



Shaping Tomorrow's
Built Environment Today

MINUTES

Refrigeration Committee (REF)

June 29, 2016

Marriott St. Louis Grand

St. Louis, MO

MEMBERS PRESENT:

Matt Ritter, *Chair*
Karim Amrane, *Vice Chair*
Roberto Aguilo
Bryan Becker
Didier Coulomb
Martin Dieryckx
Julia Keen, *BOD Ex-O*
Javier Korenko
Cesar Lim, *Consultant, CTTC liaison*
Jason Robbins
Dave Rule
Nick Shockley

MEMBERS NOT PRESENT:

Shamila Nair-Bedouelle
Richard Royal
Jim Vallort, *Coordinating Officer*

ASHRAE STAFF:

Steve Hammerling, AMORTS

GUESTS:

Jim Caylor
Donnilyn Charles
Ken Cooper
Helen Davis
Dan Dettmers
Ayman Eltaloung
Brian Fricke
Pranav Godbole
Bruce Griffith
Charles Hon, *Incoming Member*
Glenn Hourahan, *Incoming Member*
Ozunimi Iti
Rainer Jakobs
Georgi Kazachki
Greg May
Barbara Minor, *Incoming Member*
John Neel
Caleb Nelson
Gustavo Pottker
Rajan Rajendran, *Incoming Member*
Ivan Rydkin
Doug Scott
Daryl Stauffer
Arvind Surange
Jim Wolf
Shitong Zha

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MOTIONS

No.	Motion	Status
1	the minutes from the REF Winter Meeting in Orlando be approved	PASSED
2	the minutes from the REF Spring Meeting be approved.	PASSED
3	REF recommends to Honors and Awards Committee that they award Claude Dumas the Milton W. Garland Award for <i>Oil Transfer and Recycling System for Ammonia Refrigeration Installation</i> .	
4	REF recommends to Honors and Awards Committee that they award Dr. Andy Pearson the Comfort Cooling for Drammen Fjernvarme District Heating & Cooling System.	PASSED
5	Hon, Minor, and Rajendran be appointed to Briley Award Judging Subcommittee.	PASSED
6	REF co-sponsor workshop for Las Vegas on joint ASHRAE/AHRI/DOE research initiative on flammable refrigerants with MTG.Low GWP refrigerants.	PASSED

ACTION ITEMS – Annual 2016

No.	Responsibility	Action Item	Page
1	Staff	Send articles, forms, deadline and pertinent information to Briley judging subcommittee	3
2	Dierczyk, Coulomb	Submit programs for Las Vegas meeting by August 8 deadline	3
3	Aguilar	Draft proposal on program to consider in Las Vegas for a program in Long Beach on CO ₂ Installation Do's and Don'ts	3
4	REF	Recommend a revision, reaffirmation or withdrawal of the <i>Refrigerants and their Responsible Use PD</i> scheduled to expire in July 2017	4
5	REF	Reach out to participate in UNEP/ASHRAE partnership meetings and help develop speakers list for UNEP	4
6	REF	Finalize REF liaison assignment list	5
7	REF	Submit ideas for Tech Council Innovative Idea list	5
8	Staff	Poll members for best day/time for Fall REF e-meeting	6

ACTION ITEMS – Spring 2016

No.	Responsibility	Action Item	Status
1	Staff	Request volunteer for judging Milt Garland and Comfort Cooling awards	Complete
2	Amrane, Dierczyk	Summarize energy efficiency HVAC&R programs/standards in Europe, Middle East, Australia, Japan, India and elsewhere in the world for a presentation in St. Louis.	Ongoing

ACTION ITEMS – Winter 2016

No.	Responsibility	Action Item	Status
1	Royal	Ritter asked the Education subcommittee to develop list of topics, volunteers and schedule.	Ongoing

2	Coulomb & Dierczyk	Proposed chairs for Las Vegas programs were asked to develop details for Spring Conference call	Complete
3	Korenko	Developing Economies subcommittee to develop responses to the action items in developing economies ad hoc report that REF can address	Ongoing
4	Ritter	Suggest PAOE points related to refrigeration activities by March 1 deadline	Delete
5	Staff	Send reminder requests to assigned individuals requesting TC/SSPC liaison reports	Complete
6	Ritter	Request ideas for the Innovative Ideas list after the meeting	Complete

LIST OF ATTACHMENTS

No.	Attachment
A	Draft Ammonia PD
B	CTTC Report
C	Refrigerant Issues report
D	2016-17 MBOs
E	Tech Council Innovative Ideas List

LIST OF ACRONYMS

AC	Air Conditioning	GWP	Global Warming Potential
AHRI	Air-conditioning, Heating & Refrigeration Institute	HVAC&R	Heating, Ventilating, Air Conditioning & Refrigeration
AI	Action Item	IIR	International Institute of Refrigeration
ALI	ASHRAE Learning Institute	MBO	Management by Objectives
AMORTS	Assistant Manager Research & Technical Services	MOP	Manual of Procedures
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers	MTG	Multidisciplinary Task Group
BOD	Board of Directors	PEAC	Presidential Elect Advisory Council
CNV	Chair Not Voting	PD	Position Document
CO	Coordinating Officer	PMS	Project Monitoring Subcommittee
CO ₂	Carbon Dioxide	REF	Refrigeration Committee
CV	Chair Voting	ROB	Rules of the Board
CTTC	Chapter Technology Transfer Committee	RP	Research Project
DOAS	Dedicated Outdoor Air System	SSPC	Standing Standard Project Committee
DOE	Department of Energy	SY	Society Year
DRSC	Document Review Subcommittee	TAC	Technical Activities Committee
Ex-O	Ex-Officio	TC	Technical Committee
GCCA	Global Cold Chain Alliance	UNEP	United Nations Environment Programme
GRMI	Global Refrigerant Management Initiative		

1. CALL TO ORDER

Chair Matt Ritter called the meeting to order at 8:00 AM. Members and guests introduced themselves.

2. REVIEW OF AGENDA

Ritter confirmed quorum was met. No changes were suggested to the agenda.

3. MINUTES

A. It was moved (KA) and seconded (NS) that,

- (1) the minutes from the REF Winter Meeting in Orlando be approved.

MOTION 1 PASSED: 7-0-0, CNV

BACKGROUND: Minutes were distributed in Feb. 18 email.

B. It was moved (MD) and seconded (NS) that,

- (2) the minutes from the REF Spring Meeting be approved.

MOTION 2 PASSED: 7-0-0, CNV

BACKGROUND: Minutes were distributed in June 6 email.

4. CHAIR'S REPORT – Ritter

A. Motions from Past Meetings Requiring Higher Body Approval

- Program related motions were discussed at Spring Meeting. No other motions required higher approval.

B. New Information Items for REF

- Ritter encouraged members to respond to ASHRAE email to send thank you letter to employers if they wish
- REF will consider motions for various awards later in meeting

5. VICE-CHAIR'S REPORT – Amrane

A. Fiscal Report

Budget is doing well with line items under budget. Will monitor committee member travel and adjust if necessary.

B. MOP/ROB/Reference Manual

No changes for this meeting to these documents.

C. Other

1. 2L Research

Amrane noted ASHRAE approved \$1.2M from ASHRAE Research Reserve Fund. Research done by ASHRAE will be overseen by MTG. Low GWP Refrigerants and run through ASHRAE Research procedures.

2. GRMI

Ritter noted REF continues to monitor Global Refrigerant Management Initiative (GRMI) activities. The focus of the GRMI is on education, training, certification of technicians to reduce refrigerant emissions. ASHRAE is on the GRMI Steering Committee which last met in

Australia and next meets in Vienna this July. The group has developed a list of goals and objectives and will continue to further refine goals, and review and target membership. ASHRAE's representative on GRMI steering committee will be Walid Chakroun.

6. BOD/TECH COUNCIL REPORTS

A. BOD EX-Officio – Keen

Keen presented a Presidential Elect Advisory Committee (PEAC) report. Highlights include:

- Change to role of PEAC going forward to be more of a planning committee
- ASHRAE sought outside consultant on Strategic Plan
- BOD meeting in Bangkok in fall
- \$1.2M approved from ASHRAE research reserve for 2L refrigerant research. Part of \$5.2M in funding from DOE, AHRI
- ASHRAE certifications now ANSI accredited
- 2016 publications include Standard 62.1, 62.2, 90.1, 55 User's Manual, 160, 52.2, DOAS, Cleanrooms

Keen thanked all for time and service to ASHRAE activities and asked for any feedback from committee members to take to the BOD. Bill Walter introduced himself as incoming BOD Ex-O.

7. AWARDS

REF went into executive session to discuss award nominations. One submittal was switched by the judging team from Milt Garland to Comfort Cooling, so there was one nomination for the Milton Garland Award and two for the Comfort Cooling Award.

A. Milt Garland

There was discussion related to nominations received for the Milton Garland Award.

It was moved (NS) and seconded (JR) that,

(3) REF recommends to Honors and Awards Committee that they award Claude Dumas the Milton W. Garland Award for *Oil Transfer and Recycling System for Ammonia Refrigeration Installation*.

MOTION 3 PASSED: 9-0-0, CV

B. Comfort Cooling

There was discussion related to nominations received for the Comfort Cooling Award.

It was moved (JR) and seconded (NS) that,

(4) REF recommends to Honors and Awards Committee that they award Dr. Andy Pearson the Comfort Cooling for Drammen Fjernvarme District Heating & Cooling System.

MOTION 4 PASSED: 9-0-0, CV

C. Briley Award

Ritter noted six ASHRAE Journal articles were selected for consideration for the Briley Award. This award is given annually to the best feature article in the Journal related to refrigeration. Typically, incoming members are asked to score and recommend winner to Refrigeration Committee in the Fall for the winner to receive the award at the REF Winter Meeting.

It was moved (JR) and seconded (KA) that,

(5) Hon, Minor, and Rajendran be appointed to Briley Award Judging Subcommittee.

MOTION 5 PASSED: 8-0-0, CV

Staff was asked to send articles, forms, deadline and pertinent information to subcommittee (**AI #1**).

8. SUBCOMMITTEE REPORTS

A. ASHRAE Learning Institute (ALI) – **Royal**, Seeton, Becker

Royal was not in attendance to update on ALI efforts. He agreed to review status and send updates after meeting as appropriate.

B. Programs – **Diercyckx**, Kazachki, Royal

1. St. Louis

REF sponsored Seminar 13, *Advancements in Compressor Design, Testing and Performance Modeling for New Efficiency Standards and Alternative Refrigerants*, for the St. Louis meeting.

2. Las Vegas (approved in ORL)

Diercyzk suggested avoiding a repeat of topics from UNEP conference but the consensus was audience was likely pretty different so a repeat would be fine. REF decided to submit following programs approved in Orlando for Las Vegas (**AI #2**):

- Safety Considerations for AC and Refrigeration Equipment in Developing Economies (Dierczyk) - Seminar
- Optimization of Direct AC Systems with Lower GWP (Dierczyk) - Workshop
- Food Cold Chain for Developing Countries (Coulomb) - Workshop

Amrane noted MTG-Low GWP refrigerants seeks REF co-sponsorship of a forum for Las Vegas on the joint ASHRAE/AHRI/DOE research initiative on flammable refrigerants.

It was moved (KA) and seconded (MD) that,

(6) REF co-sponsor workshop for Las Vegas on joint ASHRAE/AHRI/DOE research initiative on flammable refrigerants with MTG.Low GWP refrigerants.

MOTION 6 PASSED: 8-0-0, CV

Aguilar suggested a program on CO₂ installation Do's and Don'ts. He was asked to draft a proposal to consider in Las Vegas for a program in Long Beach (**AI #3**).

C. Refrigeration Handbook chapters – **Shockley**

Fenton noted he was unable to reach initial contact for R42 chapter review so he will seek someone else on his list or perhaps more outside reviewers. Lim noted he is reviewing this chapter now. Becker will contact reviewers from UC-Davis. Ayman agreed to get Shockley contact to review chapter as well.

D. Ammonia Position Document – **Rule**, Cole Kazachki, Royal

The *Ammonia as a Refrigerant* position document (PD) committee approved a revised PD (**Attachment A**) and sent to REF for a courtesy review. REF is reviewing and offering comments to the PD committee for their consideration. The PD expires in July 2017. REF committee members were asked to review and send track change review comments to staff before August

19th. PD would not be sent to DRSC at this time. The PD committee will resubmit PD before October.

The *Refrigerants and their Responsible Use* PD is scheduled to expire in July 2017. REF will work to recommend a revision, reaffirmation or withdrawal as appropriate (**AI #4**).

- E. Developing Economies – **Korenko**, Aguilo, Lim, Surange
REF assigned three members to assist in the development of a specialty conference on *Sustainable Management of Refrigeration Technologies in Mobile Marine and Fisheries Sectors*. The conference is co-organized with UNEP and IIR. It will be rescheduled for spring 2017. Details are available at www.ashrae.org/marine2017.

Korenko noted there is some confusion in developing economies on R22 replacements. It is not necessarily a technical issue, it is often a fiscal issue, but intensive communication, education, on transitions is helpful.

- F. UNEP/ASHRAE Partnership – **Nair-Bedouelle**, Coulomb, Amrane, Ritter
REF remains supportive of the 2015-2016 Work Plan of ASHRAE-UNEP Global Cooperation Agreement and the Developing Economies Ad Hoc Final Report. REF has MBOs focused on the implementation of these goals.

UNEP/ASHRAE partnership meeting was held yesterday without REF representation. REF should see what happened and get involved. They asked REF for help in finding refrigeration speakers list for UNEP (**AI #5**).

9. OTHER REPORTS

- A. Chapter Technology Transfer Committee (CTTC) Liaison Report (Lim)
Lim attended CTTC meetings in St. Louis. His report to CTTC will be included with minutes (**Attachment B**).

Lim noted there is no formal REF liaison on CTTC for next year. If a liaison is desired REF can follow up with CTTC.

- B. Consultant Report
Doug Scott updated REF on RP-1634. The project is close to completion (targeted for Aug. 16th) but may need an extension. The PMS is meeting tomorrow. There was discussion on if the PMS would seek outside reviewers from REF, TC 10.1 or 10.5. The consensus was that the PMS was able to do reviews and could seek outside reviews, perhaps for targeted areas, if they wished to do so.

He noted UNEP didn't fund but may still develop translations of a shortened version of the publication. The UNEP version would focus on international areas of interest.

Ritter encouraged REF to think of how this document could be used as there would be a number of opportunities for seminars, training, case studies, etc.

- C. Refrigerant Issue Update – Ritter
Ritter presented report on Refrigerant Issues at meeting (**Attachment C**).

D. Liaisons

1. TCs & SSPCs

REF will work to fill liaison assignments (**AI #6**).

2. IIR - Coulomb

Coulomb reported he met with Comstock to publish a dictionary of refrigeration terms. Noted IIR would co-organize the ASHRAE Fisheries conference in spring. Referred to www.iifiir.org for updates on seminars, integration of IIR publications and other items of interest.

3. GCCA liaison report

Vallort submitted formal GCCA liaison report. This was sent to REF (and relevant TC's) in May 12th email.

4. Other

TAC member Ken Cooper visited REF and offered to help with TC liaison list. Amrane accepted this invite and Cooper's offer to develop a mailing list. Cooper noted TCs have expressed that REF would be working on perception and visibility of refrigeration in ASHRAE and avoid duplication of TC efforts.

10. STRATEGIC ISSUES

A. MBO Updates – MBO leaders (**Attachment D**)

Amrane presented MBOs for next Society Year. Noted most MBOs were continuing or modified and some new MBOs were added.

B. Tech Council Innovative Ideas (**Attachment E**)

1. New Suggestions

Ritter asked REF for comments to add to innovative idea list (**AI #7**). The following idea was suggested and would be reported to Tech Council subcommittee:

TOPIC: ASHRAE can work to increase ASHRAE's role and presence in the global refrigeration community

INITIATOR: Refrigeration Committee

PROPOSED SOLUTION: Refrigeration Committee could hold meetings in conjunction with international refrigeration events such as conferences, workshops, Montreal Protocol, etc.

C. REF Strategic Planning

1. Amrane listed some themes for REF to concentrate on next SY

- codes/standards issues
- refrigerant transitions (to 2L, etc.)
- focus on developing economies
- energy efficiency (worldwide)

2. Another area of interest related to ASHRAE as an international organization would be a discussion on barriers to international member participation. The following questions should be discussed.

- How can we get ASHRAE more involved in international discussions?
- How can we increase ASHRAE's international presence in these areas?
- How ASHRAE get involved in outside organizations?
- What are the current barriers from doing so?
- How can we make participation in ASHRAE more accessible to international members?
- What resources are there to help introduce ASHRAE members to ASHRAE culture?

3. Other

- Robbins asked if ASHRAE Standards and publications could be translated to reach out to international audience. Some publications are currently translated by local chapters, but most are not. The *Ammonia as a Refrigerant* PD may be a good one to translate. This may be an item for Innovative Idea list.

11. NEXT MEETING

REF will hold a fall web meeting in mid-October. Staff will poll members for best day/time (**AI #8**). REF will next meet face to face at the ASHRAE Winter Meeting in Las Vegas on Sunday, January 29, 2017 from 8a-12pm.

12. HANDOVER TO NEW CHAIR – Ritter, Amrane

A. Recognize Outgoing Members

Ritter recognized outgoing members Javier Korenko, Bryan Becker, and Cesar Lim, thanking them for their contributions and presented Certificates of Appreciation.

B. Recognize Incoming Members

Ritter welcomed Karim Amrane as the incoming chair of REF. Amrane introduced incoming members to REF, Glenn Hourahan, Charles Hon, Barbara Minor and Rajan Rajendran.

Amrane thanked outgoing chair Matt Ritter for his work and accomplishments over his term on the committee.

Amrane would make subcommittee assignments and present MBOs for the 2016-17 Society Year in report to Tech Council. Major themes for REF in the next Society Year include codes/standards issues, refrigerant transitions, focus on developing economies, and energy efficiency.

13. ADJOURNMENT

Committee adjourned at 12 PM.



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www.ashrae.org

ASHRAE Position Document on

AMMONIA AS A REFRIGERANT

Approved by ASHRAE Board of Directors (*completed by ASHRAE staff*)

Month day, 20YR

Reaffirmed by ASHRAE Technology Council (*if applicable, completed by ASHRAE staff*)

Month day, 20YR

Expires (*completed by ASHRAE staff*) Month day, 20YR

ASHRAE

S H A P I N G T O M O R R O W ' S B U I L T E N V I R O N M E N T T O D A Y

COMMITTEE ROSTER

The ASHRAE Position Document on “Full Title” was developed by the Society’sName of Committee.....
Position Document Committee formed on Month Day, 20YR, with ...Name... as its chair.

First and Last Name

Affiliation
City, State, Country

First and Last Name

Affiliation
City, State, Country

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City, State, Country

Former members and contributors (if any)

First and Last Name

Affiliation
City, State, Country

First and Last Name

Affiliation
City, State, Country

First and Last Name

Affiliation
City, State, Country

First and Last Name

Affiliation
City, State, Country

Cognizant Committees

The chairperson(s) of (list cognizant committee(s) and names of their chair(s) also served as ex-officio members.

First and Last Name

Committee, Chair
Affiliation
City, State, Country

First and Last Name

Committee, Chair
Affiliation
City, State, Country

HISTORY
of
REVISION / REAFFIRMATION / WITHDRAWAL DATES

The following summarizes the revision, reaffirmation or withdrawal dates (*to be completed by ASHRAE staff, if necessary*)

Note: Technology Council and the cognizant committee recommend revision, reaffirmation or withdrawal every 30 months.

CONTENTS

ASHRAE Position Document on

“Full Title”

SECTION	PAGE
Abstract	
Executive Summary	
Issues	
<i>Add all main section headings</i>	

ABSTRACT

Ammonia has been continuously used as a refrigerant since the initial practical use of the vapor-compression refrigeration cycle was developed. It has remained the main refrigerant used in industrial refrigeration systems because of its superior thermodynamic properties and low cost. Restrictions on CFC, HCFC, HFC and - HFO refrigerants have re-focused attention on ammonia to emerge as one of the widely used refrigerants that, when released to the atmosphere, does not contribute to ozone depletion and global warming. Ammonia is generally considered to be friendly to the environment. ASHRAE encourages the continued use of ammonia for - industrial and commercial refrigeration, food preservation, space conditioning, heat pumps and other applications. ASHRAE participates in a variety of programs such as a dedicated chapter in the Refrigeration Handbook and several current and former research projects to promote the economic and environmental benefits of ammonia refrigeration and will continue to provide guidance for the proper design, safe use and management of risk.

EXECUTIVE SUMMARY

Globally, there is a growing interest in ammonia as a refrigerant, both by itself, and in cascade refrigeration systems with carbon dioxide and other secondary system designs. Restrictions on CFC, HCFC, HFC and HFO containing refrigerants have focused attention on ammonia to emerge as one of the widely used refrigerants that, when released to the atmosphere, does not contribute to ozone depletion and global warming. New technology and equipment is leading to low and reduced ammonia charge designs. The application of these new low charge systems and packages creates an opportunity to use ammonia systems in a broad range of industrial, commercial and space conditioning applications that would not have been considered with traditional designs. These changes will require industry to provide proper recommendations for both design safety and guidance for regulatory and code agencies.

Ammonia is an efficient and popular refrigerant due to its superior thermodynamic properties and low cost. Ammonia is environmentally friendly having zero GWP and zero ODP. It is hazardous when released in large quantities due to its toxicity. However, ammonia does exhibit a unique refrigerant characteristic due to its irritating odor. Persons exposed to an ammonia release will not voluntarily stay near concentrations that are health-threatening. Although ammonia will burn in a narrow range of high concentrations, it is difficult to ignite and will not support combustion after the ignition source is withdrawn. Ammonia has an ASHRAE flammability class of 2L and is classified as non-flammable by the US Department of Transportation 49 CFR.

ASHRAE encourages the continued use of ammonia for industrial and commercial refrigeration, food preservation, space conditioning, heat pumps and other applications.. ASHRAE participates in a variety of programs to promote the economic and environmental benefits of ammonia refrigeration and will continue to provide guidance for the proper design, safe use and management of risk.

1. THE ISSUE

Refrigerant selection has become increasingly complex in recent years. Globally, the interest in ammonia and other natural refrigerants has become more focused due to restrictions on the use of CFC, HCFC, HFC and HFO containing refrigerants. The consideration of these refrigerants continues to come under question due to the environmental concerns caused from ozone depleting potential (ODP), global warming potential (GWP), energy efficiency, total equivalent warming impact (TEWI) and life cycle climate performance (LCCP).

Ammonia is a natural refrigerant that has been used for many years in a variety of applications due to its high thermal efficiency. Since ammonia is environmentally friendly having zero (GWP) and zero (ODP) characteristics, ammonia is emerging as one of the primary natural refrigerants of choice.

New technology is leading to low and reduced ammonia charge designs. The application of these new low charge systems and packages creates an opportunity to use ammonia in a broad range of new industrial, commercial and space conditioning applications that would not have been considered with traditional designs. These changes will require industry to provide proper recommendations for both design safety and guidance for regulatory and code agencies.

2. BACKGROUND

Ammonia (chemical symbol NH₃, United Nations Chemical I.D. #1005) is produced both naturally and as a byproduct of numerous man-made reactive processes. Large amounts of naturally occurring ammonia gas come from livestock animals, soil surfaces and even the human body. Manmade processes that emit ammonia to the atmosphere include fuel combustion processes and sewage treatment plants.

The nitrogen component of ammonia was first recognized as an important fertilizer around 1840, and ammonia was first used as a refrigerant around 1850. Ammonia was first commercially produced in the United States about 1880 as a distillation by-product of coal processing to produce coke and coal gas.

The first direct-synthesis commercial process was developed in Germany by Fritz Haber and Carl Bosch in 1913. The wide variety of ammonia uses throughout agriculture and industry, combined with varied and highly efficient manufacturing processes, has kept the costs of commercially manufacturing ammonia low. Natural gas is one of the feedstocks used for large scale ammonia production. The rapid increase in the availability of natural gas in the U.S. and elsewhere due to new drilling technologies has kept the cost of this feedstock down, helping to keep down the cost of the ammonia product.

2.1 Ammonia Specification and Applications Ammonia is an alkaline, colorless chemical compound that is well recognized as the basis for household cleaning products. It also has many agricultural, industrial and commercial uses. It is available in five generally recognized grades—fertilizer, refrigerant, federal, metallurgical, and semiconductor—depending on its level of purity.

Refrigeration grade ammonia is 99.98 percent pure and is relatively free of water and other impurities (maximum: 150 ppm water, 3 ppm oil, 0.2 ml/g noncondensibles). It is readily available, inexpensive, operates at pressures comparable with other refrigerants and is capable of absorbing large amounts of heat when it evaporates.

Of the estimated 131 million metric tons of ammonia produced commercially throughout the world each year (8 million metric tons in the United States), over 80 percent is used for agricultural purposes¹. Some of the agricultural uses of commercial ammonia include:

- Direct injection into soil as a fertilizer (amount can be as much as 150 pounds annually per acre).
- Production of urea (colorless crystalline material that is a highly concentrated form of nitrogen fertilizer and a source of protein in livestock feeds).
- Pre-harvest cotton defoliant.
- Anti-fungal agent on certain fruits.

The remaining 20 percent of commercially manufactured ammonia is used for numerous industrial applications, such as:

- Direct injection in selective catalytic reduction control of nitrogen oxides for stack emissions.
- Direct injection of ammonium hydroxide for stack emissions to neutralize sulfur oxides from sulfur-containing fuels.
- Nitrogen component for the manufacture of explosives such as TNT and nitroglycerin.
- Closed-loop refrigerant in many industrial and commercial refrigeration systems.
- Neutralizing agent for acid constituents in sewage treatment plants.

Less than 2 percent of all the ammonia commercially produced in the world is used as a refrigerant.

2.2 Refrigeration Uses of Ammonia

With continued restrictions on the use of CFC, HCFC, HFC and HFO containing refrigerants alternative refrigerants for use in existing refrigeration systems are actively being investigated. These alternative refrigerants must have thermodynamic characteristics similar to those of Halocarbons and be safe for humans and the environment.

Ammonia is one alternative refrigerant for new and existing refrigerating systems. Ammonia has a low boiling point (-28°F @ 0 psig), an ozone depletion potential (ODP) of 0.00 when released to atmosphere and a high latent heat of vaporization (eight (8.17 at -28°F) times greater than R-12 and six (6.18 at -28°F) times greater than R-134a). In addition, ammonia in the atmosphere does not directly contribute to global warming. These characteristics result in a highly energy-efficient vapor-compression cycle with ammonia as the refrigerant with minimal environmental impact.

From a purely economic analysis, without unnecessary regulatory burdens, ammonia should find broader applications as a refrigerant than it currently enjoys.

Ammonia's use in the HVAC&R industry will increase as regulatory and code officials become informed of its relative safety. Applications for ammonia-based refrigeration systems include thermal storage systems, HVAC chillers, process cooling, air conditioning, winter sports, district cooling systems, heat pump systems, supermarkets, convenience stores, and increasing output efficiencies for power generation facilities. Ammonia is also already being used as a refrigerant in several high profile projects including The International Space Station, Biosphere II, large heat pump installations and supermarkets.

Ammonia is increasingly used in cascade refrigeration systems with carbon dioxide. In these systems, ammonia is used in the high stage to reject heat to the environment. Carbon dioxide is used in the low stage to absorb heat from the load to be cooled, and to reject the heat to the ammonia high stage. Such systems allow the use of ammonia in a wider range of applications, because the less hazardous carbon dioxide can be used in more locations, while the highly efficient ammonia can be kept in a central mechanical room or rooftop package. Ammonia is also used in conjunction with other secondary fluids, such as water or glycol, for the same reasons noted above.

2.3 Health and Safety

Ammonia is hazardous at high concentration levels. The National Institute for Occupational Safety and Health (NIOSH), in its 2007 Pocket Guide, has set the immediately dangerous to life and health (IDLH) level, the level at

which an individual could be exposed for 30 minutes without a respirator and not experience any lasting health effects, at 300 parts per million. Ammonia's sharp, irritating, pungent odor actually helps reduce exposure to potentially dangerous concentrations. The average odor threshold is 5 ppm, well below concentrations that may cause harmful effects to the human anatomy.

The chart below, which is based on data from ATSDR 2004, shows the effects of various concentrations of ammonia.

The self-alarming property of ammonia is recognized by virtually all engineers, designers, technicians and mechanics that deal with and work on ammonia systems regularly. Thus, small leaks are repaired quickly and not

Body Part	Concentration	Effect
Eyes	500 ppm and below	No permanent eye damage to even chronic exposure
Eyes	100-200 ppm	Eyes irritated
Skin	5000 ppm and above (vapor)	Full body chemical suit required
	Pure liquid	Second degree burns with blisters
Lungs	400 ppm	Immediate throat irritation
	1700 ppm	Cough
	2400 ppm	Threat to life after 30 minutes

neglected or dismissed as insignificant.

The threshold limit value (TLV) consists of two components—the time-weighted average (TWA) concentration and the short-term exposure limit (STEL). The TWA is the time weighted average concentration for a normal eight-hour work day and a 40-hour work week. The STEL is a 15-minute time weighted average exposure that should not be exceeded at any time during the work day, even if the eight-hour TWA is within the TLV. The TWA of ammonia is 25 ppm. The STEL for ammonia is 35 ppm. OSHA's personal exposure limit (PEL) is 50 ppm.

Modern ammonia systems are fully contained closed-loop systems with fully integrated controls, which regulate pressures throughout the system. Also, every refrigeration system is required by codes, which are effective, mature and constantly updated and revised, to have safety relief valves to protect the system and its pressure vessels from over pressurization and possible failure. The most common and preferred method of release is by venting of the vapor from the relief valves to the atmosphere at a safe location. Ammonia is lighter than air (molecular weight of ammonia is 17, molecular weight of air is 28).

2.4 Environmental Aspects

Ammonia is not a contributor to ozone depletion or global warming.

Thus, it is an environmentally friendly refrigerant. Ammonia has no cumulative effects on the environment and a very limited (a few days⁷) atmospheric lifetime. Because of the short lifetime of ammonia in the atmosphere, it is considered to be biodegradable. It is even used to reduce harmful stack gas emissions by injection into boiler and gas turbine exhaust streams. In such systems, only part of the ammonia is consumed in the emission control process, and a small fraction "slips" into the environment.

Ammonia may be released to the atmosphere by sources such as decaying organic matter, animal excreta, fertilization of soil, burning of coal, wood, etc., and by volcanic eruptions. Ammonia may be released into water as effluent from sewage treatment and/or industrial processes and as run-off from fertilized fields or areas of livestock concentrations. Ammonia may be released into soils from natural or synthetic fertilizer applications, livestock excrement, the decay of organic material from dead plants and animals or from the natural fixation of atmospheric nitrogen.

2.5 Considerations of Ammonia As A Refrigerant

While the benefits of ammonia as a refrigerant are well known (high energy efficiency, zero ODP, zero GWP, low TEWI, excellent LCCP, self-alarming pungent odor), barriers to expanding its use into HVAC&R applications must be addressed. These barriers, both real and perceived, generally relate to human health and environmental safety, and to ammonia refrigeration system installation cost. Ammonia reacts with copper in the presence of common contaminants such as air and water. Therefore, with the exception of some copper containing bronze alloys used in compressor and pump bearings, ammonia systems are constructed using aluminum, carbon steel, and stainless steel components. Joints are most often welded, rather than brazed. A lack of technicians trained to understand and handle ammonia refrigeration systems also presents a barrier to its implementation, especially in markets where ammonia has not traditionally been used.

In properly constructed and commissioned refrigeration systems, ammonia contributes to a high theoretical COP compared to many refrigerants that are currently in use⁸. The high efficiency of ammonia systems also benefits the environment by requiring less energy for a given refrigeration load, and thus less carbon dioxide emissions associated with the production of electricity.

2.6 Regulatory Classifications

Anhydrous ammonia (Chemical Abstracts Service, CAS #7664-41-7) is currently classified by the U.S. Environmental Protection Agency (EPA) as an extremely hazardous substance (EPCRA, Sec. 302, 303). It is included on the following Emergency Planning and Community Right-to-Know Act (EPCRA) lists:

- Reportable Quantity List (Section 304) -Chemicals on this EPCRA list require notification to EPA and state and local agencies of releases in excess of the reportable quantity (currently 100 pounds).
- Extremely Hazardous Substance List (Section 302) -Chemicals on this EPCRA list, at facilities with quantities in excess of the Threshold Planning Quantity (TPQ), are subject to EPCRA requirements, which mandates numerous reporting and planning provisions. The TPQ of ammonia is 10,000 pounds.
- Section 313 - Chemicals on this EPCRA list are subject to the annual toxic release inventory reporting (Form R).

While the EPA addresses ammonia from the environmental perspective, the U.S. Occupational Health and Safety Administration (OSHA) addresses ammonia from the perspective of worker safety. OSHA defines ammonia as a hazardous material and, depending on its use, imposes certain regulations on its use, storage, handling and occupational exposure.

EPA and OSHA classify all CFCs and HCFCs as hazardous substances, and thus the use of these refrigerants requires specific reporting and management practices comparable to ammonia.

2.7 Risk Assessment

All refrigerating systems require risk assessment; ammonia systems are not exceptions. OSHA's Process Safety Management (PSM), 29CFR1910.119, provides guidelines for a comprehensive program developed by employees and management at facilities to ensure that proper safety, maintenance and operating procedures are followed, and thereby minimize potential hazards. This PSM incorporates ANSI/ASHRAE Standard 15, Safety Standard for Refrigeration Systems¹⁰ as well as other standards for design, installation, maintenance and operation. Although it only affects plants with large refrigerant charges, its requirement for what-if or hazop analyses are directed towards reducing risks and promoting plant safety, so PSM can be a good program for smaller plants also.

The International Institute of Ammonia Refrigeration (IIAR) has developed a similar process safety management plan, tailored for smaller facilities. Facilities affected by OSHA's PSM are also affected by EPA's Risk Management Program (RMP), which is intended to prevent, detect and respond to accidental releases of hazardous chemicals and to inform local communities of the risks.

With an appropriate application of PSM and RMP programs to ammonia refrigeration systems, safety to individuals, communities and the environment is enhanced. However, the application of PSM and RMP programs must be refined and tailored to avoid imposing unreasonable and overly burdensome barriers on new and existing ammonia refrigeration systems.

3. RECOMMENDATIONS

3.1 ASHRAE's Strong Position

ASHRAE has a long history of involvement with the use of ammonia as a refrigerant. Ammonia is considered to be an essential refrigerant in industrial and commercial refrigeration and space conditioning due to its high efficiency and environmentally friendly characteristics. ASHRAE has a significant role to play in encouraging the proper and safe use of ammonia in the following areas: policy; research, standards, codes and guidelines and technology exchange and education.

ASHRAE will:

- Promote authoritative information on ammonia by seminars and publications.
- Continue research on ammonia topics such as handling, application, operation, control of emissions and new technology.
- Maintain and develop standards and guidelines for practical and safe application of ammonia in industrial and commercial refrigeration, food preservation, space conditioning, heat pump systems, winter sports and other applications. Encourage the broad use of ammonia in traditional and new applications.
- Provide programs and publications of innovative designs and application of ammonia..

- Advise governments and code officials with information regarding ammonia.

3.2 Policy

ASHRAE's Ammonia as a Refrigerant Position Document emphasizes the important role that ammonia can play as an alternative to CFC, HCFC, HFO and HFC refrigerants. It also identifies ASHRAE's concerns about the use of ammonia and establishes what the Society will do to encourage and support its proper and safe use as a refrigerant.

Ammonia has been identified by the EPA¹² as a viable alternative to currently used refrigerants because it does not deplete the ozone layer or contribute to global warming. The United Nations Environmental Program (UNEP) has identified ammonia as an excellent refrigerant for replacement of many current CFC and HCFC applications [2010 Technical Options Report] as part of the reassessment of the Montreal Protocol. Other countries, notably Germany, have established policies to encourage and promote the use of ammonia, including the replacement of such HCFC refrigerants as R-22 for applications such as water chillers and commercial refrigeration systems for supermarkets.

Other international organizations have issued positions or statements of support for the use of ammonia as a refrigerant. These include the Australian Institute of Refrigeration, Air-Conditioning and Heating, the International Institute of Refrigeration, the German Institute of Refrigeration, etc.

3.3 Research

ASHRAE is unique among technical engineering societies because it sponsors an extensive member-supported research program. In 2013-2014, the ASHRAE Board of Directors has approved funding for ASHRAE research projects and grant and aid payments of nearly \$3 million. A significant portion of current projects relate to alternative refrigerants, including ammonia. In past years, ASHRAE has promoted several research projects related to various aspects of ammonia refrigeration. The most recent ASHRAE research plan includes a goal to facilitate the use of natural and low global warming potential (GWP) synthetic refrigerants and seek methods to reduce their charge. ASHRAE has had recent and/or current research projects that involve ammonia, including:

- Condensation-Induced Hydraulic Shock Laboratory Study, \$81,800 project managed by TC 10.3 at Georgia Institute of Technology (970-RP).
- Evaporation of Ammonia Outside Smooth and Enhanced Tubes with Miscible and Immiscible Oils, \$115,675 project managed by TC 1.3 at Texas Tech University (977-RP).
- In-Tube Condensation of Ammonia in Smooth and Enhanced Tubes With and Without Miscible Oil, \$147,000 project managed by TC 1.3 at University of Illinois (1207-RP).
- Flow Regime and Pressure Drop Determination for Two-Phase Ammonia Upward Flow in Various Riser Sizes, \$215,240 project managed by TC 1.3 at Danish Technical Institute (1327-RP).
- Evaporation in Flooded Corrugated Plate Heat Exchangers with Ammonia and Ammonia/Miscible Oil, \$97,585 project managed by TC 10.3 at Ghulam Ishaq Khan Institute (1353 RP).

ASHRAE encourages the submission of proposals for new research projects related to refrigeration and other applications that use ammonia. Several future ammonia projects are included in the most recent research plan.

3.4 Standards, Codes and Guidelines

ASHRAE plays a major role in development of voluntary standards and guidelines governing the application and use of refrigerants, including ammonia. In addition, other organizations adopt the technical requirements developed by ASHRAE into various codes and regulations.

The most important ASHRAE standards dealing with ammonia are ANSI/ASHRAE Standard 34-2013, Designation and Safety Classification of Refrigerants¹⁶, and ANSI/ASHRAE Standard 15- 2013, Safety Standard for Refrigeration Systems. Standard 34 classifies ammonia as a Group B2L refrigerant, because of toxicity and flammability concerns. Standard 15 establishes the requirements for safely applying ammonia in refrigerating systems. In general, ammonia can be used in unlimited quantities in direct systems for industrial occupancies. However it must be used in indirect (secondary) systems for commercial and public occupancies, while its general use in small absorption equipment is unrestricted.

The ASHRAE Refrigeration Handbook states that there is renewed interest in ammonia for HVAC systems because of the scheduled phaseout and increasing costs of CFC and HFC refrigerants. While ammonia is inappropriate for direct systems, the use of secondary systems that use ammonia to chill water or another secondary refrigerant are a viable alternative to halocarbon systems for HVAC applications.

Other technical organizations have issued standards/ guidelines addressing the proper application of ammonia as a refrigerant. These standards/guidelines cover the design, installation and operation of ammonia refrigeration systems [ANSI/ IAR 2-2014, ANSI / IAR 4-2015, ANSI / IAR 5-2013, ANSI / IAR 7-2013].¹⁸⁻²⁰ International standards also address safety and application of ammonia [ISO 5149, Refrigeration Safety²¹; ISO 1662, Refrigerating Plants – Safety Requirements; CEN EN 378, Refrigerating Systems Safety and Environmental Requirements].

The proper application of ammonia as a refrigerant is governed by state and local building, mechanical and electrical codes. In the U.S., these codes are issued by various model code organizations such as International Code Council (ICC) and National Fire Protection Association (NFPA). Because of its classification as a hazardous chemical, ammonia is often specifically covered by various requirements in fire codes. The Code Interaction Subcommittee of ASHRAE's Standards Committee will review proposed fire and mechanical codes that could affect refrigeration applications. ASHRAE has established a policy to encourage adoption of ASHRAE standards in model codes.

Electrical codes, especially the National Electric Code²⁴, are relevant to ammonia because ammonia in high concentrations can form flammable mixtures with air. Standard 15 and ANSI / IAR 2-2014 establishes design procedures for applying ammonia, including proper ventilation levels, which are referenced in electrical codes to assure the safe application in buildings.

The advent of low charge, packaged ammonia systems will require code organizations to make provision for their application. Some standards, such as IAR 2 2014, have started to address this, however further work is required from all code organizations to ensure that this new technology can be used to its full potential.

In some cases, very stringent local toxic gas ordinances have been applied to ammonia, even though they were intended to apply to highly toxic chemicals. These types of ordinances can be very restrictive.

3.5 Technology Transfer and Education

ASHRAE plays a very important role in providing technical information on the proper application of ammonia as a refrigerant. In this role, ASHRAE assists in transfer of technology and in education of the technical community. These important activities are carried out through a number of vehicles: ASHRAE Handbook, ASHRAE Journal and ASHRAE Transactions; special publications; and through a number of educational forums.

A major source of technical information on ammonia is the ASHRAE Handbook. The 2013 Fundamentals²⁵ volume contains general information on Thermodynamics and Refrigeration Cycles. (Chapter F2) and on Refrigerants (Chapter F29), including the thermodynamic properties of ammonia. Another major resource for information on ammonia is the 2010 ASHRAE Handbook—Refrigeration volume¹⁷, covering Liquid Overfeed Systems (Chapter R4), Ammonia Refrigeration Systems. (Chapter R2) and Refrigeration System Chemistry (Chapter R6). An additional resource is the ASHRAE publication Thermophysical Properties of Refrigerants [2013].

ASHRAE has published a number of technical papers, articles and special reports addressing the use of ammonia. These include notices and articles regarding ammonia refrigeration in ASHRAE Journal. Technical papers presented at ASHRAE meetings are published in ASHRAE Transactions, and in various special publications. A summary of more than 30 technical articles and references can be found on ASHRAE Online.

Key parts of ASHRAE's technology exchange and education functions are fulfilled by the Annual and Winter Conference technical programs, including seminars, forums, symposia and technical sessions. In addition, the Society offers a self-directed learning course on the Fundamentals of Refrigeration. Local ASHRAE chapters also sponsor refrigeration-related programs and speakers, which have recently shown a strong interest in ammonia.

Technical activities focusing on ammonia are addressed within ASHRAE by the Refrigeration Committee, which is now a standing committee. In addition to the Refrigeration Committee, the Chapter Technology Transfer Committee (CTTC) encourages grass roots regional and chapter activities, which focus on refrigeration. The Refrigeration Committee maintains a speakers list of speakers/topics that includes ammonia. Various technical committees (TCs 10.1, 10.3, 10.5, 1.3, 8.5 etc.) also focus on ammonia-related issues.

REFERENCES

1. US Geological Survey, Mineral Commodities Summaries, January 2011
2. NIOSH Pocket Guide to Chemical Hazards, National Institute for Occupational Safety and Health, September 2007, Publication No. 2005-149
3. IIR Ammonia Data Book, December 1992 (Rev. May 2008), International Institute of Ammonia Refrigeration, Alexandria, VA, p. 4-11.
4. Toxicological Profile for Ammonia, 2004, Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, Department of Health and Human Services, Washington D.C.
5. IIR Ammonia Data Book, December 1992 (Rev. May 2008), International Institute of Ammonia Refrigeration, Alexandria, VA, p. 4-10.
6. IIR Ammonia Data Book, December 1992 (Rev. May 2008), International Institute of Ammonia Refrigeration, Alexandria, VA, p. 3-1.
7. IIR Ammonia Data Book, December 1992 (Rev. May 2008), International Institute of Ammonia Refrigeration, Alexandria, VA, p. 3-3.
8. ASHRAE 2013 *Handbook – Fundamentals, Chapter 29, Table 8, ASHRAE, Atlanta, Ga.*
9. EPA Community Right-to-Know Act (also known as SARA Title III), 42 US Code, 2011
10. ANSI/ASHRAE Standard 15-2013, *Safety Standard for Refrigeration Systems*. ASHRAE, Atlanta, Ga.
11. IIR Ammonia Refrigeration Management Program (ARM), 2005, International Institute of Ammonia Refrigeration, Alexandria, VA.
12. EPA Final Rule for the Significant New Alternatives Program (SNAP), March 18, 1994, 59 CFR 13044.
13. AIRAH Position Statement: Refrigerant -717 (Ammonia), Australian Institute of Refrigeration, Air Conditioning and Heating, Issue No. 1, Jan. 6, 1992.
14. IIR 6th Informatory Note on CFC's and Refrigeration, The International Institute of Refrigeration, November 1990.
15. DKV Status bericht Nr. 5.Sicherheit und Umweltschutz bei Ammoniak-Kalteanlagen, The German Institute of Refrigeration, November 1998.
16. ANSI/ASHRAE Standard 34-2013, *Designation and Safety Classification of Refrigerants*, ASHRAE, Atlanta, Ga.
17. ASHRAE 2014 *Handbook—Refrigeration*, ASHRAE, Atlanta, Ga.
18. Standard for Safe Design of Closed-Circuit Ammonia Refrigeration Systems, ANSI/IIR 2-2014. International Institute of Ammonia Refrigeration, Alexandria, VA
19. Installation of Closed-Circuit Ammonia Refrigeration Systems, ANSI/IIR 4-2015, International Institute of Ammonia Refrigeration, Alexandria, VA
20. Start-up and Commissioning of Closed-Circuit Ammonia Refrigeration Systems, ANSI/IIR 5-2013, International Institute of Ammonia Refrigeration, Alexandria, VA
21. Developing Operating Procedures for Closed-Circuit Ammonia Mechanical Refrigerating Systems, ANSI/IIR 7-2013, International Institute of Ammonia Refrigeration, Alexandria, VA
22. Mechanical refrigerating systems used for cooling and heating - Safety Requirements, ISO 5149-1993, American National Standards Institute, New York, NY.
23. Refrigerating Plants -Safety Requirements, ISO 1662-1971 (Withdrawn).
24. Refrigerating Systems and Heat Pumps - Safety and Environmental Requirements, CEN EN 378:2008, CEN-Comite Europeen de Normalisation, Bruxelles, Belgium.
25. National Electrical Code, NFPA 70-2014, National Fire Protection Association, Quincy, Mass.
26. ASHRAE 2013 *Handbook—Fundamentals*, ASHRAE, Atlanta, Ga.
27. ASHRAE 2014 *Handbook—Refrigeration*, ASHRAE, Atlanta, Ga.

28. Thermophysical Properties of Refrigerants, ASHRAE, Atlanta, Ga. 2013

CTTC REF Consultant Report
ASHRAE Annual Conference – St. Louis 2016

June 24, 2016

ASHRAE Refrigeration Committee (REF)
Consultant Report to
Chapter Technology Transfer Committee
2016 Annual Conference, St. Louis

REF Consultant: Cesar Luis dL. Lim, P.E.
cesarluis.lim@gmail.com

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CTTC REF Consultant Report
ASHRAE Annual Conference – St. Louis 2016

TOPICS

- Refrigeration Update
- Chapter Program Support
- Advance Chapter Interest in Refrigeration

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CTTC REF Consultant Report
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- Refrigeration Update
 - The 2016 ASHRAE Annual Conference will have a Seminar on the Advancements in Compressor Design, Testing and Performance Modeling for New Efficiency Standards and Alternative Refrigerants as follows:

1. Analysis of the Performance Rating Standards of Positive Displacement Refrigerant Compressors by Joe Sanchez
2. Representation of a Positive Displacement Compressor Map with Vapor Injection by Matt Cambio

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- Refrigeration Update
 3. A Study of Methods to Represent Compressor Performance Data over an Operating Envelope Based on a Finite Set of Test Data by Vikrant Aute
 4. Sizing Low and High Compression Stages of Reciprocating Compressor for Optimum Vapor Injection Performance in Economized Cycle by Alex Lifson

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- Refrigeration Update
 - Seminar Session: Ammonia and CO2: Advances in Application

1. Transition to Natural Refrigerants by Brandon France
2. Low Charge Ammonia Case Studies by Andy Peason
3. An Owner Perspective: electronic Refrigerant Injection Control (ERIC) Ammonia Application by John Scherer
4. Transcritical CO2 in a Refrigerated Warehouse by John Gallaher

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CTTC REF Consultant Report
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- Refrigeration Update
 - Seminar: Innovation in a Commercial Refrigeration System with Natural Refrigerants and Low GWP Synthetic Refrigerants

1. Natural, Low-GWP Refrigerants for Light Commercial Refrigeration: Examples of Successfully Converted Application Using, R 290, R 600a and R 744 by Stefan Elbel
2. Reducing GWP with a Low Charge Ammonia/CO2 Chiller by Scott Mitchell

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- **Refrigeration Update**
 - 3. Decreasing Environmental Impact by Using Propane in Refrigerated Display Cases by Sean Gouw
 - 4. Advance Low-GWP Alternatives for Stand-Alone Refrigeration System by Michael Petersen

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**CTTC REF Consultant Report
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- **Refrigeration Update**
Seminar: Lubrication Effects Beyond The Compressor
 1. Managing Lubricants in a Large Commercial Refrigeration System, by Danny Halel
 2. Lubricant Management Heuristics and Impacts on System Chemistry, Valves and Other System Components by Christopher Reeves
 3. Lubricants in Heat Exchangers: A Slippery Slope by Scot Wujek
 4. The Benefits of Using a Coalescing Oil Separator on System Efficiency and Capacity by Marc Scancarello

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**CTTC REF Consultant Report
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- **Refrigeration Update**
 - **ASHRAE Guide for Sustainable Refrigerated Facilities and Refrigeration Systems**
 - Massey University final draft completion is delayed by Two Months (July 2016 new Target date) and approval of the Guide would be completed by October 2016 instead of August 2016
 - Guide will be used for New and Existing Facilities and will be Applicable in Countries Outside U.S.

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**CTTC REF Consultant Report
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- **Refrigeration Update**

First International Conference:
Sustainable Management of Refrigeration Technologies in Mobile Marine and Fisheries Sectors
January 11-13, 2017
Bangkok, Thailand
Co-organized by:
ASHRAE, United Nations Environment Programme, International Institute of Refrigeration, Government of Thailand Division of Industrial Works, and (UNIDO)



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**CTTC REF Consultant Report
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- **REF Webpage with Links**
 - Members First! Tech Council Newsletter
 - **REF Operations**
 - Recent Meeting Minutes
 - Manual of Procedures, Rules of the Board, REF Reference Manual
 - Members First! Newsletters
 - REF Consultant Report to CTTC

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**CTTC REF Consultant Report
ASHRAE Annual Conference – St. Louis 2016**

- **REF Webpage with Links**
 - **REF Resources/Chapter Program Support**
 - To Support Chapters, REF has Developed Refrigeration-themed Program Materials
 - "Tips on Hosting Successful Refrigeration-focused ASHRAE Chapter Meeting"
 - ASHRAE Distinguished Lecturers (DL) list (edited to include only Refrigeration Topics)
 - ASHRAE Refrigeration Speakers list (expanded for improved geographic coverage in developing countries)
 - Sister Refrigeration Organizations

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CTTC REF Consultant Report
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- **REF Webpage**
 - **Refrigeration Technology Awards by REF**
 - Recognize the Designer and Owner of the Refrigeration Project exhibiting the Best Innovation and/or New Technology with Links to:
 - "Milton W. Garland Commemorative Refrigeration Award for Project Excellence"
 - "Refrigeration Comfort Cooling Award for Project Excellence"
 - Awarded at Plenary Session during Annual Conference

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CTTC REF Consultant Report
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- **REF Webpage**
 - **Member Resources**
 - REF Assists Technical Committees (TCs) with Refrigeration Oriented Goals and Provides links to:
 - Refrigeration TC Webpages
 - Refrigeration TC Activity Report
 - Refrigeration-related ASHRAE Research
 - Refrigeration-related Standards and Guidelines

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CTTC REF Consultant Report
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- **Chapter Program Support – Efforts Underway**
 - Encourage Expert Refrigeration Speakers for DL Program
 - Encourage Refrigeration Programs with broad appeal to Chapters
 - Develop list of Refrigeration Programs and Speakers with wide appeal

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CTTC REF Consultant Report
ASHRAE Annual Conference – St. Louis 2016

- **Advance Chapter Interest in Refrigeration**
 - REF seeks to promote Refrigeration Education and Training for Students and Seasoned Practitioners
 - Technology Transfer Programs
 - Refrigeration Programs at ASHRAE Conferences
 - "George C. Briley ASHRAE Journal Award"
 - Best Refrigeration-related Article
 - Awarded at REF Meeting, Winter Conference

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CTTC REF Consultant Report
ASHRAE Annual Conference – St. Louis 2015

- **Advance Chapter Interest in Refrigeration**
 - Standing Columns in ASHRAE Journal on Refrigeration Applications by Andy Pearson, Ph.D. C. Eng.
 - January 2016 - "Remembering Milt Garland"
 - February 2016 – "Food, Glorious Food"
 - March 2016 – "Business as Usual?"
 - April 2016 – "Creating Utopia or Gomorrah?"

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CTTC REF Consultant Report
ASHRAE Annual Conference – St. Louis 2015

- **Advance Chapter Interest in Refrigeration**
 - May 2016 – "Food Price, Quality, Security"
 - June 2016 – "Role of Utilities"

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CTTC REF Consultant Report
ASHRAE Annual Conference – St. Louis 2015

- **Advance Chapter Interest in Refrigeration**
 - REF continues to work with and thru CTTC to Identify and Develop Resources and Implement Programs to enhance Chapter Refrigeration Activities including:
 - Work with the TCs to develop Hands-on, Low Cost Refrigeration Projects for College Lab Classes
 - Present Seminars at ASHRAE Conferences on Refrigeration Topics
 - Promote and solicit applications for Milt Garland, Comfort Cooling, and George Briley Refrigeration Awards
 - Submit recommendations to CTTC for PAOE criteria for Chapter Refrigeration Activities
 - Strongly encourage RVCs to actively promote strong Chapter participation in the recently approved "R in ASHRAE" Award

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CTTC REF Consultant Report
ASHRAE Annual Conference – Atlanta 2015

THANK YOU

For your Participation & Support

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REF Regulatory Update

Matt Ritter
June 2016

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Acknowledgements

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Montreal Protocol

- **High momentum right now**
- **Key remaining issues**
 - Technology (HAT)
 - Baseline and Schedule
 - Finance
 - IP
 - Legal (Trade)
- **Other influences**
 - Codes and standards
 - Ratification
- **Many expecting some type of agreement this year**
- **Updated TEAP Report**
- **July (extended) and October Meetings**
- **Bilateral Meetings**





UNFCCC

- Paris Agreement signing started April 22nd at UN HQ, lasts 1 year

- Cannot take effect until 55 countries, representing 55% of emissions ratify
- 177 signed intention to ratify
- 17 have ratified and 0.04% of global emissions
- US and China expected in 2016, EU in 2017



United Nations
Framework Convention on
Climate Change

- Met once this year

- Few industry observers; conflicts over observer participation
- Objective is to try to improve iNDCs
- Achieving implementation is challenging

- May provide momentum for MP amendment

- Direct impact on HFCs minimal

- For ASHRAE, greater involvement will be in the building efficiency sector and how countries implement iNDCs



U.S. EPA

- Change of status (delisting) rule for HFCs (Round 1)

- Foams, MAC, Commercial Refrigeration, and Aerosols
 - Transition times vary and 134a targeted in certain markets

- SNAP 2.0

- Comment period ended June 16th
 - Chillers – 134a, 407C, and 410A
 - Refrigerated food processing and dispensing – 134a, 404A, and 507A
 - Household refrigerators and freezers – 134a
 - Cold storage warehouses – 134a, 407C, 404A, 507A
 - MVAC – HCFC/HFC blends light duty vehicles
 - Rigid PU spray foam – 134a, 245fa, 365mfc, 227ea, methylene chloride, formic acid
 - Fire suppression – PFCs, SF₆, and 23
- Timelines later than transition dates in Round 1 of SNAP delisting
- Final rule expected by October 1st



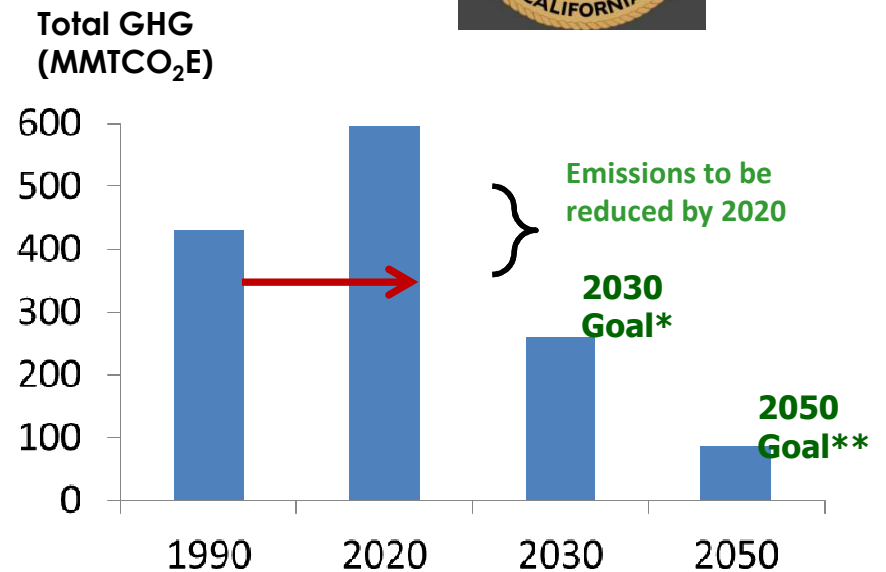
- Section 608 (Refrigerant Management) Proposed Revisions

- Adds HFCs to existing program and updates many sections
- Still under development by EPA

- One more listing rule expected in 2016

CA GHG Emission Reduction Goals

Stationary Refrigeration or Stationary Air-Conditioning Sector	Refrigerants Prohibited in New Equipment with a 100-year GWP Value:	Proposed Start Date
Non-residential refrigeration	150 or greater	January 1, 2020
Air-conditioning (non-residential and residential)	750 or greater	January 1, 2021
Residential refrigerator-freezers	150 or greater	January 1, 2021



* Executive Order B-30-15 and pending legislation

** Executive Order S-3-05

Phase-down, Ban at GWP 2500 in 2020, Incentives

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Regional Regulatory Programs

Australia

- Will to reduce domestic HFC emissions by 85 percent by 2036
- Expected to be cap and phase-down with sector controls, proposal in 2016

Canada

- Published consultation document outlining targeted sectors and hybrid program
- Proposal published in 2016 (Gazette 1) and planned for 2017 (Gazette 2)

European Union

- 1st F-gas review in 2017 concentrating on the quota allocation system and the ban on Multipack systems
- Members states are preparing national regulations to implement the F-gas regulation

Japan

- Manufacturers and importers shall ensure that the weighted average of GWP of domestic shipments does not exceed the target index for sectors

United States

- SNAP 2.0 proposal released in April 2016 and final in Q4 2016
- Product sector bans run from 2020-2025 for this proposed rule



Moving Forward



Patch Work Regulatory Approach to Continue

- In progress and not consistent
- Difficult from a global perspective
- US EPA SNAP a unique program

Codes and Standards

- Barriers remain and limited to certain sectors
- High interest from U.S. government and a number of projects underway
- Training/Safety Critical

Influence of Global Regulation

- Early HFC phase down by developing countries
- Many different alternatives
- Counterfeit and contaminated refrigerants

Refrigeration Committee
Karim Amrane, Chair
Date:6/20/2016

Item #	MBO	Status	Date Due	Assigned To	Applicable Strategy #	MBO Comments	UPDATE
Included in Definition of Roles							
1	Develop and Expand Refrigeration Education & Outreach	OPEN	1/31/2017	Royal, Shockley, Rule	1c, 3d	<ul style="list-style-type: none"> i) Broadcast information on Milton Garland comfort cooling & Briley Awards in ASHRAE Insights and Members Newsletter. ii) Organize ALI Subcommittee. Assist in the development of programs for regional chapters on refrigeration concepts. Liaise with YEA. Royal developing course proposal with ALI. iii) Continue to support Handbook Subcommittee to assist with Refrigeration Handbook chapters. Shockley working with Don Fenton. iv) Update position document on ammonia 	Awards were publicized in January Journal article and Members 1st newsletters. 2 nominations for Milt Garland Award expected. Handbook chapter reviews ongoing with reviewers found through GCCA and ASHRAE CoF. REF exploring ALI course for Las Vegas. PD on ammonia expected for Las Vegas
2	Support of ASHRAE Developing Economy Objectives	OPEN	1/31/2017	Dieryckx, Minor, Coulomb	4a, 4b, 3b	<ul style="list-style-type: none"> i) Training on environmental and safety concerns of alternative refrigerants for developing countries ii) Develop guidance on available alternatives or resources which promote energy efficient alternatives iii) Support dissemination of GRMI principles to developing countries 	REF exploring deliverables requested from Ad Hoc report. Programs relevant to developing economies planned for Las Vegas. ASHRAE is on GRMI steering committee.
3	Implementation of UNEP Partnership Goals	OPEN	Ongoing	Nair-Bedouelle, Aguilo, Robbins	4a, 4b	<ul style="list-style-type: none"> i) ASHRAE & UNEP will explore opportunities to promote responsible and sound management of refrigerants ii) ASHRAE and UNEP to cooperate and coordinate efforts related to energy efficiency in the buildings sector iii) ASHRAE through its Distinguished Lecturer (DL) program will work with UNEP to provide speakers to collaborative activities between UNEP and ASHRAE chapters/sections 	Joint ASHRAE, UNEP, IIR conference on sustainable management of refrigeration technologies in mobile marine and fisheries sectors (Bangkok 2017). Linked to MBO#2 deliverables
4	Serve as the Technical Experts for Refrigeration related issues for ASHRAE	OPEN	Ongoing	Hon, Rajendran, Dieryckx, Minor	3a, 3c	<ul style="list-style-type: none"> i) Provide technical input to Tech Council and/or ASHRAE staff on refrigeration related legislative and regulatory issues ii) Act as a technical resource to RAC and the MTG on Lower GWP refrigerants on the ASHRAE research effort addressing flammable refrigerants 	Ongoing
5	Efficient communication and operation of the REF Committee	OPEN	Ongoing	Amrane, Shockley, past Chairs	2a, 2b, 2c	<ul style="list-style-type: none"> i) Assure Technical Committee alignment ii) Development of a Planning Subcommittee for REF (current and future leadership) iii) Continued collaboration with other REF related organizations 	REF established subcommittee structure to help coordinate liaison activities and assignments. Liaisons with IIR, IAR, GCCA, UNEP assigned. Liaising with ASHRAE TCs, SSPCs as well

IDEA	TOPIC	Initiator	PROPOSED SOLUTION	Action By	Completion Date	STATUS	COMMENTS
2013-5	Bridging the ASHRAE Generations - Forum(s) on topics suggested by YEA - 90.1, Handbook, etc - using Life Members	Larry Markel	Send to Life members and to Yea. Every 6 months set up forms on major initiatives.	Send to YEA - Committee Charlie Culp? 9/22 DD	On going	Draft Letter has been developed and will be forwarded to each YEA and LIFE members committee	Status Update Needed.
2014-20	Add YEA member on TAC	TAC	TAC to make formal motion to Tech Council. Motion will come forward to TechC from TAC in a consultant or liaison position. Jharrod/Jvallort drafting letter.	Completed	On going	MV - 9/22/15 - No not yet, but we did interface with their ExCOM at the Atlanta meeting. Tentative plan to develop a web posted video with YEA on the benefits of joining a TC. Two members of TAC resigned this week so I plan to take this opportunity to suggest we consider filling at least of these	
2014-26	Confirm if there is a standard white paper procedure and if not develop a procedure.	Tech Council/ Assigned to TAC 1/26	White papers can be an alternative to Position Documents		On going. Sent to DRC and on their agenda (St Louis)	9/24 - SH -Has requested that this be part of DRSC's agenda to start discussion.. Is on St Louis agenda	
2014-27	On-line Research Suggestion Box on Member side of ASHRAE website. Grassroot input path for those willing to provide thoughtful input that a topic related TC can consider and possibly act on or refer proposer to completed research.	RAC	RAC is starting to develop and evaluate for feasibility. Grassroot input path for those willing to provide thoughtful input that a topic related TC can consider and possibly act on or refer proposer to completed research.		On going	MV - 9/22/15 - ASHRAE web staff is currently very busy revamping TC website templates and other tasks under new Marketing Dept. I.T. staff support is also needed to develop the online database of suggestions. As a result, this project is on-hold until I.T. and web staff free-up more bandwidth. Action by staff.	
2014-28	On-line database covering ASHRAE's 840+ funded projects since 1960 – currently Excel spreadsheet. ?? Status	RAC/Staff	RAC is starting to develop and evaluate for feasibility.		On going - multi year project	MV - 9/22/15 - Initial online database has been created by ASHRAE I.T. staff. ASHRAE Research staff is now in the process of populating the database with information on about 100 fairly recent projects	
2015-06	Look into a forum to get qualified intertested authors to assist in writing Design Guides, and ASHRAE publications	Erich Binder	TC 5.8 and 9.2 are developing a Hazardous Spaces guide but do not have a formal way of getting interested people outside of the TC's involved.	Erich Binder	Ongoing.	Erich Binder to bring to members council at their November 2015 meeting.	
2016-01	ASHRAE Journal articles should all include dual units for all articles to assure accessibility to international members.	REF Member Martin Diercylox	Request to Journal staff that they assure dual units are included in all articles			Jim Vallort to discuss with Chuck Gullede	

2016-02	<p><i>The key point of my suggestion is to open our meetings to electronic access by our (corresponding) members or others interested. A low budget approach may be to provide a web connection and using skype to open our meeting to those interested to connect (e.g. corresponding members that are not at the meeting/conference would be the primary target audience) and watch the meeting proceedings; possibly, dedicate a short Q&A session in the agenda in order to allow some interaction with web attendees. This may also offer an opportunity to have, if necessary, a dedicated slot in the agenda for short presentations on hot issues or research topics etc., from the electronic participants. This of course will require some preparation/arrangements ahead of time. If skype is not suitable it may be possible to use another electronic platform, but that would probably have a cost that we would probably like to avoid. Having internet connection at the meeting rooms is a trend for our meetings, so I believe that this will not have an additional cost. A dedicated PC would be necessary but as a first step it may be possible to limit this concept for a dedicated time slot in the agenda and use a participant's PC during that period (it will take some coordination but the chair or vc of the participating committee may wish to set an example, at least at the beginning). Depending on the response and engagement, one may then consider expanding the electronic participation/attendance for longer periods in future meetings, e.g. arrange with a com member that has volunteered / committed ahead of time to provide an extra PC during the meeting. One may even consider this in the future as a way of VM to also participate electronically during a full scale electronic meeting. On the other hand, this may not be suitable or a good idea, so that will have to be clearly stated at the time, if and when the full eMeetings are considered. As a first step, the idea of invited speakers for short presos on hot issues or research ideas etc., and maybe a dedicated short session for communication with CM may be a good starting point.</i></p>	<p>Costas Balares EHC Member</p>	<p>CEC Recommendation - Jharrod</p>				
2016-3	<p><i>To have name badges for all attending committee meetings to improve interactions in committee meetings. People could simply go to registration and request a name badge, even if they are not registered for the conference. This idea originated by Barry Bridges.</i></p>	<p>Barry Bridges TAC Member</p>	<p>CEC - w/endorsement</p>				
2016-4	<p><i>To partner with philanthropic organization such as Red Cross or Bone Marrow registry to reach a large number of potential donors. This idea originated by Mike Galler.</i></p>	<p>Mike Galler TAC Member</p>	<p>On Cap Campaign agenda</p>				
2016-5	<p><i>To coordinate some 'technical' activities for kids, similar to programs that are currently organized for Spouses, such as providing bus transportation to local venues of interest or on-site as a kids-club.</i></p>	<p>TAC Member</p>	<p>CEC recommendation and student activities</p>				
2016-6	<p><i>Continue/expand support for ASHRAE Lounge.</i></p>	<p>TAC Member</p>	<p>CEC with thank you</p>	<p>completed</p>			
2016-7	<p><i>Allow for greater use of meeting rooms for technical presentations associated with committees, even if it means that committees are requesting more meeting space. It is a shame to get requests turned down, only to see that the room was available. This can be an excellent way to get more people at our committee meetings, and since this is program that ASHRAE could not fit in its session tracks, there should not be a conflict.</i></p>	<p>TC 7.5 Member</p>	<p>Being addressed in TAC</p>	<p>Ongoing TAC/CEC</p>			
2016-8	<p><i>Attract other associations from the building sciences, such as BOMA, IFMA, APPA, and APE, and offer them a forum to express their comments/ideas to ASHRAE. Ideal forums would include TCs, SPCs, and SSPCs, especially subcommittee meetings associated with these committee types.</i></p>	<p>TC 7.3 John Constantinide</p>	<p>TAC</p>				
2016-9	<p><i>Give members of other building science associations a discount for attendance.</i></p>	<p>TC 7.3 John Constantinide</p>	<p>What is negotiated in the MOU?</p>	<p>Discussed in MOUs</p>			
2016-10	<p><i>Provide transportation awards for YEAs living outside of North America to travel to and attend a winter or annual conference, with the provision that they shadow one or more TC Chairs or attend TC meetings over a certain range of sections.</i></p>	<p>TC 7.3 John Constantinide</p>					
2016-11	<p><i>If not done already, TAC could offer TC Chair mentors for the College of Fellows' Graduate Student Travel Award Recipients. This may be something we can test with Section 7 TC Chairs.</i></p>	<p>TC 7.3 John Constantinide</p>	<p>Being done</p>				

2016-12 *Make available TC Chair and Subcommittee Chair training normally provided at conferences online to accommodate those who are not able to attend a winter or annual conference in person. This may be a good option for those with conference sessions or Society meetings that conflict with these trainings. Have a specific time range set for these training sessions to be made available so that TC Chairs would need to provide Section Heads with training attendance information after the conference.*

TC 7.3 John Constantinide To TAC for consideration

2016-13 *Certification etc...*

JH sent ltr to CEC and Cert Comm