(Minutes of all meetings are to be distributed to all persons listed below within 60 days following the meeting.)

TC/TG/TRG No. TC 4.7 DATE: June 30, 2015

TC/TG/TRG TITLE: Energy Calculations

DATE OF MEETING: June 30, 2015 LOCATION: Atlanta

**MEMBERS PRESENT** | **YEAR** | **MEMBERS ABSENT** | **YEAR** | **EX-OFFICIO MEMBERS & ADDITIONAL ATTENDEES**
---|---|---|---|---
Joe Huang (CHAIR) | 2012 | Dr. Michael Wetter | 2011 | See attendance sheet additional attendees
Bass Abushakra (VICE CHAIR) | 2012 | Dr. Daniel E Fisher | 2011 |
Dr Jeff Haberl. PhD (Research) | 2015 | Chris Balbach (SEC) | 2013 |
Joel Neymark (Standards Chair) | 2011 | Keith Cockerham (Prg) | 2013 |
Dr Wangda Zuo | 2013 | | |
Dr Kamel Haddad, PhD | 2013 | Dr. Malcolm Cook | 2012 |
Erik Kolderup (Handbook) | 2013 | | |
Joshua New (Webmaster) | 2015 | | |
Dru Crawley (SCM) | 2015 | | |
Ralph Muchleisen (DDM) | 2013 | | |
Ron Judkoff (Applications) | 2013 | | |
Tim McDowell | 2015 | | |
Chip Barnaby | 2015 | | |

Total attendance of voting members: 7 present, 5 absent.

**DISTRIBUTION**

**ALL MEMBERS OF THE TC/TG/TRG**
TAC CHAIR: Walter T. Grondzik
TAC SECTION HEAD: Michael R. Bilderbeck
SPECIAL PUBLICATIONS LIAISON: James Dale Aswegan
STANDARDS LIAISON: David P Yuill
HANDBOOK LIAISON:
RAC RESEARCH LIAISON: Hugh D. McMillan
PROF DEV COMM LIAISON: Harris Sheinman
CHAP TECH TRANSFER LIAISON: Michael Vaughn
STAFF LIAISON (RESEARCH): Michael Vaughn
STAFF LIAISON (TECH SERVICES): Michael Vaughn
STAFF LIAISON (STANDARDS):

**HANDBOOK RESPONSIBILITIES**

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<th>Chapter Title</th>
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-- Page 1 --
These draft minutes have not been approved and are not the official, approved record until approved by this committee.

ASHRAE TC 4.7 Energy Calculations
Atlanta Meeting

MOTIONS AND ACTION ITEMS

MOTION: A motion passed to review the minutes from the Atlanta meeting; 6-0-0 CNV.

MOTION: Orlando Program: 4 Seminars and 1 Workshop are proposed, including a Seminar on Calibration (DDM) and a Seminar on Technology Performance (SCM). A motion to approve the Program by Judkoff, Kolderup seconded motion to approve the program (6-0-0-CN).
### TC/TG/TRG MEETING SCHEDULE

<table>
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<tr>
<th>LOCATION – past 12 months</th>
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### TC/TG/TRG SUBCOMMITTEES

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### RESEARCH PROJECTS – Current

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### LONG RANGE RESEARCH PLAN

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### STANDARDS ACTIVITIES - List and Describe Subjects

- SPC 140 Standard Method of Test for Building Energy Software – Ronald Judkoff
- SPC 205 Data Exchange Protocols for Energy Simulation of HVAC&R Equipment Performance - Chip Barnaby
- SPC 209 Energy Simulation Aided Design – Jason Glazer

### TECHNICAL PAPERS from Sponsored Research - Title, when presented (past 3 yrs. present & planned)

Appendix 3

### TC/TG/TRG Sponsored Seminars - Title, when presented (past 3 yrs. present & planned)

Appendix 4

### TC/TG/TRG Sponsored Forums - Title, when presented (past 3 yrs. present & planned)

Appendix 5 - NONE

### JOURNAL PUBLICATIONS - Title, when published (past 3 yrs. present & planned)

None
**Attendance**

Below is a complete listing of attendees at this meeting. It includes the voting members of the committee listed on the first page.

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-- Page 4 --
### Active projects

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<thead>
<tr>
<th>#</th>
<th>Title</th>
<th>Joint TC</th>
<th>Cog SC/ Contractor</th>
<th>PMSC</th>
<th>Dates / status</th>
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<tbody>
<tr>
<td>1588-RP</td>
<td>Representative layer-by-layer descriptions for fenestration systems</td>
<td>4.5</td>
<td>SCM/ White Box Technologies</td>
<td>Haberl</td>
<td>Haberl reported. Contractor doing well and proceeding. Primary tool will be using multilayer properties with EnergyPlus. Final Report in October 2015.</td>
</tr>
<tr>
<td>1629-RP</td>
<td>Testing and Modeling Energy Performance of Active Chilled Beam Systems</td>
<td>5.3</td>
<td>Applications/</td>
<td></td>
<td>Due for completion in May 2016</td>
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### Completed projects

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<th>PMSC</th>
<th>Dates / status</th>
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<tbody>
<tr>
<td>1416-RP</td>
<td>Development of Internal Surface Convection Correlations for Energy and Load Calculations</td>
<td>4.1</td>
<td>SCM., Univ of Texas</td>
<td>Dan Fisher (Chair), Steve Bruning, Jan Kosny</td>
<td>Completed. Final report approved by Full Committee in Chicago Jan 24, 2012.</td>
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<tr>
<td>1413-RP</td>
<td>Developing standard procedures for filing missing weather data</td>
<td>4.2</td>
<td>Oklahoma State University</td>
<td></td>
<td>Completed.</td>
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</table>
# RESEARCH PLAN

**ASHRAE**  
Technical Committee 4.7 Energy Calculations  
Research Plan (July 1, 2014)

<table>
<thead>
<tr>
<th>Title</th>
<th>Society status</th>
<th>TC 4.7 Status</th>
<th>Actors or TC 4.7 Prime Contact</th>
<th>Subcommittee*</th>
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<tbody>
<tr>
<td><strong>Active co-sponsored projects led by another TC</strong></td>
<td></td>
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<tr>
<td>1413-RP Developing standard procedures for filing missing weather data (TC 4.2 lead)</td>
<td>Completed</td>
<td>Completed</td>
<td>Chip Barnaby (member TC 4.2)</td>
<td>DDM</td>
</tr>
<tr>
<td>1588-RP Representative layer-by-layer descriptions for fenestration systems with specified bulk properties such as U-factor and SHGC (Co-sponsor TC 4.5)</td>
<td>In Progress</td>
<td>In Progress</td>
<td></td>
<td>SCM</td>
</tr>
<tr>
<td>1629-RP Testing and Modeling Energy Performance of Active Chilled Beam Systems (Co-sponsor tc 5.3)</td>
<td>In Progress</td>
<td>In Progress</td>
<td></td>
<td>APP</td>
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<tr>
<td><strong>WS approved by TC</strong></td>
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<tr>
<td><strong>WS under development</strong></td>
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<tr>
<td>1661-RTAR Modelica Models for the Evaluation of Supervisory Control Strategies in the ASHRAE Handbook.</td>
<td>Sent back to authors,</td>
<td>Re-writing the WS, due back to RAC by Aug 15, 2015, now includes referenced to Open Source Modelica software</td>
<td>Wetter, Zuo</td>
<td>SCM</td>
</tr>
<tr>
<td>1666-WS Experimental Evaluation of the Thermal and Ventilation Performance of Stratified Air Distribution Systems Coupled with Passive Beams</td>
<td>Work Statement needs to be presented to TC4.7</td>
<td>Generated by TC 5.3 and submitted without TC 4.7 co-sponsorship</td>
<td>Fred Bauman</td>
<td>SCM</td>
</tr>
<tr>
<td>1050-RTAR Development of an Improved Inverse Model Toolkit (RP1050) and Diversity Factor Toolkit</td>
<td>RTAR approved by RAC in February 2015, needs WS</td>
<td>Haberl to provide revised WS for Orlando.</td>
<td>Jeff Haberl</td>
<td>DDM</td>
</tr>
</tbody>
</table>

-- Page 7 --
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<tr>
<th>RP for supporting the ASHRAE BEQ Rating Program</th>
<th>Proposals have been submitted. They will be evaluated and a recommendation will be made in Orlando. May be awarded</th>
<th>TC 4.7 is a co-sponsor along with TC 7.6.</th>
<th>M. Brandemuehl</th>
<th>APP</th>
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## Appendix 3

### TECHNICAL PAPERS FROM SPONSORED RESEARCH

<table>
<thead>
<tr>
<th>RP</th>
<th>Title</th>
<th>Contractor</th>
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<tr>
<td>ID</td>
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<td>Institution</td>
<td>Date</td>
<td>Authors</td>
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Appendix 4

Atlanta Summer Meeting TC/TG/TRG SPONSORED SEMINARS

PRESENT:

Tuesday 11:00 AM-12:00 AM
Seminary 48
Model Predictive Control: Application to Chilled Water Plants and Radiant Slab Cooling
Room: 204/205

PLANNED:

Orlando

Seminar 59: Simulation Calibration Methods: Which Should I Choose?
Seminar 67: Simulation for Cutting–Edge Building Design
Workshop 2: ASHRAE Standard 205P: Better Data, Better Models, Better Results
MINUTES
ASHRAE TC 4.7 Energy Calculations – Main Meeting
Atlanta, GA
Tuesday, June 30, 2015, 6:00-8:30 pm

Minutes (recorded by Bass Abushakra)

1. Roll Call at 6:10 pm, 7 Voting Members present. 3 Voting Members are rolling off after Atlanta (Abushakra, Fisher, Wetter). 2 Corresponding Members are rolling on after Atlanta (Crawly, Haberl). See Roster for attendance.

2. Minutes from Chicago reviewed. Kolderup moved, Judkoff seconded to approve the Minutes 6 – 0 – 0-CNV Motion passes.

3. Announcements/Liaisons:
   New standard MOT to determine heat gains from office equipment was released.
   Upcoming workshops and conferences:
   IBPSA World - Hyderabad.

4. Membership: 12 voting members, 7 present, 5 absent
   Absent: Balbach, Cockerham, Cook, Fisher, Wetter.

5. Subcommittee Reports:

5.1 Applications (Judkoff):
   Program: 2 seminars for Orlando (Calibration 2.0; Technology Performance Exchange and building component library). 2 papers accepted and will be presented in St. Louis, 1 for St Louis (Standard 209).
   RTAR’s: 1 written.

5.2 DDM (Muehleisen):
   19 people were present. Discussed program. Calibration seminar (with Applications) for Orlando.
   WS: Based on Jeff Haberl’s RTAR (updating the Toolkit). Discussion between Haberl and Jump to form a new RTAR. Handbook chapter should be updated with RP-1404 materials.

5.3 SCM (Crawley):
   Discussion on WS in program. One of 1666 submitted without TC4.7 as a co-sponsor.
   WS on Data-Centers was discussed; TC9.9 did not approve
   WS-1661 should be resubmitted by Aug 15, otherwise it would be dropped
   WS-1748 revised version was circulated. Comments by Sep 1st.
5.4 Research (Haberl):

5.4.1 RP’s:

TRP-1588 Bulk window properties. Contractor is making good progress. Primary tool will be using multilayer properties with EnergyPlus. Final Report due in October 2015.
TRP-1629: Test Chamber on Chilled Beam on track due for completion in May 2016.

5.4.2 WS’s, RTAR’s:

WS-1661 rewriting the WS due back to RAC by Aug 15.
WS-1748 rewriting the WS due back to RAC by Aug 15.
RTAR-1763 (from DDM), approved by RAC with comments. (based on a redo of RP-1550)
865 Toolkit possible RTAR. Talks about adding new models.

Additional Material:
- RAC: has developed now “staged-funding and project monitoring”. It’s a process about writing WS with tasks associated with budget items. Contractors will be judged on the milestones of the project.
- There is a webbased training launched in June 2016 to write RTAR’s and WS’s, PES committee, and PMS committee.
- What does 4.7 does than makes a difference (Guideline 14-2014): research getting out for the users.

5.5 Handbook:

Chapter 19 of HoF (2017). June 21 2016 is the deadline for full TC to approve the revision. We have an outline for proposed changes. The handbook subcommittee will meet online to deliberate between now and January.

5.6 Program:

Orlando:
4 Seminars and 1 Workshop: Seminar on Calibration (DDM); Seminar on technology performance (SCM);

St. Louis:
Seminar Standard 209, Paper Session (3 papers on history of HVAC, daylighting simulation)

Motion to approve the Program by Judkoff, Kolderup seconded motion to approve the program(6-0-0-CNV).
5.7 Standards:

5.7.1 SSPC 140 SMOT

Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs.
- This is the 25th anniversary of the Std 140 committee; PC founded in 1990.
- Current IRS rules (IRS notice 2008-40, published Apr 2008) relating to the deduction for energy efficient commercial buildings require software used for assessing tax credits be tested to Standard 140-2007. Currently 13 programs are qualified; 8 programs qualified updated versions. (Last check 22Jun2015).
  New submittals ron.judkoff@nrel.gov

Qualified programs listed at http://energy.gov/eere/buildings/qualified-software-calculating-commercial-building-tax-deductions
- RESNET lists 8 (up from 6, last check 22 Jun2015) tools as either accredited for HERS ratings, tax credit compliance, IECC performance verification, or existing home tax credit compliance. Required tests include NREL’s HERS BESTEST (included in Std 140-2011,-2014), along with equipment modeling and other modeling tests developed by RESNET. New submittals to RESNET (http://www.resnet.us/professional/programs/software).
- ASHRAE 90.1 and 189.1 reference Standard 140;
  - 90.1-2013, published Fall 2013 updated their reference to 140-2011.
  - 2015 IECC cites 140-2011; IGCC citation accords with IECC.

Standard 140-2014 Continuous Maintenance Revision Published:
- Adds ground-coupled slab analytical verification tests to 140-2011 tests.
- SSPC 140 agreed on continuous maintenance proposal to submit to SSPC 90.1, to update their reference from “140-2011” to 140-2014”. Neymark to submit asap.

Proposed Addendum A to 140-2014. (ASHRAE RP-865 Airside-Mechanical Equipment tests adaptation):
- Test suite based on ASHRAE RP-865; first 140 suite based on ASHRAE research.
- Airside analysis of Fan Coil (FC), Single Zone (SZ), Constant Volume (CV), and Variable Air Volume (VAV) systems.
  - These are steady-state analytical verification tests.
  - Provides basis for future Volume 2 test suite with hourly varying weather, and other steps toward testing performance in more realistic (less idealized/in-depth-diagnostic) context.
- Robust participation: 7 simulation trial participants from 4 countries + Quasi-Analytical Solution by NREL.
- Standard 140 adaptation during 2016.
5.7.2 SPC 205:
Standard on Component description performance data that is written by manufacturers to be used by the simulation community. A very good draft is written. Public Review will start and comments will be deemed supported. Body of the standard is a representation specification (Chillers, Unitary AC, and Fans). Pumps, VRF’s and Water Heater are still in the brainstorming stage. Electronic supporting data will be put online for users not only ASHRAE Members without passwords, but definitely would need official approval.

5.7.3 SPC 209:
Jason Glazer is the chair of the committee Building Energy Simulation for the design process, a draft will be put out for public review. Modeling cycles are presented, from a box model before schematic design, to the operation phase falling short of doing a calibration. The standard should (would) recommend methods from Guideline 14, because the standard recommends doing regression between energy use and outdoor temperature.

5.7.4 Standard 214:
Attempt to standardize rating programs.

5.7.5 SPC 189.1:
IGCC will be the only standard used in the US. It is actually Standard 189.1 one you open IGCC.

5.8 Website:
tc47.org is the address and is linked to ashrae.org. The website is working better than before.

6. Related Activities:
SPC 191 water conservation is reorganizing and has a new Chair, after stalling for a while

MTG EAS: Energy Efficient Air Handling System

SGPC 20 - MTG BIM: (Chip) An interest in formalize ASHRAE type data to put in BIM object. From Guideline 20, How to write a use case and take it to MTG BIM.

TC 2.8: No input from attendance.

TC 4.1: No input from attendance.

TC 4.2: (Dru) is updating the data for the handbook. Concluded a project to adjust data for elevation and location. Discussion on All-Sky data and not only Clear-Sky data.
TC 4.3: No input from attendance.

TC 4.5: No input from attendance.

TC 6.5: No input from attendance.

TC 7.5: (Haberl) Smart meters had presentations in this conference, and used for dynamic simulations, to help utilities aggregate and forecast energy for neighborhoods.

TC 7.6: (Haberl) revisiting Confidence Intervals in Guideline 14. Maybe develop an RTAR on that topic.

Building SMART: (Chip) MTG BIM is connected with this.

IBPSA: (Chip) USA. Josh was a speaker during the Atlanta dinner. Discussion on teeming with ASHRAE 2016 Energy conference. Joe Huang will lead a steering committee for that conference. (Kolderup) talked about Students Travel Grants up to 8 (information is found ibpsa.us). Digital copies of historic material. Scanned proceedings and uploaded to the IBPSA-USA website.

IBPSA-Canada 2016 conference.

IBPSA-World Simulation conference 2015 papers are already received and ready for review.

Building Simulation 2017 (international conference). Phil Haves, Eric Kolderup and Chip Barnaby are organizing it. It will be held in San Francisco.

BPI-2400-S-2011: No input from attendance.

Guideline 14: 2014 edition is out. It has one Errata. Available from ASHRAE. Within a year a committee work will start on the next edition.

IEA Annex 60: (Wangda) Modelica work between US and Europe. Open-source tools to the public. Users will be able to connect components from different libraries.

IEA Annex 66: (Wangda) will meet in August in Germany. The work is Occupant Behavior.

ASHRAE Historical Committee: Were did the load calculations come from, solar, daylighting sources. Building Simulations will be a part of the work on the ASHRAE historical committee. Were did the work come from, who did it.

Other:
Inverse Model Toolkit is now used in the Navy to baseline their fleet.
7. **Old Business:** No input from attendance.

8. **New Business:** No input from attendance.

9. **Executive Session:** No input from attendance.

10. **Adjourn:** Motion by Kruis seconded by Judkoff to adjourn. Meeting Adjourned at 8:04 pm.

**Attachments**

A. Agenda  
B. Simulations and Component Models Subcommittee Agenda and Minutes  
C. Data-Driven Models Subcommittee Agenda and Minutes  
D. Applications Agenda and Minutes  
E. Handbook Subcommittee Agenda and Minutes  
F. SSPC 140 Agenda and Minutes
Attachment A

Agenda

ASHRAE TC 4.7 Energy Calculations – Main Meeting
Salon C, Atlanta Hilton, Atlanta, Georgia
Tuesday, June 30, 2015, 6:00-8:30 pm

1. Roll call and introductions (5 minutes)  
   Balbach

2. Accept agenda & approve minutes of previous meeting (10 minutes)  
   Huang

3. Announcements/Liaisons (5 minutes)  
   Huang

4. Membership (5 minutes)  
   Huang

5. Subcommittee reports  
   5.1 Applications (10 minutes)  
   Judkoff

   5.2 Data-Driven Modeling (10 minutes)  
   Musahl

   5.3 Simulation and Component Models (10 minutes)  
   Crawford

   5.4 Research (15 minutes)  
   Haberl

   5.4.1 Research Projects  
   • 1588-RP Representative Layer-by-Layer Descriptions for Fenestration Systems with Specified Bulk Properties Such as U-factor and SHGC (co-sponsored with TC 4.5)
   • 1629-RP Testing and Modeling Energy Performance of Active Chilled Beam Systems (co-sponsored with TC 5.3) (completed ?)

5.4.2 Workstatements, RTARs, Requests for Co-sponsorship  
   • 1661-RTAR Models for the Evaluation of Supervisory Control Strategies in the ASHRAE Handbook (sent back to Authors) – SCM (contact Waroda Zep for status)

   • 1748-RTAR Assess and Implement Natural and Hybrid Ventilation Models in Whole-building Energy Simulations (Phase 2) – SCM (Tony says he will be sending a draft this week YJH)

   • 1888-WS Experimental Evaluation of the Thermal and Ventilation Performance of Stratified Air Distribution Systems Coupled with Passive Beams – (request for co-sponsorship by TC 5.3) (status ?)

   • XXXX-RTAR Development of an Improved Inverse Model Toolkit (RP1050) and Diversity Factor Toolkit (RP1093) for Analyzing Building Energy Savings from Time Series Data.

   • Requests for co-sponsorship

5.5 Handbook (10 minutes)  
   Kolderup

5.6 Program (15 minutes)  
   Cockerham

5.7 Standards (15 minutes)  
   Neymark  
   SPC 140 SMOT Excel Bldg Energy Analysis Computer Programs  
   Neymark  
   SPC 205 – Std. Representation of Perf. Sim. Data for HVAC&R & Other Equip’l Equipment  
   Barnaby

5.8 Web Site (5 minutes)  
   Glazer New

6. Related activities reports (15 minutes)  
   SPC 101 Water Conservation
   MTG.EAS Energy Eff AHU Systems
   MTG.BIM Building Information Modeling
   SGPC 20 Documenting HVAC&R Work Process and Data Exchange Requirements
   TC 2.6 Building Environmental Impacts and Sustainability
   TC 4.1 Load Calculation Data and Procedures
   TC 4.2 Climatic Information
   TC 4.3 Infiltration & Ventilation Requirements
   TC 4.5 Fenestration
   TC 6.5 Radiant Heating and Cooling
   TC 7.5 Smart Building Systems (now includes TC 7.4)
   TC 7.6 Building Energy Performance

BuildingSMART (formerly IAI International Alliance for Interoperability)
IBPSA: USA, Canada, World
BPI-2400-S-2011 Standardization Qualification of Whole-house Energy Savings Est. Guideline 14
IEA Annex 60
IEA Annex 66
ASHRAE Historical Committee

7. Old Business  
   Huang

8. New business  
   Huang

9. Executive Session  
   Huang

10. Adjourn  
   Huang

Note TC 4.7 Email list hosted at onebuilding org
Attachment B

Agenda:

Draft Agenda

TC 4.7 Simulation and Component Models Subcommittee
6:00-7:30 pm, Monday, 29 June 2015
Crystal C/D, Lobby, Atlanta Hilton
Atlanta, Georgia

6:00 Call to order / introductions / changes to the agenda
Crawley

6:10 Research Projects
- 1629-RP Testing and Modeling Energy Performance of Active Chilled Beam Systems
  (TC 5.3 / TC 4.7)

6:20 Draft Work Statements/RTARs
- 1666-WS Experimental Evaluation of the Thermal and Ventilation Performance of Stratified Air Distribution Systems Coupled with Passive Beams (TC 5.3 Room Air Distribution, requesting TC 4.7 co-sponsor)
  Bauman, Zimmerman
- 17xx-WS Development of Improved and Integrated Energy Modeling Software for Data Centers (TC 9.9 / SPC 90.4P / TC 4.7)
  Amistadi, Davidson
- 17xx-WS Development of a Reference Building Information Model (BIM) for Daylighting Optimization (TC 1.5 / TC 4.7)
  Haberl
  Wangda/Wetter
- 1748-WS Assess and Implement Natural and Hybrid Ventilation Models in Whole-Building Energy Simulations – Phase 2 (TC 4.7 / TC 4.10)
  Fontanini/Huang

6:50 New Research Topics/Research Plan
- New Research Topics (RTARs and WSs can be submitted 4 times a year—six weeks before Winter and Annual meetings and 1 March/1 August.)
  - Several new research topics at last meeting:
    - Research for new ground heat transfer tables in the HOF (Krus)
    - Research for better simulations for occupants (Hong)
    - Better **hygrothermal** modeling for highly efficient buildings, including VOC issues, etc.
      Current project supported by the IEA (Rode).
    - Mixed mode / ventilation

7:20 Program Ideas
- 2016 Winter (Orlando), 2016 Annual (St. Louis), 2017 Winter (Las Vegas)

7:25 New Business

7:30 Adjourn

Next Meeting: Monday, January 25, 2016 Orlando, Florida
Meeting Minutes:

Draft Minutes

TC 4.7 Simulation and Component Models Subcommittee
6:00-7:30 pm, Monday, 29 June 2015
Crystal C/D, Lobby, Atlanta Hilton
Atlanta, Georgia

Call to order / introductions / changes to the agenda

Crawley

Research Projects

- 1629-RP Testing and Modeling Energy Performance of Active Chilled Beam Systems
  No report on status. Project was due to be completed in May 2016 (TC 5.3 / TC 4.7)

- 1666-WS Experimental Evaluation of the Thermal and Ventilation Performance of Stratified
  Air Distribution Systems Coupled with Passive Beams (TC 5.3 Room Air
  Distribution, requesting TC 4.7 co-sponsor) Bauman, Zimmerman
  TC 5.3 submitted the work statement to RAC but did not request that TC 4.7 co-
  sponsor.

- 17xx-WS Development of Improved and Integrated Energy Modeling Software for Data
  Centers (TC 9.9 / SPC 90.4P / TC 4.7) Amistadi, Davidson
  This draft work statement was put on hold by TC 9.9. Will bring the topic back
  to the meeting in Orlando.

- 17xx-WS Development of a Reference Building Information Model (BIM) for Daylighting
  Optimization (TC 1.5 / TC 4.7) Haberl
  This draft work statement has fallen off the research plan, no progress.

- 1661-WS Development and Validation of Dynamic Models for the Evaluation of Chilled-Water
  Systems Control Strategies in the ASHRAE Handbook (TC 4.7/ TC 7.5 / TC 1.4)
  Have received some feedback on the draft work statement. Working to have
  draft work statement for the TC meeting on Tuesday for possible TC approval.
  Wangda/Wetter

- 1748-WS Assess and Implement Natural and Hybrid Ventilation Models in Whole-Building
  Energy Simulations – Phase 2 (TC 4.7 / TC 4.10) Fontanini/Huang
  Revised version circulated at subc (based on comments at last meeting).
  S&CM subc to provide comments to Tony by 1 Sept.

New Research Topics/Research Plan

- Several new research topics discussed:

  PC Thomas … idea for new research on coils, higher latent loads not covered by current coil
  models. PC to circulate RTAR by end of September

  Haberl/Huang… updating the HVAC 01 and 02 Toolkits. Jeff and Joe … to circulate by end of
  September.

Program Ideas

Chris Ballech talked about program opportunities, tracks related to TC 4.7 for upcoming
meetings in Orlando, St Louis.
TC 4.7 Data Driven Models Subcommittee Meeting
6:00 – 7:30 pm, Monday, January 26, 2015
Monroe, 6th Floor, Palmer House
Chicago, IL

Agenda:

7:30 Call to order / introductions / changes to the agenda

Attendees: Ralph Muehliessner, Jeff Haberi, Ron Judkoff, Chris Baltach, Joe Huang, Jaya Mahboubil, Amir Roth, Bass Abushehre, Clinton Davis, Mitchell Paulus, Jim Spielbauer, Peter Armstrong, Peter Lutich, Anthony Fontanini, Zulfikar Curi, Sukorow, Oh, Mini Maitrata, Kris Kinney

7:40 Discussion of Program (10 minutes)

- Summer Meeting 2015 (Atlanta) Review
- Winter Meeting 2016 (Orlando)

Tracks of interest:

- Track 6: Cutting Edge Technologies: creative ways to improve efficiencies in the effort to achieve net zero buildings
- Track 7: The Great Debate: sessions present divergent methods for accomplishing the same task

Ron Judkoff had interest in presenting Room/ANSI calibration validation work. Committee decided that a Calibration 2.0 session with 2 or 3 different methods of calibration, ended with Ron presenting the MOT would fit Track 7. Jaya Mahboubil to chair session.

Seminar ideas: M&V / Whole Building DDM?

  (no program discussion – just info/announcement)

- Summer Meeting 2016 (St. Louis)
  tracks of interest:
  - Track 5: Smart Building Systems / Remote Monitoring and Diagnostics
  - Track 8: Renewable Energy Systems and Net Zero Buildings

Conference Paper / Seminar Ideas
- DDM related to monitoring and diagnostics?

Chris B. Announced that deadlines for conference paper session submission for St. Louis was mid Sep.
No specific session discussions for St. Louis

8:00: Work Statements / RTAR’s (30 minutes)

- Existing WS and RTAR’s
  - Habari: Inverse Modeling Tool Update RTAR “Development of an Improved Inverse Model Toolkit (IMT) for Analyzing Building Energy Savings from Time Series Data” (RP 1050)

Jeff H: BPAR 1763 for 1050 (IMT) +1053 (diversity toolkit) update has gone up to RAC and returned with comments.
Jeff said there were several comments important for others considering writing an RTAR:

- statements need to be clear on deliverables for enforcing contracts
- Statement of why this is needed and different from other commercial offerings might be similar
- Question of how many users of the previous toolkit:
- How is this software going to be maintained in the future?

- Data Driven Schedules? (David Rosworth, Ralph Muehliessner)
Muehleisen said nothing has been done but he's still interested and he will follow up with D. Bosworth before next meeting and he will talk with Tianheng Hong who has been doing related work with Annex 66.

Amir Roth said to check with Rudi Chaudry of U. Cambridge. Ron J. says to check also with Da Yan of Tsingua (working on Annex 66) to see where they are before starting any work.

Jeff Haberl says to look at the diversity factor toolkit and planned redo thereof in RTAR to see what overlap there is with this possible research project.

- Inverse Modeling Test Scheme / Standards? (Chris Balbach)

- David Jump idea from NY: Develop and test a methodology to validate public domain and proprietary energy baseline modeling capabilities well as savings estimation using inverse modeling methods on whole building data. The goal is to create a method of test of inverse models.

Joe Huang mentioned that David Jump was emailing he and Jeff Haberl about this and sent a one-pager to Jeff Hand Joe H. Jeff was helping him. Muehleisen will look over this and will follow up with Jeff J and David Jump. Muehleisen was directed to pester Jeff H. to make sure this goes somewhere.

There was a fairly long discussion about the topic relating to the general idea. Discussion points included:
- What sorts of data would be used?
- Could this be done with variations of the validation MOT?
- Could we do this with synthetic data done via simulation?
- Do we want to do another shootout? (Haberl says it’s a "LOT" of work)

8:45: Handbook Contributions
- Looking for volunteers to update/review relevant sections of Fundamentals Chapter related to DDM
  - Table 1
  - Fundamentals 19.22-19.28
    - Add Machine learning other than ANN?
    - Add non-parametric regression techniques (Gaussian Process or Kriging models)?

Muehleisen says that DDM section is fairly long but focused on simple regression methods. This could be trimmed to expand the section to more advanced methods including new machine learning and non-parametric regression).

Bass A. is interested in being part of any revisions.

Jeff H. says current table is a mishmash, needs updating
  Dynamic and static methods, forward and inverse are all mixed up.

TC 7.5 is not addressing MPC, should it be here? Peter Armstrong volunteers to look at this.

Muehleisen will try to coordinate efforts between DDM subcommittee and 4.7 handbook chair Kolderup.
Muehleisen will pester people to get stuff done related to DDM.

8:55  New Business

No New Business

9:00  Adjourn

Meeting Adjourned at 8:30
TC 4.7 Applications Subcommittee Meeting Minutes: 6/30/15: Atlanta

3:33pm: Ron Judkoff, Chair, called to order.

Agenda and minutes from Chicago Winter meeting (Jan 2015) circulated a few days ago.

Announcements:

- ASHRAE Call for papers for St Louis (Summer 2016) (see attachment)
- Proposed changes to TC 5.2 Title Purpose & Scope, from to “Design system”. Bass briefed the progress. Maybe Craig Ray can report more details in full committee meeting. (see attachment)

Program:

Keith Cockerham not present, and Chris Balbach called away by family emergency so reported by Joe Huang.

Orlando Conference:

- Wangda Zuo: Seminar: Use of Simulation Tools for Cutting Edge building design. speakers: Arpad Balabzs (SOM), Jeff Boyer (dbHMS), Wangda Zuo (Miami)

- Wangda Zuo: High Performance Computing for buildings. Speakers: David Bosworth (BUILD), Nathaniel Jones (MIT), Jou Hand (ESRU, UK), Neal Kruis

- Tim: Resubmit a seminar about Standard 205.

St. Louis Conference:

- Jeff Haberl mentioned two recent accepted papers for Orlando conference and a third almost accepted, but will have to wait until St. Louis because of timing. Need to figure out which format the paper will be presented. Jeff will contact the CEC that TC is willing to package a seminar which CEC tends to like because it makes it easy for them.

- Eric mentioned that Standard 209 can be presented. To be discussed in Orlando.

Research:

- Eric Kolderup updated the activity in BEMBook. RMI working on it (Ellen Francom). IBPSA-USA will host it on line. Discussed the possibility of TC 4.7’s involvement. No conclusion yet.
- Eric Kolderup Updated the activity on SPC209. It hasn’t been voted out for public review yet, but it is mostly done, and will likely be voted out at the next Winter meeting. 209 requires at
least two cycles of modeling and a design charrette. 209 recommends modeling throughout the design process, but only requires that a subset of the recommendations be implemented for compliance with 209. Judkoff asked if 209 required simulation in the early design phase when it can really make a difference on the energy use of the building. Early simulation is encouraged but not required in the standard. The SPC209 will be ready for public review when the entire standard is drafted (targeted Jan 2016).

- Jeff Haberl mentioned that 209 references and the Diversity Factor Toolkit.

Ideas for New RTARs:

- Guidelines on simulating tall buildings (Joe Huang), no new update.
- Reconciling differences between simulation results and actual energy use (Joe Huang, Son XXXX from ORNL); Jeff Haberl and Neal Kruijs volunteered to review. Danny Parker from FSEC is measuring the building energy consumption in 60 houses in Florida and the data is public on a website. Joe Huang suggested that we can model the buildings using their data and see how well the model matches the dynamics. The data can be used for various purposes. Need to review the data for their availability and resolution.
- Comparing ASHRAE 90.1 App G Models to Real Buildings (Joe Huang). Nothing new to report.
- How to process, convert, or modify weather files for use in energy simulations (Jeff Haberl), nothing new to report.
- Liping Wang presented an RTAR “Optimizing change-over mixed-mode cooling systems for houses using building simulation” (this led to lots of discussion).
  - Requirements need to be specific for bidder selection
  - Need to address the value to ASHRAE
  - Joe mentioned that DOE-2 has the feature of automatic switching between the natural and mechanical ventilation, and does this in a near optimal way, but EnergyPlus doesn’t do this.
  - Some ideas: Comparison of different tools for mixed-mode ventilation
  - Consider both energy savings and comfort from air movement around occupants
  - EnergyPlus outputs velocity profiles
  - Jeff Haberl, Kamal Haddad, and Liping will revise the RTAR.

- Neal Kruijs will work on an RTAR to update the ASHRAE F and C ground coupling factors. (Put on the agenda for next meeting)

Attachment 1
TC 4.7 Applications Subcommittee

Agenda

Atlanta

Tuesday, 30 June 2015
3:30-5:00pm Atlanta Hilton: Salon C (2)

1) Introductions and Agenda Review (5 minutes)
   a. Sign-up sheet
   b. Around Room
   c. Agenda Mods

2) Announcements (5 minutes)
   a. ASHRAE Call for papers for St Louis (Summer 2016)
   b. Proposed changes to TC-5.2 Title Purpose & Scope, “Duct Design”.

3) Program (15 minutes) (Keith Cockerham)
   a. 2015 Summer (Atlanta)
   b. 2016 Winter (Orlando)
   c. 2016 Summer (St. Louis, MO)
   d. 2017 Winter (Las Vegas)

4) Research (65 minutes)
   a. Updates on related activities (10 minutes each)
     - Update on BEMBook and other COMNET-related activities (Ellen Franconi)
     - Update on SPC209P, Energy Simulation Aided Design for Buildings Except Low-Rise Residential Buildings (Jason Glazer, if available)
- Ideas for new RTARs (15 minutes each)
  - Guidelines on simulating tall buildings (Joe Huang)
  - Reconciling differences between simulation results and actual energy use (Joe Huang)
  - Comparing ASHRAE 90.1 App G Models to Real Buildings (Joe Huang)
  - How to process, convert, or modify weather files for use in energy simulations (Jeff Haberl)
  - Others?
- Topics for discussion (whatever time remains)
  - Should TC 4.7 maintain a set of prototypical building models and input files, possibly building on DOE's "Reference Building Models"?
  - Any other issues or concerns (does not have to be turned into an RTAR or WS).
  - Emphasis and Focus of Future Applications Subcommittee Meetings and Activities

### ATTACHMENT 2

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**ATTACHMENT 3**

ASHRAE has announced a call for papers for its 2016 Annual Conference, which takes place June 25-29 in St. Louis, Mo.

To submit a Conference paper abstract or a technical paper and for more information about the conference, go to [www.ashrae.org/stlouis](http://www.ashrae.org/stlouis).

“The 2016 Annual Conference Technical Program features a great mix of the engineering basics as well as advanced systems and professional development,” Wade Conlan, chair of ASHRAE’s Conferences and Expositions Committee, which oversees the Conference, said. “Among the eight tracks are two that will push boundaries: Smart Building Systems as well as Renewable Energy Systems and Net Zero Buildings. And we are going back to the core of air conditioning with a track on Advances in Refrigeration Systems and Alternative Refrigerants.”

Papers are sought for the following tracks: Advances in Refrigeration Systems and Alternative Refrigerants; Fundamentals and Applications; HVAC Systems and Equipment; Smart Building Systems/Remote Monitoring and Diagnostics; Indoor Environment: Health, Comfort, Productivity; Professional Skills Beyond Engineering; and Renewable Energy Systems and Net Zero Buildings. Papers also are sought for the fourth annual Research Summit, which reports results on any aspect of ASHRAE-related research.

Authors have two options to prepare their papers:
Conference Papers: Abstracts due Sept. 14, 2015. Upon acceptance, papers will be due Jan. 4, 2016. These “final” papers undergo a single-blind review, are submitted as a PDF and have an eight single-spaced page maximum length.
Full Technical Papers, which are due Sept. 14, 2015. Papers submitted for review must be both technically accurate and clearly written. These papers undergo a rigorous double-blind review and can be a maximum of 30 double-spaced pages.

ASHRAE authors enjoy benefits that include:

- No publication charges
- Interaction with other researchers
- Reduced Conference registration ($105)
- Technical Papers published in ASHRAE Transactions
- Conference Papers published in the 2016 ASHRAE Annual Conference — Papers
  (download)

ATTACHMENT 4

Proposed Changes to TC 5.2 Title and Scope
May 2015
ORIGINAl
Title: Duct Design
Technical Committee 5.2 is concerned with the design, characteristics, and construction of all types of ductwork for the handling of air and other gases, but does not include chimneys.
PROPOSED WORDING – WITH CHANGES OVERLAID
Title: Duct Design Systems
Scope: Technical Committee 5.2 is concerned with the design, construction, and operating characteristics, and construction of ductwork duct systems for the handling air and other gases, but does not include chimneys. This includes consideration of duct system materials and sizes, air velocities, and air leakage, as well as pressure changes and energy use related to ducted flows.

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ATTACHMENT 5

TC 4.7 members,

I'm forwarding this announcement from Glenn Friedman of TC 4.1 concerning the new
ASHRAE/ANSI Standard 203-2014, "Method of Test for Determining Heat Gain of Office Equipment Used in Buildings", which should be of equal interest to TC 4.7 for use in building energy simulations. It might be worthwhile for TC 4.7 members to review this new standard, and see whether the MOT is equally appropriate for determining equipment heat gain for annual simulations.

I look forward to seeing everyone in Atlanta in less than two weeks.

Joe
TC 4.7 Chair
Attachment E
Draft Agenda and Minutes

TC 4.7 Handbook Subcommittee
5:00-6:00 pm, Tuesday, January 27, 2015
Empire Ballroom (Lobby), Palmer House
Chicago, IL

TC 4.7 Handbook Subcommittee
Agenda
Atlanta
Tuesday, June 30, 2015
5:00-6:00pm,
Room: Salon C, Atlanta Hilton

1) Introductions and Agenda Review (5 minutes)
2) Schedule for 2017 Fundamentals Handbook Revision
   a. June 2015, 50% draft (not there yet)
      • September 2015 (50%)
      • December 2015 (90%)
   b. January 2016, 95% draft to TC for review
   c. June 2016, TC approves revised chapter (final due June 21, 2016)
   d. Early 2017, review galley prints
   e. June 2017, publication
3) Reminder of target audience description
   a. See doc link below
4) Reminder of editing process
   a. 2013 Chapter 19 doc in Dropbox folder. See link below
   b. Use track changes to add notes and edits. Otherwise changes will not make it into the 2017 version.
   c. Files with tracked changes may be emailed to Erik Kolderup, erik@kolderupconsulting.com.
   d. Source files and references may be uploaded to the Dropbox folder.
5) Review outline of proposed changes and discuss assignments for committee members.
   a. See 2013 Outline link below for reference.
6) Assign action items

Resources:
- Outline of Chapter 19 including proposed changes for 2017 with committee member work assignments. In Dropbox folder: https://www.dropbox.com/sh/9vuxz7a99u6gyev2/Unv3Nv8LdeJ
- Description of target audience. Google Doc: https://docs.google.com/document/d/174pP_sNv185MA1dZTMToMwh9wiiU0brT1E7i14EY7nBrE/edit?usp=sharing

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<td>Occupant behavior</td>
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<td>Calibration</td>
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1. Reviewed the schedule for the 2017 Fundamentals Handbook Revision
   a. June 2015, 50% draft (not there yet)
      i. September 2015 (50%)
      ii. December 2015 (90%)
   b. January 2016, 95% draft to TC for review
   c. June 2016, TC approves revised chapter (final due June 21, 2016)
   d. Early 2017, review galley prints
   e. June 2017, publication

2. Briefly discussed the target audience definition
   a. The definition is in a Google doc: link below.

2. Reviewed the editing process
   a. Get the 2013 chapter Word version from the Dropbox. Link below.
   b. Add comments and/or use Track Changes for edits and save as a separate version.
   c. New contributions and Online Handbook content (spreadsheets, color graphics, etc)
      may be provided as separate documents
   d. Email your document(s) to Erik Kolderup, erik@kolderupconsulting.com.

3. Chapter outline review and roles for committee members.
   b. Names of committee members assigned to each section are listed in the outline.
c. McDowell and Kruis to propose reorganizing and consolidating sections related to modeling approaches, characteristics of models, and modeling strategies.

d. See also the document “HOF 2017 Chapter 19 Outline, Draft 07-01-2015.docx” for notes from the discussion of proposed changes and an updated draft outline.

e. Kolderup will investigate using Basecamp to track comments on drafts.

4) Next steps


5) Adjourn 5:55 pm

Resources:

- Word version of 2013 Chapter 19 for review and markup. In Dropbox folder:
  https://www.dropbox.com/sh/9vzn7g99u6xvev2/Uv3Nv8LdeI

- 2017 Chapter 19 Draft Outline. In Dropbox folder:
  https://www.dropbox.com/sh/9vzn7g99u6xvev2/Uv3Nv8LdeI

- Description of target audience. Google Doc:
  https://docs.google.com/document/d/174pPsNyLISMA1dZTMT0Mwh9wiUibwTdl7i4EY7nBrE/edit?usp=sharing
SSPC 140 Meeting Summary – 6/29/15 (submitted to TC4.7 6/30/15, resubmitted with minor edits 1/8/16)

**Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs.**

- This is the 25th anniversary of the Std 140 committee; PC founded in 1990.
- **Current IRS rules** (IRS notice 2008-40, published Apr 2008) relating to the deduction for energy efficient commercial buildings require software used for assessing tax credits be tested to Standard 140-2007. Currently **13 programs are qualified**: 8 programs qualified updated versions. (Last check 22Jun2015). New submittals ron.judkoff@nrel.gov
- RESNET lists **8 (up from 6)**, last check 22Jun2015 tools as either accredited for HERS ratings, tax credit compliance, IECC performance verification, or existing home tax credit compliance. Required tests include NREL’s HERS BESTEST (included in Std 140-2011-2014), along with equipment modeling and other modeling tests developed by RESNET. New submittals to RESNET (http://www.resnet.us/professional/programs/software).

- **ASHRAE 90.1 and 189.1 reference Standard 140;**
  - 90.1-2013, published Fall 2013 updated their reference to 140-2011.
  - 2015 IECC cites 140-2011; IGCC citation accords with IECC.

**Standard 140-2014 Continuous Maintenance Revision Published:**

- Adds ground-coupled slab analytical verification tests to 140-2011 tests.
- SSPC 140 agreed on continuous maintenance proposal to submit to SSPC 90.1, to update their reference from “140-2011” to 140-2014”. Neymark to submit asap.

**Proposed Addendum A to 140-2014. (ASHRAE RP-865 Airside-Mechanical Equipment tests adaptation):**

- Test suite based on ASHRAE RP-865; first 140 suite based on ASHRAE research.
- Airside analysis of Fan Coil (FC), Single Zone (SZ), Constant Volume (CV), and Variable Air Volume (VAV) systems.
  - These are steady-state analytical verification tests.
  - Provides basis for future Volume 2 test suite with hourly varying weather, and other steps toward testing performance in more realistic (less idealized/in-depth-diagnostic) context.
- Robust participation: 7 simulation trial participants from 4 countries + Quasi-Analytical Solution by NREL
- Standard 140 adaptation during 2016.
Building Thermal Fabric Tests Update (140, Section 5.2)

- Address advances in modeling state of the art since 1995
- Iterate on spec revisions and simulation trials, with draft NREL final report including updated spec and example results.
- Consideration of revisions to existing test cases and inclusion of additional excursion (parametric sensitivity) test cases continues in collaboration with SSPC 140. Test case revisions must be compatible with current parsimonious framework of the test cases.
- Consider including version of the spec in OpenStudio (zBXML compatible) format for automated input.

Test suite progress:

- First round simulation trial
  - Updated test spec distributed July 22, 2014.
  - Results received Sep – Nov, 2014; compile by NREL Jan 2015
    - 7 participants from 7 countries
    - Good/constructive comments on spec.

- 2nd round simulation trial revisions
  - 17 topical revisions, to address comments from January
    - Some work remains.
  - Working Group (software developers) addressing first round results disagreements.
  - Add extension cases as time allows; extension cases can be completed during additional rounds.
    - Window excursion cases for other glass types, and including window frames.
    - Weather driven infiltration cases – keep constant infiltration rate cases in base case to reduce noise.

Next steps:

- Continue topical revisions
  - Equivalent constant surface coefficients for programs that do not automatically calculate convective and/or radiative surface heat transfer.
  - A couple others remain.

Empirical Validation: SSPC 140 is interested in including empirical validation test suites IF they are worthy (high quality experimental data, with well vetted test specifications). On this topic we heard presentations from:

- R. Judkoff of NREL re forthcoming DOE sponsored data sets

- T. Hong on IEA BCS Annex 58

- J. New on ORNL.

References to Standard 140. Standard 140 is referenced by:

- IRS, Standard 90.1
- Standard 189 (High Performance Green Building Design) Appendix D
- IECC, IGCC
- Implicitly referenced for ASHRAE Building Energy Quotient IF that is based on the COMNet User’s Manual;
- RESNET references Section 7 tests (adapted from HERS BESTEST 1995).
- Florida Building Commission
- Various international references.

Full SSPC 140 meeting notes are available from the Chair on request.
Listing of test suites either included in Std 140 or listed in Annex B23 (of Std 140) is included below. (Included per Jan 2010 request by TC 4.7 Chair; a more comprehensive listing requires a literature survey.)

**Analytical Verification Tests and Comparative Tests already in Standard 140 (or with addenda in progress)**
- NREL/IEA 12/21 “IEA BESTEST” (building thermal envelope fabric load tests)
- NREL/IEA 22 “HVAC BESTEST Volume 1” (analytical verification tests)
- NREL/IEA 22 “HVAC BESTEST Volume 2” (comparative tests)
- NRCan/IEA 22 “Furnace BESTEST” (analytical verification and comparative)
- NREL/HERS Council “HERS BESTEST” (comparative tests, simplified residential)
- NREL/IEA-34/43 “Ground-Coupled Slab-On-Grade In-Depth Tests” (analytical verification)
- NREL/IEA-34/43 “Multi-Zone Non-Airflow” (analytical verification and comparative)
- ASHRAE RP-865 “Air-Side Mechanical Equipment Analytical Verification Tests”

**Other Analytical Verification and Comparative Tests**
- NREL “BESTEST-EX” (comparative physics and calibration tests, existing homes)
- ASHRAE RP-1052 “Development of an Analytical Verification Test Suite for Whole Building Energy Simulation Programs – Building Thermal Fabric”
- “RADTEST Radiant Heating and Cooling Test Cases”
- IEA-34/43 Airflow Tests by Japan (final report still in progress)

**Empirical Validation Tests**
- “ETNA BESTEST Empirical Validation Test Specification (NREL and Electricite de France)
- IEA-34/43: “Empirical Validations of Shading/Daylighting/Load Interactions in Building Energy Simulation Tools (EMPA, Switzerland)
- IEA-34/43 “Chilled Water and Hot Water Mechanical Equipment and Control Comparative and Empirical Validation Tests (empirical and comparative, TUD, Germany)
- IEA-34/43 “Double-Skin Façade Empirical Validation Tests” (Aalborg U., Denmark)
- IEA 22 Economizer Control Tests for the Empirical Validation of Building Energy Analysis Tools (Iowa ERS, US and Spain)
- New Research: There is a possibility of developing a test facility for empirical validation of software used to model retrofits of existing building (i.e., software that is currently the subject of the BESTEST-EX test suite). Such a test facility would be expensive relative to developing comparative and analytical verification tests, but such expense would be well justified if U.S. energy policy moves towards supporting energy efficiency retrofits of energy-inefficient houses that comprise a large portion of the current U.S. housing stock.