

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

**1791 Tullie Circle, N.E./Atlanta, GA 30329
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TC/TG/TRG MINUTES COVER SHEET

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

TC/TG/TRG NO. TC 8.5 DATE December 1, 2010

TC/TG/TRG TITLE Liquid to Refrigerant Heat Exchangers

DATE OF MEETING Monday, June 28, 2010 LOCATION Albuquerque, NM

| MEMBERS PRESENT | YEAR APPTD | MEMBERS ABSENT | YEAR APPTD | EX-OFFICIO MEMBERS AND ADDITIONAL ATTENDANCE |
|-------------------------------|------------|-------------------------------|------------|--|
| Amir Jokar | 2008 | John Thome | 2008 | Mark Kedzierski |
| Petur Thors | 2009 | James Bryan | 2008 | Liping Liu |
| Joe Huber | 2009 | Jim Bogart | 2008 | Rupal Choksi |
| Ken Schultz | 2008 | <i>Corresponding Members:</i> | | Evraam Gorgy |
| Satheesh Kulankara | 2008 | Michael Ohadi | 2001 | James Schaefer |
| Zahid Ayub | 2008 | Keith Starner | 1993 | Jun Wang |
| Andreas Knoepfler | 2008 | Tom Ortiz | 2008 | Edvin Cetegeu |
| | | Ty Newell | 2005 | Jacob Wagner |
| | | Josua Meyer | 2005 | Trevor Houck |
| <i>Corresponding Members:</i> | | Parviz Payvar | 2008 | Kevin Dunshee |
| Axel Kreigsmann | 2008 | Lorenzo Cremaschi | 2009 | Tony Jacobi |
| Steve Eckels | 2008 | Mahesh Valiya-Naduvath | 2008 | |
| Ben Dingel | 2007 | Jamal Yagoobi | 2008 | |
| Ebrahim Al Hajri | 2009 | Olivier Pelletier | 2004 | |
| Stanislav Perencevic | 2009 | Samuel Yana-Motta | 2009 | |
| Omar Abdelaziz | 2009 | Kash Oza | 2008 | |
| Justin Kauffman | 2009 | Michael Taras | 2009 | |
| Andreas Beutler | 2009 | Dan Kihm | 2009 | |
| William McQuade | 2002 | Harry Li | 2009 | |
| Art Fovargue | 2009 | Jeb Schreiber | 2009 | |

DISTRIBUTION

All Members of TC/TG/TRG plus the following:

| | |
|---|---|
| TAC SECTION HEAD: | William McQuade |
| TAC CHAIR: | Charles Wilkin |
| ASHRAE MANAGER OF RESEARCH AND TECHNICAL SERVICES: | Michael R. Vaughn, P.E. |
| ALL COMMITTEE LIAISONS AS SHOWN ON TC/TG/TRG ROSTERS: | Filza Walters — ALI/PDC Richard Hermans — RAC Research Liaison Nathan Hart — Chapter Technology Transfer Liaison John Clark – Special Publications Martin Dieryckx– Standards Liaison |

ADDITIONAL DISTRIBUTION

| | |
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| MANAGER OF STANDARDS | Stephanie Reiniche |
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**AMERICAN SOCIETY OF HEATING, REFRIGERATION,
AND AIR-CONDITIONING ENGINEERS, INC.**

Minutes

Technical Committee 8.5

Liquid-to-Refrigerant Heat Exchangers

June 28, 2010

2010 ASHRAE Annual Conference, Albuquerque, NM, June 26-30, 2010

1. Call to Order and Reading of TC8.5 Scope

Chairman Amir Jokar called the meeting to order at 4:23 pm. The scope of TC 8.5 was read: "TC8.5 is concerned with the thermal and mechanical design, performance, and application of devices for accomplishing heat transfer between refrigerants (including secondary refrigerants) and liquids. Such devices include liquid cooled refrigerant condensers and refrigerant evaporators for cooling liquids".

2. Introduction of Members and Guests (Sign attendance sheet)

Members and guests introduced themselves. Please note that attendees should provide their email address on the circulated sign-up sheet at the meeting if they want to be assured of receiving committee meeting minutes. The following were present:

| | |
|--------------------|-------------------------------|
| Amir Jokar | ThermoFluids Tech |
| Ben Dingel | Trane |
| Steve Eckels | Kansas State University |
| Ken Schultz | Trane |
| Zahid Ayub | Isotherm, Inc. |
| Art Fovargue | James Madison University |
| Petur Thors | Wolverine Tube, Inc. |
| Satheesh Kulankara | Johnson Controls |
| Joe Huber | Alfa Laval |
| Axel Kriegsmann | Wieland-Werke AG |
| Andreas Knoepfler | Wieland-Werke AG |
| Andreas Beutler | Wieland-Werke AG |
| Justin Kauffman | JCI |
| Bill McQuade | JCI |
| James Schaefer | HTRI |
| Omar Abdelaziz | Oak Ridge National Laboratory |
| Ebrahim Alhajri | The Petroleum Institute |

| | |
|----------------------|-------------------------|
| Rupal Choksi | AHRI |
| Stanislav Perencevic | Gunter AG&Co KG |
| Kevin Dunshee | Carrier Corp. |
| Evraam Gorgy | Kansas State University |
| Trevor Houck | SWEP North America |
| Jacob Wagner | Kansas State University |
| Edvin Cetegeu | ORNL |
| Jun Wang | Trane/Ingersoll Rand |
| Mark Kedzierski | NIST |
| Liping Liu | University of Illinois |
| Tony Jacobi | University of Illinois |

3. **Establish Quorum Requirements**

Voting members present were: Amir Jokar, Zahid Ayub, Andreas Knoepfler, Ken Schultz, Joe Huber, Petur Thors, and Satheesh Kulankara. Voting members absent were: John Thome, Jim Bogart, and James Bryan. With seven of ten voting members present, the quorum was satisfied.

Votes below are listed as [for-against-abstain] and should add up to seven.

4. **Review/Approve Previous Meeting Minutes**

Minutes from the previous meeting (Orlando) were circulated prior to the meeting. The committee voted [7-0-0] to approve the minutes as circulated. Meeting minutes will become official and re-circulated.

5. **Chairman's Comments**

Chairman Amir Jokar noted that this was his last meeting serving as chairman. Amir expressed appreciation and thanks to committee members for work done during his tenure.

6. **Section Head Comments**

Section Head Bill McQuade offered the following comments:

- Bill offered some clarification and comments related to membership:
 - Voting members are assigned annually by the chairman
 - Bill suggested staggering assignments so that not all voting members roll off (of voting status) at the same time. The committee may want to consider having members rolling off of voting status early (before 4 year tenure is up) if it would result in better staggering.
 - Bill suggested keeping list of corresponding members only to those active and interested in the committee's work. It could be beneficial to send an email to members to make sure they are interested in remaining on the membership list.

- Bill presented Amir with a certificate of Appreciation for his tenure as TC8.5 committee chairman. Congratulations Amir.
- Bill suggested that, if possible, any small subcommittee meetings be conducted by phone or web meeting to avoid using up meeting space to allow more programs. GoToMeeting is recognized by ASHRAE and is an example of a suitable web conferencing software tool.
- Bill reminded the committee that there are two service awards that committee members may be eligible for. Both the ASHRAE Distinguished Service Award and Exceptional Service Award are available to members meeting the required service "point" requirements. Bill suggested maintaining an accurate ASHRAE biography (stored online) and reviewing the point system to determine eligibility.

7. Comments from Liaisons (Handbook, Standards, Journal, Research, Program, TEGA, Technical Services, Refrigeration)

No liaisons were present.

8. Handbook Subcommittee Report

Subcommittee chair Jim Bogart was absent but provided an update to Ami via email with the following content:

- TC8.5 is responsible for two chapters in the ASHRAE Handbook, HVAC Systems and Equipment volume
 - Chapter 38 – Condensers (liquid-cooled sections only)
 - Chapter 41 – Liquid Coolers.
 - the next publication will be 2012.
- There are four members of TC8.5 who have agreed to review chapters for which we are responsible.
 - Andreas Knoepfler, Wieland-Werke (Ch. 41)
 - Satheesh Kulankara, JCI (Ch. 38)
 - Justin Kauffman, JCI
 - Kash Oza, Standard Refrigeration / Alfa Laval (Ch. 41)
- Status of reviews
 - Three members have already submitted their first reviews.
 - Andreas made several minor editorial corrections and suggested that we evaluate whether information from RP1316 will be available to include. This is contingent on project completion and approval of the final report.
 - Satheesh made several editorial corrections and added a discussion on the results of two of Steve Eckels' ASHRAE projects. He also suggested that we change **Figure 1 – Heat Removed in Condenser** from showing R-22 data to a current refrigerant, such as R-134a.
 - Kash has no suggested changes.
 - Awaiting input from Justin
- 2012 volume schedule & milestones
 - Year 1, July 1, 2008 to June 30, 2009 - committee to be established (TASK COMPLETE)
 - Year 2, July 1, 2009 to June 30, 2010 - Chapters to be reviewed by volunteers (TASK UNDERWAY with reasonable progress made)
 - Year 3, July 1, 2010 to June 30, 2011 - Final revisions to be made and final approval vote complete for entire TC
 - July / August 2011 – submit final chapter versions (I don't have the final deadline but it usually occurs in this timeframe)

The committee agreed that following the completion of RP-1316, that the PI should be asked to submit potential handbook updates.

9. Program Subcommittee Report

Subcommittee chair Omar Abdelaziz reported on Program status.

TC8.5 co-sponsored Seminar 75 “Recent Advances in Heat Transfer and Fluid Flow” held at the Orlando Winter Meeting. Attendance to this seminar was good. TC8.5 is co-sponsoring Seminar 61 “Refrigeration Systems Using Environmentally-Friendly Refrigerants” at this meeting (Wednesday).

Amir Jokar reported that he had submitted a Conference Paper and it was accepted. It is unclear if this submission will evolve into a conference session. For conference papers, authors submit papers assigned to a specific “track” and the evolution of an actual program is not in the hand of the TC. If there is at least 2 papers on a general topic, then a conference session is the likely result.

Amir clarified that the current policy of ASHRAE is to record Seminars. Conference paper sessions are not recorded, but these result in published documents (ASHRAE Transactions).

Omar reminded the committee that when programs are submitted, only the topic is really considered (not presenters or titles of presentations). If the topic does not relate well to the major theme of upcoming meetings, it could be passed over for other alternatives.

Omar agreed to clarify if journal papers submitted to the Journal of HVAC&R Research can be used as a program session set up by the TC.

Potential future programs include Seminars from committee sponsored research and Forum(s) discussing appropriate research paths for new synthetic refrigerants that are gaining traction in the industry.

10. Membership Subcommittee Report

Subcommittee chair Kash Oza was absent.

Ben Dingel is the current Vice Chairman and will become Charmain following this meeting. Ebrahim Al-Hajri will serve as Secretary following the next meeting. Justin Kaufmann volunteered to fill the Vice-Chair position.

11. Standards Subcommittee Report

Joe Huber reported activity related to two standards for which the committee has responsibility.

Proposed Standard 181 - Methods of Testing for Liquid-to-Liquid Heat Exchangers. Six volunteers have offered to serve on the committee for developing this standard. This committee needs to be approved by ASHRAE before “official” work can begin. Approval is expected at this meeting. The committee needs to have an appropriate balance of members in the eyes of ASHRAE (industry, academics, etc.). Joe stated he would like to have a standards (sub)committee meeting related to this standard in Las Vegas.

Joe then mentioned Standard 22 - Methods of Testing for Rating Water-Cooled Refrigerant Condensers. Previously, the committee voted to revise this standard. The appropriate paperwork was submitted and Joe has not yet received any word as to status.

12. Journal/Insights/Webmaster Subcommittee Report

Webmaster Joe Huber reported that he continues to update the committee website as needed, with no major changes noted. The URL for TC 8.5's website is:
<http://www.tc85.ashraetcs.org/>.

13. Research Subcommittee Report

[Secretary's Note: Ken prepared a summary of TC8.5 research activities and circulated this via email (dated 7/20/2010) to the committee. Material reprinted from this email is highlighted in *italics* below (thank you - Ken).]

In addition to the discussion of specific research projects (see below), Research Subcommittee Chairman Ken Schultz reported on information shared at the Research Chair Breakfast.

The Research Strategic Plan 2010-2015 has been published; <http://www.ashrae.org/technology/page/39>. "The plan identifies key HVAC&R research needs and provides that information to ASHRAE members and technical committees as guidance while they develop research projects and to the Research Administration Committee as it approves and funds research proposals. The Research Plan is not meant to take the initiative for research design from the cognizant committees, but rather to use input from ASHRAE members to identify strategic research needs that are appropriate for many committees to collaborate on, that may require larger budgets, and for which additional outside funding may be available to supplement ASHRAE's budget." RTAR's don't need to explicitly fit into the RSP. They do need to describe how the project will benefit ASHRAE and society. "If it's good research, it will get funded."

RAC is consulting with the following organizations as it reviews, prioritizes, and selects research projects: AHRI, CIBSE, CEC (California Energy Commission), and USGBC.

Some budget numbers:

| | <i>FY 2010-2011</i> | <i>FY 2011-2012</i> |
|-------------------------------|---------------------|------------------------|
| <i>current commitments</i> | <i>\$2,616,000</i> | <i>\$802,000</i> |
| <i>additional commitments</i> | <i>310,000</i> | <i>1.7M-2.2M</i> |
| <i>total commitments</i> | <i>\$2,926,000</i> | <i>for Spring 2011</i> |

About 15 projects were awarded at Louisville; these consumed a good share of the available funds. The remaining funds may allow 1-3 projects to be awarded this fall. The remaining (~20) TRP's in the queue are expected to be awarded in Spring 2011. So, it is a good time to submit new RTAR's.

The Research Manual has been updated. Existing RTAR's can continue to refer to the old Research Strategic Plan (2005-1010), new RTAR's should refer to the new Plan (2010-2015). Again, research proposals do [not] have to directly address the plan, but those that do will likely be given higher priority.

New forms have been created for RTAR and WS evaluations. The forms attempt to categorize the evaluation criteria and responses by RAC members. Criteria include well established need, appropriateness for ASHRAE, reasonable budget, etc. The forms are meant to provide a means for documenting RAC comments/questions and transmitting them back to the TC's more consistently and clearly.

As a project deliverable, only papers submitted to the HVAC&R Research journal and as Transactions Technical paper are acceptable; "Conference" papers are not acceptable (not as rigorously reviewed). PMS members will be invited to review these papers (through Manuscript Central). There is expectation that the PMS will have already reviewed [any] papers prior to submission. Papers need only be submitted to meet the project deliverable, not necessarily accepted. This prevents final payment to the PI being impacted by potential tardiness in or length of the review process.

Following is a summary of TC8.5 sponsored research projects and the status of each project.

1316-RP – Experimental Evaluation of the Heat Transfer Impacts of Tube Pitch in a Highly Enhanced Surface Tube Bundle

Current Status: Active

The Principal Investigator for this project is Steve Eckels at Kansas State University. A summary of the research progress was presented at the Sunday research review.

A durable design for the in-tube thermistors has finally been achieved. The original plastic thermistors were cracking and failing under the stress of the high water pressure. The thermistors are now embedded in a hollowed-out set screw. With this problem solved, data collection is now proceeding at a good pace.

Data has been collected on the bundles with P/D ratios of 1.167 and 1.33 using R134a. Local heat transfer coefficients (HTC) have been computed and plots created. Heat flux is the dominant factor in HTC. Mass flux has some influence at low heat fluxes. HTC decreases with quality at higher heat fluxes.

Local HTC's increase to a peak around a local heat flux of 10 kW/m² (3000 Btu/hr-ft²) and then decrease to a plateau. For P/D = 1.167, the plateau is well below the pool boiling curve. Curiously, bundle performance appears to increase for P/D = 1.33; both the peak and the plateau are higher than for P/D = 1.167.

The endplates for the bundle with P/D = 1.5 are being prepared. Data collection should take several weeks. Following this, testing with R123 will commence. Analysis of the data will continue with a draft final report expected to be submitted for review prior to the Las Vegas meeting in Jan11.

A paper on "Pool Boiling of R-134a and R-123 on Smooth and Enhanced Tubes, Average Heat Transfer Coefficient Analysis" has been approved for publication in HVAC&R Research. A paper describing the local heat transfer measurements on water heated tubes undergoing pool boiling is in development.

The PI proposed holding monthly meetings via electronic means to keep the PMS (and others as interested) updated on progress and results. The PI will initiate the meeting invitations.

PMS Chairman Petur Thors noted that the principal investigator will hold a GOTO meeting prior to converting the test section to P/D = 1.5. Petur made a motion for a no-cost extension for 1316-RP through April 2011. The motion was seconded by Ken Schultz and approved with one abstention due to absence from the room [6-0-1].

1345-RP – Waterside Fouling Performance of Brazed-Plate Type Condensers in Cooling Tower Applications

Current Status: Active.

The Principal Investigator for this project is Lorenzo Cremaschi at Oklahoma State University. A summary of the research progress was given at the Sunday research review.

Tests have been completed on the first three BPHE's (A1, A2, and A3) with the high fouling potential water at 105°F refrigerant saturation temperature. The fourth BPHE (A4) has been under test for about 30 days. The A1 BPHE with the "soft" chevron angle (30°) had a fouling resistance that steadily increased to a value of ~0.002 hr-ft²-°F/Btu. The fouling resistances in the A2 and A3 BPHE's with the "hard" chevron angle (60°) were roughly an order of magnitude less than this. The A4 BPHE is showing about the same fouling as the A2 and A3, but with more oscillatory behavior. The A3 BPHE (long, narrow aspect) experienced a very

large increase in pressure drop, as much as 3.5 times the clean value. Speculation continues that localized buildup of precipitate is occurring near the exit ports.

The test matrix calls for testing two of the geometries at a higher saturation temperature (120°F) with the high fouling potential water and one of the geometries with a medium fouling potential water at 105°F. In addition, it is proposed to run a test of a smooth tube in an attempt to provide a means of comparing fouling between BPHE's and tubes in the same physical and chemical setup. Testing is now projected to run through next summer.

Ken Schultz made a motion to allow a 1 year no-cost extension to 1345-RP until October of 2011. The motion was seconded by Joe Huber and approved with one abstention due to absence from the room [6-0-1].

1394-RP – Study of Carbon Dioxide Condensation in a Chevron Angle Plate Geometry Exchanger

Current Status: Active

The Principal Investigator for this project is Amir Jokar, previously of WSU-Vancouver.

The PI worked with the PMS to address questions about the draft final report. The PMS recommended approval of the final report on 01-May. The committee approved the final report by email ballot with the resulting vote (9 approve / 0 reject / 1 abstain / 1 no response) submitted to Donna Daniel on 11-May-2010.

ASHRAE still needs the "Disposition of ASHRAE Sponsored Research Results" form – Zahid will complete this.

Future Research Projects

The topic of potential future research projects was discussed. Ken offered the following summary of this discussion:

- *1556-WS: Characterization of Liquid Refrigerant Flow Emerging from a Flooded Evaporator Tube Bundle. author: Jon Hartfield
This project is being led by TC 1.3, with TC 8.5 as a cosponsor. The work statement was approved by RAC at the Louisville meeting (Jun09). This project is likely to go out for bid in Spring 2011.*
- *TC 3.6 (Water Treatment): How Mechanical Filtration of Cooling Loops Affects Efficiency of Equipment with Enhanced Tubes. RTAR being drafted(?)
Ken provided some background/bibliography on fouling to Scott Mayes following the previous meeting, but has not heard anything more. Ken will follow up to learn status of this project idea. TC 3.6 might also be interested in cosponsoring the fouling projects listed below.*
- *"Fouling of Tube-in-Tube Type Condensers" This would continue our line of projects attempting to quantify the impact of fouling on heat transfer performance in various types of exchangers. It appears that 1345-RP has determined a procedure for successfully running (precipitation) fouling tests. The consensus during the TC 8.5 meeting was that it is time to start working on an RTAR. (But did anyone volunteer to lead the draft of an RTAR?) In the past, AHRI has indicated cofunding might be available for this project; Ken will contact AHRI to determine interest at this time. HTRI has expressed interest in doing this project.*
- *There was also consensus that the timing is right for resubmission of the fouling in enhanced tubes WS. A new WS should account for the fact that low fouling potential water did not produce any measurable fouling effect. It has also been suggested that we consider adding a modeling aspect – how should fouling be described (ie, is " $\beta_2 \cdot FF$ " the correct/best description)? This topic has also been raised in TC 8.2. Joe, Ben, and Ken volunteered to draft an RTAR.*

- *“Enhancement of Internal Flow Heat Transfer Coefficient with Micro-Encapsulated Phase Change Material” No champion has stepped forward for this project idea and so it will be dropped.*
- *“Characteristics of new low GWP refrigerants in heat transfer equipment” The interest in this topic continues to increase. Some concern was expressed that thermodynamic properties are not yet well enough established to do exacting heat transfer performance calculations. It was suggested that attention at this point could be placed on performance of the new refrigerants relative to today’s refrigerants. It was noted that DOE and it’s contractor Navigant Consulting are preparing a report on or roadmap for alternate refrigerants. **Post-meeting, Joe initiated contact with TC’s 1.3, 3.1, 8.4, and 8.5, along with Sam Yanna Motta and Jon Hartfield, to begin a coordinated effort to address this topic.***
- *“New Technologies for Reducing Refrigerant Charge” This topic was proposed by Samuel Yana Motta as a corollary to the project on low GWP refrigerants because of their main drawbacks (many of them are flammable or toxic to some degree and some will be expensive). One comment made was that this topic might be difficult to pursue from a pre-competitive position.*
- *“CO2 in Secondary Loops” This topic was raised by Omar Abdelaziz at previous meetings, but not discussed specifically this time. The rationale is that the flammable and/or toxic nature of the natural and new low GWP refrigerants might require use of secondary loops to separate these fluids from occupied spaces.*
- *“Nanofluids for HVAC” This topic also being considered by TC 1.3. As part of his New Investigator project, Amir Jokar has compiled an extensive bibliography of work in this area. Ken Schultz reported the results of a benchmarking exercise recently conducted on measurements of the thermal conductivity of various nanofluids. “Nan et al.’s theory was found to accurately reproduce the [exercise’s] experimental data, thus suggesting that no anomalous enhancement of thermal conductivity was observed in the nanofluids tested in” the benchmarking exercise. Published reports in the area of boiling/evaporation using nanofluids, although agreeing that critical heat flux can be increased, are inconsistent with regard to improved or degraded heat transfer coefficients and remain uncertain as to the fundamental phenomena occurring. The consensus was that this field remains too young and uncertain for us to play an effective role, at least in the short term.*

14. **New Business**

No additional items.

15. **Schedule Next Meeting**

The next committee meeting will be held on January 31, 2010 at 4:15 PM in Las Vegas, NV.

16. **Adjourn**

Following all discussions, the meeting was adjourned by majority vote [6-0-1].