube.  
 Head-to-head testing under controlled conditions.
  
- \* **Meyer, J. P., 2000**  
 “Experimental Evaluation of Five Refrigerants as Replacements for R-22”  
*ASHRAE Transactions 2000, Vol 106, Pt 2.*  
 Atlanta, GA. USA, 1996. Pages 585 - 588. (MM-00-6-4)  
 Compares cooling capacity, COP, and relative cost of R-22, R-290, R-134a, R-404A R-407C and R-410A in a vapor compression experimental test rig.  
 Head-to-head testing under controlled conditions.

- \* Mumpower, K., 1993  
AREP Report #21, "Compressor Calorimeter Test of Refrigerant R-290 (Propane)  
Bristol Compressors, Inc., Bristol, VA, USA, March 1993.  
A compressor was tested with both R-22 and R-290 using a secondary refrigerant calorimeter in a laboratory setting.  
Head-to-head testing under controlled conditions.
  
- \* Oellrich, L. R., 1994  
"Propane and Butane as Possible Alternatives to R12, R22, and R502 - Some Experimental Results in Power Range of Commercial Refrigeration and their Discussion,"  
*Proceedings of the Natural Working Fluids Conference,*  
IIR/IIF, Hanover, Germany, 1994. Pages 693 - 702.  
Referenced in Colbourne & Suen, 2000.  
Comparison of COP for R-12, R-134a, R-290, & R-290/600 blends  
Head-to-Head testing under controlled conditions.
  
- \* Payne, W. V., Domanski, P. A., Muller, J., 1998  
"A Study of a Water-to-Water Heat Pump Using Flammable Refrigerants,"  
*Proceedings of the Natural Working Fluids Conference,*  
IIR/IIF, Oslo, Norway, 1998. Pages 658 - 667.  
Referenced in Colbourne & Suen, 2000.  
Comparison of capacity and COP for R-22, R-290, R-32/152a (50/50%), R-32/290 (50/50%).  
Head-to-head testing under controlled conditions.
  
- \* Pearson, S. F., 1996  
"Uses of Hydrocarbon Refrigerants,"  
*Proceedings of the Natural Working Fluids Conference,*  
IIR/IIF, Aarhus, Denmark, 1996. Pages 439 - 446.  
Referenced in Colbourne & Suen, 2000.  
Comparison of COP R-12, R-413A, & Care 30 (R-290/600a blend); R-22 & Care 40 (R-290); R-404A, R-1270 & Care 50 (R-290/170 blend); R-404A, R-407C & RX3D (R125/134a/600a blend).  
Head-to-head testing under controlled conditions.
  
- \* Peixoto, R. A., Epof, S., Parra, D., 2000  
"Experimental Investigation on the Performance of Commercial Freezers Using Refrigerant HC-600A"  
*Preliminary Proceedings of the 4<sup>th</sup> IIR-Gustav Lorentzen Conference on Natural Working Fluids at Purdue*  
Purdue University, West Lafayette, IN, USA. Pages 159 - 165.  
Compares performance of R-600a with R-134a.  
This paper presents a comparative experimental study on the performance of R-600a and R-134a in commercial freezers. The tests were performed in a monitored climate chamber, with temperature, humidity and air velocity controlled.  
Head-to-head testing under controlled conditions.
  
- \* Pelletier, O., Palm, B., 1996  
"Performance of Plate Heat Exchangers and Compressor in a Domestic Heat Pump Using Propane,"  
*Proceedings of the Natural Working Fluids Conference,*  
IIR/IIF, Aarhus, Denmark, 1996. Pages 497-506.  
Referenced in Colbourne & Suen, 2000.  
Comparison of isentropic efficiency, volumetric efficiency, heating COP of R-22 and R-290.  
Head-to-head testing under controlled conditions.

- \* Riffe, D. R., 1995
  - “Dual Cycle Isobutane Refrigerator/Freezer,”
  - Proceedings of the 1995 International CFC and Halon Alternatives Conference*, Washington, DC, USA, 1995. Pages 259-267.
  - Referenced in Colbourne & Suen, 2000.
  - Comparative efficiency performance of R-12, R-134a and R-600a
  - Researcher performed calorimeter tests for a number of compressors using R-600a. The paper, also, presents some analytical analysis.
  - Head-to-head compressor efficiency testing under controlled conditions and some simulations.
  
- \* Riffe, D. R., 1994
  - “Isobutane as a Refrigerator Freezer Refrigerant,”
  - Proceedings of the 1994 International Refrigeration Conference at Purdue*, Purdue University, USA, 1994. Pages 245-254.
  - Referenced in Colbourne & Suen, 2000.
  - Comparison of capacity and EER of R-12, R-134a, & R-600a
  - Researcher performed calorimeter tests for a number of compressors using R-600a. The paper, also, presents some analytical analysis.
  - Head-to-head compressor efficiency testing under controlled conditions and some simulations.
  
- \* Setaro, T., Boccardi, G., 2000
  - “Comparative Study of Evaporation and Condensation of Propane and R22 in a Brazed Plate Heat Exchangers and a Tube & Fins Coil”
  - Preliminary Proceedings of the 4<sup>th</sup> IIR-Gustav Lorentzen Conference on Natural Working Fluids at Purdue*.
  - Purdue University, West Lafayette, IN, USA, 2000. Pages 233 - 238.
  - Compares capacity and overall heat transfer of R-290 with R-22.
  - In this paper the analysis of an experimental test campaign to characterize the heat transfer and pressure drop through a brazed plate heat exchanger and a tube and fins coil is presented for R-22 and propane.
  - Head-to-head testing under controlled conditions.
  
- \* Tiedemann, T., Kruse, H., 1994
  - “Evaluation of Zeotropic Hydrocarbon Mixtures in a Lorenz-Meutzner Cycle Refrigerator Freezer,” *Proceedings of the Natural Working Fluids Conference*, IIR/IIF, Hanover, Germany, 1994. Pages 607-620.
  - Referenced in Colbourne & Suen, 2000.
  - Comparison of COP for R-134a, several HC blends
  - Head-to-head testing under controlled conditions and simulation.

## HEAD-TO-HEAD SIMULTANEOUS TESTING IN REAL-WORLD CONDITIONS

- \* Cleland, D. J., Adams. S. D., Keedwell, R. W., 1999  
“Use of Hydrocarbons as Drop-in Replacements for Fluorocarbon Refrigerants in on-farm Milk Cooling Equipment”  
*Proceedings of the 20<sup>th</sup> International Congress of Refrigeration*  
IIR/IIF, Sydney, 1999, Volume II, Paper 653.  
Energy use and cooling capacity of R-22 and Care 50 (R-170/290) in refrigerated farm milk silos. Head-to-head simultaneous testing under field conditions.

## PHYSICAL TESTS NOT UNDER THE SAME CONDITIONS

- \* Bodio, E., Chorowski, M., Wilczek, M., 1995  
“Propane-Butane a Promising Alternative”  
*Proceedings of the 19<sup>th</sup> International Congress on Refrigeration*,  
IIR/IIF, The Hague, Netherlands, 1995. Vol IVb Pages 762 - 765.  
Compares performance of propane/butane with R-12.  
References Bodio, 1993 for comparative data.  
The results of long-term use of propane/butane has a drop-in are presented. A refrigerator was shown to have run continuously for 5 years after conversion.  
Physical tests not under same conditions.
- \* **Dijkstra, E., Machielsen, C., Menard, D., 1996**  
**“Cooling of a Bulk Milk Tank with R290/R600a in the Netherlands,”**  
*Proceedings of the International Conference on Ozone Protection Technologies*,  
Washington, DC, USA, 1996. Pages 340-349.  
**Referenced in Colbourne & Suen, 2000.**  
**Comparison of energy consumption for R-12, R-22, R-134a and ECOOL-PIB (R-290/600a blend)**  
**ECOOL-PIB was tested under conditions resembling the real conditions in the milking stable of a farm. The EER and other data was compared with R-12.**
- \* Powell, L., 1996  
“Field Experience of HCs in Commercial Applications”  
*Proceedings of the 1996 International Conference on Ozone Protection Technologies*  
Washington, DC, USA, 1996. Pages 237 - 246.  
Identifies a number of field tests of Calor Gas HCs and HC blends. Provides energy efficiency gain claims without supporting data.  
Field studies using HC blends.

## SIMULATION AND THEORETICAL ANALYSIS

- \* Babu, T. P. A., Arora, C. P., 1998  
“Design Modifications Needed in the Compressor for Using Alternative Refrigerants to R-12”  
*Proceedings of Emerging Trends in Refrigeration and Air-Conditioning*  
IIR/IIR Conference, New Delhi, India, March 1998. Pages 171 - 179.  
This paper discusses the modifications needed in the R12 compressor to use alternate refrigerants. The refrigerants considered for theoretical analyses were R-290, R-22, R-134a, R-152a, R-600a, and R-290/R600a blend. The results of the theoretical analysis were used to ascertain volumetric efficiency, displacement volume, starting torque, winding temperature, and motor rating for each refrigerant. This data allows for the selection of the best drop-in replacement.  
**Simulation.**
  
- \* Chen, S., Judge, J. F., Groll, E. A., Radermacher, R. 1994  
“Theoretical Analysis of Hydrocarbon Refrigerant Mixtures as a Replacement for HCFC-22 for Residential Uses”  
*Proceedings of the 1994 International Refrigeration Conference at Purdue*  
Purdue University, West Lafayette, IN, USA, Pages 225 - 230.  
Compares theoretical COP and SPF of R-22, R-410A, R-407C, R-290, R-600, and R-600a in residential AC/HP.  
**Simulation.**
  
- \* Devotta, S., Kulkarni, S. M., 1996  
“Assessment of Alternatives to CFCs for Household Refrigerators Using ERA Program”  
*Proceedings of the 1996 International Conference on Ozone Protection Technologies*  
Washington, DC, USA, 1996. Pages 300 - 307.  
Compares energy consumption rates for R-12, R-123a, R-290/600a (propane/isobutane blend), and R-600a (isobutane).  
This is a theoretical assessment of alternatives for R-12 using a computer program, EPA Refrigerator Analysis Program.  
**Simulation**
  
- \* Devotte, S., Padalkar, A. S., Joshi, S. N., Sawant, N. N., and Sane, N. K., 2000  
“Comparative Assessment of CO<sub>2</sub> for Window Air-Conditioners”  
*Preliminary Proceedings of the 4<sup>th</sup> IIR-Gustav Lorentzen Conference on Natural Working Fluids at Purdue*  
Purdue University, West Lafayette, IN, USA, 2000. Pages 17 - 24.  
Compares COP of CO<sub>2</sub> with R-22, R-134a, R-290, R-407C and R-410A.  
This is a theoretical comparison using a moderate condensing temperature of 44 °C.  
**Simulation**
  
- \* Domanski, P., 1995  
“Minimizing Throttling Losses in the Refrigeration Cycle”  
*Proceedings of the 19<sup>th</sup> International Congress on Refrigeration,*  
IIR/IIF, The Hague, Netherlands, 1995. Vol IVb Pages 766-773.  
Comparative data for many HFC and HC refrigerants.  
**Simulation.**
  
- \* Douglas, J. D., Braun, J. E., Groll, E. A., Tree, D. R., 1995  
“Trade-off Between Flammability and Performance of Hydrocarbon/Flame Suppressant Mixtures as Refrigerants”  
*Proceedings of the 19<sup>th</sup> International Congress on Refrigeration,*  
IIR/IIF, The Hague, Netherlands, 1995. Vol IVa Pages 155-162.  
A general simulation method for comparing refrigerants was presented.  
**Simulation.**

- \* Douglas, J. D., Groll, E. A., Braun, J. E., Tree, D. R., 1996  
 “Evaluation of Propane as an Alternative to HCFC-22 in Residential Applications”  
*Proceedings of the 1996 International Refrigeration Conference at Purdue*  
 Purdue University, West Lafayette, IN, USA, 1996. Pages 13 - 20.  
 Compares first-cost based evaluation of R-22, propane, and several HFC and HC/HFC blends.  
 Theoretical analysis based on work by others.
  
- \* Engler, T., Oellrich, L. R., Venkatarathan, G., Murthy, S. S., 1999  
 “Screening of Single Component Fluids for Compression Heat Pump Applications”  
*Proceedings of the 20<sup>th</sup> International Congress of Refrigeration*  
 IIR/IIF, Sydney, Australia, 1999. Volume II, Paper 171.  
 Compares COP and heat capacity for HCs, HFCs, HFEs, and HCFCs  
 Simulation.
  
- \* Hesse, U., Spauschus, H. O., 1995  
 “Selection of R502 and R22 Alternatives for Different Applications”  
*Proceedings of the 19<sup>th</sup> International Congress on Refrigeration,*  
 IIR/IIF, The Hague, Netherlands, 1995. Vol IVb Pages 833-843.  
 Provides comparison of capacity and COP for R-22, R-502, HFC blends, R-290, R-1270 & ammonia. Theoretical comparison of properties.  
 Simulation.
  
- \* Itard, L. C. M., Fedotov, V., Machielsen, C. H. M., 1995  
 “Thermodynamic Efficiency of Several Non-Azeotropic Mixtures in the Wet Compression/Resorption Heat Pump Cycle”  
*Proceedings of the 19<sup>th</sup> International Congress on Refrigeration,*  
 IIR/IIF, The Hague, Netherlands, 1995. Vol IVb Pages 1152-1159.  
 Compares COP of R-123, R-600, HFC blends, and HC blends.  
 Simulation.
  
- \* Joachim, P., 1996  
 “A Fresh Look at Hydrocarbon Refrigeration Experience and Outlook”  
*Proceedings of the 1996 International Conference on Ozone Protection Technologies*  
 Washington, DC, USA, 1996. Pages 252 - 259.  
 Compares COP of HCs and HC blends relative to R-12, R-22 and R-502.  
 Theoretical comparison of properties.  
 Simulation.
  
- \* Jung, D., Kim, C., Lim, B., Lee, H., 1996  
 “Testing of Hydrocarbon Mixture in Domestic Refrigerators,”  
*ASHRAE Transactions 1996*, Vol 102 Pt 1. Pages 1077-1084.  
 Referenced in Colbourne & Suen, 2000.  
 Comparison of energy efficiency for R-12 and R-290/600a HC blend.  
 Performance tests are made for two refrigerators. All refrigeration components remained the same throughout the tests, except that the length of the capillary tube and the amount of charged were changed for the mixture. Researchers used the AHAM Standard for household refrigerators and household freezers as their test method.  
 Simulation.

- \* Jung, D., Kim, C., Hwongbo, H., Ji, H., 1996  
 “Effect of Suction Line Heat Exchangers on the Performance of Various HCFC22 Alternatives”  
*Proceedings of the 1996 International Conference on Ozone Protection*,  
 Washington, DC, USA, 1996. Pages 47 -54.  
 Comparisons of COP and capacity for HCFC: R-22; HFCs: R-32, R-125, R-134a, R-143a, R-152a; and HCs: Propane (R-290), Cyclopropane (HC-270), Propylene (R-1270).  
 In this study, thermodynamic analysis is done to simulate the performance of residential air conditioners charged with various fluids.  
 Simulation.
  
- \* Kazachki, G., Gage, C., 1997  
 “Thermodynamic, Energy-Efficiency, and Economic Criteria for Evaluation of Alternative Refrigerants for Heat Pumps”  
*IIR/IIF 1997-4, Refrigeration Science and Technology Proceedings  
 Heat Pump Systems, Energy Efficiency and Global Warming*  
 Linz, Austria, 28 September - 1 October 1997  
 Simulation.
  
- \* Keller, F. J., Sullivan, L., Liang, H., 1996  
 “Assessment of Propane in North American Residential Air Conditioners”  
*Proceeding of the 1996 International Refrigeration Conference at Purdue*  
 Purdue University, West Lafayette, IN, USA. Pages 39 - 44.  
 Compares TEWI of R-22, R-410A, R-290, and R-290/R-227ea mixture.  
 Three unitary systems were evaluated for use with propane as the refrigerant. These three systems were then compared to systems using R-22 and R-410A. The propane systems included one using safety measures, another using propane with flame suppressant, and one using a secondary heat transfer loop.  
 Simulation.
  
- \* Kruse H., 1996  
 “The State of the Art of Hydrocarbon Technology in Household Refrigerators”  
*Proceedings of the 1996 International Conference on Ozone Protection Technologies*  
 Washington, DC, USA, 1996. Pages 179 - 188.  
 Comparisons of system cost and TEWI reduction for CFC-12, HFC-134a; HC-600a (isobutane) and mixture of R-290/600a (propane/isobutane)  
 Theoretical study to evaluate in a technology and cost study the advantages and disadvantages of possible replacements to CFCs and HCFCs.  
 Simulation.
  
- \* Mathur, G. D., 1996  
 “Performance of Vapor Compression Refrigeration System with Hydrocarbons: Propane, Isobutane, and 50/50 Mixture of Propane/Isobutane”  
*Proceedings of the 1996 International Conference on Ozone Protection Technologies*  
 Washington, DC, USA, 1996. Pages 835 - 844.  
 Compares COP R-12, R-134a, R-290, R-600a, and R-290/600a mixture.  
 A theoretical investigation to determine the performance of a vapor compression refrigeration system with hydrocarbons.  
 Simulation.
  
- \* Morikawa, Y., 1996  
 AREP Report #238, “Performance Tests with Refrigerant R-290”  
 Matsushita Electric Industrial Co., Ltd., Shiga-ken, Japan, February 1996.  
 Performance simulation on R-290 in air conditioners and heat pumps.  
 Simulation.

- \* Peixoto, R. A., Fiorelli, F. A. S., Silvaes, O. M. 1998  
 “Numerical Simulation of Capillary Tube-Suction Line Heat Exchangers Using R-12, R-401A, R-409A and HC Blend”  
*Proceedings of Emerging Trends in Refrigeration and Air-Conditioning*  
 IIR/IIF Conference, New Delhi, India, March 1998. Pages 248 -256.  
 Theoretical comparisons of cooling capacity for R-12, R-401A, R-409A, and R-290/600a Simulation.
  
- \* Suwono, A., Samudro, H. M., Tandian, N., Adriansyah, W., 1995  
 “Theoretical and Experimental Study of the Application of Propane/n-butane Mixture as Refrigerant Replacing R12,”  
*Proceedings of the 19<sup>th</sup> International Congress on Refrigeration,*  
 IIR/IIF, The Hague, Netherlands, 1995. Volume IVa, Pages 552-559.  
 Referenced in Colbourne & Suen, 2000.  
 Theoretical COP of R-290/600a blends - no comparative data for R-12 or HFCs  
 Experiments were taken for R-290 for a 3 HP system, comparisons to other refrigerants were not made.  
 Test of only one refrigerant simulation.
  
- \* **Ure, Z., 1995**  
**“Effective Control, Energy Efficiency, and System Diversification Influence on TEWI”**  
*Proceedings of the 19<sup>th</sup> International Congress on Refrigeration,*  
**IIR/IIF, The Hague, Netherlands, 1995. Vol IVb Pages 1021-1028.**  
**Compares COP and capacity for R-12, R-22, R-502, R-134a, R-717, and R-290**  
**Theoretical study with an overview of the history of modern refrigerants.**
  
- \* Venkatarathan, G., Agrawal, N., Murthy, S. S., 1998  
 “Study of Ternary Hydrocarbon Zeotropic Mixtures as Alternatives to CFC 114 in High Temperature Heat Pump Systems”  
*Proceedings of Emerging Trends in Refrigeration & Air-conditioning*  
 IIR/IIF Conference, New Delhi, India, March 1998. Pages 99 - 107.  
 Researchers perform theoretical investigation using mixtures of cyclobutane/isobutane/cyclopropane as alternatives for R-114.
  
- \* **Zhidkov, V. V., Zhelenzy, V. P., Butner, A. G., 1996**  
**“Ecological and Energetical Aspects of Changing-over Refrigerant Equipment of Joint-stock Company “NORD” to Alternative Refrigerants”**  
*Proceedings of the 1996 International Refrigeration Conference at Purdue*  
**Purdue University, West Lafayette, IN, USA. Pages 507 - 512.**  
**Compares COP and TEWI of R-134a, R-600a, and several HC, HC/HFC and HFC blends.**  
**Theoretical study using TEWI to compare refrigerants.**  
**Simulation.**

ANALYSIS/SUMMARY OF DATA FROM OTHERS

- \* Colbourne, D., 1999  
“Practical Application of Hydrocarbon Refrigerants: Production Costs and Operational Performance”  
*Proceedings of the 20<sup>th</sup> International Congress of Refrigeration*  
IIR/IIF, Sydney, Australia, 1999. Volume II, Paper 252.  
Compares the COP, cooling capacity and energy consumption of a chiller with R-407C and a R-290/170 blend.  
Compares the COP and capacity for R-22, R-290 and a R-290/170 blend in a split-system air-conditioner.  
Compares COP for R-407C and a blend of R-290/170 in a packaged air cooling unit.  
Summary paper of field trials using data from others.
  
- \* Colbourne, D., Suen, K. O., 2000  
“Assessment of Performance of Hydrocarbon Refrigerants,”  
*Proceedings of the 4<sup>th</sup> IIR-Gustav Lorentzen Conference on Natural Working Fluids at Purdue*.  
Purdue University, 2000. Pages 133 - 140.  
Analysis of other published data.  
Documents and compiles relative efficiencies of alternative refrigerants for use in various applications from 54 technical papers. Refrigerants include a number of HFCs, HFC blends, HC and HC blends.  
Summary paper using data from others.
  
- \* Darabi, J. A., Salehi, M., Saeedi, M. H., Ohadi, M. M., 1995  
“Review of Available Correlations for Prediction of Flow Boiling Heat Transfer in Smooth and Augmented Tubes,” (CH-95-12-2),  
*ASHRAE Transactions 1995*, Vol 101 Pt 1. Pages 965-975.  
Referenced in Colbourne & Suen, 2000.  
General reference only. No data on HC-HFC performance.
  
- \* Halozan, H., 1995  
“Propane for Heat Pumps”  
*Proceedings of the 19<sup>th</sup> International Congress on Refrigeration*,  
IIR/IIF, The Hague, Netherlands, 1995. Vol IVb Pages 1136-1143.  
Compares COP and capacity of R-22 and R-290.  
Summary article which does not document sources of data.
  
- \* Han, H. D., Zheng, Q. R., 1999  
“Researches on the Replacements for R12 and R22 Used in Marine Refrigeration Units for Coming 21<sup>st</sup> Century”  
*Proceedings of the 20<sup>th</sup> International Congress of Refrigeration*  
IIR/IIF, Sydney, 1999, Volume II, Paper 013.  
Compares the COP and capacity of R-12, R-22, R-134a, R-717, R-290, and R-407C.  
Summary article which does not directly document sources of data.
  
- \* Jurgensen, H., 1994  
“Application of Hydrocarbons as Refrigerant in Household Refrigerators,”  
*Proceedings of the Natural Working Fluids Conference*,  
IIR/IIF, Hanover, Germany, 1994. Pages 589-594.  
Referenced in Colbourne & Suen, 2000.  
Comparison of energy consumption and TEWI for R-12, R134a, R-290, R-600a, & R-290/600a (50/50%) blend  
Analysis using test data from others.

- \* **Konig, H., 1997**  
 “Comparison of R-410A, R-407C and Propane in Heat Pump Applications”  
*IIR/IIF 1997-4, Refrigeration Science and Technology Proceedings*  
*Heat Pump Systems, Energy Efficiency and Global Warming*  
 Linz, Austria, 28 September - 1 October 1997, Pages 94 - 104.  
 Comparison of COP for R-22, R-290, R-407C and R-410A  
 Theoretical analysis using data from others.
  
- \* **Kruse, H., 1995**  
 “Energy Savings When Using Hydrocarbons as Refrigerant,”  
*Proceedings of the 1995 International CFC and Halon Alternatives Conference*,  
 Washington, DC, USA, 1995. Pages 386 - 395.  
 Comparison of capacity and EER for R-12, R-134a, R-600a, and R-290/600a  
 Analysis using data from others.
  
- \* **Kruse, H., 2000**  
 “Refrigerant Use in Europe,”  
*ASHRAE Journal*, Volume 42, No. 9, September 2000.  
 TEWI comparisons of R-22 and R-502 substitutes: HFC Blends, R-270, Ammonia, CO2.  
 Analysis using data from others.
  
- \* **Nowotny, S., 1995**  
 “Conversion of Refrigerators and Freezers Manufactured in Developing Countries to the  
 Application of Environmental Benign Refrigerants and Foam Blowing Agents”  
*Proceedings of the 19<sup>th</sup> International Congress on Refrigeration*,  
 IIR/IIF, The Hague, Netherlands, 1995. Volume IVb, Pages 939 - 946.  
 Compares COP and of R-12 with R-134a, HFC blends, and HC blends.  
 Summary document; source of data not disclosed in article.
  
- \* **Sand, J. R., Fischer, S. K., Baxter, V. D., 1997**  
 AFEAS/DOE Report “Energy and Global Warming Impacts of HFC and Emerging  
 Technologies,”  
 Oak Ridge National Laboratory. Oak Ridge TN, USA  
 Referenced in Kruse, 2000.  
 Summary document using data from others.
  
- \* **Suwono, A., Pasek, A. D., Tandian, N. P., Machielson, C. H. M., 1999**  
 “Application of HC Refrigerants in Various Medium and Large Scale Refrigeration Systems,”  
*Proceedings of the 20<sup>th</sup> International Congress on Refrigeration*,  
 IIR/IIF, Sydney, Australia, 1999.  
 Referenced in Colbourne & Suen, 2000.  
 Summary paper using data from others.
  
- \* **Wenning, U. G., 1995**  
 “No-frost Refrigeration: A Retrospect After Conversion to Hydrocarbons,”  
*Proceedings of the 1995 International CFC and Halon Alternatives Conference*,  
 Washington, DC, USA, 1995. Pages 396 - 403.  
 Compares COP of R-134a and R-600a.  
 Summary paper using data from others.

\* **Wenning, U. G., 1996**

**“Three Years Experience with hydrocarbon Technology in Domestic Refrigerators”**  
*Proceedings of the 1996 International Conference on Ozone Protection Technologies*  
Washington, DC, USA, 1996. Pages 350 - 356.

Compares energy consumption of R-600a to R-134a, and R-12; and TEWI of CFCs, HCFCs, HFCs, and HCs.  
Summary paper using data from others.

\* **Yajima, R., Domyo, N., Taira, S., Tarutani, I., 1997**

**“Selection and Applications of New Refrigerants for Air-Conditioners”**  
*Proceedings of the 1997 International Conference on Ozone Protection Technologies*  
Baltimore, MD, USA, 1997. Pages 82 - 91.

Compare relative COP and capacity of HFCs, HFC blends, and propane with that of R-22.  
Summary paper using data from others.

UNREVIEWED

- Alsaad, M. A., Hammand, M. A., 1998  
“The Application of Propane/Butane Mixture for Domestic Refrigerators,”  
*Applied Thermal Engineering*, Volume 18, 1998.  
Referenced in Colbourne & Suen, 2000.
- Anon, 1997  
“Performance of Dorin Semi-hermetic Compressors using R290, R22 and R404A,”  
ILK Dresden, Germany, 1997.  
Referenced in Colbourne & Suen, 2000.
- Anon, 1997  
“Testing Time for Options,”  
*Refrigeration and Air Conditioning*, UK, July 1995.  
Referenced in Colbourne & Suen, 2000.
- Arnemann, M., Gebhardt, D., Kruse, H., 1995  
“Experimentelle Bewertung neuer Kaltmittelgemische als Ersatz für R-22 und R-502.”  
*DIE KALTE und Klimatechnik* (2):66.  
Referenced in Kruse, 2000.
- Bodio, E. Chorowski, Milczek, M., 1993  
“Working Parameters of Domestic Refrigerators Filled with Propoane-Butane Mixture”  
*International Journal of Refrigeration*, IIR Vol 15, No. 5. Pages 353-356.
- Butler, D. J. G., 1997  
“Replacement of R-22 in Existing Refrigeration Systems,”  
*Proceedings of CIBSE National Conference*, London, UK, 1997.  
Referenced in Colbourne & Suen, 2000.
- Butler, D. J. G., 1998  
“Replacement of R-22 in Existing DX Liquid Chillers,”  
*Proceedings of CIBSE National Conference*, London, UK, 1998.  
Referenced in Colbourne & Suen, 2000.
- Cambridge Refrigeration Technology Ltd, 1997  
“Comparative Performance of Beer Cellar Chiller Using Care 50 and R407C,”  
Cambridge Refrigeration Technology Ltd., Cambridge, UK, 1997.  
Referenced in Colbourne & Suen, 2000.
- De’Longhi, SPA, 2000  
“Data on Experiments with R22 Replacements in a Reverse-Cycle Air-Conditioner/Heat Pump,”  
De’Longhi, Treviso, Italy, 2000.  
Referenced in Colbourne & Suen, 2000.
- Dentis, L., Mannoni, A. Parrino, M., 1999  
“HC Refrigerants: An Ecological Solution for Automotive A/C Systems,”  
*Proceedings of the V.T.M.S. Conference*,  
London, UK, 1999.  
Referenced in Colbourne & Suen, 2000.
- Fabdec Ltd, 1997  
“Data on Milk Tank Performance Tests Using R22 and Care 50,”  
Ellesmere, UK, 1997.  
Referenced in Colbourne & Suen, 2000.

Frehn, B., 1993

“Hydrocarbons as Alternative Refrigerants for Heat Pumps Initial Operational Experience,”  
*KI, Klima-Kalte-Heizung*, Heidelberg, Germany, 1993.  
Referenced in Colbourne & Suen, 2000.

Gaibel, J. A., Chato, J. C., Dobson, M. K., Ponchner, M., Kenney, P. J., Shimon, R. L., Villqneuva, T. C., Rhines, N. L., Sweeney, K. A., Allen, D. G., Hershberger, T. T., 1994

“Condensation of a 50/50 Blend of R32/R125 in Horizontal Tubes with and without Oil,”  
ACRC TR-56, University of Illinois, USA, 1994.  
Referenced in Colbourne & Suen, 2000.

Green, R., 1995

“Drop-in Tests Focus on two R22 Options,”  
*Refrigeration and Air Conditioning*, UK, July 1995.  
Referenced in Colbourne & Suen, 2000.

Haukas, H. T., 1992

“Practical Performance of Alternatives to R12 and R502 in Refrigerators and Freezers,”  
*Proceedings of the Institute of Refrigeration*, London, 1992.  
Referenced in Colbourne & Suen, 2000.

IMI Air-conditioning Ltd., 1997

“Test Report on Split Air-Conditioners Using R22, R290 and Care 50,”  
Brighthouse, UK, 1997.  
Referenced in Colbourne & Suen, 2000.

James, R. W., Missenden, J. F., 1992

“The Use of Propane in Domestic Refrigerators,”  
*International Journal of Refrigeration*, Vol 15, No. 2, 1992.  
Referenced in Colbourne & Suen, 2000.

Jung, D., Radermacher, R., 1993

“Prediction of Evaporator Heat Transfer Coefficient and Pressure Drop of Refrigerant Mixtures,”  
*International Journal of Refrigeration*, Vol. 16, No. 5, p 330-338, 1993.  
Referenced in Colbourne & Suen, 2000.

Keedwell, R. W., Barnett, J. W., 1997

“Hydrocarbon Refrigerants in Farm Milk Vats,”  
New Zealand Dairy Research Institute, Auckland, New Zealand, 1997.  
Referenced in Colbourne & Suen, 2000.

Korner, F., 1994

“Erfahrungen zum Einsatz von Propan in der warmepumpen-an-wendung,”  
FKW/IKET Seminar, Frankfurt, Germany, 1994.  
Referenced in Colbourne & Suen, 2000.

Kruse, H., 1995

“Energy Savings When Using Hydrocarbons as Refrigerant,”  
*Proceedings of the Greenpeace Conference on Hydrocarbons and other Progressive Answers to Refrigeration*, London, 1995.  
Referenced in Colbourne & Suen, 2000.

Linde Refrigeration, 1998

“Data on Scroll Compressor Calorimeter Tests Using Care 50, R1270 and R404A,”  
Abingdon, UK, 1998.  
Referenced in Colbourne & Suen, 2000.

- Lystad, T., 1995  
“Testing of a Heat Pump with Propane as Working Fluid,”  
*Proceedings of the Natural Working Fluids Workshop*, (HHP-AN22-1), Trondheim, 1995.  
Referenced in Colbourne & Suen, 2000.
- Maclaine-cross, I. L., Leonardi, E., 1996  
“Comparative Performance of Hydrocarbon Refrigerants,”  
*Proceedings IIR Conference*, Melbourne, Australia, 1996.  
Referenced in Colbourne & Suen, 2000.
- Maplin Environmental Ltd., 1998  
“Data on Chiller Tests Using Care 50 and R407C,”  
South Woodham Ferrers, UK, 1998.  
Referenced in Colbourne & Suen, 2000.
- Pearson, S. F., 2000  
“A More Efficient Halocarbon Substitute for R22,”  
*Proceedings Institute of Refrigeration*, London, 2000.  
Referenced in Colbourne & Suen, 2000.
- Petz, M., Wolf, R., 1995  
“Performance Tests of a Vehicle Compressor with R12, R134a, R290, and R600a,”  
*Proceedings of the Greenpeace Conference on Hydrocarbons and progressive answers to refrigeration*,  
London, UK, 1995.  
Referenced in Colbourne & Suen, 2000.
- Richardson, R. N., Butterworth, J.S., 1994  
“The Performance of Propane/Isobutane Mixtures in a Vapor Compression Refrigeration System,”  
*International Journal of Refrigeration*, IIR, Vol 18, no 1, 1994.  
Referenced in Colbourne & Suen, 2000.
- Richardson, R.N., Castle, T. P., 1996  
“Performance of Care 30 Refrigerant in a Simulated Automotive Air Conditioning System,”  
Institute of Cryogenics, Southampton University, UK, 1996.  
Referenced in Colbourne & Suen, 2000.
- Rodecker, A., 1995  
“Propane an Alternative Coolant for Heat Pumps,”  
*Proceedings of the Natural Working Fluids Workshop* (HHP-AN22-1), Trondheim, 1995.  
Referenced in Colbourne & Suen, 2000.
- Treadwell, D., 1994  
“Application of Propane (R290) to a Single Package Unitary Air-Conditioning Product,”  
Lennox Industries Inc., USA, 1994.  
Referenced in Colbourne & Suen, 2000.
- Weist, M. 1994  
“Kohlenwassertoffe als Kaltmittel für Kühl - und Gefriergeräte,”  
Seminar Kohlenwassertoffe als Kaltmittel, FH Karlsruhe, 1994.  
Referenced in Colbourne & Suen, 2000.