AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.

1791 Tullie Circle, N.E./Atlanta, GA 30329

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TC/TG/TRG MINUTES COVER SHEET

(Minutes of all TC/TG/TRG Meetings are to be distributed to all persons listed below within 60 days following the meeting.)

TC/TG/TRG NO TC 3.1 DATE 28 June 2010

TC/TG/TRG TITLE Refrigerants and Secondary Coolants

DATE OF MEETING 25 January 2010 LOCATION Orlando, FL

MEMBERS PRESENT	YEAR APPTD	MEMBERS ABSENT	YEAR APPTD	EX-OFFICIO MEMBERS AND ADDITIONAL ATTENDANCE
Sean Cunningham (Chair) – *voting*	07/2008	William Walter – *voting*	07/2008	Kirsten Ahrenstorf - Guest
David Wilson (Vice Chair) – *voting*	07/2008			Bruce Badger - Guest
Kevin Connor (Handbook) - *voting*	07/2006	Karim Amrane –CM		Steve Brown – Guest
Don Bivens (Research) – *voting*	07/2008	John Andrepont –CM		John Dieckmann – Guest
Samuel Sami (Program) - *voting*	08/2008	Earl Clark –CM		Makoto Kaibara - Guest
Felix Flohr – *voting* (international)	07/2007	Thomas Clemens – CM		Umar Khokhar – Guest
Gustavo Rolotti – *voting*	08/2008	Denis Clodic - CM		Chieko Kondo - Guest
Ganesan "Sonny" Sundaresan (Journal) – *voting*	07/2007	Alan Cohen –CM		Hans-Joachim Kretzschmar – Guest
Steve Kujak – *voting*	07/2009	Barry Fields – CM		Julie Majurin – Guest
		Richard Jacobsen –CM		Dan Manole – Guest
		James Lavelle - CM		Haruo Ohnishi - Guest
Debra Kennoy (Secretary) – non-voting CM		Georgi Kazachki – CM		Nur Pehlivaroglu - Guest
Barbara Minor (Webmaster) – non-voting CM	08/2008	Dominic Kolandayan - CM		Chun-Cheng Piao – Guest
		Bert McJimsey – CM		Raveen Rajasooria - Guest
		Nandini Mouli - CM		Maryline Rassi – Guest
Robert Doerr – CM		Sunil Nanjundaram – CM		Alice Riemer - Guest
Cynthia Gage –CM		Bjorn Palm - CM		Marc Scancarello - Guest
Osami Kataoka – CM		Thomas Reinarts – CM		Chris Seeton – Guest
Kenneth Lilje –CM		Rajiv Singh – CM		John Senediak – Guest

Mark McLinden – CM		Steven Szymurski – CM		Amy Shifflett - Guest
Robert Richard – CM		Koichi Watanabe – CM		Andrew Swallow – Guest
		Thomas Watson – CM		Kenji Takizawa – Guest
		Andrzej Wesolowski – CM		Kai Wang – Guest
		Xiaomei Yu – CM		Tukahiro Yamaguchi – Guest
		Jing Zheng – CM		

KEY CONTACTS

SPLS Liaison*	Janice Peterson
TAC Chair:	Donald Brundage
TAC Section Head:	Brian Michael Silvetti
All Committee Liaisons As Shown On TC/TG/TRG Rosters:	RAC Research: Raymond Cohen Special Pubs: Stanley Mumma Standards: Katherine Hammack Handbook: Hassan M. Bagheri Chapter Technology Transfer: Nancy J. Mitchell-Veeck Professional Development: Florentino Mendez
Manager Of Standards* Manager Of Research & Technical Services	Stephanie Reiniche Michael R. Vaughn

* receives a copy of the TC 3.1 meeting minutes

These final minutes have been approved by this committee.

1. CALL TO ORDER (Sean Cunningham, Chair)

A. Introductions of members and guests – Chair called the meeting to order at 4:15 P.M. and attendees introduced themselves.

B. Agenda Revision/acceptance

i. Motion to accept the agenda was accepted unanimously. There was no formal vote.

C. Establishment of a quorum – There were 9 voting members present out of 10, which constitutes a quorum. Note that one missing member is an international member and his absence is not counted against the quorum determination.

Voting members for this meeting:
Don Bivens - present
Kevin Connor - present
Sean Cunningham - present
Felix Flohr (International member) - present
Steve Kujak - present
Gus Rolotti - present
Samuel Sami - present
Sonny Sundaresan - present
Bill Walter - not present
Dave Wilson - present

2. APPROVAL OF JUNE 2009 MEETING MINUTES

S. Sundaresan motioned and S. Kujak seconded to accept minutes as modified. (Research Section 4.d.iii.4.d to be modified to read "Motion to accept WS1580 with the above modifications. Motion passed 6/0/0/ (CV).")
Motion passed 7 / 0 / 1 / 9 (CNV)

3. CHAIRMAN'S ANNOUNCEMENTS (Sean Cunningham)

A. Section 3 Meeting Report

1) Hightower Award
Award was presented this year to Dharam Punwani (TC 1.1). Individuals can be nominated based on technical leadership such as activity on technical committees.

2) Google Groups tool
ASHRAE is seeing an ever-growing need for on-line corroboration. They suggest the use of Google groups to accomplish this.

3) Upcoming events
Natural Refrigerants - in Sydney, Australia 12APR10 – 14APR10
Climate 2010 in Turkey - 05MAY10 – 12MAY10
Purdue Conference - 12JUL10 – 15JUL10

B. Roster review

2009 – 2010		*2010 – 2011 (Proposed)*		
	Position		***Position***	***Roll-off date***
Sean Cunningham	Chair / ALI Coordinator	*David Wilson*	*Chair*	*30JUN2011*
David Wilson	Vice Chair	*Debra Kennoy*	*Vice Chair*	
Kevin Connor	Handbook Subcommittee Chair	*Umar Khokhar*	*Secretary*	
Don Bivens	Research Subcommittee Chair	*Barbara Minor*	*Research Subcommittee Chair*	
Samuel Sami	Program Subcommittee Chair	*William Walter*	*Standards Subcommittee Chair*	*30JUN2012*
Felix Flohr	International Member	*Don Bivens*	*Member*	*30JUN2012*
Stephen Kujak	Member	*Stephen Kujak*	*Member*	*30JUN2013*
Gus Rolotti	Member	*Maryline Rassi*	*Member*	
Ganesan Sundaresan	Member	*Ganesan Sundaresan*	*Member*	*30JUN2012*
William Walter	Member	*Felix Flohr*	*International Member*	*30JUN2011*
Debra Kennoy	Secretary – Non-Voting	*Samuel Sami*	*Program Subcommittee Chair - Non-Voting*	
Barbara Minor	Webmaster – Non-voting	*Kevin Connor*	*Handbook Subcommittee Chair - Non-Voting*	
		Sean Cunningham	*Webmaster – Non-Voting*	

1) Members rolling off in 01JUL10:
   Sean Cunningham, Kevin Connor, Gus Rolotti, Samuel Sami

2) The committee is looking for voting members. Members must have been Corresponding Members for one year. Contact the chair if interested.

4. Research Subcommittee (Don Bivens) - see Attachment 1

a. Report from Research Subcommittee Chairs Meeting
   The draft Strategic plan for ASHRAE research (2010-2015) is available on the website at: www.ashrae.org/technology/page/39. The last day to submit comments is 22FEB10. Comments are to be submitted to: ashrae.rap@gmail.com

b. Completed Research Projects
   2 projects completed in the last 6 months:
   i. Partitioning of Non-Condensable Gases in Refrigerant Liquid and Vapor Phases (1303-TRP)
   ii. Identification and Evaluation of Working Fluids for High Temperature Heating Applications (1308-TRP)

c. Ongoing Projects

i. Binary Refrigerant Flame Boundary Concentrations (1507-RFP)
   i. Description: databank for useful binary pairs in commercial refrigerants (60 C and 100 C). Identify standard flammable mixture for confirming accuracy of data from flame test apparatus. To aid assessment of new refrigerant blends for SSPC 34.
   ii. Project Monitoring Subcommittee: Bob Richard, Debra Kennoy, Sonny Sundaresan, S. Szymurski, T. Leck
   iii. Status:
   Project was awarded to Safety Consulting Engineers (SCE) in the 4th quarter of 2009.

   A. Kusmierz gave a status report: literature flammability test data on refrigerant pairs of flammable/nonflammable compounds is being located/reviewed (Task 1). Literature findings will be submitted to PMS for use in the identification of the binary pairs for initial testing. Lab flammability test apparatus will be checked for proper operating conditions and test results by testing a refrigerant pair of known flammable composition.

ii. Energy and Performance of Secondary Coolant Low Temperature Refrigerant Systems (1484-RP)
   i. Description: Literature Research and Industry Review (includes model identification and verification vs operating systems)
   ii. Committee: Kevin Connor, Xudong Wang, D. Bivens, and David Hinde (TC 10.7) as PMS.
   iii. Other information: Eckhard Groll – PI, with Joe Poland / Travis Horton
   Status:
   Project is nearing completion.

   The draft final report was previously sent to all members of TC 3.1 (voting and corresponding members) for comment, with a deadline for the comments of 02FEB10. Some of the comments already received (and discussions during the presentation) were related to the need to consolidate cost data for the HFC DX systems versus the alternative secondary loop and CO2 direct systems, include peak load effects for systems in different climatic areas, and presenting quantitative system performance comparisons in a summary section.

   J. Poland gave a presentation based on the draft final report.

   TC will vote on second draft.

d. Work Statements – current

Work Statements 1580, 1583, and 1584 have been approved by RAC (ASHRAE Research Administration Committee). A meeting of RAC will be held on 27JAN10 where the amount of funding for approved work statements will be announced, with decisions

then to be made on which work statements will be publicized for bid proposals. (Note that these work statements had been prioritized during the JUN09 TC 3.1 meeting - #1 (1583), #2 (1580), #3 (1584).

i) Assessment of Burning Velocity Test Methods (1583-RFP)
   (1) This is an approved Work Statement.
   (2) B. Minor will head this activity.
   (3) Volunteers for Project Monitoring Subcommittee:
   D. Kennoy, B. Minor, R. Richard, S. Szymurski, K. Takizawa
   (4) *TC vote: 9 / 0 / 0 (previous meeting)*
   estimated cost: $80,000 ($40,000 per contractor) - potential co-sponsor: AHRI
   estimated duration: 12 months

ii) Study of Input Parameters for Risk Assessment of 2L Flammable Refrigerants in Stationary Applications and Commercial Refrigeration. (1580-RFP)
   (1) This is an approved Work Statement.
   (2) B. Minor will head this activity.
   (3) Volunteers for Project Monitoring Subcommittee:
   D. Kennoy, B. Minor, S. Sundaresan, B. Walter, D. Wilson
   (4) *TC vote: 6 / 0 / 0 / 9 (3 ballots not returned)*
   estimated cost: $250,000
   estimated duration: 12 months

iii) Alternative Approaches to Predicting the Burning Velocity of Refrigerants (1584-RFP)
   (1) This is an approved Work Statement.
   (2) D. Kennoy will head this activity.
   (3) Volunteers for Project Monitoring Subcommittee:
   S. Cunningham, D. Kennoy, B. Minor, R. Richard, S. Szymurski
   (4) *TC vote: 9 / 0 / 0 (previous meeting)*
   estimated cost: $60,000 - potential co-sponsor: AHRI
   estimated duration: 9 - 12 months

e. Non-Prioritized Research Suggestions

i. No activity reported on the RTAR for Risk Assessment of 2L Flammable Refrigerants in applications using large quantities of refrigerants such as centrifugal chillers, supermarket racks, and sea containers. This RTAR was initially discussed in June 2009.

ii. No progress on the proposed RTAR for identification of new fluids for high temperature energy conversion applications and low grade heat recovery. First step is to review existing literature as a basis for preparing a draft RTAR. S. Brown provided already available information. The next step is to formally prepared the RTAR. S. Brown agreed to work on this.

iii. TC 8.9 (J. Dieckmann) requested that TC 3.1 agree to cosponsor a study to evaluate new low GWP refrigerants in home appliances including HFO-1234yf and HFO-1234ze. TC 3.1 offered several objections. The TC 8.9 representative offered to limit the study to a performance evaluation of HFO-1234yf with R-134a. He also indicated that AHAM may be willing to cosponsor 25% of the contract. The final decision was that an electronic copy of the RTAR should be distributed to TC 3.1 for comments. A decision can be made by letter ballot. A copy of this RTAR is found as Attachment 2.

f. On Hold

i. Fractionation testing and error analysis for refrigerant blends (supports SSPC 34) Continuing on hold until new SPC 177P (MOT Fractionation Measurement of Refrigerant Blends) committee determines if needed for further research.

g. ASHRAE RESEARCH GOALS LIAISONS - update

i. Natural Refrigerants and Charge Reduction (Liaison: B. Minor)
    i. This was originally written to address only natural refrigerants. The research plan today includes low GWP refrigerants.

ii. HVACR Components Research (Liaison: S Sundaresan)
    i. Nothing new to report

5. HANDBOOK SUBCOMMITTEE (Kevin Connor)

a. Fundamentals was issued in 2009.

b. A new team is needed. Volunteers need to go through the chapters (Chapter 29, 30, and 31).
    a. Chapter 29 – S. Cunningham
        i. Cynthia Gage volunteered to help with Chapter 29. She can handle the environmental properties.
    b. Chapter 30 – M. McLinden
    c. Chapter 31 – K. Connor

c. Will need the final text by JUL2012. Issue will be JUL2013.

d. The Handbook Subcommittee will need to meet in JUN2010.

6. PROGRAM (Samuel Sami)

A. <u>Orlando, 23-27 January 2010</u>

i) Forum: 2L and What To Do With It.
Chair: Bill Walter.

ii) Seminar: Advances in Refrigeration and Secondary Coolants.
Chair: Samuel Sami.
Presenters: Purdue University, Dow Chemical, Arkema Inc

B. Albuquerque, 26-30 June 2010: Program packages due 12FEB10 for seminar

i) Seminar: Removing Barriers to Next Generation Refrigerants.
Chair Barbara Minor
Volunteers: ARTI (possible review of regulations and standards for low GWP refrigerants), Arkema, NIST

ii) Seminar: Systems with Natural Refrigerants – Components and Field Experience.
a. Requested by ASHRAE Refrigeration Committee (cosponsor)

C. Las Vegas, January 2011 Program packages due 06AUG10 for seminar

i) Forum: ASHRAE Standard 34 400 and 500 Series Blends – Should We Retire 500 as Azeotropes?
Chair: David Wilson

ii) Cosponsor a symposium / conference paper with TC 10.7 – possibly titled Advancements in Refrigeration
(1) Cascade Refrigeration (1484) can be presented

Motion to approve the program plan was made by S. Sundaresan and seconded by G. Rolotti. Motion passed: 8 / 0 / 0 / 9 (CNV).

7. STANDARDS (**Sean Cunningham for Jim Lavelle)**

A. SPC-177P for Measuring Fractionated Compositions of Refrigerant Blends (Bob Richard)

- SPC 177P activities continues making good progress
  - Further evaluation is needed for fractionation
  - Analysis of range is more refined – this is an improvement
  - Looking to assemble a common apparatus design
  - 2012 is the target for an MOT on fractionation for public review

B. ASHRAE Standard 34, *Designation and Safety Classification of Refrigerants* (Bill Walter)

- Meeting of full committee immediately after this meeting.
- All continuous maintenance proposals went through the public review process without comment.

C. ISO Standard 817, *Refrigerants – Number Designation* (Bob Doerr)

ISO 817 continues in DIS form. No change from June 2009. Hoping for a public review soon.

8. WEB SITE (Barbara Minor)

- Meeting minutes are now posted on the ASHRAE website.
- Suggestion: post the Research Plan as a separate document here.

9. OTHER BUSINESS

i) TC 3.4 (C. Seeton) is asking TC 3.1 and TC 8.1 to cosponsor a study to evaluate the physical properties measurements of HFO / lubricant mixtures. TC 3.1 expressed a general interest but would like to see the details of the proposal in writing.

ii) Don Bivens reported that JSRAE gave a presentation entitled "The Role of Refrigerant for Wider Deployment of Heat Pumps". Tom Watson (McQuay) is currently the Tech Council President and can be contacted for further details are needed.

10. MEETING ADJOURNED – 6:20 PM

Motion to adjourn was made by S. Sundaresan and seconded by D. Wilson. Motion passed by general consensus.

ATTACHMENT 1

TC 3.1 RESEARCH PLAN (2008 – 2009 - 2010)
With modifications on Feb. 22, 2010

ASHRAE Research Projects		
	Project Title	**Comments/Status**
2002-2003 Research Plan	**Partitioning of Non-Condensable Gases In Refrigerant Liquid & Vapor Phases (1303-RP)**	Project completed. R.C. Cavestri PI. Minor, Rolotti, Richard - PMS. Poster presentation at Salt Lake City meeting.
2003-2005 Research Plan	**Identification And Evaluation Of Working Fluids For High Temperature Heating Applications. (1308-RP)**	Project completed. Steven Brown PI. Minor, Watson, Meurer, Pucciano (TC 9.4) – PMS. Poster presentation by Brown at Salt Lake City meeting.
2006-2009 Research Plan	**1507-RP: Binary Refrigerant Flame Boundary Concentrations** and databank for useful binary pairs in commercial refrigerants (60 C and 100 C). Identify standard flammable mixture for confirming accuracy of data from flame test apparatus. To aid assessment of new refrigerant blends for SSPC 34.	Project awarded to Safety Consulting Engineers. Committee: Bob Richard, Debra Kennoy, Sonny Sundaresan, Steve Szymurski, and Tom Leck as PMS.
2006-2009 Research Plan	**1484-RP: Energy and Performance of Secondary Coolant Low Temperature Refrigeration Systems** – Literature Research and Industry Review (includes model identification and verification vs operating systems)	Project nearing completion. Eckhard Groll – PI, with Joe Poland/Travis Horton. Kevin Connor, Xudong Wang, D. Bivens, and David Hinde (TC 10.7) as PMS. Completion by 1/31/2010
Priority	**(Work Statements approved; now designated as Tentative Research Projects - TRPs)**	
1 **3**	Burning Velocity Method Survey and Cost, Error, and Ease of Use Analysis **1583-TRP: Assessment of Burning Velocity Test Methods** **1584-TRP: Assessment of Alternative Approaches to Predict Burning Velocity of a Refrigerant**	To provide method evaluation and burning velocity data with error analysis for flammable refrigerants, to be used in future risk assessments and flammability classification methodology (as in ISO 817). WS's approved by ASHRAE RAC. Minor, Kennoy, Richard, Cunningham, and a representative from ARTI
2	**1580-TRP: Risk Assessment of 2L Flammable Refrigerants in Stationary Applications (occupied spaces)** **a) residential a/c & heat pumps** **b) small commercial refrigeration**	Stationary refrigeration & a/c applications, risk assessment. WS approved by ASHRAE RAC. Minor, Kennoy, Wilson, Walter, Sundaresan, and a representative from ARTI.
On hold pending SPC 177P	Fractionation testing and error analysis for refrigerant blends (supports SSPC 34)	Continuing on hold until new SPC 177P (MOT Fractionation Measurement of Refrigerant Blends) committee determines if need for further research. Robert Richard.

TC 3.1 Non-prioritized Research Suggestions
Updated Feb. 22, 2010

Non-Prioritized Research Projects (long range)		
	Secondary fluids for refrigeration: properties of low temperature secondary coolants such as formate/acetate water solutions ……..reconsider after completion of 1484-RP	Property data in vendor literature, but wide variation in values, possibly due to additives, and/or analytical procedures.
	Identification of new fluids for high temperature energy conversion applications (CHP/ organic Rankine cycle); also low grade heat recovery. See completed project report 1308-RP.	Identify TCs with interest in CHP to determine fluid needs (TCs 1.1, 1.3, 1.10). Dr. Sami possible draft RTAR. Steve Brown of Catholic University has provided a list of references for papers on working fluids in organic Rankine cycle applications.
	What are required properties needed to design equipment and rooms for use of flammable refrigerants, particularly 2L flammable refrigerants. Need risk assessments (future).	Std 15 ad hoc committee formed to evaluate (Minor, Wilson, Hinde)
	Low GWP refrigerant properties, stability, materials compatibility – receive summary of papers on this topic scheduled for NIST/IIR conference June, 2009	Would be a testing program; Data needs being evaluated based on the conference papers.
	Ice Slurry Properties……..Thermal Storage	No current interest, so on hold.
	Lubricants for carbon dioxide	TC 3.4 prepared RTAR and WS, but now on hold as more data becoming available on this topic.
New June 22, 2009	Risk Assessment of 2L flammable refrigerants in applications using large quantity refrigerants such as centrifugal chillers, supermarket racks, sea containers, No progress on RTAR as of February 2010, so this suggested project is on hold.	RTAR to be prepared by members of TC8.2, 10.7, TC3.1; David Hinde, Phillip Johnson, Norbert Mueller

ATTACHMENT 2

Research Topic Acceptance Requests (RTARs)

Unique Tracking Number Assigned by MORTS _____

RESEARCH TOPIC ACCEPTANCE REQUEST (RTAR) FORM

(Sponsoring TC/TG/SSPC: ___8.9_____

Title:
Evaluation of HydroFlouro-Olefin (HFO) 1234yf for use in Domestic Refrigeration

Applicability to ASHRAE Research Strategic Plan:
The proposed research will assess the feasibility of using a new promising low global warming potential fluid in domestic refrigerators. This project directly addresses ASHRAE Research Goals D2, D3, and A6.

Research Classification:
Basic/applied research

TC/TG/SSPC Vote:

Reasons for Negative Votes and Abstentions:

Estimated Cost:
$100k

Estimated Duration:
18 months

RTAR Lead Author
David Yashar

Expected Work Statement Lead Author

Co-sponsoring TC/TG/SSPCs and votes:

TC 3.1 Refrigerants and Secondary Coolants

Possible Co-funding Organizations:
The Association of Home Appliance Manufacturers (AHAM) has expressed interest in collaboration and possibly co-funding this research. Also, manufacturer in-kind support is expected in the form of donations of the proposed alternative fluid from chemical manufacturers and test cabinets from appliance manufacturers.

Application of Results:
Refrigeration: Chptr 48: Household Refrigerators and Freezers
Fundamentals: Chptr 16: Refrigerants

State-of-the-Art (Background):

Residential refrigerators and freezers sold in the U.S. currently use the hydrofluorocarbon (HFC) refrigerant HFC-134a. The industry switched to this refrigerant in the early 1990s, when chlorofluorocarbon (CFC) refrigerants were being phased out as a result of the Montreal Protocol banning use of CFCs. The switch from CFCs was spurred primarily by a concern regarding the chlorine from these substances getting into the stratosphere and breaking down the ozone layer which protects the earth from UV radiation. HFC refrigerants have no chlorine, but concerns have been raised about their global warming impact. As an example, HFC-134a has a global warming potential (GWP) of 1430 times that of carbon dioxide, based on impact over 100 years[i]. As a result, legislation is being considered and enacted to limit the use of HFC's. The European Union passed a law requiring that automobile air conditioning systems of new-model vehicles use refrigerants with a GWP of 150 or less starting in 2011, with a transition to total ban of higher-GWP refrigerants by 2017[ii]. The U.S. House of Representatives passed a greenhouse gas bill that includes a provision to reduce use of HFC refrigerants to 17% of current levels by the year 2032[iii]. The senate has not yet voted on this bill.

Very few alternatives to HFC-134a have been considered. The list of possible substitutes is limited to the new HFO fluids and two natural fluids, carbon dioxide and isobutane. There are, however, substantial barriers associated with the adoption of the natural alternatives for domestic refrigeration in the U.S. market. Isobutane is used extensively outside the U.S. in domestic refrigerators, however it is highly flammable and safety regulations limit the quantity of this refrigerant allowable for use in an appliance. In many urban centers in the U.S., this limit is specified by UL Standard 250[iv], which requires that no more than 50g of the refrigerant can leak from a refrigerator during a catastrophic leak event. This limits the allowable charge amount such that it is insufficient to achieve optimal performance for most refrigerators, particularly the larger products that are common in the U.S. market.

Carbon dioxide has received the most attention for use in automobile air conditioning systems, but consideration has also been given to its use for refrigeration applications[v]. The carbon dioxide cycle is typically transcritical for air-cooled systems operating at design conditions. This severely limits the achievable efficiency of such a system, compared to one using a conventional refrigerant. Furthermore, the pressure levels realized with carbon dioxide are quite high, and displacements for domestic refrigeration are low. This makes development of an efficient compressor challenging, while also making the use of efficiency enhancements such as work recovery expanders more difficult. The TC members are not aware of any carbon dioxide compressor suitable for this application that is current commercially available.

Advancement to the State-of-the-Art:
It is possible that HFC refrigerants could be eliminated from use in refrigerators at some point in time, but the list of possible alternative fluids is limited with the best candidates untested to date. This work will be the first to address the feasibility of employing an HFO as the working fluid in a domestic refrigerator. The results of this study will serve as the first definitive indicator of whether these fluids should be pursued for the future domestic refrigerating products. Furthermore, it will provide direction for specific research needed by the industry to design and optimize components for these new refrigerants (e.g. capillary tubes, compressors, heat exchangers).

Justification and Value to ASHRAE:

This work is directly aligned with the ASHRAE Research Strategic Plan. This work will seek to answer whether these environmentally benign fluids can be used in a domestic refrigerator with suitable energy efficiency (Goal A6). Also, this work will research the potential of the new HFO refrigerants (Goal D2), and serve as the baseline performance indicator for these fluids (facilitating Goal D3).

Objectives:
The objective of this research topic is to evaluate the possibility of employing HFO 1234yf as a working fluid in domestic refrigeration. Analytical work will use thermodynamic cycle analysis to evaluate the extent to which this refrigerant can directly replace HFC-134a. The laboratory work will consist of two phases, a compressor calorimeter testing phase and a refrigerator cabinet testing phase. The compressor calorimeter testing will be done to compare the capacity and COP of an R-134a compressor used in a test cabinet when operating with R-134a and HFO 1234yf. The cabinet tests will be performed on two state of the art refrigerator cabinets of different configurations and produced by different manufacturers. During the cabinet tests, the refrigerators will be evaluated by measuring the energy consumption according to the test method outlined in ANSI AHAM HRF-1[vi] and document the cyclic operation parameters of the unit, first charged with HCF-134a, then with HFO-1234yf. This project deliverables are as:

1. A complete set of well-analyzed data to be used by the appliance industry to assess the potential of HFO 1234yf for use in energy efficient domestic refrigerators.
2. Initial guidelines for the use of HFO 1234yf in domestic refrigerators containing suggested changes in components and refrigerant charge.

Key References:

[i] http://www.ipcc.ch
[ii] Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 relating to emissions from air conditioning systems in motor vehicles and amending Council Directive 70/156/EEC, OJ L 161, 14.6.2006, p. 12., http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:161:0012:0018:EN:PDF
[iii] Climate Change Bill H.R. 2454 (Waxman-Markey Bill), "American Clean Energy and Security Act of 2009", Passed by U.S. House of Representatives on 6/26/09, http://www.govtrack.us/congress/bill.xpd?bill=h111-2454
[iv] UL Standard 250, "UL Standard for Safety Household Refrigerators and Freezers", Nov 1993.
[v] Aprea, C. and Maiorina, A. "An experimental evaluation of the transcritical CO2 refrigerator performances using an internal heat exchanger" International Journal of Refrigeration, Vol 31, No. 6, sept 2008. pp 1006-1011.
[vi] Association of Home Appliance Manufacturers, "HRF-1-2008: Energy and Internal Volume of Refrigerating Appliances" 2008.