

AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIR-CONDITIONING ENGINEERS, INC.  
1791 Tullie Circle, NE / Atlanta, GA 30329  
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TC/TG/TRG MINUTES COVER SHEET

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

TC/TG/TRG No. TC 4.7 DATE: July 24, 1998

TC/TG/TRG TITLE: Energy Calculations

DATE OF MEETING: June 23, 1998 LOCATION: Toronto

MEMBERS PRESENT	YEAR APPTD	MEMBERS ABSENT	YEAR APPTD	EX-OFFICIO MEMBERS & ADDIT'L ATTENDANCE
Chip Barnaby	1995	George Reeves	1993	
Bill Bahnfleth	1996	Per Sahlin	1996	
Dan Fisher	1994	David E. Knebel	1994	
Carol Gardner	1997	Jean Lebrun	1996	
Jeff Haberl	1996			
Philip Haves	1994			
Sanford Klein	1997			
Les Norford	1994			
Robert Sonderegger	1994			
Jeff Spitler	1995			
Ed Sowell	1994			
George Walton	1996			
Michael Witte	1994			
Fred Winkelmann	1996			

DISTRIBUTION

**ALL MEMBERS OF THE TC/TG/TRG**

TAC CHAIRMAN: Irv Bales

TAC SECTION HEAD: Jeff Biscup

**LIAISONS:**

Program: Larry Degelman Journal: none

Handbook: George Reeves

TECHNICAL SERVICES: Claire Ramspeck

MANAGER OF RESEARCH: William A. Seaton

ADDITIONAL DISTRIBUTION: \_\_\_\_\_

ASHRAE TC/TG/TRG ACTIVITIES SHEET

DATE: July 24, 1998

TC/TG/TRG NO.: TC 4.7 TC/TG/TRG TITLE: Energy Calculations

CHAIRMAN Charles Barnaby VICE CHAIRMAN Robert Sonderegger SECRETARY Jeff Spitzer

TC/TG/TRG MEETING SCHEDULE			
LOCATION - past 12 months	DATE	LOCATION - planned next 12 months	DATE
Toronto	6/23/98	Chicago	1/26/99
San Francisco	1/20/98	Seattle	6/22/99

  

TC/TG/TRG SUBCOMMITTEES	
Function	Chair
Simulation and Component Models Applications Inverse Methods	Dan Fisher Joe Huang Jeff Haberl

  

RESEARCH PROJECTS - Current		Monitoring	Report Mode
Project Title	Contractor	Comm.Chm.	At Meeting
Appendix 1			

  

LONG RANGE RESEARCH PLAN				
Rank	Title	W/S Written	Approv	To R & T
1.	See attachment 5			
2.				
3.				
4.				

<b>HANDBOOK RESPONSIBILITIES</b>					
<b>Year &amp; Volume</b>	<b>Chapter</b>	<b>Title</b>	<b>No.</b>	<b>Deadline</b>	<b>Handbook Subcom. Liaison</b>
1997	28	Energy Estimating Methods			NONE
<b>STANDARDS ACTIVITIES - List and Describe Subjects</b>					
SPC 140P Standard Method of Test for Building Energy Software - Ron Judkoff					
<b>TECHNICAL PAPERS from Sponsored Research - Title, when presented (past 3 yrs. present &amp; planned)</b>					
Appendix 2					
<b>TC/TC/TRG Sponsored Symposia - Title, when presented (past 3 yrs. present &amp; planned)</b>					
Appendix 3					
<b>TC/TG/TRG Sponsored Seminars - Title, when presented (past 3 yrs. present &amp; planned)</b>					
Appendix 4					
<b>TC/TG/TRG Sponsored Forums - Title, when presented (past 3 yrs. present &amp; planned)</b>					
Characterizing the Performance of Central Plants for Multi-Building Campuses, Chicago (1/99) Who Needs Moisture Calculations in Building Energy Simulations? What Do You Need?, Toronto (6/98) How should ASHRAE Computer Models be Expressed? Boston(6/97) Priorities for Near-Term Developments in Building Simulation Programs, San Antonio(6/96), Fast Multizone Models for System Optimization, San Antonio(6/96)					
<b>JOURNAL PUBLICATIONS - Title, when published (past 3 yrs. present &amp; planned)</b>					

**Additional Attendance\***

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\* In order to preserve the e-mail addresses for all attendees, this is actually a complete list of attendees and recent attendees. It includes the voting members of the committee

listed on page 1. An X in the "Present?" column indicates presence at this meeting.

**Appendix 1****RESEARCH PROJECTS -- CURRENT**

<u>Project Title</u>	<u>Contractor</u>	<u>Comm.Chm.</u>	<u>At Meeting</u>
RP-699 Ice-On-Pipe Brine Thermal Storage System (??)		Knebel	?
865-RP Development of Accuracy Tests for Mechanical System Simulation	Penn State/Texas A&M	Walton	Yes
987-RP Loads Toolkit	Univ. of Illinois	Crawley	Yes

**Appendix 2**

**TECHNICAL PAPERS FROM SPONSORED RESEARCH**

June 1997

664-RP Fisher, D.E., C.O. Pedersen. 1997. Convective Heat Transfer in Building Energy and Thermal Load Calculations. ASHRAE Transactions V 103 n 2.

January 1997

787-RP Rock, B., D. Wolfe. 1997. A Sensitivity Study of Floor and Ceiling Plenum Energy Model Parameters. ASHRAE Transactions v 103 n 1 1997.

June 1995

741-RP Spitler, J.D., J.D. Ferguson. 1995. Overview of the ASHRAE Annotated Guide to Load Calculation Models and Algorithms ASHRAE Transactions v 101 n 2 1995.



**Appendix 3****TC/TG/TRG SPONSORED SYMPOSIA****Title, When Presented*****FUTURE:***Chicago - January 1999

Symposium: *Application of Heat Balance Methods to Energy and Thermal Load Calculation*  
Chair – Chip Barnaby

Seattle - June 1999

Symposium: *Recent Innovations in HVAC System Modeling*  
Chair – Carol Gardner

Symposium: *Methods for Calibrating Building Energy Simulation Programs*  
Chair -- Agami Reddy

Symposium: *Applications of Heat and Mass Balance Methods to Energy and Thermal Load Calculations*  
Chair – Chip Barnaby

Dallas - February 2000

Symposium: *Accuracy tests for simulation models*  
Chair – Mike Witte

***PAST:***Toronto - June 1998

Symposium: *Baseline Calculations for Measurement and Verification of Energy and Demand Savings*  
Chair – Robert Sonderegger.

Boston - June 1997

TC 4.7/9.6 Symposium--“*Field Methods for Analyzing Equipment, Building and Facility Energy Use*”  
Chair: Agami Reddy (409/862-2189, areddy@loanstar.tamu.edu).

San Antonio - June 1996:

Symposium: *External Environmental Impacts*  
Chair - S. Reilly.

Symposium: *The Great Energy Predictor Shootout II*  
Chair - Haberl

Atlanta - February 1996:

Symposium: *User Tools for Building Energy Simulation*

Chair - C. Gardner; three papers promised

## **Appendix 4**

### **TC/TG/TRG SPONSORED SEMINARS**

#### ***FUTURE:***

##### Chicago - January 1999

"Simulation Tool Interoperability and Component Model Portability", to be chaired by Phil Haves.

##### Seattle - June 1999

"Parameter Estimation for Modeling Actual Building Systems" (or may be a symposium), chaired by Carol Gardner

#### ***PAST:***

##### Toronto - June 1998

"Neural Nets: What Are They and What Can They Do?" chaired by Moncef Krarti

##### Boston - June 1997

"Practical Applications of Energy Calculations" chaired by Barnaby;

##### Philadelphia - January 1997

TC 4.7/9.6 Seminar--"Calibration of Computer Simulation for Building Energy Analysis" Taghi Alereza

##### Atlanta - February 1996:

Measurement of Energy and Demand Savings-ASHRAE Guideline 14P

Chair: George Reeves (co-sponsored with TC 9.6, Systems Energy Utilization)

##### San Diego - June 1995:

Innovative Uses of Building Energy Simulations Programs - C. Barnaby

Jan. 1995 - Innovative Uses of Computer Simulation - C. Gardner

Jan. 1995 - Predictor Shootout II: Measuring Results for Energy Conservation Retrofits - J. Haberl

Jan. 1995 - Energy Calculations for Measure Analysis - ?

Jan. 1994 - User Tools for Computer Energy Analysis - C. Gardner

Jan. 1994 - User Tools for Building Energy Simulation - C. Gardner

Jan. 1994 - Standardizing Formats for HVAC Component Models - How to Avoid Reinventing the Wheel  
- P. Sahlin

## ASHRAE TC 4.7

## Minutes

Toronto Meeting June 23, 1998

1. The meeting was called to order at 6:04 p.m. The following members were present Barnaby, Sonderegger, Spitler, Norford, Gardner, Bahnfleth, Haberl, Haves, Fisher, Klein, Sowell, Walton, Winkelmann, Witte. Knebel, Lebrun, Reeves, Sahlin absent.
2. Jeff Biskup (TAC section head) and Carl Speich (RAC section head, Room 746) came and fulfilled their liaison roles. Jeff Biskup will have a plaque for Chip at the next meeting. Carl Speich gave a list of suggested research projects submitted by the membership.
3. The agenda was distributed and is attached as attachment 1. The agenda was accepted on a voice vote. Sonderegger moved, Bahnfleth seconded, to approve minutes. The minutes need one correction: Agami Reddy was appointed as the chair of the "Compilation of Diversity Factors and Schedules for Energy and Cooling Load Calculations", not Bill Bahnfleth. The motion carried unanimously.
4. Jeff Haberl presented the report of the Inverse Methods subcommittee. The minutes are attached as attachment 2.
5. Dan Fisher presented the report of the Simulation and Component Models subcommittee. The minutes are attached as attachment 3.
6. George Walton reported on 865-RP. The project is slightly behind, but it is hoped that it can be finished by the next meeting. Walton moved, Fisher seconded that "A no cost extension be granted until March 31, 1999." 11-0-3
7. Dru Crawley reported on 987-RP. "We're in pretty good shape." The contractors have been providing samples of code and documentation to the review committee. They will be providing a CD with more hot links from their code in Chicago.
8. Joe Huang reported on the Applications subcommittee. The minutes are attached as Attachment 4.
9. Curt Pedersen (PES chair) reported on 1049-TRP. ("Building System Design Synthesis) Only one proposal was received, which the PES recommends not be accepted, since they don't believe it will achieve an acceptable result. A lengthy discussion followed regarding why no other bids were received. Sowell moved, Norford seconded: "TCs 4.7 and 1.5 recommend to RAC that the proposals received in response to TRP 1049 be rejected because they will not satisfy the objectives of the Work Statement. We further recommend that the work statement be reopened for proposals and, because of the complexity of the project, the proposal period extend to a minimum of 90 days so that potential bidders have enough time to respond." Motion carried 13-0-1.
10. Robert Sonderegger reported on 1050-TRP (Toolkit for Calculation ). It had been previously been returned to the bidder for additional information. The PES recommends approval. Robert Sonderegger moved, Bahnfleth seconded, that the proposal by the University of Dayton for 1050-TRP be accepted and that a contract be let. Motion carried 12-0-2.
11. 1052-TRP Analytical Verification Suite. 3 proposals received. Unanimously agreed that the best bid was from the low bidder, Oklahoma State University, Jeff Spitler, P.I. Walton moves, Haves second, to recommend OSU etc. etc. 11-0-3. approved.

12. 1093-TRP Diversity Factors PES report was given by Agami Reddy. The PES recommended that the Texas A&M proposal be accepted, possibly with some contingency that certain items must be addressed. A lengthy discussion of the approach to be taken was held. Haves recommended, Walton seconded that Texas A&M be awarded the contract for 1093-TRP contingent on them addressing the issues of obtaining data from Europe, determining occupancy schedules, and the methodology thus proposed be approved by the PMSC in advance. The motion carried 12-0-2.
13. Dru Crawley presented a draft research plan. Fisher moved, Gardner seconded that the draft research plan be approved. The motion carried 12-0-2. The approved research plan is attached as Attachment 5.
14. Joe Huang distributed a work statement, "Modeling Two- and Three-dimensional Heat Transfer Through Composite Wall and Roof Assemblies in Hourly Energy Simulation Programs", Attachment 6. Haves moved, Walton seconded, that the work statement be approved, with minor editorial modifications. Joe Huang was directed to make minor editorial changes. The motion carried 13-0-1.
15. Les Norford gave the Handbook Subcommittee Report, attachment 7.
16. Carol Gardner gave the Program Subcommittee Report.

Chicago:

A seminar regarding Energy Calculations: what technologies have been developed and are under development. The group consensus was that any action on this should be postponed.

Seminar: Simulation Tool Interoperability and Component Model Portability, to be chaired by Phil Haves.

Forum: Characterizing the performance of central plants for multi-building campuses, to be moderated by Jeff Haberl.

Seattle:

Symposium: Methods for Calibrating Building Energy Simulation Programs, Chair Agami Reddy

Symposium: Applications of Heat and Mass Balance Methods to Energy and Thermal Load Calculations, Chair: Chip Barnaby

Symposium: Recent Innovations in HVAC System Modeling, to be chaired by Carol Gardner.

Dallas:

Symposium: Accuracy tests for simulation models, chair Mike Witte.

Moved by Bahnfleth, seconded by Haves, that the program plan be awarded, prioritized in order read. The motion carried unanimously on a voice vote.

17. SPC-140P met and voted the Standard Method of Test out of the subcommittee. An amended set of minutes for the January 1998 meeting are attached as Attachment 8, and the minutes for the June meeting are attached as Attachment 9.
18. Curt Pedersen reported on IBPSA. Building Simulation 99 to be held in Kyoto, September 13-15, 1999. (<http://www.users.kudpc.kyoto-u.ac.jp/~j45827/>) IBPSA-USA will meet the Saturday night in Chicago, Saturday, January 23, 1999.

Robert Sonderegger reported on GPC-14P.

Agami Reddy reported on TC 9.6 activities.

Dru Crawley reported on the International Alliance for Interoperability. ASHRAE has become a member, represented by Bruce Hunn. Jim Forrester is the liaison.

19. Remote meeting participation. The chair announced that we are not really ready for remote meeting participation.
20. The meeting was adjourned at 8:31. Spitler moved, everyone seconded. Unanimously carried.

# Attachment 1

## TC 4.7 Energy Calculations

### Agenda

6:00 - 8:30 PM, Tuesday, June 23, 1998  
Sheraton Civic Ballroom Toronto, ON

- |  |             |
|--|-------------|
| 1. Roll call and introductions                                 | Spitler     |
| 2. Accept agenda and approve minutes of San Francisco meeting  | Barnaby     |
| 3. Announcements   | Barnaby     |
| 4. Membership  | Barnaby     |
| 5. Subcommittee reports  |             |
| 5.1 Applications   | Huang       |
| 5.2 Inverse Methods  | Haberl      |
| 865-RP Accuracy Tests for Mech. System Simulations             | Walton      |
| 5.3 Simulation and Component Models                            | Fisher      |
| 987-TRP Loads Toolkit  | Crawley     |
| 5.4 Research   | Crawley     |
| 1049-TRP Building System Design Synthesis contractor selection |             |
| 1050-TRP Inverse Toolkit contractor selection                  |             |
| 1052-TRP Analytical Verification Suite contractor selection    |             |
| 1093-TRP Diversity Factors contractor selection                |             |
| 1999-2000 Research Plan  |             |
| 5.5 Handbook   | Norford     |
| 5.6 Program Chicago / Seattle / Dallas                         | Gardner     |
| 5.7 Standards: SPC-140, SMOT for Energy Software               | Judkoff     |
| 6. Reports on related activities                               |             |
| IBPSA  | Pedersen    |
| GPC 14P Measurement of Energy/Demand Savings                   | Sonderegger |
| TC 9.6 Systems Energy Utilization                              | Reddy       |
| IAI International Alliance for Interoperability                | Crawley     |

7. Old Business

Educational outreach

Hittle

8. New Business

Remote meeting participation

Barnaby

9. Adjourn

**ATTACHMENT 2  
MINUTES**

**TC 4.7 Subcommittee on Inverse Methods  
Monday, June 22nd, 7:30 - 9:00 p.m.  
Hilton, Osgood East  
Chair: Jeff Haberl**

REVISED AGENDA

1. Introductions (all)
2. Discussion of the minutes from January 1998 (all)
3. Discussion of how to split up Inverse Methods and Applications (all).
4. Review and vote on Long Range Research Plan (all)
5. Discussion of Work Statements (all):
  - + 1051 WS: "Toolkit for calibrating computer simulation program..." (Haberl)
  - + Other work statements (all)?
6. Program (all)
  - + Chicago 1999
    - Forum "Characterizing the Performance of Central Plants for Multi-building Campuses", Moderator: Jeff Haberl
  - + Seattle 1999
    - Symposium "Methods for Calibrating Building Energy Simulation Programs", Chair: Agami Reddy
  
    - Potential paper: Jeff Haberl
  - + Dallas 2000
6. Old Business (all)
7. New Business (all)
8. Adjourn



## ATTENDEES:

NAME	AFFIL.	EMAIL
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The meeting was called to order at 7:37 p.m. by Jeff Haberl (JH) and introductions were then made.

JH then presented his objectives for the meeting:

1. get three work statements into research plan
2. discuss a work statement that got returned from San Francisco
3. thoughts on program. There is one program in this conference. Currently nothing on program for future conferences
4. thoughts on the “divorce” between IM & Applications - on how to divide up topics and work statements.

There was a motion to approve the minutes by Buhl, 2nd by Joel. Approved. Fred Buhl corrected the spelling of his name in the notes.

JH then proceeded to review the existing work statements. JH mentioned that JH and Joe Huang met yesterday and discussed how to divide up the existing work statements. JH then reviewed the status of existing workstatements, and it was concluded that there were only two one-pagers that remained on TC 4.7 Inverse Methods subcommittee Long Range Research Plan (LRRP).

- The #1 1997/98 WS had become a project out for bid (Linear & CP Linear Toolkit).
- The #3 1997/98 WS was still under revision in the IM subcommittee (Calib.Methods).
- The #4 1997/98 WS had moved to the TC 4.7 Applications Subcommittee (Test Suite - Building Fabric).
- The #6 1997/98 WS was dead (Neural Nets).
- The #10 1997/98 WS had been moved to TC 9.6 by Joe Huang.

JH then mentioned that only two one-pagers remained (1) was for Calibrated Simulation, (2) was previously #7 from the June 1997 A&IM LRRP.

JH then mentioned that two more one pagers had been proposed and would be discussed.

JH said that the one pager for WS 1051 was under discussion will be deferred until after the LRRP had been discussed.

JH then gave the group a few minutes to read the one-pagers. Discussion then began on the one-pager for in-situ, semi-empirical chiller models: “Methodology development to extend RP 827 semi-empirical chiller models to include models for screw chillers, air-conditioners, and heat pumps”.

JH asked Agami Reddy to explain why this approach is superior to existing methods in DOE-2, e.g.,

Agami Reddy said that the semi-empirical models are more physical and are more accurate, and amenable to use for fault-detection.

Jim Willson suggested that the scope be expanded to include air-cooled as well as water-cooled systems.

Agami said the model should work for air-cooled, but doesn't recall whether an air-cooled system was modeled.

Phil Haves mentioned that Jim Braun is doing an ASHRAE project on chiller models for fault-detection, so that if the WS includes mention of fault-detection, there should be reference to Jim Braun.

JH explained that these models are simplified model with inputs suitable to be measured economically, and not like the inputs required for detailed simulation models.

Haves reiterated that the WS needs to be clarified to avoid appearing to overlap with Jim Braun's work.

ACTION: Chip Barnaby suggested also looking at LeBrun's HVAC 01 toolkit models to see what could be "mined", since those models also developed lumped parameters.

Chip Barnaby wondered what made this work statement a IM project ?

JH said that this is because the physical parameters are obtained through regressions.

Kelly Kissock asked how these models compare to M. Hydemann's work at PGE ?

JH said that PG&E is using a tri-quadratic method that is found in DOE-2 and that the RP 827 models use the Gordon Semi-empirical models, which are superior (in his opinion).

ACTION: JH said that TC 4.7 IM needs to make sure the WS does not step on toes of TC 4.11, and communicate one-pager to Jim Braun, and do a careful study of HVAC-01 to discuss any similarities or differences from LeBrun's report.

The discussion then went on to the one-pager: "Development of a procedure for baselining energy use at large central plants".

JH said that this one-pager was developed out of his work at Texas A&M on whole campus plant energy use. ASHRAE has no procedure or advice on how to determine the base line energy pattern at the central plant level. JH says we don't have a method to look at a whole plant like we look at a single building. Much discussion on the objectives of this work statement then continued. Basically, the discussion highlighted that those attending TC 4.7 IM could not come to a consensus about what it means to "baseline a central plant".

JH then froze the discussion and this one-pager and suggested that TC 4.7 IM sponsor a Forum in Chicago to clarify what is this topics with the justification that this one-pager is not yet ready.

ACTION: The Forum for Chicago would be: "Characterizing the performance of central plants on multi-building campuses ". JH volunteered to be the moderator.

Discussion then went on to a new, hand-written one-pager by Kelly Kissock. KK described the one-pager which was to modify the linear and change-point linear toolkit (now out for bid) to handle linear & change-point linear models that included additional independent variables. Examples were given including the Symposium paper that KK had just delivered in Robert's 10:15 Symposium on Baselining models.

KK mentioned that change-point models often fail in these cases. He said that ASHRAE had not developed change-point models to account for these other parameters.

Robert Sonderreger said that accounting for non-weather factors has been going on for years.

JH said that there was still a need for a methodology development to solve these problems.

JH then asked for votes on which of the above should be in the research plan.

- 1. chiller model (approved),
- 2. baselining plant model (mixed),
- 3. KK’s change-point plus independent models (opposed).

Therefore, the following one-pagers are on the Research Plan (in order of priority) :

- 1.”Development of Toolkit for comparing results of hourly building energy simulation program against measured energy and internal environmental data (WS 1051).
- 2. “Semi-empirical chiller models”

The long-range research plan was voted and carried unanimously.

ACTION: JH deferred discussion on WS 1051 to Chicago, pending comments from Robert Sonderegger, Chip Barnaby and David Claridge.

JH requests that Sonderegger, Barnaby and Claridge to send in their comments to him by the end of August.

JH said that 1051 would reported as “under revision”.

Phil Haves said that the WS title does not mention calibration, but the text mentions it frequently.

JH said the WS is meant to be wider than calibration.

Phil Haves suggested the WS be extended to be wider than calibration.

ACTION: Phil Haves and Mike Witte both agreed to review the WS and have comments to Haberl by the end of August.

ACTION: JH will collect the comments and modify the WS for Chicago.

Discussion then went on to Program. The program discussed consisted of:

+ Chicago 1999  
 Forum “Characterizing the Performance of Central Plants for Multi-building Campuses”, Moderator: Jeff Haberl

+ Seattle 1999  
Symposium “Methods for Calibrating Building Energy Simulation Programs”, Chair: Agami Reddy  
  
Potential paper: Jeff Haberl  
+ Dallas 2000

ACTION: Haberl will develop an abstract for the Chicago Forum and past to Carol Gardner.

There were no other volunteers or program suggestions for Chicago or Seattle .

JH said he’ll have 1 - 2 papers for a *Symposium* on calibrated computer models for Seattle. Agami Reddy agreed to be the chair, as authors are no longer allowed to be Symposium Chairs.

The Symposium for RP-865 moved to Applications subcommittee.

The meeting was adjourned at 9:10 p.m.

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**TECHNICAL COMMITTEE 4.7 – ENERGY CALCUALTIONS  
PRIORITY 3****PROJECT TITLE**

Development of Toolkit for Comparing Results of Hourly Building Energy Simulation Programs against Measured Energy and Internal Environmental Data

**OBJECTIVE**

The objective of this research is to develop a toolkit that will assist ASHRAE engineers in comparing the results of hourly simulation programs such as DOE-2 and BLAST to measured data from actual buildings. Such procedures would be delivered in toolkit that would be similar to the ASHRAE HVAC 1 and HVAC 2 toolkits in format and would contain algorithms and documented computer code for assessing how well computer simulations are calibrated to measured building energy data. This research includes performing a literature search to determine the different methods that are currently being used to calibrate hourly simulation programs, development of standard procedures for performing the calibrations, and documenting the procedures.

**BENEFITS**

The project will benefit ASHRAE membership as well as the general public as follows:

1. ASHRAE to develop standard procedures for assessing how well computer simulations are calibrated to measured building energy data.
2. Software suppliers as an aid for incorporating ASHRAE calibration assessment procedures into their building energy analysis programs.
3. Text book publishers for documenting calibration assessment procedures.
4. ASHRAE for developing more effective training programs for teaching engineers how to calibrate computer simulation programs.
5. Improving indoor air quality by providing ASHRAE members with improved procedures for calibrating building energy simulation programs.
6. Improving energy efficiency by providing ASHRAE members with improved procedures for calibrating building simulation programs.

**ESTIMATED COST**

\$95,000

**ESTIMATED DURATION**

18 months

**METHOD OF PUBLISHING RESEARCH RESULTS**

A Technical Paper will be presented at an ASHRAE meeting. An ASHRAE special publication may also result.

**POTENTIAL CO-SPONSORS**

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None yet identified.

ASHRAE ONE PAGE WORK STATEMENT  
FROM TC 4.7 APPLICATIONS AND INVERSE METHODS SUBCOMMITTEE

TITLE: A&IM RANK: **\*\*NEW\*\***  
Methodology Development to Extend RP 827 Semi-empirical Chiller Models to include Models for Screw Chillers, Air-conditioners, and Heat Pumps.

OBJECTIVE:

The objective of this research is to expand upon the previous work by RP 827 which previously developed in-situ measurement methods for pumps, fans and chillers. Specifically, RP 827 utilized semi-empirical models to characterize chiller performance that can be readily applied to chillers installed in existing building and recommended a test procedure for applying the models (Gordon and Ng 1994). The models cited in RP 827 include centrifugal and reciprocating chillers and required on-site measurements of the thermal output, chiller electrical input, and temperatures for the chilled water supply and condenser water return. This proposed workstatement would expand the RP 827 models to develop models for screw chillers, air-conditioners, and heat pumps. This work would be beneficial to energy service companies who could use it to more accurately assess the thermal interaction of retrofits to plug and light loads beyond the previously accomplished work.

SCOPE:

This research includes: (1) Thorough literature search into the current semi-empirical models that are used to model chillers, air-conditioners and heat pumps, (2) development of new semi-empirical models for screw chillers, air-conditioners, and heat pumps, (3) validation and testing of the models with measured data.

BENEFIT:

The project will benefit ASHRAE membership as well as the general public as follows:

1. ASHRAE to develop a standard methods for in-situ measurement of screw chiller, air conditioner and heat pump performance using semi-empirical models.
2. Software suppliers as an aid for incorporating semi-empirical models.
3. Text book publishers for documenting such semi-empirical models.
4. ASHRAE for developing more effective training programs for teaching engineers and architects how to apply such semi-empirical models.
6. Improving energy efficiency by providing ASHRAE members with improved semi-empirical models.

ESTIMATED COSTS:  
\$95,000

DURATION:  
18 calendar months

CONTRIBUTORS:  
Jeff Haberl

Gordon, J.M., Ng, K.C. 1994. "Thermodynamic Modeling of Reciprocating Chillers", Journal of Applied Physics, Volume 75, No. 6, March 15, 1994, pp. 2769-2774.



# Attachment 3

## Simulation and Component Models

June 22, 1998

### Minutes

The meeting was called to order at 6:03 pm. The 28 people in attendance are listed on page 2. The following subjects were discussed:

#### 1. Program

The TC 4.7 sponsored forum, "*Who needs moisture calculations*", which was organized and chaired by Mike Brandemuehl, generated a lot of interest. The following needs were identified:

- Existing DX coil models are not good for off-load design conditions.
- Moisture adsorption and desorption models are needed
- Comfort and peak demand issues related to moisture (in addition to energy) should be investigated.

A high priority will be placed on obtaining a better DX model for planned upgrades to the Secondary Toolkit.

The planned seminar "*Beyond Spreadsheets*" was canceled for lack of presenters.

Chip Barnaby reported that he only has two papers in hand for the Chicago symposium: "*Application of heat (and mass) balance methods to energy and thermal load calculation*". The symposium will be postponed until Seattle. Fred Winkelmann, \_\_, \_\_ and agreed to review the papers. Other reviewers are needed.

Dan Fisher will expedite the Seattle symposium: "*Recent innovations in HVAC System modeling*". The call for papers has not yet been published.

After some discussion, including a brief communication with TC 1.5, it was decided to sponsor a seminar in Chicago on interoperability of simulation tools. The seminar will include a comparison of NMF and Modelica. Phil Haves will chair the seminar with assistance from Ed Sowell.

#### 2. Research Projects

Dru Crawley reported on RP 987: *Loads Toolkit*. The project is progressing. The contractors have been providing samples of code and documentation to the review committee. They will be providing a CD with more hot links from their code in Chicago.

Three projects were submitted for the research plan:

- "*Modeling 2 & 3D heat transfer through composite Wall and Roof Assemblies in Hourly Energy Simulation Programs*" Joe Huang reported that the work statement had been delayed in San Francisco in order to allow time for discussion with TC 4.4. As a result of this discussion it was determined that there was no duplication of effort with TC 4.4 and that it would be best to proceed without seeking co-sponsorship.
- Chip Barnaby submitted a new one pager, "*Standard HVAC Equipment Characteristics for Energy Calculation*" for consideration. The committee supported the effort. A lengthy discussion resulted in Phil Haves and Robert Sonderegger volunteering to assist in completing the work statement.
- Dru Crawley & Jan Hensen also submitted a one pager for consideration: "*Development of HVAC System templates for simulation Programs*". After some discussion it was decided to pursue the project. Ed Sowell and Ian Beausoleil-Morrison will assist Dru and Jan in the work statement development.

... "*Modular simulation of building envelope performance*" will remain on the backburner for now.

#### 3. Neutral Model Format

Ed Sowell led a discussion on NMF. The committee agreed that it was important for the TC to support the concepts embodied in NMF, but viewed NMF as a long term, low level investment. The committee was particularly interested in comparisons between NMF and other languages, such as Modelica.

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The meeting was adjourned at 7:19pm.

## Attendance

Last Name	First Name	E-Mail
Barnaby	Chip	cbarnaby@wrightsoft.com
Beausoleil-Morrison	Ian	ibeausol@nrcan.gc.ca
Brandemuehl	Mike	michael.brandemuehl@colorado.edu
Buhl	Fred	buhl@gronk.lbl.gov
Claridge	David	claridge@esl.tamu.edu
Crawley	Dru	drury.crawley@hq.doe.gov
Fisher	Dan	d-fisher@uiuc.edu
Fraser	Kathleen	kfraser@canuck.com
Haberl	Jeff	jhaberl@tamu.edu
Haves	Philip	p.haves@lboro.ac.uk
Hensen	Jan	jan@esru.strath.ac.uk
Huang	Joe	YJHuang@lbl.gov
Knappmiller	Kevin	kevink@kevtex.com
McDowell	Tim	tess@bestware.net
Norford	Les	lnorford@mit.edu
Perkovich	Mark	mark.perkovich@carrier.utc.com
Rees	Simon	sjrees@okstate.edu
Ruddeck	Claus	cr@ibe.dtu.dlr
Smith	Vernon	vsmith@archenergy.com
Sommer	Klaus	sommer.roycroft@t-online.de
Sonderegger	Robert	rsc@oak.synergic.com
Sowell	Ed	sowell@fullerton.edu
Spitler	Jeff	spitler@okstate.edu
Swami	Muthusamy	swami@fsec.vcf.edu
Van Heerden	Eugene	e.vheerden@eng.up.ac.za
Walton	George	gwalton@nist.gov
Winkelmann	Frederick	fcw@pegasus.lbl.gov
Witte	Michael	mjwitte@gard.com

# Attachment 4

## MINUTES

**TC 4.7 Subcommittee on Applications**  
**Tuesday, June 23rd, 4:00 - 5:30 p.m.**  
**Sheraton, Kent Room**  
**Chair: Joe Huang**

### REVISED AGENDA

1. Introductions (all)
2. Announcements  
the new Applications subcommittee - who we are? (all)
3. Approval of the minutes from the old A&IM subcommittee meeting (all).
4. Review and vote on long range research plan (all).  
TC 4.7 LRRP  
Former TC 4.7 A&IM LRRP  
Current Applications LRRP
5. Discussion of Work Statements:  
  
1052 WS: "Development of an Analytical Verification...building Fabric" Judkoff, Neymark, Barnaby.  
  
WS: "Development of a toolkit for preparing weather data..." Haberl, Crawley.  
  
Others?  
  
WS: "Standard operating conditions in North American Residential Buildings" Parker, Huang.
6. Old Business (all)
7. New Business (all)
8. Adjourn

## ATTENDEES:

NAME	AFFIL.	EMAIL
Jeff Haberl	Texas A&M	jhaberl@tamu.edu
Joe Huang	LBNL	yjhuang@lbl.gov
Jim Willson	LG&E Enertech	jim.willson@lgenergy.com
Fred Buhl	LBNL	bhul@gronk.lbl.gov
Phillip Haves	Loughborough Univ.	p.haves@lbobo.ac.uk
Robert Sonderegger	SRC Systems	rsc@oak.synergic.com
Agami Reddy	Drexel Univ.	agami@erols.com
Fred Winkelmann	LBNL	fcw@pegasus.lbl.gov
Jan Hensen	Univ. of Strathclyde	jan@esru.strath.ac.uk
George Walton	NIST	gwalton@nist.gov
Klaus Sommer	Univ. of Applied Science	sommer.roycroft@t-online.de
Ian Beusolei-Morrison	CETC Ottawa	ibeausol@nrcan.gc.ca
Chip Barnaby	Wrightsoft	cbarnaby@wrightsoft.com
Kevin Knappmiller	Keutec LLC	kevink@keutec.com
DruCrawley	USDOE	drury.crawley@ee.doe.gov
Dan Null	Flack & Kurtz	null@ny.fk.com

The meeting was called to order at 4:07 p.m. by Joe Huang (JH) and introductions were then made.

JH then presented his objectives for the meeting:

1. Discussing the creation of the new sub-committee.
2. Discussing the Long Range Research Plan.
3. Discussion of work statements.
4. Discussion of program.

Joe Huang then asked Jeff Haberl to review the minutes from the San Francisco meeting. Haberl then reviewed the minutes, pointing out that most of the meeting was spent reviewing and editing WS so that they can go forward to the full TC.

JH then went on to discuss how the outstanding work statements had been divided up between the Inverse Methods (IM) subcommittee and the Applications Subcommittee.

JH reviewed that he and Haberl met and discussed how to split up the topics and WS so that work could move ahead in two subcommittees. JH said that the work had been split between inverse methods going to IM and all else going to Applications.

Chip Barnaby said that the goal of Applications should be to move simulation into the finger tips of the HVAC design engineer.

Chip said that the reason for the split was to allow for work to accelerate in Applications without holding back Inverse Methods. This was based on the fact that most of the work statements that were coming out of the old Applications and Inverse Methods Subcommittee was mostly Inverse Methods and not Applications.

George Walton agreed with Chip that the split was needed.

Chip reminded that Inverse Methods needed to develop inverse methods and that Applications should “assume” that models work and concentrate on applications.

With this in mind JH asked the subcommittee to look at the WS to see if they indeed applied to Chip’s new definition.

Jim Willson suggested that an appropriate applications for this sub-committee should be something like “calibration of computer simulation”.

Chip agreed that this was a valid WS for the Applications Subcommittee.

Agami Reddy then suggested that when an architecture firm designs a building that they need to have a package of simulation programs, beyond just energy simulations, and how could the applications subcommittee provide this.

Chip suggested that that type of “one program fits all” is the Holy Grail of simulation.

Fred Buhl suggested that a Task Group had been formed to look into this on “Integrated Design”. Several people agreed that none of the efforts to date had had any success to date.

It was also suggested that the task of “one program fits all” may not yet be possible since there was so much simplification that was needed to be able to simulate a building. Typically, there was way too much information in an Autocad file for a simulation program.

Haberl reported that Std. 90.2 had come to ASHRAE TC 9.6 and asked for the development of a work statement that would develop a communications backbone that developers could use to develop compliance tools for 90.2 and that this might become a backbone for an effort that could handle a “one program simulates all”.

Jim Willson said that this subcommittee needed to know more about the ASHRAE members and what they are using simulation for.

Joe Huang suggested that the Applications subcommittee should look into doing workshops about how simulation programs can be applied to all aspects of HVAC design.

Kevin Knappmiller suggested that a seminar would be a good place for the discussion of how simulation is used.

JH agreed with Kevin and said that the discussion of this topic would be deferred until the program discussion.

JH then asked the subcommittee to look at the existing LRRP and gave folks a minute to read the LRRP.

JH then asked Danny Parker to talk about the development of guidelines for using DOE-2 simulations for residential simulations. Danny mentioned that some work had been done by AEC for EPRI years ago but that not much had been done since.

Danny said that the work that had been done for 90.2 had been done by LBNL but had not been done in many other places.

JH said that such a one-pager could address issues such as thermostat settings, window shade settings, etc.

Danny cited examples such as the ground coupling and that it was important for simulating residences.

Haberl mentioned problems with calibrating DOE-2 to a Habitat house, including the ground coupling, input of A/C efficiency, etc.

Chip said that the importance of the project should be on the assembly of good recommendations about the inputs "Energy Conservation Guidelines for Simulating Residential Single Family Residences".

Robert Sonderegger reminded the committee that there may be some inputs that could be misleading, such as the thermostat setting.

Klaus Sommer reminded the committee that there are many, many inputs that must be used and that a major portion of this WS would be to determine those that are important.

**ACTION:** Danny Parker agreed to write the WS and Jeff Haberl agreed to help.

Dan Null brought up the problem that there is very little advice about what to use for the default curves in DOE-2 and BLAST programs. He said that he is always at a loss as to what to use and he would find it very useful to have a table of values to use.

Dan said that what would be nice would be to have a table of published information that describes the available input that a practitioner might be forced to utilize.

Kevin said that this was an interesting issue. He asked if there was anything fundamentally wrong with developing such a thing. He cited the example about diffusers where the main published data was throw...and that this was not appropriate CFD analysis.

Dan said that the information should be limited to that type of information that is available in the public domain.

Klaus said that the results should be generic so that it gives advice about how to validate this type of work to any program.

JH said that what he thought was being discussed was the production of a table of coefficients for generating the default variables for a simulation program.

Dru Crawley said that the subcommittee should contact Mark Hydeman and see what he has accomplished for chillers.

Kevin said that publishing this would help get manufacturers to publish this information.

Chip reminded the committee that at precursor for this WS was the development of procedures to facilitate this on an ongoing basis.

Haberl mentioned that some manufacturers provide the numbers that are needed for their equipment and some don't.

Dan made another suggestion that fan curves were another place where one wonders if the simulation program is really simulating the fan.

**ACTION:** Dan Null agreed to write the WS. Jeff Haberl agreed to help with the WS.

Jim Willson asked the committee about where one was going to get numbers for cooking equipment, DHW, etc.

Kevin said that this was available from TC 5.10 Commercial Kitchen ventilation in combination with folks from 6.2.

JH reviewed the titles of the one-pagers:

“Input values for residences in North America”, by Parker and Haberl.

“Default performance factors for primary and secondary equipment simulation inputs for commercial buildings”. by Dan Null and Jeff Haberl.



Discussion then moved on to the WS on developing a toolkit for preparing weather data for use by a simulation program.

Chip said that this should probably move to TC 4.2 with co-sponsorship by TC 4.7.

ACTION Chip agreed to edit this WS and take to TC 4.2 for their use.

Kevin suggested some items for program, including what ASHRAE needs from TC 4.7: “TC 4.7, Who we are, where we’ve been, what we’re doing, where we’re going and how can we help you”,

ACTION: “TC 4.7, Who we are, where we’ve been and where we’re going”, Kevin will chair the seminar. Possible speakers: Marx Ayres, Kurt Peterson, Dave Knebel, Gene Stamper, Gideon Shavit.

JH then gave the floor to Carol Gardner to discuss program.

Carol said that there was a Symposium about “Beyond Spreadsheets” and where this had gone.

Phil Haves said that this had mutated into “Interoperability ...” and that he had two papers in hand.

The meeting was adjourned at 5:40 p.m.

**Attachment 5**  
**ASHRAE**  
**Technical Committee 4.7 Energy Calculations**  
**1999-2000 Research Plan**  
**1 July 1998**

Priority	Title	Status	Subcommittee Responsible
<b>1</b>	Define Performance Factors for Primary and Secondary Equipment Simulation Inputs for Commercial Buildings	WS being developed	Applications
<b>2</b>	Standard HVAC Equipment Characteristics for Energy Calculations	WS being developed	Simulation and Component Models
<b>3</b>	Standard Operating Conditions in North American Residential Buildings	WS being developed	Applications
<b>4</b>	Extend and Develop Methodology of 827-RP to include Models for Screw Chillers, Air-Conditioners, and Heat Pumps	WS being developed	Inverse Methods
<b>5</b>	Development of HVAC System Templates for Energy Simulation Programs	WS being developed	Simulation and Component Models

**ASHRAE TC 4.7 Energy Calculations  
Research Strategy**

**Scope**

Technical Committee 4.7 is concerned with identifying, evaluating, developing, and recommending procedures for calculating energy performance of buildings.

## **Goal**

Accurate energy models at every engineer's fingertips

## **Research Strategy**

TC 4.7 pursues research in three major areas:

- Simulation and Component Models
- Inverse Methods
- Applications

In the simulation and component model area, research focus includes first principle models, algorithms, and solution techniques for individual components, equipment, systems, and entire buildings.

In the inverse methods area, the focus is on deriving calculation methods from measured data, developing statistical simulation methods, and calibrating simulation models to measured data.

For the applications area, the focus is on use of simulation in practice—development of case studies, problem-solving procedures, and input data compilations such as materials properties and internal gains—in general, technology transfer.

Technical Committee 4.7 actively develops work statements for new projects to keep a balanced portfolio of projects in all three areas.

## Attachment 6

### Modeling Two- and Three-dimensional Heat Transfer Through Composite Wall and Roof Assemblies in Hourly Energy Simulation Programs

Draft Work Statement for consideration at the  
TC 4.7 Full Committee meeting  
in Toronto, June 23 1998

#### Background

Nearly all current building energy simulation programs model conduction through the building envelope as one-dimensional heat flow. For composite wall and roof assemblies with dissimilar sections, the typical modeling method is a parallel path technique that divides a wall, for example, into a "stud" and a "non-stud" portion. For conventional wood-frame walls with relatively small differences in conductivity ( $< 20$ ) and minimal thermal mass effects, the parallel path technique produces satisfactory results. The parallel path technique, however, produces serious errors when there are large differences in thermal conductivity (as much as 1000 in metal-frame construction) or significant lateral heat flows as in complex concrete or masonry wall systems.

For such composite assemblies, a number of simplified methods have been developed to calculate their R-values (Tuluca et al. 1997), but their use in dynamic simulations has not been studied. The R-values produced by these steady-state calculations are not mutually consistent. Furthermore, none address transient thermal effects that can be significant under dynamic conditions, particularly in concrete and masonry systems. Thermal mass effects are less significant (but not negligible) in metal-frame systems, but there another problem arises. Because of strong thermal bridging, Kosny and Desjarlais (1994) and Bazjanac et al. (1996) have found that surface discontinuities such as corners, wall/roof interface, and window perimeters can account for up to half of the heat flow of metal-frame walls, and yet these conditions are typically ignored in whole-building simulations.

#### Justification of Need

In recent years, there has been a trend towards the use of metal-frame construction in both residential and commercial construction as the relative cost of wood to metal continues to increase. There has also been rapid development of new construction technologies where highly conductive structural materials such as metal or concrete are combined with high-performance insulative materials to produce assemblies with complicated networks of three-dimensional thermal bridges. Meanwhile, the dynamic modeling of even conventional concrete and masonry assemblies continues to be problematic. This situation has greatly increased the need for more accurate modeling of multi-dimensional heat flows in composite walls and roofs in hourly simulations.

At present, multi-dimensional heat transfer effects in such assemblies are either ignored or approximated using equivalent R-values from various steady-state methods. For metal-frame walls, a study showed that the parallel-path method could underpredict loads by as much as 47% (Kosny 1997). The various equivalent R-value methods, on the other hand, are mutually

inconsistent and incomplete in not characterizing the dynamic thermal behavior of composite assemblies.

There is a need for adding a multi-dimensional heat flow modeling capability to typical building energy simulations that is accurate, comprehensive, compatible with the overall simulation method of those programs, and does not require inordinate effort to use. Previous efforts in this area include a technique to create a single set of response factors for composite wall assemblies using a parallel-path approach (Mitchell et al. 19##), the creation of equivalent one-dimensional response factors (Huang et al. 1996), or thermal properties for fictitious one-dimensional layers (Kosny 1997), both through detailed two- or three-dimensional numerical analysis. Because of the increased importance of thermal bridging, this procedure should also provide information on the in-situ conditions of wall and roof assemblies and guidelines on how to model the heat flows at wall intersections, window perimeters, and other anomalous areas.

### **Objectives**

The objective of this project is to develop a procedure to simulate lateral heat flows and thermal bridging in composite wall and roof assemblies that is flexible and comprehensive, but simple enough to be used in hourly building energy simulations. This procedure should rely on results from detailed multi-dimensional modeling of the heat flow in composite assemblies, but develop from them equivalent one-dimensional response factors or material properties that are suitable for use in whole-building energy simulation programs. In addition, the contractor should investigate the actual construction characteristics of typical wall assemblies in the field, and provide guidance on how best to model their thermal behavior in hourly simulations. The contractor should also verify the accuracy of both the detailed modeling and the simplified procedure against field measurements, and provide a library of response factors or material properties for typical assemblies.

### **Scope**

The contractor will undertake the following tasks, assisted as specified below by the Project Monitoring Subcommittee (PMS). The contractor's effort must be designed to interact closely with the PMS, allowing time for review and decisions at several key stages. A final report will summarize key results and identify directions for future work if warranted.

Task 1. As a preliminary activity, determine the in-situ construction details of typical composite wall and roof assemblies and quantify the amount of thermal anomalies such as double-studding, thermal bridging at surface intersections, etc. This information is critical to the accurate modeling of composite assemblies and is of value in itself.

Task 2. Model the dynamic heat transfer characteristics of composite assemblies using detailed multi-dimensional heat transfer programs, and develop an accurate and practical procedure for incorporating the detailed results into typical building energy simulations.

Task 3. Submit to the PMS a proposed library of common composite wall and roof assemblies for detailed multi-dimensional analysis. Depending on the selected simplified procedure, generate a library of either equivalent response factors or fictitious material properties for these assemblies.

Task 4. Implement the simplified procedure in a commonly used hourly simulation program. This implementation should be more than a "proof of concept", but rather a fully functional routine that can be used by ASHRAE members with little or no additional work.

Task 5. Gather or obtain existing field measurement data on the thermal performance of representative composite assemblies and use that data to validate the simulation procedure. The field measurement data should be hot box measurements of at least two-dimensional composite wall assemblies and ideally include varying boundary conditions for determining the dynamic response of such assemblies. Potential sources for such data include former or ongoing ASHRAE projects sponsored by TC 4.1 (full citation need) and TC 4.4 (981-TRP "Thermal performance of cold-ormed steel ceiling/roof framing assemblies").

Task 6. Prepare project report and technical paper. The contractor will prepare a detailed technical report that describes the characterization of composite wall thermal properties, the methodology used for the detailed multi-dimensional analysis, the validation of those results against field measures, and simplified calculation method. A technical paper will be prepared that summarizes this report, and provides guidance for ASHRAE members on the use and limitations of the simplified procedure.

## **Deliverables**

The deliverables for the project are:

1. Letter report describing the in-situ construction details of typical composite wall and roof assemblies and categorizing them by area and assembly characteristics (stud, clear-wall, double-stud, wall or floor intersection, etc.) - two months after contract award.
2. Draft report describing test results of detailed multi-dimensional analysis of test composite wall and roof assemblies, and proposed methodology for implementation in whole-building simulation program. The contractor will also submit a list of proposed wall and roof assemblies to be included in the library - six months after contract award.
3. Draft report describing the implementation of the simplified procedure in an hourly simulation program and preliminary validation of the detailed modeling and simplified procedure against field measurements - one year after contract award.
4. Draft report describing the completed library of typical composite assemblies, and how to utilize that library in a whole-building energy simulation - 15 months after contract award.
5. Final technical report including the completed validation against field data, documentation of the simplified procedure as a stand-alone module in a modular language, the working implementation in a selected hourly simulation program. The last two items should be delivered in electronic form along with explanation and a simple user's guide - 18 months after contract award.
6. Technical Paper to be presented at an ASHRAE meeting - 18 months after contract award.
7. Work with TC4.7 and the PMS to incorporate results into the *ASHRAE Handbook of Fundamentals* - 18 months after contract award.

## **Additional Information for Bidders**

Criteria for selecting the contractor are (relative weighting of each factor is shown in parenthesis):

1. Technical quality of the proposal, originality, and responsiveness to the project goals (40%).
2. Technical qualifications and relevant experience of the individuals directly assigned to the project (30%).
3. Proven ability to interact effectively with a technical monitoring committee in development of ideas and review of contractor products (10%).
4. Reasonableness of proposed costs and technical effort, considering planned work and project objectives (20%).

Joe Huang, Richard Strand, and Jan Kosny contributed to the writing of this work statement.

## **Budget and Timing**

The project is estimated to cost \$95,000 and cover a period of about 18 months. Contractor costs are not to include purchase of computer hardware or monitoring equipment. Reasonable costs for acquisition of data and commercially available software are allowable, but any software finally recommended shall be appropriate for widespread purchase and thus be readily and widely available.

## **References**

1. Bazjanac, V., Feustel, H., Huang, Y.J. "The modeling of two-dimensional heat flow in DOE-2 simulation", Consultant Report, Energy Efficiency Division, Calif. Energy Commission, Dec.1996.
2. Huang, Y.J., Bazjanac, V., Feustel, H., and Trowbridge, J. "Two-dimensional wall response factors", *DOE-2 User News*, Vol.17, Nol. 3, pp.6-12, Lawrence Berkeley National Laboratory, Fall 1996.
3. Kosny, J. and Desjarlais, A.O., "Influence of architectural details on the overall thermal performance of residential wall systems," *Journal of Thermal Insulation and Building Envelopes*, Vol.18, July 1994.
4. Kosny, J. Draft work statement for "Development of accurate one-dimensional substitutes for complex two and three~dimensional structures for DOE-2 and BLAST material libraries", June 1997.

- 
5. Mitchell, J. et al., Univ. of Wisconsin (full reference needed)
  6. Tuluca, A., Lahiri, O., and Zaidi, J. "Calculation methods and insulation techniques for steel stud walls in low-rise multifamily housing", *ASHRAE Transactions*, Vol. 103, Part 1, pp, 550-562, Jan.1997

TC 4.1 project ? (full reference needed)

7. "Thermal performance of cold-formed steel ceiling/roof framing assemblies", ASHRAE Project 981-TRP (ongoing).



## Attachment 7

### **TC 4.7 Handbook Subcommittee Meeting**

Handbook of Fundamentals  
Chapter 30  
Energy Estimating and Modeling Methods  
Monday, June 22, 1998

Present:

Chip Barnaby  
Dave Claridge  
Kathleen Fraser  
Ian Beausoleil-Morrison  
Dan Nall  
Les Norford (chair)  
Klaus Sommer

The meeting began at 5:15 p.m. Norford reviewed the schedule for the 2001 Handbook of Fundamentals:

January 1998 review of chapter completed, revisers committed  
June 1998 first draft prepared by the subcommittee  
June 1999 draft approved by the TC  
January 2000 final version approved by TC  
April 2001 HoF to printer

Bahnfleth, Hittle and Norford have reviewed the chapter and marked it up with a number of relatively minor changes, appropriate in the aftermath of the major changes made to the 1997 chapter. These changes serve as a first-pass revision. Norford identified three major activities:

- Coordinating with TC4.1 for coverage of the heat balance method, given that TC 4.1 aims to include this method in the loads calculation chapter. Spitler, the author of the heat-balance presentation in the current chapter, will take the lead. As a function of TC4.1 action, the descriptive material and the example will be moved or retained, as needed to ensure its continued inclusion in HoF, and the presentation in the TC4.7 chapter. Spitler will also revise the presentation as necessary to help practicing engineers identify the applications, assumptions, and limitations of the method.
- Tightening the presentation of inverse methods. The current chapter presents degree-day and bin methods and also has a separate and major section on inverse methods. There is some overlap in the material. Reddy will review this part of the chapter.

- Making the chapter more useful for practicing engineers. Nall and Fraser will review the entire chapter from the perspective of practicing engineers – those in design and those working with energy data, such as performance contractors. Barnaby suggested that the introductory section include a road map of tasks and appropriate tools; Norford will ensure that such a map is included, with contributions from Fraser and others.

### **Other actions include:**

- Beausoleil-Morrison will identify future trends and help provide guidance about identifying the important aspects or inputs of different methods.
- Krarti will provide material on ground-coupled heat transfer and when it is important.
- Brandemuehl will review the material in the current chapter on secondary and primary systems, with an eye on what is needed in an energy calculations chapter and guidance for users of the modeling tools.
- Fraser suggested that the chapter include a reference to the DOE Web listing of energy-calculation software.
- Both the road map and new descriptive text will address advanced practice, such as is involved in design of buildings with buoyancy-driven airflows or displacement ventilation. Norford will ask Chen (MIT) to help prepare this and will solicit input from Nall.

Norford will incorporate reviewer comments and first-cut new material prior to the Chicago meeting, for the benefit of the subcommittee. In accordance with the above schedule, it is planned to have a review draft to the entire TC in time for comments and possibly a vote at the Seattle meeting in June 1999.

The chair notes, in these minutes, his appreciation for those willing to help improve the chapter.

The meeting adjourned at 6:00 p.m.

## Attachment 8

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DATE: 01/22/98

**MINUTES**  
**SPC-140 SMOT FOR BUILDING ENERGY SOFTWARE**  
**San Francisco 01/19/98**  
R. Judkoff

### ATTACHMENTS

- A. Agenda for January 19, 1998 meeting
- B. Cover letter included with Working Draft 98/1
- C. Discussion material that was faxed regarding time convention (results table not included)
- D. Mailing List

### CORRESPONDANCE SINCE LAST MEETING

- Working Draft 98/1 was distributed in early January.
- Summary of time convention sensitivity tests of shaded east west windows (attachment C) was distributed in mid-January.

### GENERAL

None

### INTERMODEL COMPARISON BASED TESTS

The purpose of the meeting was to discuss voting member comments regarding proposed Standard Method of Test 140, Working Draft 98/1.

**Attendees** (see mailing list for full names, etc)

Beausoleil-Morrison (non-voting)  
Corson (non-voting)  
Crawley  
Fraser  
Haberl (attended via speaker phone)  
Judkoff (chair)  
Maeda  
Neymark (non-voting)  
Ranfone (non-voting)  
Schaefer (non-voting)  
Sonderregger  
Walton  
Wilcox  
Witte (attended via speaker phone)

**Committee Discussion**

Approval of Prior Minutes

**Motion (Walton): Accept Minutes of December 1997 Conference Call.**

2nd (Sonderegger):

Vote: Yes = 6, No = 0, Abstain = 1 (chair)

Absent = (Winkelmann)

Attending via Speaker Phone = (Haberl, Witte)

Motion passed.

**Major Comments on Working Draft 98/1 by Voting Members**

Judkoff asked the voting members to indicate whether they had issues that would prevent them from voting for sending the proposed standard out for public review.

Crawley requested to include the RP-865 tests. Discussion followed. The committee generally concluded that adding more tests would delay public review for at least 2 years which is not desirable. Also the RP-865 work is not yet done.

This led to discussion regarding SPC 140 becoming a standing committee at some appropriate future time primarily because there are a number of other tests that can be included in the SMOT as they become available (e.g. RP-865). The discussion was inclusive; the topic will be addressed later.

Fraser was concerned that the Purpose could be misinterpreted. After some discussion the committee generally concluded that language regarding the purpose should remain unchanged. Fraser also indicated that Section 3.1.2 should include language to state the concept that modeling methods should be consistent throughout the cases (for example, if a software gives a choice of window models, the same window model should be used for all cases modeled); the committee generally agreed that this language should be added.

Sonderegger requested to add the site elevation to section 3.3.1.2 and strengthen some introductory language in 3.3.1 to double check and diagnose result differences for Case 600 before moving on with the other cases. The committee generally agreed that these comments should be incorporated

**Public Review Options**

Wilcox noted that the period for Public Review is for 120 days while the period for Public Review And Trial Use is 1 to 3 years.

**Motion (Wilcox): Send out Working Draft 98/1 for public review after minor editorial revisions**

Second (Maeda):

Vote: Yes = 4, No = 2 (Crawley, Fraser), Abstain = 1 (chair)

Absent = (Winkelmann)

Attending via Speaker Phone = (Haberl, Witte)

Motion failed.

Haberl and Witte noted that they wanted to follow the process agreed to in the 12/97 conference call minutes that this round of comments be incorporated and then the revised draft be sent out with a letter ballot.

**Motion (Walton): Incorporate voting member written editorial changes/comments to Working Draft 98/1 and send to voting members with letter ballot. The revised draft is to have a format in accordance with the ASHRAE style manual.**

Second (Crawley):

Vote: Yes = 6, No = 0, Abstain = 1 (chair)

Absent = (Winkelmann)

Attending via Speaker Phone = (Haberl, Witte)

Motion passed.

Haberl and Witte also expressed positive support for the motion.

NREL will incorporate written comments to Working Draft 98/1 and send out a letter ballot with the new draft in the near future.

Fraser and Sonderegger submitted their written comments.

The meeting was adjourned.

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**Attachment A - Meeting Agenda January 19, 1998**

**SPC 140 Agenda, 1/19/98, San Francisco**

- Approval of December conference call minutes
- Discuss time convention sensitivity tests for east/west shading
- Poll voting members regarding comments on Draft 98/1, about 15 to 20 minutes for each voting member to:
  - discuss their most significant comments
  - indicate in general if they would recommend Draft 98/1 for public review, and if not then
  - provide very specific comments or text on what needs to be changed so they would recommend Draft 98/1 for public review.

**Attachment B - Transmittal memo accompanying Working Draft 98/1**

7 January 1998

Ron Judkoff  
NREL  
1617 Cole Blvd.  
Golden, CO 80401

**To: SPC 140P Members (distribution below)**

**From: Ron Judkoff and Joel Neymark**

**Subject: Working Draft 98/1**

Enclosed is Working Draft 98/1. This draft is ready for a full scan by the entire committee. It incorporates the committee's comments made since the last draft. **Per the recent conference call we are planning that this draft will be reviewed and comments will be submitted in time for the San Francisco meeting.** There are a few editorial items that remain to be accomplished; these are listed near the beginning of the document. Additionally, we have not yet completed the time convention sensitivity tests for east/west shading that were requested at the last conference call. We will try to complete these in time for the San Francisco meeting for discussion of our conclusions then.

Regarding the public review process, keep in mind that after (if) the committee votes to recommend this for public review, ASHRAE staff will give the proposed Standard a thorough review for editorial issues before it actually goes out for public comment. At that time there will be some interaction between the committee (or committee designee(s)) and ASHRAE staff regarding incorporation of editorial changes. This will likely result in some revisions between what the committee eventually votes on and what ultimately goes out for public review. If issues requiring substantive change come up during the ASHRAE staff review process, full committee input will be solicited.

Please submit your comments to us in writing at the San Francisco meeting. One possible format is to give us copies of all the pages where comments are noted in the margins or otherwise submit comments separately (hardcopy or electronic). Or give us the entire marked up copy of your draft if you prefer (but you still may want to somehow keep a copy of your comments for your own records), although if there are too many of these we may not be able to carry them. Please also remember to review the contents of the enclosed diskette.

Finally, for our meeting in San Francisco, the agenda will likely be to poll each attending committee member regarding: general impressions of the full document, areas where they had their most significant comments, and most importantly whether they will generally be willing to make the recommendation for public review based on this draft (after some expected editorial changes). If a committee member feels they would not be willing to make the recommendation for public review, then they should state why. There should be roughly 15 to 20 minutes for each attending voting member to make statements or otherwise have their most significant comments discussed, so please prepare accordingly.

Distribution: Crawley, Fraser, Haberl, Maeda, Sonderegger, Walton, Wilcox, Winkelmann, Witte, Bevirt, Heldenbrand, Richards, Barnaby, Buhl, Gardner, Pegues, Spitler, Yuill.

**Attachment C. Discussion material that was faxed regarding time convention (results table not included)****RE: Time convention sensitivity for east/west windows with shading**

Dear SPC 140 Voting Member.

Attached is our summary for time convention sensitivity tests regarding shaded east/west windows. **There is only very small difference between these and previous sensitivity tests using unshaded windows.** Proposed minor changes to the App B discussion on this is included as p. 2 of the fax. If the font of Table 1 on page 3 ends up as too small for readable fax transmission, we will be prepared to hand out the table again in San Francisco.

**Time convention, additional sensitivity tests**

When looking at an e/w shaded case (Case 630) for checking time convention sensitivity for annual integrated peak cooling (**see Table 1**) there was very little difference versus for e/w windows without shading. Essentially, the delta kW is the same, but since there is a bit less cooling load with shading, the delta % is slightly higher. Consistent with this is that when just looking at shaded incident and transmitted solar radiation, the delta % due to time convention sensitivities is roughly the same although delta W/m<sup>2</sup> is slightly less.

The effect of time convention on annual shading coefficient of window shading devices is also small: < 3% for worst case hours and < 1% on annual values. The effect of time convention on annual transmissivity coefficients of windows is < 1% for both worst case hours and annual values.

The "630-620" loads outputs used for listed example results (see Table 1) have negligible sensitivity to time convention as long as the time convention is consistent. Variation in west-facing and east-facing annual radiation outputs (e.g. "630b-620b" vs "630a-620a") are compensating and therefore only slightly affect the load values.

Just for curiosity we also did a couple tests with high mass and east/west windows (Case 920) also shown in Table 1. Variation of integrated hourly peak cooling load with time convention was even less than for the low mass cases (in terms of both kW and % variation). Annual cooling load sensitivity was approximately the same as for low mass in MWh but higher in terms of % due to lower loads for high mass; however, this remains as only a 1% order of magnitude issue, and therefore negligible.

To incorporate our new information, we propose the following minor changes in the underline/strikeout format below.

**Proposed rev to concluding portion of B.11.3 (underline strikeout)**

The effect of distorting the calculations was negligible ( $\leq 1\%$ ) for most outputs. The most significant potential differences identified are:

- 3% for annual peak cooling load in the east/west window cases (with or without shading present),
- 8% for hourly cooling loads (9% with shading present) and 8% for hourly solar transmission (with or without shading present) during hours when the equation of time causes the maximum difference between solar time and standard time occurring in February, October and November. However, the differences for these worst case hours cancel out on an annual basis and are not coincident with



occurrence of annual peak loads so that the effect on results required to be entered in the Standard Output report are negligible.

Since the worst potential difference for results required to be entered in the Standard Output report is 3%, and that for just peak cooling loads in the cases with east/west windows, it is reasonable to conclude that potential difference in results generated for Standard 140 due to ignoring the solar tim convention is negligible.

**Attachment D - SPC 140 ADDRESS LIST**

(note: in general email attachments should go out as both \*.DOC and \*.WP5)

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## Attachment 9

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DATE: 07/08/98

**MINUTES**  
**SPC-140 SMOT FOR BUILDING ENERGY SOFTWARE**  
Toronto 06/22/98  
R. Judkoff

### ATTACHMENTS

- A. Agenda for June 22, 1998 meeting
- B. Cover letter included with Working Draft 98/2
- C. Mailing List

### CORRESPONDANCE SINCE LAST MEETING

Working Draft 98/2 was distributed in early June.

### GENERAL

None

### INTERMODEL COMPARISON BASED TESTS

The purpose of the meeting was to vote to recommend SPLS public review approval of Working Draft 98/2.

**Attendees** (see mailing list for full names, etc)

Buhl (non-voting)  
Crawley  
Fraser  
Haberl  
Judkoff (chair)  
Maeda (absent)  
Neymark (non-voting)  
Sonderegger  
Walton  
Wilcox (arrived after the votes were conducted)  
Witte



**Committee Discussion**

Approval of Prior Minutes

**Motion (Winkelman): Accept Minutes of January 1998 meeting (San Francisco) amended to include Sonderegger as attending.**

2nd (Sonderegger):

Vote: Yes = 8, No = 0

Absent = (Wilcox, Maeda)

Motion passed.

**Motion (Sonderegger): To recommend SPLS public review approval of ASHRAE Proposed Standard 140P, "Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs," Working Draft 98/2 dated June 3, 1998 including changes made in writing during the June 22, 1998 (Toronto) SPC 140 meeting; these changes are recorded in the Chair's copy of Working Draft 98/2.**

2nd (Walton)

Vote: Yes = 8, No = 0

Absent = (Wilcox, Maeda)

Motion passed.

(applause)

**Motion (Sonderegger): To authorize the Chair to make minor editorial changes as needed to satisfy the requirements of ASHRAE Staff editorial review.**

2nd (Witte)

Vote: Yes = 8, No = 0

Absent = (Wilcox, Maeda)

Motion passed.

**Motion (Crawley): Recommend SPC 140 become a Standing Standard Project Committee (SSPC) at the time of ASHRAE publication of the Standard (justification as provided in informational Annex B13 of Standard 140P Working Draft 98/2).**

2nd (Winkelman)

Vote: Yes = 8, No = 0

Absent = (Wilcox, Maeda)

Motion passed.

Wilcox arrived just after the above votes were conducted, was informed of the committee's actions, and requested the minutes indicate his agreement with all of the above actions.

Adjourned

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**Attachment A - Meeting Agenda**

**SPC 140 Agenda, 6/22/98, Toronto**

- Approval of January meeting (San Francisco) minutes
- Vote on Standard 140P Working Draft 98/2 regarding recommendation for public review
- Discussion regarding SPC 140 becoming a standing committee

**Attachment B - Transmittal memo accompanying Working Draft 98/2**

05 June 1998

Ron Judkoff  
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1617 Cole Blvd.  
Golden, CO 80401

**To: SPC 140P Members (distribution below)**

**From: Ron Judkoff and Joel Neymark**

**Subject: Working Draft 98/2**

Enclosed is Working Draft 98/2. This draft is ready for a vote to "recommend SPLS public review approval".

Regarding the public review process, keep in mind that after a committee votes to recommend a Standard for public review, ASHRAE staff will give the proposed Standard a thorough review for editorial issues before it actually goes out for public comment. At that time there will be some interaction between the committee (or committee designee(s)) and ASHRAE staff regarding incorporation of editorial changes. This will likely result in some revisions. If issues requiring substantive change come up during the ASHRAE staff review, full committee input will be solicited.

**Changes between Working Draft 98/1 and Working Draft 98/2**

Working Draft 98/2 incorporates the committee's written comments collected and discussed at the San Francisco (January 1998) meeting including conforming to ASHRAE format as well as additional changes noted below.

*Changes resulting from conforming to ASHRAE Format*

Conforming to ASHRAE format led to a number of changes including:

- All placeholder sections were deleted.
- All the "tks" were removed.
- Abbreviations and Acronyms (Section 3.2) were revised
- Output Requirements were moved from Annex A to Section 6. However, Standard Output Reports remains as a normative annex (A2).
- Section renumbering (see Table of contents).
- "Appendix" changed to "Annex".
- Various style changes to match the AFUE Standard Method of Test (103-1993) and the BACnet Standard (which has many annexes (appendices)); note ASHRAE Standards format changes over time and is not fully consistent from Standard to Standard.
- The Temperature Bin Conversion Program discussion was moved from normative Annex A2 to an informative annex (see Annex B12). Additional discussion was added to Section 6.1.7.1 describing the binning requirements in detail so that this software could be included without the source code; we were not able to find the source code which was developed in the UK in 1991. (SSPC 90.1 has also been able to include informational software in Standard 90.1 without source code in this manner.)
- A more mandatory tone ("shall" etc.) was used where appropriate, but not in places where it would conflict with prior committee consensus. (E.g. "Standard output reports ... shall be used"; "... consistent modeling methods shall be used ...").
- A Nomenclature section was added to informational Annex B1 (Tabular Summary of Test Cases) and the abbreviations listing was removed from notes under the tables; this is now more complete and easier to read.
- A Nomenclature section was added to informational Annex B8 (Example Results).

Deleting placeholder sections generated a number of revisions.

- On the advice of ASHRAE Staff, detailed discussion of overall validation methodology was removed from the beginning of the Foreword and replaced with a reference to informative Annex B13. Annex B13 was added and includes the discussion of validation methodologies as well as other research (both completed and in-progress) that are relevant to Standard 140. The Annex B13 discussion includes brief descriptions of: ASHRAE RP-865, HERS BESTEST, and HVAC BESTEST.
- Methods of Test (now Section 4) was reworked as follows:
  - All mention of placeholder sections was deleted.
  - Some discussion from Draft 98/1 was transferred to Annex B13 (see above).
  - The following "introductory" sections from Working Draft 98/1 Section 3.0 were moved to this section:
    - 3.1 "General Description of Test Cases" (except for 3.1.2 Modelling Approach)
    - 3.2 "How to Perform the Comparative Tests".
- Working Draft 98/1 Section 3.0 "Comparative Tests" has now become Section 5.0 "Test Procedures" in Working Draft 98/2. Section 5 (98/2) includes "Modeling Approach" as Section 5.1 and "Input Specifications" as Section 5.2.

#### *Other changes*

The Scope (Section 2) was revised to match language in ASHRAE's files. Using different language (i.e. Draft 98/1 language) in the Purpose or the Scope would require Standards Committee approval. (None of the SPC 140 Voting Members objected to this change in the email message we sent out several weeks ago.)

The presentation of In-Depth cases was revised so that Case 220 is now the In-Depth Base Case instead of Case 200. For IEA BESTEST more software could do Case 220 than could do Case 200. This change is intended to reduce potential confusion regarding creating input decks for taking the test.

Regarding the Standard Output Report, we added a category for "Physical Meaning of Options Used" (see Annex A2 and its attachments).

Cooling loads have been clarified as sensible cooling loads throughout.

#### **Preliminary Meeting Agenda for San Francisco**

- (a) vote regarding moving Working Draft 98/2 on to public review,
- (b) discuss possibility of making SPC 140 a standing committee.

Distribution: Crawley, Fraser, Haberl, Maeda, Sonderegger, Walton, Wilcox, Winkelmann, Witte, Ramspeck (2), Ranfone, Barnaby, Beausoleil-Morrison, Buhl, Corson, Pegues, Schaefer, Spitler, Yuill.

**Attachment C - SPC 140 ADDRESS LIST**

(note: in general email attachments should go out as both \*.DOC, \*.RTF and \*.WP5)

**VOTING MEMBERS**

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