DRAFT MINUTES

MTG.LowGWP COMMITTEE
June 24 & 27, 2018 Meeting (Part A & Part B)

SUNDAY, June 24, 2018
5:00 PM - 6:00 PM CDT
Hilton Americas Hotel
Grand B Room – 4th floor

MEMBER ATTENDEES, STAFF & GUESTS: Total Attendance - 41

Voting Members			Staff		Guests							
Chair	**Jim Wolf**	x	Mike Vaughn	x	Neal Lawrence	x	Kevin Teakeu	x	Maher Mousa	x	John Withouse	x
Vice Chair	Bill McQuade				Chris Miles	x	Neil Monson	x	Karim Amrane	x	Kent Anderson	x
Res. Co-Chair	Brian Fricke	#			Ed Wuesthoff	x	Mike Fischer	x	Brian Bogdan	x	Kent Anderson	
Res. Co-Chair	Ken Schultz	#			Kouichi Jamase	x	Tao Cao	x	Dave Winningham	x	Glenn Hourahan	x
Codes & Stds Chair	Phil Johnson	#	See attached list for additional guests									
Program Chair	Steve Eckels	#	Alternate 1		Alternate 2		Alternate 3		Alternate 4		Alternate 5	
REF	Jason Robbins		**Charles Hon**	x								
SSPC 34	Debra Kennoy		Sam Yana-Motta		Chris Seeton		Sean Cunningham					
SSPC 15	Dennis Dorman		Greg Scrivener									
TC 1.1	**Ray Rite**	x	Sankar Padhmanabhan		Samuel Sami							
TC 1.3	**Omar Abdelaziz**	x	Satheesh Kulankara	x	Evraam Gorgy							
TC 2.5	**Larry Burns**	x	John Karakash									
TC 3.1	**Barbara Minor**	x	Steve Kujak		Bob Richard		Greg Linteris		Kenji Takizawa	x	Bob Low	
TC 3.2	Thomas Leck		Sonny Sundaresan		Alan Cohen							
TC 3.3	Marc Scancarello		Joe Nigro									
TC 3.4	**Joe Karnaz**	x	Chris Seeton		Danny Halel	x						
TC 3.8	Danny Halel		Mark Adams									
TC 6.3	**Siva Gopalnarayanan**	x	Kevin Mercer									
TC 8.2	**Phil Johnson**	x	Laurent Abbas		Ray Good							
TC 8.4	**Vikrant Aute**	x	Yirong Jiang		Patrick Geoghegan		Chad Bowers					
TC 8.5	**Steve Eckels**	x	Satheesh Kulankara		Kashif Nawaz							
TC 8.7	Dermot McMorrow		**Doug Tucker**	P								
TC 8.11	**Dutch Uselton**	x	Ankit Sethi									
TC 10.1	Doug Scott		Dan Dettmers		Wayne Borrowman							
TC 10.7	**Brian Fricke**	x	Tim Anderson		Charles Hon							
AHAM	Masud Chowdhury		Randy Cooper									
AHRI	**Xudong Wang**	x	TBD									
U.L.	Brian Rodgers		Mark Skierkiewicz									
UNEP	Shamila Nair-Bedouelle		**Ayman Eltalouny**	P								

x – Denotes Member, Alternate, Guest, or Staff noted was in attendance for this meeting.
P – Denotes Member, Alternate, Guest, or Staff noted was in attendance for part of this meeting.
- Denotes Non-Voting MTG leadership position
Bold – Denotes committee or person was represented in MTG votes at this meeting
a - Denotes voting member that arrived after votes cast

26 Voting Members Currently – 14 needed for Quorum – Quorum? – YES, 16 present at start of meeting and 2 more joined later

ADDITIONAL GUEST ATTENDEES:

Guests									
Roy Crawford	x								
Allen Karpman	x								
Sayam Havibabu	x								
Antoine Bou Abboud	x								
Jun Wang	x								
Richard Weekley	x								
Yunho Hwang	x								
Allen Karpman	x								
Sayam Havibabu	x								
Antoine Bou Abboud	x								

DRAFT MINUTES PART A

MTG.LowGWP COMMITTEE
June 24 2018 Meeting (Part A)

MAIN MTG MEETING - PART A:

A. CALL TO ORDER, Welcome comments and round of introduction

B. REVIEW ROSTER & DETERMINE QUORUM
Quorum Reached: YES – 16 voting members or Alternates present at start of meeting. Two more joined later.

C. ASHRAE Code of Ethics Commitment – Chair
In this and all other ASHRAE meetings, we will act with honesty, fairness, courtesy, competence, integrity and respect for others, and we shall avoid all real or perceived conflicts of interests. (See full Code of Ethics: https://www.ashrae.org/about-ashrae/ashrae-code-of-ethics)

D. ADDITIONS AND/OR CHANGES TO THE AGENDA – None

E. APPROVAL OF CHICAGO MEETING DRAFT MINUTES
Motion #1 – That the Draft Chicago meeting minutes be approved as drafted
MTG Vote: 15-0-1-10 (26) CNV

F. CODES & STANDARDS Working Group Interim Meeting Activity Reports
Reports from interim meetings between Society meetings, if any, are appended to the MTG draft minutes for this meeting as **Attachment 1**.

Motion #2 – That the following Codes & Standards Subcommittee Activity Reports and Agenda be appended to the end of the MTG draft minutes for this meeting in Houston as **Attachment 1**:

- Activity Report from 23-Jan-2018 Chicago meeting
- Agenda & Activity Report from 19-Mar-2018 web conference meeting
- Agenda from 26-Jun-2018 Houston meeting

MTG Vote: 15-0-1-10 (26) CNV

AI #1 Houston (MORTS) – Append Codes & Standards Subc. items noted in Houston Motion #2 to Houston minutes as Attachment #1

G. CHAIR'S REPORT - WOLF
a) Status on Joint AHRTI / ASHRAE / DOE-ORNL effort on A2L Refrigerants
AHRTI – All A2L projects completed and final reports available. Follow-on A3 project with California Air Resource Board (CARB) underway with U.L. as contractor. PTAC, Mini-split, and single & 3-door reach-in coolers being evaluated for A3 releases. Expect to complete testing this summer.

ASHRAE – All three ASHRAE projects 1806, 1807, and 1808 still underway. RP-1806 Task 1(Model Improvement, Calibration, and Validation) completed and being reviewed now by PMS for approval before proceeding to Task 2 (Simulation Study) and Task 3 (Risk Assessment Updates). RP-1807 1st draft of final report completed and submitted to PMS for approval in December 2017. RP-1808 1st draft final report submitted to PMS for approval in May 2018.

DOE-ORNL working on following two projects:
i. NIST modeling tools for burn velocity
ii. Investigate the Proper Basis for Setting Charge Limits of A2L, A2, and A3 for Various Types of Products
Part 1 Comprehensive Lit. Review complete – Summarized output from workshop
The draft report was reviewed by the PMS. Limited comments were received. ORNL team is working on part 2 of the report addressing the reduced order modeling technique. Mr. Baxter noted that part 2 is expected to be ready for review by the end of the summer.

b) Current & On-going Action Items – See Page 15 – Delayed until the Wednesday meeting

c) New Information Items:
The following two new projects have been developed by AHRTI FRS for our consideration & support as part of Phase 2 of the A2L joint research effort:

- WS-1855, DETERMINATION OF THE IMPACT OF COMBUSTION BYPRODUCTS ON THE SAFE USE OF FLAMMABLE FLUORINATED REFRIGERANTS – Estimated cost & duration $240,000 -12 to 18 months – ASHRAE will lead on this project and AHRTI will co-fund.
Attachment 2

  Note: The submission deadline for RAC review of WSs at the 2019 winter meeting is December 3rd this year since the winter meeting starts early on January 12th.

AI #2 Houston (All) – Volunteers requested for new WS-1855 to serve on PES and PMS. Contact Brian Fricke if interested.

- AHRTI ##### - ASSESS REFRIGERANT DETECTOR CHARACTERISTICS FOR USE IN HVACR EQUIPMENT
Phase IA (Sensor response compared to proposed requirements) is estimated to cost $40,000 – 2 month duration
Phase 1B (Response time testing verification) is estimated to cost $75,000 – 5 months duration
Phase 2 (Reliability evaluation methods) is estimated to cost $50,000 – 3 months duration
Phase 3 (Sensor robustness) is estimated to cost $135,000 – 8 months duration
Total cost / duration: $300,000 / 18 months
Attachment 3

  Note: RAC in turn approved in Houston the co-funding request for this project as follows:
  Co-RP-7, *Assess Refrigerant Detector Characteristics for Use in HVACR Equipment (Phase 1),* be funded to AHRTI, for a period of 7 months at a cost to ASHRAE of $23,000. TC 3.8 (Refrigerant Containment) will monitor the project on behalf of ASHRAE.

AI #3 Houston (MORTS) – Contact TC 3.8 (Refrigerant Containment) Chair for a TC volunteer to serve on PES and PMS for new Co-RP-7 as ASHRAE representative.

AHRTI also has the following three other projects in development for Phase 2 of the A2L research effort:

- Validation of Mitigation Methods Specified in Standards for Air Conditioning Equipment
- Validation of mitigation methods specified in standards for refrigeration equipment
- Leak rate characterization (include evaluation of different types such as A2Ls vs. A3s including ducted systems)

MTG.LowGWP
WINTER MEETING 2018
HOUSTON, TX
PART A (CONTINUED)

H. RESEARCH SUBC. REPORT – FRICKE & SCHULTZ

a) **RP-1806**, *Flammable Refrigerants Post-Ignition Simulation and Risk Assessment Update*
Contractor: Gexcon US - P.I.: Scott Davis – Cost: $843.5k – 12 month duration – Project start: Jan. 2017
Schultz Lead:
Update: Estimate project is approximately 6-8 months behind schedule due to complexities created by AHRTI 9007 refrigerant release configuration. In order to try and recover schedule, the PMS is therefore recommending that a pilot of Task 2 (Simulation Study) and Task 3 (Risk Assessment Updates) be executed. Up to three relevant scenarios called out under Task 2 (subsets of full fault trees, for one or more equipment types) should be chosen and the model exercised to provide an understanding of the sensitivity of the outcomes (physical and level of risk) to the uncertainties and variabilities in the inputs. The scenario(s) should be chosen in consultation with the contractors (Gexcon and Navigant). The PMS would then review the outcome of the pilot and make a recommendation on moving forward or not (Go/NoGo #2) with the rest of the scenarios laid out under Task 2, or use the pilot results to guide further improvements of the model within the available budget funds. See **Attachment 5** for additional information.

b) **RP-1807**, *Guidelines for Flammable Refrigerant Handling, Transporting, Storing and Equipment Servicing, Installation and Dismantling*
Contractor: Navigant Consulting - P.I.: William Goetzler – Cost: $95k - 12 month duration – Project start: Mar. 2017
Fricke Lead:
Update: Project consists of the following four tasks:
Task 1. Review Requirements/Best Practices for A2L/A3 Refrigerants from Countries outside US
Task 2. Review Relevant US Requirements/Standards
Task 3. Develop Requirements/Guidelines for A2L/A3 Refrigerants
Task 4. Identify Testing to Confirm Proposed Requirements
Task 5. **NEW!** Include Canada in Section 2 of report
1st draft of final report completed and submitted to PMS for approval in December 2017. PMS will continue to review 1st draft of report to determine if it is ready for a MTG approval vote.

c) **RP-1808**, *Servicing and Installing Equipment using Flammable Refrigerants: Assessment of Field-made Mechanical Joints*
Contractor: Creative Thermal Solutions - P.I.: Stefan Elbel – Cost: $115k – 6 month duration – Project start: May 2017
Fricke Lead:
Update: Project's P.I. gave a presentation on the 1st draft of the final report submitted in May 2018 outlining the fitting types, tests, and project results for project. PMS will continue to review 1st draft of report to determine if it is ready for a MTG approval vote.

Subcommittee Meeting Attendance – 54 members and guests

I. ADDITIONAL DISCUSSION OF HOUSTON & ATLANTA PROGRAM IDEAS

Program Research Summit – Eckels Lead

AI #4 Houston (Eckels) – Send our program ideas to TC 10.7 and others for co-sponsorship votes.

MEETING RECESSED AT 6 PM CDT, SUNDAY, 6/24/18

DRAFT MINUTES PART B
MTG.LowGWP COMMITTEE
June, 27, 2018 Meeting

Wednesday, June 27, 2018
10:00 AM - 12:00 PM CDT
Hilton Americas Hotel
346AB Room – 3rd floor

MEMBER ATTENDEES, STAFF & GUESTS: Total Attendance - 51

Voting Members			Staff		Guests							
Chair	**Jim Wolf**	x	Mike Vaughn	x	Mary Koban	x	Dominique Taudin	x	Stephen Spletzer	x	Tyler Karnaz	x
Vice Chair	**Bill McQuade**	x			Julius Ballanco	x	Jim Kelsey	x	Andrew Klein	x	Chris Campo	x
Res. Co-Chair	**Brian Fricke**	x			Jeff Newel	x	Dominic Kolandayan	x	Roy Crawford	x	Casey Scruggs	x
Res. Co-Chair	**Ken Schultz**	x			Minao Mehdizadeh	x	Joshua Hughes	x	John Whithouse	x	Jeremy Smith	x
Codes & Stds Chair	**Phil Johnson**	x	See attached list at end of minutes for additional guests									
Program Chair	**Steve Eckels**	x	Alternate 1		Alternate 2		Alternate 3		Alternate 4		Alternate 5	
REF	Jason Robbins		**Charles Hon**	x								
SSPC 34	Debra Kennoy		Sam Yana-Motta		Chris Seeton		Sean Cunningham					
SSPC 15	Dennis Dorman		Greg Scrivener									
TC 1.1	**Ray Rite**	x	Sankar Padhmanabhan		Samuel Sami							
TC 1.3	**Omar Abdelaziz**	x	Satheesh Kulankara	x	Evraam Gorgy							
TC 2.5	**Larry Burns**	x	John Karakash									
TC 3.1	Barbara Minor		Steve Kujak		Bob Richard		Greg Linteris		Kenji Takizawa		Bob Low	
TC 3.2	**Thomas Leck**	x	Sonny Sundaresan		Alan Cohen							
TC 3.3	**Marc Scancarello**	x	Joe Nigro	x								
TC 3.4	**Joe Karnaz**	x	Chris Seeton		Danny Halel	x						
TC 3.8	**Danny Halel**	x	Mark Adams	x								
TC 6.3	Siva Gopalnarayanan		Kevin Mercer									
TC 8.2	**Phil Johnson**	x	Konstantinos Kontomaris									
TC 8.4	**Vikrant Aute**	x	Yirong Jiang		Patrick Geoghegan		Chad Bowers					
TC 8.5	**Steve Eckels**	x	Satheesh Kulankara	x	Kashif Nawaz							
TC 8.7	Dermot McMorrow		Doug Tucker									
TC 8.11	**Dutch Uselton**	x	Ankit Sethi	x								
TC 10.1	Doug Scott		Dan Dettmers	x	Wayne Borrowman							
TC 10.7	**Brian Fricke**	x	Charles Hon	x	Tim Anderson							
AHAM	**Randy Cooper**	x	Masud Chowdhury									
AHRI	**Xudong Wang**	x	TBD									
U.L.	**Brian Rodgers**	x	Mark Skierkiewicz									
UNEP	Shamila Nair-Bedouelle		**Ayman Eltalouny**	x								

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P – Denotes Member, Alternate, Guest, or Staff noted was in attendance for part of this meeting.
- Denotes Non-Voting MTG leadership position
Bold – Denotes committee or person was represented in MTG votes at this meeting
a - Denotes voting member that arrived after votes cast
26 Voting Members Currently – 14 needed for Quorum – Quorum? – YES, 19 present for votes

ADDITIONAL GUEST ATTENDEES:

Guests									
Karim Amrane	x								
Bassam Elassoad	x								
Miguel Boscan	x								
Skip Ernst	x								
Niel Hayes	x								
Jeff Warther	x								
Sarah Kim	x								
Carolina Solano	x								
Shelby Kent	x								
Lydia Dobler	x								
William Schultz	x								
Chandra Gollapudi	x								
Mike Saunders	x								
Hewitt Gaudin	x								

DRAFT MINUTES PART B
MTG.LowGWP COMMITTEE
June, 24, 2018 Meeting

MAIN MTG MEETING - PART B:

RECONVENE

J. PROGRAM SUBC. REPORT - Part B - ECKELS

a) Houston 2019 Meeting

1. MTG.LowGWP co-sponsored in Chicago the TC 8.11 seminar proposal titled *A/C Sizing & Performance in Hot & Humid Climates including Low GWP Designs* for possible presentation in Houston, but this Seminar does not appear to have made it into the Houston program.

b) Program Proposals for MTG.LowGWP Consideration

1. Update on Global Polices and Programs for Best Use of Refrigerants
   - Refrigeration Committee Lead / MTG & TC 3.1 co-sponsor
   - Yunho Hwang/Steve Kujak/Steve Eckels Organizers
   - Montreal Protocol Update
   - EU F-Gas Impacts
   - US GHG Regulation or CARB
2. Products Standards Incorporation of 2l Refrigerants
   - MTG Lead / TC 3.1 Co-sponsor
   - Update on IMC UMC Code Corporate of 2L's
   - UL 60335-2-40 Requirements for 2L Refrigerants
   - Standard 15 Updates and Progress on 2L Refrigerants
   - Standard 15 Updates and Progress on 2L Refrigerant for Unitary Products
   - UL 60335-2-89 Requirements for 2L Refrigerants
3. Whole Room Testing
   - TC 3.1 Lead /MTG Co-sponsor
   - AHRTI-9007: Benchmarking Risk by Whole Room Scale Leaks and Ignitions testing for A2L Refrigerants
   - AHRTI-9007-02: Benchmarking Risk by Whole Room Scale Leaks and Ignitions Testing for A3 Refrigerant
   - 1806
   - NFPA A3 Testing (need to confirm)
   - Daikin UL Testing (need to confirm)
   - Carrier furnace utility closet testing (need to confirm)
4. Service and Practice
   - TC 3.1 Lead /MTG Co-sponsor
   - RDL and NATE
   - ASHRAE RP-1807: Guidelines for Flammable Refrigerant Handling and Equipment Servicing and Installation
   - ASHRAE RP-1808: Servicing and Installing Equipment using Flammable Refrigerants: Assessment of Field-made Joints
   - NFPA Firefighters
5. Optimization for Alternate Refrigerants
   - TC 1.13 Lead /MTG co-sponsor
6. Check of new & retro fittings w/ Low GWP Refrigerants
   - TC 3.2 Lead / MTG co-sponsor
7. Life after R404A
   - TC 10.7 Lead / MTG co-sponsor
   - Using A3s (hydrocarbons) in Self-contained equipment
   - Regulatory /policy side of refrigerant transitions
   - Lab test with A2L direct replacement refrigerant
   - No pain no gain – transition from R-502 to R-22 to R-404A to ???

8. Advances in Low GWP Refrigeration System Architectures
    - TC 10.7 Lead / MTG co-sponsor
    - Micro-Distributed Systems
    - Advanced Trans-critical CO_2 for Hot Climates
    - Use of HFO Refrigeration in Supermarket Refrigeration systems
    - Topic from Low-GWP MTG?

Motion #3 – That MTG.LowGWP co-sponsor the eight topics outlined in the Program report above.
MTG Vote: 14-0-1-11 (26) CNV

c) Atlanta 2019 Meeting Tracks
1. Program Website – www.ashrae.org/atlanta - Opened 3/26/18
2. Atlanta Conference Tracks:
    - Track 1 Systems and Equipment
    - Track 2 HVAC&R Fundamentals and Applications
    - Track 3 Refrigeration
    - Track 4 Construction, Operation, and Maintenance of High Performance Systems
    - Track 5 Common System Issues and Misapplications
    - Track 6 The Convergence of Comfort, Indoor Air Quality, and Energy Efficiency
    - Track 7 Building Integrated Renewables and Natural Systems
    - Track 8 The Engineer's Role in Architecture

d) Atlanta 2019 Meeting
1. Submit Deadline for complete Tech Paper & Conf. Paper abstracts - 3/26/18 – Passed
2. Conf. Paper abstract Accept/Reject notifications sent by CEC – 4/9/18 – Passed
3. Website opens for Atlanta seminar, forum, workshop proposals – 6/7/18 – Passed
4. Submit deadline for final Conf. Papers – 7/9/18 – Passed
5. Conf. Paper & Tech Paper Accept/Revise/Reject notifications sent by CEC – 7/30/18 – Passed
6. Submit Deadline for seminar & forum proposals – 8/3/18– Passed
7. Revised Conference Papers/Final Technical Papers Due -8/7/18– Passed
8. Conf. Paper & Tech Paper Final Accept/Reject notifications sent by CEC – 8/27/18– Passed
9. Seminar, Forum, Workshop, Accept/Reject Notifications sent by CEC – 9/14/18– Passed
10. All PPTs due On-line – January 4, 2019
11. Conference begins (January 12 - 16, 2019)

K. CODES & STANDARDS SUBC. REPORT – JOHNSON: – Total Attendance - 35

HOUSTON MEETING STATUS REPORT:
Time: **Wednesday, June 27, 2018 10:00 AM – 12:00 PM**
Location: **Houston, TX**

Membership
Currently 29 members of the subcommittee, plus an additional 21 people on the distribution list for subcommittee correspondence (past guests and interested parties).

Meetings
Codes & Standards Subcommittee held meetings as follows:

- Tue, 23-Jan-2018, Chicago, IL
- Mon, 19-Mar-2018, teleconference

Despite intentions expressed in Chicago, there was only one monthly interim meeting in the spring of 2018, and almost no activity via Basecamp either.

Motion: That the following Codes & Standards Subcommittee Activity Reports and Agenda be appended to the end of the MTG draft minutes for this meeting in Houston. – **See Attachment 1**

- Activity Report from 23-Jan-2018 Chicago meeting
- Agenda & Activity Report from 19-Mar-2018 web conference meeting
- Agenda from 26-Jun-2018 Houston meeting

Future monthly web conference meetings planned for July, August, September, October, and November of 2018.

Basecamp https://3.basecamp.com/3106353/projects/2779045 (or https://basecamp.com/)
All primary and alternate MTG.LowGWP members were added to the project collaboration tool (can login via e-mail). As of today, 79 people have access to the Basecamp web site for the MTG.LowGWP Codes & Standards Subcommittee.

Stakeholder List
A few minor revisions to the list were made during spring of 2018, including a refresh the status of various codes, standards, and activities.

Advocacy Plan
Some updates to the plan made during the subcommittee meeting yesterday, and several elements of the plan were marked as completed. Will continue to work on this during fall of 2018.

Presentation Slide Deck for Advocacy & Communication Efforts
No updates to the slide deck itself during spring 2018. Some additional materials have been requested for incorporation into the slide deck. Several of the seminar sessions in Chicago contained relevant content and the subcommittee will contact the authors/presenters to request materials.

Standards Updates (quick highlights only)

ASHRAE 15-2016. Public reviews were held spring 2018 for proposed addenda:

Addendum	**Review**	**Dates**
A (remove R-717)	PPR1	Feb9-Mar11, 2018
D (direct systems for human comfort)	PPR3-ISC	Mar16-Apr15, 2018
E (refrigerant conversion & mixing)	PPR1	Mar16-Apr15, 2018
H (in machinery rooms)	PPR2	Mar16-Apr30, 2018
15.2P (small residential)	APR1	May25-Jun24, 2018

Add_A received comments that were resolved with editorial changes. Both Add_D & Add_H will be revised again in order to resolve comments and go out for another public review. Add_E had no comments and is ready to publish. Comments received for 15.2P.

Addendum	**Review**	**Dates**
D (direct systems for human comfort)	PPR4-ISC	July, 2018
H (in machinery rooms)	PPR3-ISC	July, 2018

In early January SSPC15 submitted two code change proposals to ICC IMC & IFC related to addenda D & H, as placeholders to be revised should the spring PPR(s) be successful. Based on comments received, at the ICC CAH in April, ASHRAE staff recommended that the proposals be rejected, with plans to submit public comments to the ICC by the July 16 deadline, with such comments revising the proposals to match the latest language for the next addenda public reviews in July.

One other addenda related to 2L expecting letter ballot for PPR this fall (for capacity factors of pressure relief devices).

IIAR Standard 2-2014. Published

ASHRAE 34-2016. Addendum G (make 2L a class, not sub-class of 2) completed PPR2-ISC without comment and will be published. This addendum is a prerequisite for any Standard 15 addenda that use 2L (and vice versa, to avoid conflict between 15 and 34). Another addendum to publish LFL values is in process (CMP from Tharp fbo SSPC 15). In early January SSPC34 submitted a code change proposal to ICC IMC to update the Chapter 11 refrigerant table.

UL 60335-2-40 edition 2. Published 15-Sep-2017. Adds requirements for class 2 and class 3 flammable refrigerants. (edition 1 prohibited use of flammable refrigerants) Adds requirements transcritical R-744. Expands scope from 600V to 15,000V.

UL 60335-2-40 edition 3. Preliminary comment draft had public review 1-Dec-2017 thru 30-Jan-2018. Over 300 comments received. Adds requirements for class 2L. Includes national deviations from the content of IEC 2-40 edition 6. CANENA WG10 is working through comments and making revisions to the draft, meeting approximately monthly. Target to send out ballot phase draft by end of 2018.

IEC 60335-2-40 edition 6. FDIS vote passed. Released in mid-February 2018 with publication date of January 2018. Will replace edition 5.1 published 28-Apr-2016.

UL 60335-2-89 edition 1. Published 29-Sep-2017.

IEC 60335-2-89 edition 2.2. Published 12-May-2015.

IEC 60335-2-89 edition 3. CDV approved Dec-2017. Translation of CDV forecast available Mar-2018. Forecast publication date 29-Mar-2019.

ISO 817:2014 edition 3. Published 1-Jun-2014. Amendment 1 published Nov-2017.

ISO 5149-1:2014 edition 1. Published Apr-2014 (replaced 1993 edition).
Amendment 1 published Oct-2015.
ISO 5149-2:2014 edition 1. Published Apr-2014 (replaced 1993 edition).
ISO 5149-3:2014 edition 1. Published Apr-2014 (replaced 1993 edition).
ISO 5149-4:2014 edition 1. Published Apr-2014 (replaced 1993 edition).

Codes Updates:

<table>
<tr><td>ICC IMC 2018.</td><td rowspan="2">Published. Includes 2L for machinery rooms, but does not include reference to UL 60335-2-40.</td></tr>
<tr><td>ICC IFC 2018.</td></tr>
<tr><td>ICC IRC 2018.</td><td>Published. No provisions for 2L, but does include reference to UL 60335-2-40 edition 1 (no flammable refrigerants).</td></tr>
</table>

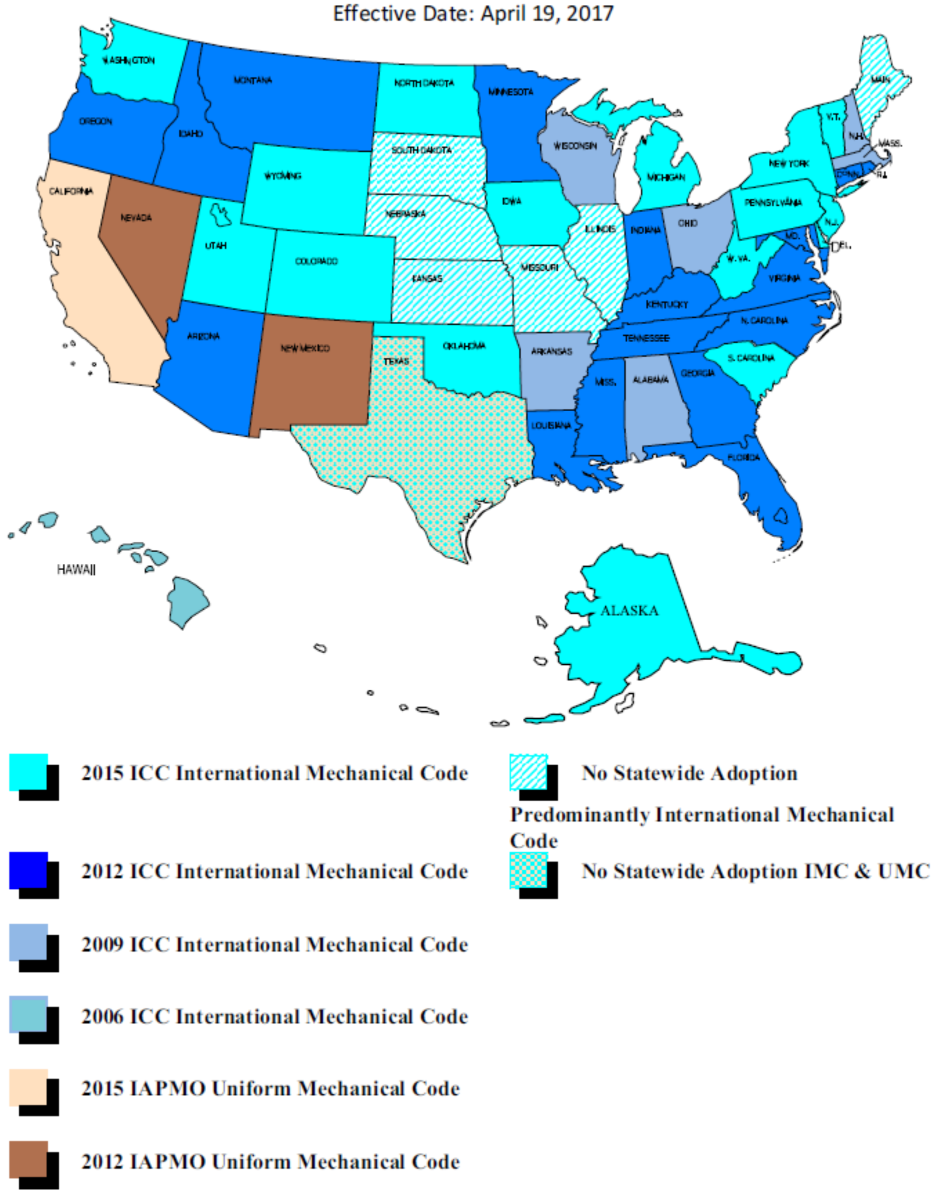
<table>
<tr><td>ICC IMC 2021.</td><td rowspan="3">Code change cycle started.
11-Jan-2018: deadline for Group A code change proposal submittals
28-Feb-2018: proposals published
15/25-Apr-2018: Committee Action Hearing (CAH)
30-May-2018: CAH Report published
16-Jul-2018: public comment deadline
24/31-Oct-2018: Public Comment Hearing
Dec-2018: Final Action after voting period & certification
2019: Group B codes go through same cycle (IECC, IRC-E, IgCC, etc.)
2020: code correlation activities
Fall 2020: forecast Publication.</td></tr>
<tr><td>ICC IFC 2021.</td></tr>
<tr><td>ICC IRC 2021.</td></tr>
</table>

IAPMO UMC 2018. Not yet published; forecast early-2018. Some 2L related proposals from task force public comments were accepted, but some rejected, creating inconsistencies. Petition in process attempting to resolve.

IAPMO UMC 2021.	Code change cycle starts soon. 16-Mar-2018: deadline for code change proposal submittals 13-Apr-2018: proposals published 15/18-May-2018: Technical Committee Meetings 20-Aug-2018: Report on Proposals published 3-Jan-2019: public comment deadline 22-Mar-2019: public comment monograph published 29-Apr/2-May-2019: Technical Committee Meetings 21-Aug-2019: report on comments published 2/16-Oct-2019: balloting 13/15-Nov-2019: Standards Council Meeting early 2021: forecast publication

2017 State Mechanical Code Adoptions

Effective Date: April 19, 2017



Respectfully Submitted,

Phillip Johnson,
Chair, Codes & Standards Subcommittee to MTG.LowGWP

L. AHRI AREP-II UPDATES – WANG

M. OLD BUSINESS

a) Agenda Item G.b. - New & On-going Action Items

1. **AI #1 Long Beach** (Wolf, Fricke, Schultz, Johnson, Eckels) – Develop answers to the nine questions proposed by David Underwood in order to support ASHRAE Ottawa Day on the Hill
   Status: Complete – See **Attachment 5**

2. **AI #5 Long Beach** (All) – Request for Low GWP Refrigerant slide donations in order to develop Chapter & GGAC slide deck for Code Officials and others. Send slides to Julius Ballanco on C&S Subc.

   Every ASHRAE Chapter will soon have a Grassroots Government Activities Committee (GGAC) chair. This new Chapter position will be tied to the PAOE Point system now. Plan is to then have GGAC Chair speak to chapter members about timely issues that impact codes, such flammable refrigerants, and then have GGAC Chair and possibly some Chapter members speak to local Code Officials about this issue using the slide deck.
   Status: On-going

3. **AI #6 Long Beach (Johnson) – Investigate further and propose a plan for the slide deck that will define the following:**
   1. What is our process for adding, modifying, or deleting slides to deck?
   2. Copyright?
   3. Can end users customize?
   4. What is our process for adding, modifying, or deleting slides to deck?
   5. Should we consider using Distinguished Lecturers (DLs) on this topic (Follow Legionella example)?
   6. Add Disclaimer to slide deck when distributed

   Status: On-going

N. NEW BUSINESS – None

ADJOURN

MEETING ADJOURNED – 11:42 PM CDT, WEDNESDAY, 6/27/18

New Action Items from Houston Meeting
MTG.LowGWP

NEW ACTION ITEMS FROM HOUSTON MEETING

Action Item	Action	Responsible Party	Page
1	That the following Codes & Standards Subcommittee Activity Reports and Agenda be appended to the end of the MTG draft minutes for this meeting in Houston as **Attachment 1**: • Activity Report from 23-Jan-2018 Chicago meeting • Agenda & Activity Report from 19-Mar-2018 web conference meeting • Agenda from 26-Jun-2018 Houston meeting	MORTS	3
2	Volunteers requested for new WS-1855 to serve on PES and PMS. Contact Brian Fricke if interested	All Members	4
3	Contact TC 3.8 (Refrigerant Containment) Chair for a TC volunteer to serve on PES and PMS for new Co-RP-7 as ASHRAE representative.	MORTS	4
4	Send our program ideas to TC 10.7 for co-sponsorship vote	Eckels	5

Carry-over Action Items from Chicago Meeting
MTG.LowGWP

NEW ACTION ITEMS FROM CHICAGO MEETING

Action Item	Action	Responsible Party	Status
1	Request larger meeting room for Sunday Research Subc. Meeting in Houston for research update.	Vaughn	Complete
2	Send Steve Eckels paragraph on proposed program titled "How can we design for LowGWPs?"	Kujak	Complete
3	Continue to develop Expo session idea into program proposal in coordination with section 3 and others for MTG consideration in Houston.	Halel	Closed
4	Please send Steve Eckels any program ideas on LowGWP that come up in TC meetings in Chicago.	All MTG Members & Guests	Complete

Status of Long Beach Meeting Action Items
MTG.LowGWP

ON-GOING ACTION ITEMS FROM LONG BEACH MEETING

Action Item	Action	Responsible Party	Status reported in Houston
1	Develop answers to the nine questions proposed by David Underwood in order to support ASHRAE Ottawa Day on the Hill – **Attachment 4**	Wolf, Fricke, Schultz, Johnson, Eckels	Complete
5	Request for LowGWP Refrigerant slide donations in order to develop Chapter & GGAC slide deck for Code Officials and others. Send slides to Julius Ballanco on C&S Subc.	All MTG.LowGWP Members	On-going
6	Investigate further and propose a plan for the slide deck that will define the following: 1. How do we want to roll it out? 2. Copyright? 3. Can end users customize? 4. What is our process for adding, modifying, or deleting slides to deck? 5. Should we consider using Distinguished Lecturers (DLs) on this topic? 6. Add Disclaimer to deck when distributed	Johnson	On-going as of 27-June-2018

Update on Recent Letter Ballot Results
MTG.LowGWP

Vote #	Motion	Voting Period	Vote Count or Status
1	Draft final report for RP-1807 be approved for Publication	8/8/18 To 9/19/18	**Quorum not reached By 9/19/18** **Revote after revised**

ADJOURN

MEETING ADJOURNED – 12:00 PM CDT, WEDNESDAY, 6/27/18

ATTACHMENT 1

MTG.LowGWP Codes & Standards Activity Reports

Activity Report from 23-Jan-2018 Chicago meeting
Agenda & Activity Report from 19-Mar-2018 web conference meeting – Still Pending
Agenda from 26-Jun-2018 Houston meeting

Activity Report from 23-Jan-2018 Chicago meeting

O. CODES & STANDARDS SUBC. REPORT – JOHNSON: – Total Attendance - TBD

Membership
Currently 28 members of the subcommittee, plus an additional 22 people on the distribution list for subcommittee correspondence (past guests and interested parties).

Meetings
Codes & Standards Subcommittee held meetings as follows:
- Tue, 27-Jun-2017, Long Beach, CA
- Tue, 23-Jan-2018, Chicago, IL

Despite intentions expressed in Long Beach, there were no interim meetings in the fall of 2017, and almost no activity via Basecamp either.

AI #5 (MORTS): That the following Codes & Standards Subcommittee Activity Reports and Agenda be appended to the end of the MTG draft minutes for this meeting in Chicago as **Attachment 1**.
- Activity Report from 15-May-2017 web conference meeting
- Activity Report from 27-Jun-2017 Long Beach & web conference meeting
- Agenda from 23-Jan-2018 Chicago meeting

Future monthly web conference meetings planned for February, March, April, and May of 2018.

Basecamp https://3.basecamp.com/3106353/projects/2779045
Per the MTG action item AI#4 in Long Beach, all primary and alternate MTG members were added to the project collaboration tool (can login via e-mail). As of today, 79 people have access to the Basecamp web site. AI#4 completed as of 16-Aug-2017.

Stakeholder List
No updates made during fall of 2017. During Chicago identified the need to refresh the status of various codes, standards, and activities. Will work on this during spring of 2018.

Advocacy Plan
No updates to the plan made during fall of 2017, however several elements of the plan were completed. During Chicago identified the need to refresh the planned activities for 2018. Will work on this during spring of 2018.

Presentation Slide Deck for Advocacy & Communication Efforts
No updates to the slide deck itself during fall 2017. However some additional materials were received that will be incorporated into the slide deck. Several of the seminar sessions in Chicago contained relevant content and the subcommittee will contact the authors/presenters to request materials.

Standards Updates (quick highlights only)

ASHRAE 15-2016. Good progress made in Chicago with revisions to Addendum D (direct systems for human comfort) and Addendum H (in machinery rooms). Expecting letter ballots for both within 2 weeks: PPR3-ISC for D and PPR2 for H. SSPC15 submitted two code change proposals to ICC IMC & IFC related to these addenda, as placeholders to be revised should the PPR(s) be successful. Also other smaller scope addenda related to 2L expecting letter ballots for PPR this spring. Addendum A (remove R 717) approved for PPR by letter ballot prior to Chicago meeting, forecast start of review period is 26-Jan-2018. Proposed 15.2 expected to be going out for Advisory Public Review (APR) this spring.

IIAR Standard 2-2014. Published.

ASHRAE 34-2016. Addendum G (make 2L a class, not sub-class of 2) had PPR1 but will go to PPR2-ISC to address some missing text from PPR1. This addendum is a prerequisite for any Standard 15 addenda that use 2L (and vice versa, to avoid conflict between 15 and 34). SSPC34 submitted a code change proposals to ICC IMC to update refrigerant table.

UL 60335-2-40 edition 2. Published 15-Sep-2017. Adds requirements for class 2 and class 3 flammable refrigerants. (Edition 1 prohibited use of flammable refrigerants) Adds requirements transcritical R-744. Expands scope from 600V to 15,000V.

UL 60335-2-40 edition 3. Preliminary comment draft out for public review 1-Dec-2017 thru 30-Jan-2018. Adds requirements for class 2L. Includes national deviations from the content of IEC 2-40 edition 6.

IEC 60335-2-40 edition 6. FDIS vote passed. Forecast publication date 16-Feb-2018. Will replace edition 5.1 published 28-Apr-2016.

UL 60335-2-89 edition 1. Published 29-Sep-2017.

IEC 60335-2-89 edition 2.2. Published 12-May-2015.

IEC 60335-2-89 edition 3. CDV approved Dec-2017. Translation of CDV forecast available Mar 2018. Forecast publication date 29-Mar-2019.

ISO 817:2014 edition 3. Published 1-Jun-2014. Amendment 1 published Nov-2017.

ISO 5149-1:2014 edition 1. Published Apr-2014 (replaced 1993 edition).
Amendment 1 published Oct-2015.
ISO 5149-2:2014 edition 1. Published Apr-2014 (replaced 1993 edition).
ISO 5149-3:2014 edition 1. Published Apr-2014 (replaced 1993 edition).
ISO 5149-4:2014 edition 1. Published Apr-2014 (replaced 1993 edition).

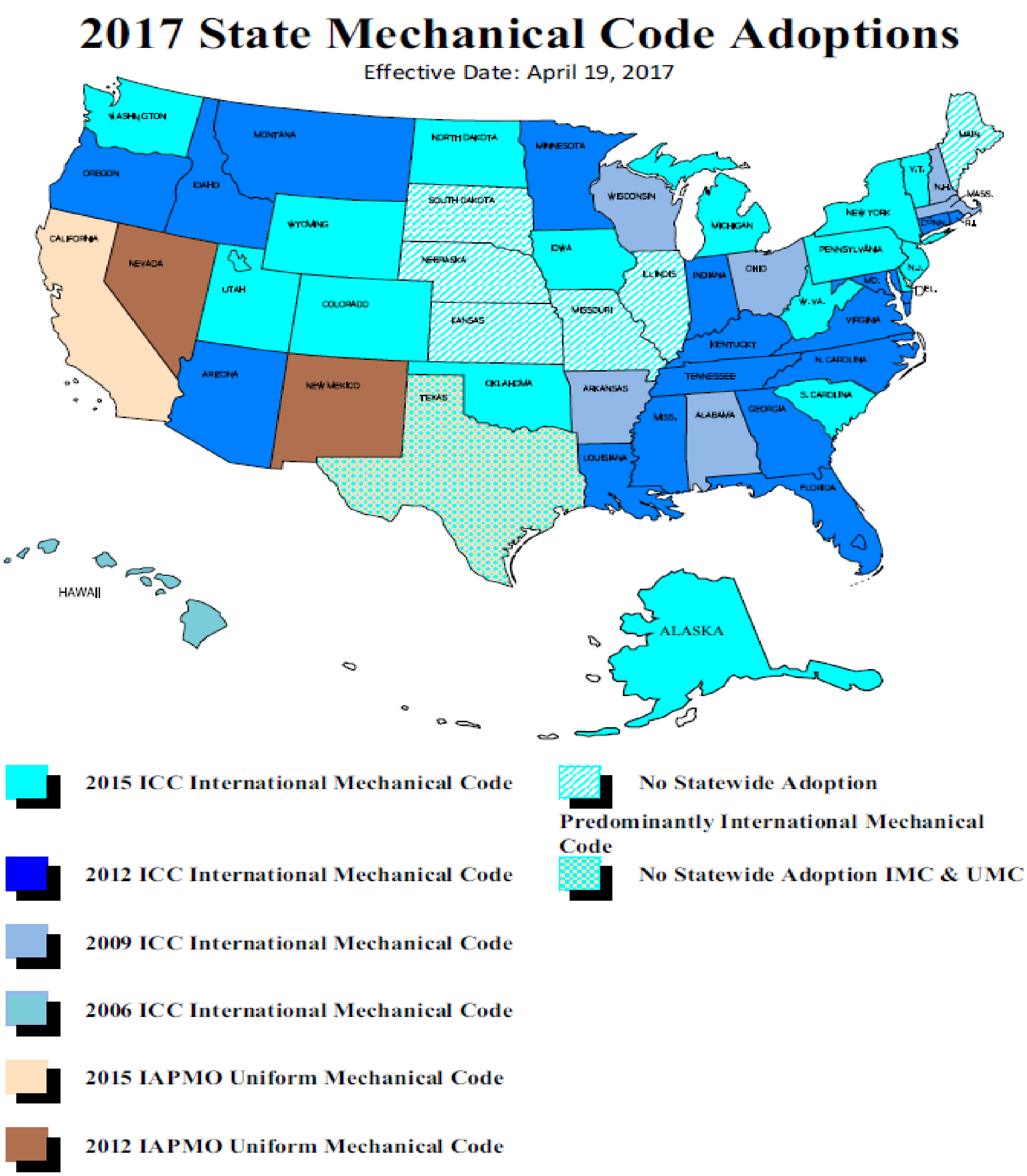
Codes Updates:

<table>
<tr><td>ICC IMC 2018.</td><td rowspan="2">Published. Includes 2L for machinery rooms, but does not include reference to UL 60335-2-40.</td></tr>
<tr><td>ICC IFC 2018.</td></tr>
<tr><td>ICC IRC 2018.</td><td>Published. No provisions for 2L, but does include reference to UL 60335-2-40 edition 1 (no flammable refrigerants).</td></tr>
</table>

<table>
<tr><td>ICC IMC 2021.</td><td rowspan="3">Code change cycle started.
11-Jan-2018: deadline for Group A code change proposal submittals
28-Feb-2018: proposals published
15/25-Apr-2018: Committee Action Hearing (CAH)
30-May-2018: CAH Report published
16-Jul-2018: public comment deadline
24/31-Oct-2018: Public Comment Hearing
Dec-2018: Final Action after voting period & certification
2019: Group B codes go through same cycle (IECC, IRC-E, IgCC, etc.)
2020: code correlation activities
Fall 2020: forecast Publication.</td></tr>
<tr><td>ICC IFC 2021.</td></tr>
<tr><td>ICC IRC 2021.</td></tr>
</table>

IAPMO UMC 2018. Not yet published; forecast early-2018. Some 2L related proposals from task force public comments were accepted, but some rejected, creating inconsistencies. Petition in process attempting to resolve.

IAPMO UMC 2021.	Code change cycle starts soon. 16-Mar-2018: deadline for code change proposal submittals 13-Apr-2018: proposals published 15/18-May-2018: Technical Committee Meetings 20-Aug-2018: Report on Proposals published 3-Jan-2019: public comment deadline 22-Mar-2019: public comment monograph published 29-Apr/2-May-2019: Technical Committee Meetings 21-Aug-2019: report on comments published 2/16-Oct-2019: balloting 13/15-Nov-2019: Standards Council Meeting early 2021: forecast dublication



Agenda & Activity Report from 19-Mar-2018 web conference meeting

Information still pending

Agenda from 26-Jun-2018 Houston meeting

AGENDA
MTG.LowGWP
Codes & Standards Subcommittee

Tue Jun 26, 1:00-3:30pm CDT, 2018
Meeting at Houston, TX
GRBCC

1. **CALL TO ORDER**
   A. Determine Attendance and Introduction of New Guests
   B. ASHRAE Code of Ethics In this and all other ASHRAE meetings, we will act with honesty, fairness, courtesy, competence, integrity and respect for others, and we shall avoid all real or perceived conflicts of interests.
2. **AGENDA REVIEW**
3. **ANNOUNCEMENTS**
   A. [repeat reminder: subcommittee membership and straw polls]
   B. [repeat reminder: Basecamp project collaboration site]
   C. Preliminary Comment Draft for CSA/UL 60335-2-40 edition 3 was out for public review comment period (1-Dec-2017 thru 30-Jan-2018). CANENA WG10 will meet in March, April, July, August, October, November, (December) to review comments.
   D. AHRTI FRS is planning a mini-conference for early October (date to be determined). Purpose to disseminate collaborative research project results, stimulate discussion & debate on how to use results.
   E. ASHRAE MTG.LowGWP is working with various TCs to plan several seminar sessions with themes related to results of research projects.
   F. IEC SC61D WG9 & WG16 will be brief by AHRTI FRS.
   G. Other (?)
4. **REVIEW ACTIVITY REPORT FROM LAST MEETING**
   A. Notes from Chicago January 2018 meeting, forward with any corrections/additions to full MTG for approval and inclusion with MTG minutes
5. **REVIEW PROGRESS ON OPEN ACTION ITEMS**
   A. Stakeholder list (identify purpose & priority for each) Lead: Menzer
   B. Codes & Standards presentation slide deck Lead: Ballanco
   C. Advocacy & outreach plan Lead: Lockwood
   D. Research results Lead: Ballanco
   E. All other items Lead: Chair
6. **NEW BUSINESS**
   A. Open
7. **NEXT MEETINGS**
   A. Webinars for July, August, September, October, November (dates TBD)
   B. Atlanta, January 15, 2018
8. **Adjourn**

ATTACHMENT 2

WS -1855

DETERMINATION OF THE IMPACT OF COMBUSTION BYPRODUCTS ON THE SAFE USE OF FLAMMABLE FLUORINATED REFRIGERANTS

WORK STATEMENT COVER SHEET

Date: **June 18, 2018**

(Please Check to Insure the Following Information is in the Work Statement)

A. Title	X
B Executive Summary	X
C. Applicability to ASHRAE Research Strategic Plan	X
D. Application of the Results	X
E. State-of-the-Art (background)	X
F. Advancement to State-of-the-Art	X
G. Justification and Value to ASHRAE	X
H. Objective	X
I. Scope	X
J. Deliverables/Where Results will be Published	X
K. Level of Effort	
Project Duration in Months	X
Professional-Months: Principal Investigator	
Professional-Months: Total	
Estimated $ Value	X
L Proposal Evaluation Criteria & Weighting Factors	
M. References	
N. Other Information to Bidders (Optional)	

Title:
DETERMINATION OF THE IMPACT OF COMBUSTION BYPRODUCTS ON THE SAFE USE OF FLAMMABLE FLUORINATED REFRIGERANTS

WS# 1855
(To be assigned by MORTS - Same as RTAR #)

Results of this Project will affect the following Handbook Chapters, Special Publications, etc.:

Responsible TC/TG: **MTG on Low GWP**

Date of Vote: **TBD**

For		TBD
Against	*	TBD
Abstaining	*	TBD
Absent or not returning Ballot	*	TBD
Total Voting Members		TBD

This W/S has been coordinated with TC/TG/SSPC (give vote and date):

Has RTAR been submitted? **NO**
Strategic Plan **2010-2018**
Theme/Goals **#8, #9**

Work Statement Authors: **

Steve Kujak, Bob Low, Greg Linteris, Bob Richards

Proposal Evaluation Subcommittee:
Chair: **Steve Kujak**
Members: **final list to be determined by the MTG**

Project Monitoring Subcommittee:
(If different from Proposal Evaluation Subcommittee)
TBD

Recommended Bidders (name, address, e-mail, tel. number): **
TBD

Potential Co-funders (organization, contact person information):

AHRTI, Xudong Wang

(Three qualified bidders must be recommended, not including WS authors.)

	Yes	No	How Long (weeks)
Is an extended bidding period needed?		X	
Has an electronic copy been furnished to the MORTS?	X		
Will this project result in a special publication?		X	
Has the Research Liaison reviewed work statement?	X		

* Reasons for negative vote(s) and abstentions
TBD

WS -1855

Title:

DETERMINATION OF THE IMPACT OF COMBUSTION BYPRODUCTS ON THE SAFE USE OF FLAMMA
FLUORINATED REFRIGERANTS

Sponsoring TC/TG/MTG/SSPC:

MTG on Low GWP Refrigerants

Co-Sponsoring TC/TG/MTG/SSPCs (List only TC/TG/MTG/SSPCs that have voted formal support)

Executive Summary:

For flammable fluorinated refrigerants, risk assessments and experiments indicate that combustion events with toxic byproducts are possible. Fluorinated refrigerants can lead to the potential formation of hazardous environments, e.g hydrofluoric acid (HF) or carbonyl fluoride (COF_2). This work is targeted to understand the consequences associat with combustion events during operation and servicing. Included would be recovery procedures from these potentia events.

Applicability to the ASHRAE Research Strategic Plan:

The proposed research is to meet the strategic goal 8 "Facilitate the use of natural and low global warming potential (GWP) synthetic refrigerants". ASHRAE has a strong interest in promoting the use of safe, environmentally friendly, naturally occurring refrigerants and synthetic low GWP refrigerants.

The project is to address one of the objectives in goal 8 which is to study safety and health issues related to these equipment/systems using low GWP refrigerants.

Application of Results:

The results of this research will provide manufactures, end users, service personnel and first responders with essential knowledge about the consequences associated with low GWP refrigerants combustion events during operation and servicing. Included would be recovery procedures from these potential events.

State-of-the-Art (Background):

Nonflammable halogenated (which include primary fluorine and chlorine, but could contain bromine and iodine) refrigerants have been determined to be safe in the presence of thermal decomposition sources based on the successful use of these materials over the last 70 years. Nonflammable halogenated refrigerants have been studied and will form small amounts of various halogenated by products, HF and COF2 to name a few. One of the hazards of using flammable halogenated refrigerants is the potential for the formation of large quantities of various halogenated decomposition products through either thermal decomposition or combustion, that possess very low acute toxicity limits.

It is necessary to clarify the decomposition products from these new flammable halogenated refrigerants to analyze the risks of using lower-GWP refrigerants. Complicating this understanding is that there is limited industry experience in handling and with using flammable halogenated refrigerants. For example today's nonflammable refrigerants do not allow small combustion events to occur when a flame or strong electrical source is present with a small amount of refrigerant flammable concentration with air. Only thermal decomposition products are formed, which have been studied at times, and it has been shown that exposure to very small amounts of HF, HCl or COF2 or COCl2 are not a concern. However, with the use of flammable refrigerant, the possibility of combustion events leads to the potential for much higher concentrations of decomposition products. The high reactivities of products such as COF2 and hydrogen fluoride (HF) make this quantification difficult when conducting experiments. These materials can react with local materials to be neutralized or they can react with water vapor in the air to form solutions of HF which can coat materials and form potential latent exposure risks. In addition, the toxicity of HF can be problematic at best since it can act as a strong mineral acid and attack tissue; however, of more concern is that HF exposure can lead to latent toxicity effects that take hours to develop and are not recoverable.

Advancement to the State-of-the-Art:

This work will advance the state of the art by providing essential knowledge related to the consequences associated with low GWP refrigerant combustion events during operation and servicing and recovery procedures from these potential events.

Justification and Value to ASHRAE:

ASHRAE has a strong interest in promoting the use of safe, environmentally friendly, naturally occurring refrigerants and synthetic low GWP refrigerants.
This research will be a valuable addition to the society as it will collect/generate basic data to support industry risk assessments to determine what potential issues that flammable or toxic refrigerants may have once they are ignited so that necessary steps can be taken to improve safety. The results can be used to further update the ASHRAE RP-1806.

Objectives:

This project is broken into two phases and this WS will only address Phase I. Phase II is informational only.

Phase 1 Objective:

The objective is to conduct literature review to understand the HF exposure risk if ignitions occur and how to clean up afterwards in variety of ignition events and to identify knowledge gaps. The literature survey will be conducted to look at two areas of concerns with toxicity risks associated with HF and COF2.

Phase 1a: Literature survey and summary of existing fluorinated refrigerant risk assessment of HF/COF2 formation. HF/COF2. Provide exposure studies/knowledge and mitigation procedures after exposure.

Phase 1b: Literature summary of byproduct formation from fluorinated refrigerant exposed to flames or hot surfaces during servicing or other related operations, e.g. processing released refrigerant through electrically heating devices or open flames in the room. This review is not limited to flammable halogen containing refrigerant but should include studies with nonflammable refrigerants as well.

Phase 2: This would be reserved for experimental validation of identified knowledge gaps from Phase 1 related to potential HF or COF2 formation from HVACR equipment manufacturing, transportation, installation, operation or servicing operations.

Scope/Technical Approach:

Task 1. Literature survey and summary of existing fluorinated refrigerant risk assessment of HF/COF2 formation. HF/COF2. Provide exposure studies/knowledge and mitigation procedures after exposure.
The existing test methods, test data and potential deficiencies and gaps should be summarized for the Project Monitoring Subcommittee (PMS) to review and approval.

Task 2. Literature summary of byproduct formation from fluorinated refrigerant exposed to flames or hot surfaces during servicing or other related operations, e.g. processing released refrigerant through electrically heating devices or open flames in the room. This review is not limited to flammable halogen containing refrigerant but should include studies with nonflammable refrigerants as well. This study should include all work conducted on CFCs, HCFCs, HFCs, and flame suppression refrigerants which could lead to a good understanding of potential breakdown products and the amounts formed.

Task 3. Identify knowledge gaps and future work if any.

At a minimum, the above tasks should answer the following specific questions or identify works to be done to answer these questions:

– How much HF forms during an event, and does the amount formed affect the actions afterwards?
– What happens to the HF formed after combustion of an A2L?
– For how long does it persist?
– Does it deposit on surfaces, and how long does it persist there?
– What special precautions need to be taken by first responders or others entering the room after an event?
– What minimum event is considered dangerous?
– Does a torch near an A2L create a situation much different from an A1?
– How does the magnitude of the ignition event (size) affect the danger? Is there a threshold for concern?

Deliverables/Where Results Will Be Published:

- Review initial investigation into Phase 1a, present a summary to the PMS and discuss various breakdown products and toxicity risk associated with potential exposures.
- After initial investigations into Phase 1b, present a summary to the PMS and discuss potential knowledge gaps
- After Phase 1b work completion, present to the PMS a proposed list of knowledge gaps and propose a Phase 2 plan to close these knowledge gaps.
- A final report.
- Any data obtained from the research.
- A project summary.

Level of Effort:

Phase 1 is expected to cost $40,000 over a 4 month project duration.

The cost and duration of Phase 2 of the program is unknown, but is estimated based on the technical needs to conduct potential laboratory testing to be $200,000 over a duration of 12 to 18 months.

Proposal Evaluation Criteria:

No.	Proposal Review Criterion	Weighting Factor
1	TBD	TBD
2	TBD	TBD
3	TBD	TBD
4	TBD	TBD
5	TBD	TBD
6	TBD	TBD

Authors:

Steve Kujak, Bob Low, Greg Linteris, Bob Richards

References:

ASHRAE Refrigeration

ATTACHMENT 3

Co-RP 7

Assess Refrigerant Detector Characteristics for Use in HVACR Equipment (Phase 1)

DO NOT CITE

AHRTI
WORK STATEMENT

AHRTI WS#

Title *Assess Refrigerant Detector Characteristics for Use in HVACR Equipment*

Co-sponsorship Request
AHRTI plans to launch the Phase 1 (Phase 1A and 1B) of the project in July 2018. The total cost of Phase I is estimated at $115,000. AHRTI invites ASHRAE's collaboration in Phase I and request a consideration of co-sponsorship at 20% of the cost (up to $23,000). ASHRAE co-funding requested- $23,000.

About AHRTI
The Air-Conditioning, Heating, and Refrigeration Technology Institute (AHRTI) is a not-for-profit organization established to undertake scientific research in the public interest. AHRTI's mission is to foster applied research on technologies to improve products, systems, and controls that benefit the general public in the areas of Heating, Ventilation, Air-Conditioning, Refrigeration (HVACR), and Water Heating.

AHRTI is an entity associated with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI). AHRI is the national trade association representing manufacturers of HVACR and Water Heating equipment within the global industry.

Background
Most refrigerants we use today in air conditioning and refrigeration applications have low toxicity and are non-flammable (CFC's, HCFC's & HFC's classified in safety group A1). These gases have relatively high global warming potential (GWP). Over the past several years lower GWP alternative synthetic gases have been developed to replace the current family of refrigerants used. Several of these proposed refrigerants fall into ASHRAE safety group A2L (mildly flammable). These are currently a sub-class of A2 refrigerants and have a burning velocity of ≤10 cm/sec when tested at 23°C and 101.3 kPa. As a result, codes and standards will require the use of sensors to detect a refrigerant leak for both residential and commercial applications to mitigate the potential for a combustion event. The requirement for sensors will be dictated by charge size which takes in account room size and the lower flammability limit (LFL) for that refrigerant.

Refrigerant detectors are required in restricted-access machine rooms that contain chillers with several hundred (or thousand) pounds of refrigerant charge. These detectors use a set point value not exceeding the Occupational Exposure Limit (OEL) to trigger an alarm and mechanical ventilation, to reduce the risk of exceeding flammability, toxicity, and oxygen deprivation limits in the case of a large leak. These detection systems are large and relatively high cost as they are typically designed to take readings in multiple locations throughout the machinery room. When codes and standards allow the use of flammable refrigerants in residential and other commercial applications sensors will need to be relatively small and easily fit within the constraints of the system. These sensors need to be robust to handle temperature and humidity changes, household and industrial contaminants, and provide acceptable responses and accurate readings.

DO NOT CITE

Justification and Value

Refrigerant detectors will need to align with the code and standard requirements such as:

UL 60335-2-40
UL 60335-2-89
ASHRAE 15
ASHRAE 15.2P (proposed)
IEC 60079-29-1, -29-2
IEC 60079-?-? (possible new standard to be developed by IEC TC72/WG12)
IEC 60730-? (possible new standard)

However, new editions for several of the standards listed above are still under development and this research will help to clarify the necessary refrigerant detector requirements and how to specify them.

Objective

The objective of the project is to assess refrigerant sensor and refrigerant detector performance requirements for class 2L, 2, 3 flammable refrigerants for use with indoor HVACR equipment, whether in an occupied space or a machinery room.

Scope

Phase 1A (Sensor response compared to proposed requirements):

The contractor will review existing and proposed requirements for refrigerant detectors as found in the following safety standards and public review documents. Some of the requirements are summarized in AHRTI Report 9009 [2], however there are more recent proposals that will be included in this project.

IEC 60335-2-40 edition 6 (Jan-2018) [8]
IEC 60335-2-89 (if there are any requirements or proposals for new requirements)
IEC 60335-2-24 (if there are any requirements or proposals for new requirements)
UL 60335-2-40, Preliminary Comment Draft PR001h (proposed for edition 3) [12]
UL 60335-2-89 (if there are any requirements or proposals for new requirements)
UL 60335-2-24 (if there are any requirements or proposals for new requirements)
ASHRAE Standard 15-2016 [3], with proposed Addenda D & H [4] [5]
ASHRAE proposed Standard 15.2P (Advisory Public Review) [6]

The contractor will assess the capability of current commercially available refrigerant detectors to meet the response time requirements, when installed in one or more locations as required by the safety standards, with set point(s) determined in a manner to meet the safety standard requirements, considering related issues such as upper detection limits, accuracy and calibration, drift over time, sensitivity to environmental conditions (temperature, pressure, humidity, vibration). This initial assessment will be limited to a paper study based on published specifications for refrigerant detectors (either by the manufacturer or as found in the literature).

The initial assessment is expected to consider the distinction between response time ratings of gas detectors, such as t(50) and t(90) response time as defined by IEC 60079-29-1 [7] which are relative to a step change in gas concentration, and the actual response time as applied with a particular choice of set point and time-varying gas concentration. The contractor shall consider typical profiles of refrigerant concentration versus time, as available in the literature for both empirical testing and simulation modeling [1] [9] [10].
Multiple measuring principles shall be considered when searching for currently available refrigerant detectors.

DO NOT CITE

The following scenarios shall be considered:

1) Refrigerating system is located inside the building either within or near occupied spaces (in various safety standards referred to as either: direct system, direct releasable system, or high probability system).
    a. Split type system(s) with refrigerant detector installed within the indoor unit. To the extent that it may change assumptions about time-varying refrigerant concentration during a leak or release event, consider both ducted and ductless types of refrigerating systems. The contractor shall choose as many system types as needed to evaluate the various requirements (single split, multi-split, refrigerated walk-in cooler, etc.), but to the extent possible will combine or group similar types into a single case within the study.
    b. Self-contained type system(s). To the extent that it may change assumptions about time-varying refrigerant concentration during a leak or release event, consider both sealed enclosure or compartment (i.e. reach-in cooler), and vented enclosure. The contractor shall choose as many system types as needed to evaluate the various requirements (water-source heat pump, reach-in refrigerated cooler, etc.), but to the extent possible will combine or group similar types into a single case within the study.
2) Refrigerating system is located inside the building in a machinery room with restricted access. One distinguishing characteristic from the scenarios above is that these systems do not have refrigerant charge quantity restrictions. To the extent that it may change assumptions about time-varying refrigerant concentration during a leak or release event, consider both self-contained packaged equipment (i.e. chiller) and field-erected equipment (process refrigeration system). The contractor shall choose as many system types as needed to evaluate the various requirements, but to the extent possible will combine or group similar types into a single case within the study.

The initial assessment in Phase 1 will identify promising candidates where current refrigerant detectors are expected to either meet the safety standard requirements, or have reasonable potential to meet the requirements based on calculations or modeling performed as part of the paper study. While specific representative refrigerant detector models will be selected by the contractor, the final report will use generic descriptions of the measuring principles, configurations and types of detectors.

Phase 1B (Response time testing verification):

The promising candidate refrigerant detectors will be tested to evaluate the capability to meet the response time requirements. Detectors will be configured and setup in a test fixture, then exposed to time-varying concentrations of refrigerant-air mixtures, and response time characteristics measured. The scenario will range from a sudden concentration change (step response to various concentration levels, from 10% of LFL up to and including 100% refrigerant), to more gradual changes versus time expected for the various scenarios identified in Phase 1A. The contractor will then make an assessment of the extent to which current refrigerant detector technologies are expected meet the requirements of the safety standards, and identify gaps and issues that will need to be addressed through future work or research.

<u>The following two Phases are for reference only. They are planned as future work after Phase 1 is complete. There still may be future revisions to these sections.</u>

DO NOT CITE

Phase 2 (Reliability evaluation methods):

There are refrigerant leak detection systems available for machine room applications. The need to identify flammable refrigerant leaks into domestic and commercial occupied spaces is different from machine room applications. One significant difference is that the sensor or detector will not necessarily be routinely checked for proper operation. Residential and light commercial HVAC&R equipment can have a life of 20 years or more. Since the flammable refrigerant sensor is part of a safety-critical control system it is important to assess the robustness and potential longevity of these devices, and to determine whether safety standards will need to define mandatory replacement intervals or equipment service, and related issues such as end of life annunciation. There is a need to conduct accelerated life testing of these sensors to determine their resilience to environmental stressors.

The Japanese Standard, JRA 4068, is a new standard for A2L refrigerant leak detector-alarms. A conference paper (JRAIA2016KOBE-0403) from the 2016 Kobe JRAIA International Symposium describes the characteristics of this standard, including some stress-type testing required for detector certification. The categories of these tests are:

- Resistance to miscellaneous gasses (ethyl alcohol vapor and hydrogen gas)
- Stability of sensor (short interval of time) in the presence of the gas to be detected.
- Long-term intermittent exposure (1000 times) to methane gas.
- Ten-day intermittent exposure (30 minutes, twice daily) to hydrogen gas
- Condensation resistance test (for sensors used in refrigeration appliances)

Only two sensor technologies are addressed: semiconductor type and infrared ray type. Three different sets of performance criteria are established. Performance Criteria 1 is for infrared ray types and Performance Criteria 2 and 3 are for semiconductor types. The test requirements are different among the classes as appropriate to the intended application. PC1 & PC2 classes must be inspected annually but can be used indefinitely. PC3 class does not have to be inspected but must be replaced every 5 years. The conference paper implies that the system of stress-tests used assures adequate longevity and robustness over the service interval or defined life of these devices. The research project should investigate the basis for this assumption.

The IEC has an existing standard for gas sensors for use in explosive atmospheres [7]. It seems to be very thorough but may include provisions that are not necessary for the application of A2L sensors to occupied spaces. The standard, IEC 60079-29-1, addresses performance requirements and test protocols for flammable gas detectors. IEC 60079-29-2 provides information to aid in selection of appropriate detection technologies for different explosive atmosphere applications. Eight different sensing technologies are reviewed. The Part 29-1 standard has a list of stress tests defined for sensors:

- Vibration test, one hour in each of three directions.
- Storage for 24 hours at temperature extremes of −25°C and +60°C.
- Long-term stability testing lasting 28 days (Group I) or 63 days (Group II) with 8 hours of exposure to the test gas once each week.
- Exposure to high humidity
- Testing in multiple orientations
- High gas concentration operation above the measuring range
- Exposure to a variety of gas mixtures including: methane, air, oxygen, nitrogen, carbon dioxide, ethane, etc.
- Exposure to poisons (catalytic and semiconductor sensors only) including a mixture of methane, air and hexamethyldisiloxane.

DO NOT CITE

Comparing the lists of stress tests from JRA 4068 and IEC 60079-29-1, one sees some similarities but enough differences to raise questions. An important deliverable for this research program is a documented list of accelerated-life tests for qualification of flammable refrigerant gas sensors that can assure robustness and reliability in unattended applications for as many as ten years.

Phase 3 (Sensor robustness):
The gas sensors/detection systems identified as being suitable for detection of flammable refrigerants in Phase 1 of this project will be subjected to harshness testing as identified in Phase 2. The results of the harshness testing will provide information regarding the suitability of commercially available sensors to meet the safety standard requirements for sensing leaks of flammable refrigerants from indoor HVAC&R equipment located in occupied spaces or machinery rooms.

Test Method:
The contractor shall document methods of test for gas sensors [Phase 2 of this project, and references 11 and 13] and evaluate the effectiveness of flammable refrigerant gas sensors, in consultation with the PMS. The test methods should consider the following factors:

- Selection of test gases
- Nature of the test release: flow rate and velocity of test gas (gradual vs. “instantaneous”), concentrations of test gas
- Test environment: size of test chamber; range of ambient temperature, pressure, humidity, and air velocity (all of which are local to the refrigerant detector as installed for use, which will be inside some types of HVAC equipment or remote installed for other equipment types)
- Sample size: Number of sensors to be evaluated
- Stabilization time (time required for sensors to acclimate/stabilize to the ambient test conditions)- includes from cold start
- Sensor orientation
- Verify initial sensor calibration per manufacturers’ specifications
- Number of exposures, and duration of exposure, of sensor to test gas
- Time of response testing: t(50) and t(90) for increasing and decreasing concentrations
- Vibration testing: frequency, excursion, peak acceleration, total duration
- High gas concentration testing (above the upper limit of the measuring range)
- Effect of dust, poisons and other gases on sensor effectiveness: selection of dust/poisons/other gases; method of test
- Long-term stability test: operate sensor in clean air for extended period, then expose sensor to test gases
- Electromagnetic immunity of sensor/detection system
- Other tests: static discharge test, impact/jarring tests, variations in supply voltage, corrosion testing (corrosive gases or salt spray)

Need to review with the contractor what tests are applicable for the selected sensors.

Sensor Evaluation:

Upon agreement by the PMS to the proposed methods of test for flammable refrigerant sensor harshness testing, the contractor shall obtain the required number of sensors/detection systems based on the down-selected list from Phase 1 and perform harshness testing according the method of test.

DO NOT CITE

Deliverables

The output from this project shall be a compilation of the information generated throughout the project. The contractor shall provide the following:

- Monthly invoices and letter reports on progress and task results;
- Progress reviews in the contractor's facilities and/or by teleconference, by AHRI project monitoring committee members, to assess the work-in-progress;
- Draft technical report, executive summary, tabulated data, and recorded video files documenting the procedures, conditions, and findings, for review by and a presentation to an AHRI project monitoring subcommittee; and
- Final technical report, executive summary and tabulated data resolving review comments provided by AHRI. Included as part of this deliverable is the source code for any model tools developed, which are expected to be AHRI properties.

Unless otherwise specified by AHRI, printed material will be delivered on standard 8-1/2 by 11 inch paper. Electronic documents shall be delivered as a consolidated document file that integrates all text, figures, tables, and photographs into a single file in both Microsoft Word and PDF file format.

Unless otherwise specified by AHRI, the contractor shall deliver the following as scheduled:

Invoices & Letter Reports on Progress	Monthly, within 30 days of reported period
Review Presentation Materials	Within 1 week after review
Technical Papers/Presentations Upon Approval by AHRI	30-days prior to submission due date
Draft Final Technical Report; Executive Summary and Tabulated Data	60 days prior to contract completion date
Final Technical Report; Executive Summary; and Tabulated Data	30 days after receipt of AHRI comments

Level of Effort

The work conducted under this project will proceed in phases with checkpoints inserted for project review at the end of each phase or segment. This is the expected timing and approximate cost for the project's phases:

	Phase 1A	2 months	$40,000
	Phase 1B	5 months	$75,000
	Phase 2	3 months	$50,000
	Phase 3	8 months	$135,000
Totals:		18 months	$300,000

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It is anticipated that the contract for this work will be awarded at the best value based on selection from competitive proposals. However, price will not be the only factor weighed in the selection process. Prior experience and expertise in the field of study, access to laboratory and/or field sites required for completion of this project, and competitive prices will all be consider in selecting a contractor for this project.

Because the exact number of test will depend on interim test results, the cost proposal should include the breakdown of fixed cost such as test setup, and variable cost i.e. the cost per test information. The contractor can assume that the refrigerants and lubricants will be provided by AHRI members.

Limitation

Solicitation of this project does not commit AHRI to award a contract, pay any cost incurred in preparing a proposal, or to procure or contract for services or supplies. AHRI reserves the right to accept any or all proposals received, or to cancel in part or its entirety a solicitation for this work prior to the signing of a contract agreement, when it is in AHRI's best interest. AHRI reserves the right to negotiate with all qualified sources.

References

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12. UL 60335-2-40, Preliminary Comment Draft (PR001h), proposed revisions for edition 3.
13. UL 2075 edition 2. Standard for Safety for Gas and Vapor Detectors and Sensors, Underwriters Laboratories, Inc., Northbrook, IL, 2013.

Other Information to Bidders (Optional)

This is work-for-hire for AHRI. Results of this work will be held confidential and releasable only to AHRI, unless otherwise released by AHRI.

Proposal Evaluation Criteria & Weighting Factors

Understanding the problem (25%)
Approach to solving the problem (25%)
Probability of (timely) success (20%)
Qualifications and experience of key personnel on gas sensing technologies (25%)
Quality of facilities to perform the work (5%)

<u>ATTACHMENT 4</u>

AI #1 Long Beach Meeting

Responses to nine questions proposed by David Underwood in order to support *ASHRAE Ottawa Day on the Hill*

ORIGINAL QUESTIONS FROM DAVID UNDERWOOD

Subject: ASHRAE Ottawa Day on the Hill

Mike/Steve,

These are question that were raised during our recent Day on the Hill meetings in Ottawa.

Please help us with answers.

1) We need to contact Steve Comstock to get more info on Refrigerant handling and maintenance training.
2) What is AHRI and HRAI doing for training
3) We need to train all refrigeration mechanics in Canada how do we do that?
4) How Many Refrigerants are included in ASHRAE Research. [We were asked how many different combinations of new refrigerants were in our studies or was this a single product being studied. This question refers to all A2l, A2 and A3 refrigerants that are currently manufactured. The Research refers to the work currently being undertaken by ASHRAE, AHRTI and DOE]
5) They had questions about the destruction and recycle process for HCFC refrigerants
6) They are looking for more direction from ASHRAE and industry on which refrigerants we want to use.
7) Pan Canadian agreement needs more support from ASHRAE. Who can we link in better?
8) Confirm who from ASHRAE will be attending the UNEP meeting in Bangkok in Oct and the CACC meeting in Montreal in November.
9) We will contact the Environment and Climate Change Canada in September 2017 with updates

Regards,

David

David Underwood, P. Eng., FASHRAE
Presidential Member 2015-2016

RESPONSES TO QUESTIONS FROM JIM WOLF & OTHERS

Dear David,

We have not answered your questions in a timely manner. I have a list of 9 questions to be answered. I can answer some of them but you will need to contact others for the rest of the questions.

1. You need to contact Steve Comstock to get information on Refrigerant handling and maintenance training by ASHRAE.

Steve Comstock's Response:
ASHRAE and UNEP have partnered on these training programs:

a. Refrigerants Literacy is a 4.5 hour web-based course that covers the basics of refrigerants properties and their use in AC/R applications. This course is aimed at policy makers those who need a basic understanding of refrigerants. UNEP makes this course available to its Ozone Action Officers and ASHRAE sells the course in our eLearning store. A final exam is included to earn a certificate of completion.
b. Sound Management of Refrigerants is a 6 hour web-based course that details how technicians and other specialists should properly handle refrigerants. Video clips are embedded to show content in a visual manner and are supported by interactive exercises to replicate hands on training. A final exam is included to earn a certificate of completion. This course is due for release in November 2018.
c. Refrigerant Management. This is a full semester university-level or technical school course. It is a complete instructional package with PowerPoints, reading assignments, lecture notes, quizzes and exam. ASHRAE makes this course available to student branches at no cost.

2. You need to contact AHRI and HRAI to find out what they are doing on training.

Xudong Wang's Response:
North American Technician Excellence (NATE) is developing a study guide for flammable refrigerants certification exam. The initial scoping of the project is complete and the writing of the guide itself began today. It is scheduled to be completed on Oct 1st. The study guide isn't a comprehensive training tool, but is meant to be used to help a technician prepare for the flammable refrigerant certification exam. It will cover the same domains as the flammable refrigerant exam: Installation, Service, Safety, Types of Refrigerants, and Tools.

NATE is continuing to develop a flammable refrigerant certification exam. We are currently validating the completed job task analysis (JTA) through a survey. NATE has also engaged numerous subject matter experts to write items for the exam starting last week. All exam development progress should be completed by mid-September with the exam forms ready to go as of November 1st.

The first users of the new exam and study guide will be technicians in the Article 5 pilot countries identified by UNEP for the Refrigerant Driving License (RDL) program. We plan to have them starting their training and testing sessions immediately after the exam becomes available. We hope to have training and testing completed for one or more groups of technicians in at least one of the pilot countries (likely Trinidad and Tobago) by the end of the year. The other potential pilot countries include: Suriname, Grenada, Maldives, Rwanda, and Sri Lanka.

Steve Comstock's Response:
ASHRAE is contributing to the Refrigerant Driver's License (RDL), an initiative by UN Environment OzonAction and AHRI that aims to create a globally-recognized qualification program for the sound and safe management of refrigerants for the supply chain network. The initiative will set minimum qualification requirements and seek international recognition

of such a program from industry and the governments. It will address the requirements for sound management of different types of current and future refrigerants, including best practices for identifying, handling, charging, recovery and recycling, leak testing, storing, record-keeping, etc. The RDL will be piloted in several developing countries this fall. It is expected to be released in late 2019.

3. Suggest you contact Steve Comstock to get information on how to train all refrigeration mechanics in Canada. Also, HRAI should have some information.

Steve Comstock's Response:

The courses above (the two web based courses and the university course) provide a good foundation that can be used in Canada. For the eLearning courses, courses a paid license for their use can be purchased by universities and companies or the government can fund access. ASHRAE can set up a portal for direct access by technicians. The university course can be used by technical schools or universities by notifying ASHRAE (probably best for that to be me). There are conditions for use that include provide feeding feedback. Like all UNEP efforts they are aimed at developing countries.

4. Related to the question on how many refrigerants are included in the ASHRAE research and the research work currently being undertaken by ASHRAE, AHRTI, and DOE. You may want to also contact AHRI. What I know is that research is being done on A2L, A2, and A3 refrigerants. Some of the refrigerants include R-32 and DR 55 (R-452B), which are both A2L.

Response from Xudong Wang:

Several refrigerants were evaluated in various AHRTI projects (not necessarily for the same type evaluation though): A2Ls (R32, R452B, R455A, R457A, R1234ze) and A3 (R290).

5. I do not have any information on destruction and the recycle process for HCFC refrigerants. Again, you should contact AHRI and HRAI for more information.

Response from Xudong Wang:

We have not looked into the refrigerant destruction, but here is a reference from EPA about the ODS destruction
https://www.epa.gov/ods-phaseout/ods-destruction-united-states-and-abroad-february-2018
That report will have useful info.

6. Regarding the direction from ASHRAE and industry on which refrigerants we want to use. ASHRAE will not make recommendations. In the industry, R-410A will be used for many more years in the U.S. and can be used in Canada in new equipment (chillers) until January 1, 2025 and in residential equipment with no limit in time - except when Canada adopts the Kigali amendment to the Montreal Protocol. Canada would need to reduce consumption (production + imports - exports) 10% in 2019, 40% in 2024, 70% in 2029, 80% in 2034, and 85% in 2036. The new alternatives are R-32, R 452B, and possible R-466A (likely a A1, non flammable) announced by Honeywell this week. I would expect that Canada would stop allowing R-410A in new residential equipment about 2027 - 2028.

7. Have no idea who we can link with on Pan Canadian agreement.

8. UNEP meeting in Bangkok has been held.

9. Your information item.

Sorry I do not have more helpful information.

Jim Wolf

<u>ATTACHMENT 5</u>

RP-1806 PMS Meeting Notes

Feb. 8, 2018

ASHRAE 1806-RP

PMS Meeting – Task 1 Review
Thu 08-Feb-2018, 10:00-11:15pm EST
Via web meeting (Skype)
Compilation of original draft notes (KS) with edits and additions offered by PMS members; distributed 21-Jun-2018 [yes, that long after the meeting].

Attendees

PMS present	PMS present	PMS absent	ASHRAE present
Ken Schultz (chair)	Greg Linteris	Kenji Takizawa	Mike Vaughn
Barbara Minor	Omar Abdelaziz	Steve Kujak (RAC)	
Xudong Wang	Phil Johnson		

Purpose

The purpose of this meeting was to discuss the outcome of Task 1 – Model Development and Validation – as documented by the PI (Scott Davis, Gexcon) in the draft report received 14 Jan 2018 and as presented at the Low GWP Refrigerants MTG Research meeting held Sun 21 Jan 2018 during the ASHRAE Winter Conference in Chicago.

Discussions

In brief, the Task 1 report:

- Summarizes the goals and objectives of the project and outlines combustion hazards and factors affecting severity.
- Describes the modifications made to FLACS to model ignition events involving fluorine-containing chemistries, i.e., HFC/HFO refrigerants.
    - The Standard Explosion Model (for premixed situations) was modified to accommodate the chemistries of "fuels" containing fluorine (and is referred to as FLACS-FEM). Simplified equilibrium models were derived from a few equilibrium reactions and compared to results from a detailed thermochemical simulation tool (Chemkin). This model will be used to predict toxic gas production.
    - The FLACS Fire Model (for both premixed and non-premixed situations, e.g., diffusion flames) was adapted for 2L flames by implementing a surrogate hydrocarbon fuel (by matching their heat release). This model was tested by comparing the predicted flame size with the visual image from an R32 test of AHRTI 9007 (but was not otherwise used).
- Summarizes the burning velocity test data collected by Gexcon for a number of refrigerant blends and comparison against data provided by the respective refrigerant suppliers. Burning velocity data was collected under both dry and humid (27°C dew point, 0.0228 kgW/kgDA) conditions.
- Describes the Model Evaluation Protocol employed.
    - This involved assessing the available data sets for relevance, applicability, and quality.
    - Quantitative evaluations were made by computing and plotting the geometric mean bias and the geometric mean variance of parameters such as concentrations at various points in time, peak concentrations, pressure rise, thermal intensity, etc.
- Summarizes comparisons of model predictions against a number of measured data sets.

- o Pre-ignition dispersion of leaked refrigerant into a space. In general, the predictions of dispersion events were judged to be in reasonably good agreement with much of the available data.
- o The availability of post-ignition data sets with high quality measurements is limited. Only qualitative comparisons were possible. Agreement was deemed to be satisfactory, considering the difficulty in specifying the initial conditions of the simulation.

Several comments and questions were raised and distributed by the PMS members prior to the meeting. These are summarized below in Appendix A and will be discussed with the PI. The content of these comments and questions do not prevent us from coming to a recommendation for the next step in this project.

Further discussion during the meeting centered mainly on the model validation as documented in the report and whether or not the model as presented is suitable to proceed with Task 2.

The PMS noted the great effort made by the contractor to collect (most successfully, some not) the data sets available from previous work, to review those data sets, conduct a thorough comparison of model predictions against the data sets, and to provide a thorough interpretation of the results.

The general consensus within the PMS is that the FLACS CFD model has been shown to represent the dispersion of leaked refrigerant into a space with sufficient accuracy. This is particularly true for leaks in the vapor phase, whether of high momentum (un-impinged jet) or low momentum (impinged).

With respect to post-ignition events, the PMS acknowledges, as was noted by the contractor, the lack of data sets consisting of accurate measurements of parameters such as initial liquid/vapor mass flows, concentrations, temperatures, and thermal intensities (heat fluxes). The model appears to reproduce the physical aspects of post-ignition events quite well qualitatively. However, the consensus within the PMS is that the FLACS-FEM model has not yet been demonstrated to <u>quantitatively</u> predict the results (consequences) of post-ignition events involving <u>Class 2L</u> flammable refrigerants. This is not to say the model is not accurate. It simply acknowledges the lack of solid data sets suitable for this purpose. Note that verification of the model to predict the outcomes in experiments with Class 3 fluids, for which GEXCON conducted the experiments in an NFPA project, is very good.

Given this, the consensus of the PMS is that given the lack of high-quality 2L experimental data against which to compare FLACS predictions, it is not possible at present to verify its accuracy for moving forward with project <u>**as laid out**</u> in the original work statement and reflected in the contractor's proposal. However, it is also the consensus of the PMS that the model <u>would be very useful</u> in advancing the understanding of the potential consequences of post-ignition events involving Class 2L fluids.

The main question to moving forward at this time concerns the sensitivities of the results of an ignition (e.g., pressure rise, temperature, thermal intensity, toxic gas formation, etc.) and their consequences (level of physical damage or injury, etc.) on the uncertainties within the model and in the inputs to the model (Task 2 work). The question extends to how these uncertainties and sensitivities flow through the risk assessment calculations to arrive at a final value with an uncertainty interval (Task 3 work). If the "strength" of an outcome is very sensitive to small variations in inputs, then confidence in translating the predictions into "real" risks might be low, due to unreasonably large uncertainty intervals for the total risk (probability and severity). On the other hand, if the outcomes predicted are not particularly sensitive to variations in inputs, then the consequences can be assessed with more confidence.

This question could be addressed through relevant example test cases. **The PMS is therefore recommending that a <u>pilot</u> of Task 2 and Task 3 be executed.** Up to three relevant scenarios called out under Task 2 (subsets of full fault trees, for one or more equipment types) should be chosen and the model exercised to provide an understanding of the sensitivity of the outcomes (physical and level of risk) to the uncertainties and variabilities in the inputs. The scenario(s) should be chosen in consultation with the contractors (Gexcon and Navigant). The PMS would then review the outcome of the pilot and make a recommendation on moving forward or not (Go/NoGo #2) with the rest of the scenarios laid out under Task 2, or use the pilot results to guide further improvements of the model within the available budget funds.

Appendix A

Comments and questions regarding Task 1 draft report:

- **Barbara (seconded by Kenji and Omar and Phil)**
  - Some disparity between Gexcon and supplier-provided "dry" BVs (Figure 4.4). Need to get agreement between Gexcon and PMS on BV descriptions that should go into FLACS. Document details of the final selections in Task 1 report.
    - ~ Document functional form including effects of fuel/air ratio, humidity, temperature, pressure …

- **Kenji**
  - Expects differences between A3 and A2L flame propagation. Is accuracy of A2L model satisfactory?
  - Radiation modeling? Affected by soot formation that model does not account for.

- **Omar**
  - Comparison of FLACS to AHRTI 9007 test results with <u>flashing liquid</u> releases are not so good. (Sections 5.5.2 and 5.5.3)
  - Comparison of FLACS to JSRAE small-scale enclosure is poor. (Section 5.6.3)

- **Xudong**
  - Report demonstrates great effort by Gexcon to collect available data and compare FLACS against that data. Needs a summary table; Xudong created a draft; see Appendix B.
  - Dispersion model generally seems okay. Few available data sets and limitations in those data sets make solid validation of the combustion model difficult.
  - "Explosion" (standard) model vs "Fire" model.
    - ~ FEM = Fluorinated Explosion Model. FLACS standard "pre-mixed" combustion model was modified to accommodate HFC/HFO chemistry.
    - ~ Fire model. For non-premixed situations – eg, diffusion flames. Needed for thermal exposure modeling. Was not modified for HFC/HFO chemistry; rather uses a surrogate method based on HC modeling with appropriate adjustments to the input parameters.
  - Would be helpful to include a brief concise summary of the model validation results and conclusions. Suggest using a table as follows:

	dispersion (vapor / flash)	over pressure	thermal intensity	temperature	toxic products
which model validated					
which model to be used					

- **Greg (and Ken)**
  - Noted the rather high sensitivity of the predicted peak pressure that should occur in the 50 m^3 test as vary the LBV of R-32 from 6.2 to 7.2 cm/s. (pp 84-85)
  - This led to the question of whether the range in predicted peak pressure (1-2 kPa) with R32 was significant or not in relation to peak pressures from a hydrocarbon ignition and in terms of consequence (level of physical damage or injury).

- Also noted during the meeting was the statement in the report that a stronger chemical-based igniter was needed in 50 m^3 tests with R1234yf than the standard electronic igniter.

❑ **Ken**

- Were dispersion tests modeled as isothermal or isenthalpic? How important are thermal effects?
  - ~ Cold (flashed) refrigerant sinks faster, promoting higher degree of stratification?
  - ~ How significant are natural convection air currents due to non-uniform heating (eg, localized heating from sun shining through a window, location changing as the sun moves through its arc over the course of a day)? Isothermal model should be conservative with thermal convection currents aiding mixing on top of currents created by refrigerant stream, yes?

❑ **Phil**

- In Section 2.2.8 Humidity Considerations (page 24), variations in equilibrium reaction temperature were noted as the humidity of the air was varied. For example, a humidity ratio of 0.0228 (27°C dew point) resulted 20°C increase in temperature with R1234yf while doubling the humidity ratio led to a 130°C increase. Please elaborate more on the comment that these variations would be expected to have minimal effect on the consequence predictions. For each consequence (over pressure, thermal exposure, toxic gas exposure), provide a brief explanation as to why the effect is expected to be minimal, such as the sensitivity of each consequence to temperature, and the resulting impact (or lack thereof) of differences in equilibrium temperature.
- Clarify how the standard model and fire model will be used; it seems like both models will be run, and selected outputs used from each model where that model better represents the physics. For example, in Section 2.3.1 the comparisons seem to be using the standard model (comparing fluorinated explosion model with surrogate fuel method applied to the standard model). Perhaps I am misunderstanding, maybe the comparison is between standard model with FEM versus the fire model with surrogate fuel.
- In Section 2.2.4 (page 12), does it make any sense to show charts for the constant UV cases? Or are the charts so similar to the constant HP charts in Figure 2.1 that there is no need to show them?
- The 27°C dew point temperature is mentioned without explanation on the rationale for the choice. In an appropriate point in the report a statement is needed, explaining that this was chosen by the PMS as representative of the reasonable worst case environmental conditions for any geographical location in the world, based on unconditioned spaces.
- On several points it seems difficult to compare model results to experimental results due to measurement characteristics of the experimental results, and in many cases lack of reported measurement uncertainty. Examples are peak transient temperatures due to thermal mass of the thermocouple, instantaneous refrigerant concentration due to response time of the sensor measurement, and thermal intensity due to response time and possibly thermal mass of the sensor. Can any consideration be made to "model the measurement methods" and use that understanding to post-process the simulation results such that the model predictions are consistent with the capability of the measurement method?

Appendix B

Summary of Task 1 verification work, provided by Xudong Wang (03-Feb-2018)

Data Sources	mixing condition	Dispersion	Overpressure	thermal intensity	temperature	toxic combustion byproduct	qualitative flame comparison
50m³ test rig	premixed only	premixed, no dispersion	w/o obstruction: predicted values are roughly 3-5 times higher than measured for R32. w/obstruction: predicted is roughly 2 times than measured within 5 meter of ignition, the diff. gets smaller when further away from ignition for R32	N/A	N/A	N/A	N/A
NFPA A3 test	partially premixed, A3 only	in general, seems good	N/A	much higher (6 times) predicted intensity with shorter predicted duration (due to sensor slow response). The overall thermal dose tends to be over predicted 30% to 400% for most of points, but some points show good agreement. Not consistent.	N/A	N/A	N/A

AHRTI-9007 task 1	partially premixed	in general, seems ok	over predicted most of cases, but trend seemed ok since the test room may have leakages/deformation etc other than the vent	N/A	not direct comparison because thermocouples react much slower, CFD provides instantaneous values. (but it would be nice to show the comparison at different locations to check if the trend is consistent, wouldn't it?)	N/A	qualitative comparison was made
AHRTI-9007 task 2	partially premixed	in general, seems ok	N/A	N/A	N/A	N/A	some variations from videos with explanations
JSRAE Room scale	premixed only	trend seemed consistent	N/A	N/A	N/A	N/A	consistent with video screenshots
JSRAE small scale	premixed only	premixed, no dispersion	generally over predict 5 times higher give and take for circular vent. For rectangular vent, results seemed improved but not consistent.	N/A	N/A	N/A	consistent with video screenshots
Jabbour and Clodic tests	partially premixed		N/A	N/A	N/A	N/A	no direct comparison due to no videos. Half of simulated cases show different results from the qualitative description from the reference. Hard to judge.

ASHRAE 1806-RP

PMS Meeting – Task 1 Review
Thu 08-Feb-2018, 10:00-11:15pm EST
Via web meeting (Skype)
Compilation of original draft notes (KS) with edits and additions offered by PMS members; distributed 21-Jun-2018 [yes, that long after the meeting].

Attendees

PMS present	PMS present	PMS absent	ASHRAE present
Ken Schultz (chair)	Greg Linteris	Kenji Takizawa	Mike Vaughn
Barbara Minor	Omar Abdelaziz	Steve Kujak (RAC)	
Xudong Wang	Phil Johnson		

Purpose

The purpose of this meeting was to discuss the outcome of Task 1 – Model Development and Validation – as documented by the PI (Scott Davis, Gexcon) in the draft report received 14 Jan 2018 and as presented at the Low GWP Refrigerants MTG Research meeting held Sun 21 Jan 2018 during the ASHRAE Winter Conference in Chicago.

Discussions

In brief, the Task 1 report:

- Summarizes the goals and objectives of the project and outlines combustion hazards and factors affecting severity.
- Describes the modifications made to FLACS to model ignition events involving fluorine-containing chemistries, i.e., HFC/HFO refrigerants.
    - The Standard Explosion Model (for premixed situations) was modified to accommodate the chemistries of "fuels" containing fluorine (and is referred to as FLACS-FEM). Simplified equilibrium models were derived from a few equilibrium reactions and compared to results from a detailed thermochemical simulation tool (Chemkin). This model will be used to predict toxic gas production.
    - The FLACS Fire Model (for both premixed and non-premixed situations, e.g., diffusion flames) was adapted for 2L flames by implementing a surrogate hydrocarbon fuel (by matching their heat release). This model was tested by comparing the predicted flame size with the visual image from an R32 test of AHRTI 9007 (but was not otherwise used).
- Summarizes the burning velocity test data collected by Gexcon for a number of refrigerant blends and comparison against data provided by the respective refrigerant suppliers. Burning velocity data was collected under both dry and humid (27°C dew point, 0.0228 kgW/kgDA) conditions.
- Describes the Model Evaluation Protocol employed.
    - This involved assessing the available data sets for relevance, applicability, and quality.
    - Quantitative evaluations were made by computing and plotting the geometric mean bias and the geometric mean variance of parameters such as concentrations at various points in time, peak concentrations, pressure rise, thermal intensity, etc.
- Summarizes comparisons of model predictions against a number of measured data sets.

- Pre-ignition dispersion of leaked refrigerant into a space. In general, the predictions of dispersion events were judged to be in reasonably good agreement with much of the available data.
- The availability of post-ignition data sets with high quality measurements is limited. Only qualitative comparisons were possible. Agreement was deemed to be satisfactory, considering the difficulty in specifying the initial conditions of the simulation.

Several comments and questions were raised and distributed by the PMS members prior to the meeting. These are summarized below in Appendix A and will be discussed with the PI. The content of these comments and questions do not prevent us from coming to a recommendation for the next step in this project.

Further discussion during the meeting centered mainly on the model validation as documented in the report and whether or not the model as presented is suitable to proceed with Task 2.

The PMS noted the great effort made by the contractor to collect (most successfully, some not) the data sets available from previous work, to review those data sets, conduct a thorough comparison of model predictions against the data sets, and to provide a thorough interpretation of the results.

The general consensus within the PMS is that the FLACS CFD model has been shown to represent the dispersion of leaked refrigerant into a space with sufficient accuracy. This is particularly true for leaks in the vapor phase, whether of high momentum (un-impinged jet) or low momentum (impinged).

With respect to post-ignition events, the PMS acknowledges, as was noted by the contractor, the lack of data sets consisting of accurate measurements of parameters such as initial liquid/vapor mass flows, concentrations, temperatures, and thermal intensities (heat fluxes). The model appears to reproduce the physical aspects of post-ignition events quite well qualitatively. However, the consensus within the PMS is that the FLACS-FEM model has not yet been demonstrated to <u>quantitatively</u> predict the results (consequences) of post-ignition events involving <u>Class 2L</u> flammable refrigerants. This is not to say the model is not accurate. It simply acknowledges the lack of solid data sets suitable for this purpose. Note that verification of the model to predict the outcomes in experiments with Class 3 fluids, for which GEXCON conducted the experiments in an NFPA project, is very good.

Given this, the consensus of the PMS is that given the lack of high-quality 2L experimental data against which to compare FLACS predictions, it is not possible at present to verify its accuracy for moving forward with project **<u>as laid out</u>** in the original work statement and reflected in the contractor's proposal. However, it is also the consensus of the PMS that the model <u>would be very useful</u> in advancing the understanding of the potential consequences of post-ignition events involving Class 2L fluids.

The main question to moving forward at this time concerns the sensitivities of the results of an ignition (e.g., pressure rise, temperature, thermal intensity, toxic gas formation, etc.) and their consequences (level of physical damage or injury, etc.) on the uncertainties within the model and in the inputs to the model (Task 2 work). The question extends to how these uncertainties and sensitivities flow through the risk assessment calculations to arrive at a final value with an uncertainty interval (Task 3 work). If the "strength" of an outcome is very sensitive to small variations in inputs, then confidence in translating the predictions into "real" risks might be low, due to unreasonably large uncertainty intervals for the total risk (probability and severity). On the other hand, if the outcomes predicted are not particularly sensitive to variations in inputs, then the consequences can be assessed with more confidence.

This question could be addressed through relevant example test cases. **The PMS is therefore recommending that a pilot of Task 2 and Task 3 be executed.** Up to three relevant scenarios called out under Task 2 (subsets of full fault trees, for one or more equipment types) should be chosen and the model exercised to provide an understanding of the sensitivity of the outcomes (physical and level of risk) to the uncertainties and variabilities in the inputs. The scenario(s) should be chosen in consultation with the contractors (Gexcon and Navigant). The PMS would then review the outcome of the pilot and make a recommendation on moving forward or not (Go/NoGo #2) with the rest of the scenarios laid out under Task 2, or use the pilot results to guide further improvements of the model within the available budget funds.

Appendix A

Comments and questions regarding Task 1 draft report:

- **Barbara (seconded by Kenji and Omar and Phil)**
  - Some disparity between Gexcon and supplier-provided "dry" BVs (Figure 4.4). Need to get agreement between Gexcon and PMS on BV descriptions that should go into FLACS. Document details of the final selections in Task 1 report.
    - ~ Document functional form including effects of fuel/air ratio, humidity, temperature, pressure …

- **Kenji**
  - Expects differences between A3 and A2L flame propagation. Is accuracy of A2L model satisfactory?
  - Radiation modeling? Affected by soot formation that model does not account for.

- **Omar**
  - Comparison of FLACS to AHRTI 9007 test results with flashing liquid releases are not so good. (Sections 5.5.2 and 5.5.3)
  - Comparison of FLACS to JSRAE small-scale enclosure is poor. (Section 5.6.3)

- **Xudong**
  - Report demonstrates great effort by Gexcon to collect available data and compare FLACS against that data. Needs a summary table; Xudong created a draft; see Appendix B.
  - Dispersion model generally seems okay. Few available data sets and limitations in those data sets make solid validation of the combustion model difficult.
  - "Explosion" (standard) model vs "Fire" model.
    - ~ FEM = Fluorinated Explosion Model. FLACS standard "pre-mixed" combustion model was modified to accommodate HFC/HFO chemistry.
    - ~ Fire model. For non-premixed situations – eg, diffusion flames. Needed for thermal exposure modeling. Was not modified for HFC/HFO chemistry; rather uses a surrogate method based on HC modeling with appropriate adjustments to the input parameters.
  - Would be helpful to include a brief concise summary of the model validation results and conclusions. Suggest using a table as follows:

	dispersion (vapor / flash)	over pressure	thermal intensity	temperature	toxic products
which model validated					
which model to be used					

- **Greg (and Ken)**
  - Noted the rather high sensitivity of the predicted peak pressure that should occur in the 50 m^3 test as vary the LBV of R-32 from 6.2 to 7.2 cm/s. (pp 84-85)
  - This led to the question of whether the range in predicted peak pressure (1-2 kPa) with R32 was significant or not in relation to peak pressures from a hydrocarbon ignition and in terms of consequence (level of physical damage or injury).

- Also noted during the meeting was the statement in the report that a stronger chemical-based igniter was needed in 50 m³ tests with R1234yf than the standard electronic igniter.

- **Ken**
  - Were dispersion tests modeled as isothermal or isenthalpic? How important are thermal effects?
    - ~ Cold (flashed) refrigerant sinks faster, promoting higher degree of stratification?
    - ~ How significant are natural convection air currents due to non-uniform heating (eg, localized heating from sun shining through a window, location changing as the sun moves through its arc over the course of a day)? Isothermal model should be conservative with thermal convection currents aiding mixing on top of currents created by refrigerant stream, yes?

- **Phil**
  - In Section 2.2.8 Humidity Considerations (page 24), variations in equilibrium reaction temperature were noted as the humidity of the air was varied. For example, a humidity ratio of 0.0228 (27°C dew point) resulted 20°C increase in temperature with R1234yf while doubling the humidity ratio led to a 130°C increase. Please elaborate more on the comment that these variations would be expected to have minimal effect on the consequence predictions. For each consequence (over pressure, thermal exposure, toxic gas exposure), provide a brief explanation as to why the effect is expected to be minimal, such as the sensitivity of each consequence to temperature, and the resulting impact (or lack thereof) of differences in equilibrium temperature.
  - Clarify how the standard model and fire model will be used; it seems like both models will be run, and selected outputs used from each model where that model better represents the physics. For example, in Section 2.3.1 the comparisons seem to be using the standard model (comparing fluorinated explosion model with surrogate fuel method applied to the standard model). Perhaps I am misunderstanding, maybe the comparison is between standard model with FEM versus the fire model with surrogate fuel.
  - In Section 2.2.4 (page 12), does it make any sense to show charts for the constant UV cases? Or are the charts so similar to the constant HP charts in Figure 2.1 that there is no need to show them?
  - The 27°C dew point temperature is mentioned without explanation on the rationale for the choice. In an appropriate point in the report a statement is needed, explaining that this was chosen by the PMS as representative of the reasonable worst case environmental conditions for any geographical location in the world, based on unconditioned spaces.
  - On several points it seems difficult to compare model results to experimental results due to measurement characteristics of the experimental results, and in many cases lack of reported measurement uncertainty. Examples are peak transient temperatures due to thermal mass of the thermocouple, instantaneous refrigerant concentration due to response time of the sensor measurement, and thermal intensity due to response time and possibly thermal mass of the sensor. Can any consideration be made to “model the measurement methods” and use that understanding to post-process the simulation results such that the model predictions are consistent with the capability of the measurement method?

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