AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE / Atlanta, GA 30329
404-636-8400

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: August 5, 1997

TC/TG/TRG TITLE: Energy Calculations

DATE OF MEETING: July 1, 1997 LOCATION: Boston

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

DISTRIBUTION

ALL MEMBERS OF THE TC/TG/TRG

TAC CHAIRMAN: James Porter

TAC SECTION HEAD: Terry Townsend

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: August 5, 1997

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

CHAIRMAN **Charles Barnaby** **VICE CHAIRMAN** **Robert Sonderegger** **SECRETARY** **Jeff Spitler**

TC/TG/TRG MEETING SCHEDULE			
LOCATION - past 12 months	**DATE**	**LOCATION - planned next 12 months**	**DATE**
Philadelphia, PA Boston, MA	1/28/97 7/1/97	San Francisco Toronto	1/20/98 6/23/98

TC/TG/TRG SUBCOMMITTEES	
Function	**Chair**
Simulation Applications and Inverse Methods	Dan Fisher 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 4			
2.				
3.				
4.				

HANDBOOK RESPONSIBILITIES

Year & Volume	Chapter Title	**No.**	Deadline	**Handbook Subcom. Liaison**
1997	28 Energy Estimating Methods			NONE

STANDARDS ACTIVITIES - List and Describe Subjects

SPC 140P Standard Method of Test for Building Energy Software - Ron Judkoff

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

Appendix 2

TC/TC/TRG Sponsored Symposia - 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)

How should ASHRAE Computer Models be Expressed? (Boston)
Priorities for Near-Term Developments in Building Simulation Programs (San Antonio),
Fast Multizone Models for System Optimization (San Antonio)

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

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

Project Title	Contractor	Comm.Chm.	At Meeting
RP-669 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.

June 1994

665-RP Bourdouxhe, Jean-Pascal H.; Lebrun, Jean; Grodent, Marc; Saavedra, Claudio. Toolkit for primary HVAC system energy calculation - part 1: boiler model. ASHRAE Transactions v 100 n 2 1994. p 759-773

665-RP Bourdouxhe, Jean-Pascal H.; Saavedra, Claudio; Grodent, Marc; Silva, Katia L.; Lebrun, Jean J.Toolkit for primary HVAC system energy calculation - part 2: reciprocating chiller models ASHRAE Transactions v 100 n 2 1994. ASHRAE, Atlanta, GA, USA. p 774-786

756-RP Reilly, Susan M.; Ward, Gregory J.; Dunne, Christopher P.; Winkelmann, Frederick C. Modeling the solar heat gain reflected from neighboring structures ASHRAE Transactions v 100 n 2 1994. p 835-842

666-RP Krarti, Moncef; Claridge, David E.; Kreider, Jan F., Foundation heat transfer algorithm for detailed building energy programs. ASHRAE Transactions v 100 n 2 1994. p 843-850

Appendix 3

TC/TG/TRG SPONSORED SYMPOSIA

Title, When Presented

FUTURE:
Toronto - June 1998

Symposium: *Accuracy Tests for Simulation Programs*
Chair - *Mike Witte*.
Potential speakers Haberl, Yuill

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

Chicago - January 1999

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

PAST:
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

Chicago - January 1995:
Symposium: *More New Algorithms for Computer Energy Analysis*

Orlando - June 1994:
Symposium: *New Algorithms for Building Energy Calculations*

Symposium: *The Great Energy Predictor Shootout*

Chair - Jeff Haberl; one paper from Kreider and Haberl and 4 top winners from Denver.

Symposium: *Differences between Calculated and Measured Loss Coefficients*
Chair - David Claridge; have 4 papers in to ASHRAE --being reviewed.

Symposium: *Energy Calculations for Measured Building Data*
Chair - David Claridge; has 1 paper in to ASHRAE --being reviewed.

Symposium: *Fast Energy Calculations*
Chair - Robert Sonderegger; has 2-3 abstracts may slip to Chicago.

Appendix 4

TC/TG/TRG SPONSORED SEMINARS

FUTURE:

San Francisco - January 1998

"Beyond Spreadsheets: Using equation solvers and modular simulation environments for energy calculations" to be chaired by Sowell; potential speakers: Sahlin, Sowell, and ????

PAST:

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

TC 4.7 Energy Calculations

AGENDA

1. Roll Call and Introductions	Spitler
2. Accept Agenda and Approve Minutes of Philadelphia Meeting	Barnaby
3. Announcements	Barnaby
4. Membership	Sonderegger
5. Subcommittee Reports	
5.1 Simulation and Component Models	Fisher
987-TRP Loads Toolkit	Crawley
5.2 Applications and Inverse Methods	Haberl
865-RP Accuracy Tests for Mech. System Simulations	Walton
5.3 Ad Hoc Neutral Model Format (NMF)	Sowell
5.4 Research	Crawley
5.5 Handbook	Norford
5.6 Program Boston / San Francisco / Toronto	Huang
5.7 Standards: SPC-140, SMOT for Energy Software	Judkoff
5.8 90.1 Envelope Technical Assistance	Sonderegger
6.0 Old Business	
Toolkit copyright policy	Barnaby
Educational outreach	Hittle
IBPSA Liaison	Crawley
SPC 152 Liaison	Amistadi
GPC 14P	Sonderegger
7.0 New Business	
8.0 Adjourn	

TC 4.7 Minutes

July 1, 1997

1. The meeting was called to order at 6:10 p.m. Role was called with 15 out of 18 members present. (Lebrun, Sahlin, Reeves are missing.)

2. Sonderegger moved to accept agenda; Norford seconded Unanimously approved.

3. Introductions were made.

4. Norford moved; Brandemuehl seconded to approve minutes as presented. Unanimously approved.

5. Announcements were made.

   IBPSA will be holding Building Simulation'97, September 8-10 in Prague.

   Clima 2000 will be held in Brussels August 30- September 2.

   Thermal Envelope conference to be held December 1998, Clearwater, Florida.

   Immediate deadlines:
   August 15 program packages for San Francisco
   October 3 - papers for Toronto
   Feb. 13 program packages due for Toronto.
   Oct. 19-20 Technology weekend- all work statements need to be in before then to be voted on.

   A proposal for revising the schedule for the ASHRAE meeting has been floated. The proposal has not generally been well received.

   The split of RAC and TAC goes into effect tomorrow.

   Journal is soliciting articles.

   George Reeves is 2001 Handbook chair. Dave Claridge is our liaison.

   TC 1.6, terminology is looking for new members.

6. Membership reported by Chip Barnaby. New roster goes into effect July 4.

7. Simulation and Component models was reported by Dan Fisher. Minutes are Attachment 1. TC4.4 had sent a work statement Fisher moved, Brandemuehl seconded that the work statement "*A Thermal and Moisture Transport Database for Common Building and Insulating Materials*" should be endorsed by the full committee. Motion passed 14-0-0, Chair not voting. **Chip Barnaby** will send a letter to Seaton indicating same. Other research items will be discussed later.

8. Jeff Haberl reported on the Applications and Inverse Methods subcommittee. Minutes are Attachment 2. Research items will be discussed later.

9. George Walton reported on the 865-RP PMSC. The PI (Gren Yuill) is recovering from surgery, so the project has fallen slightly behind schedule. Walton motioned, Haves seconded that a no-cost extension to February 28, 1998 be granted. 13-0-1. Chair not voting.

10. Ed Sowell reported on the Ad Hoc NMF subcommittee meeting, held immediately before the full committee meeting. A forum held at this meeting showed a strong interest in developing a NMF translator to spreadsheets. A sub-subcommittee is drafting a workstatement. The meeting minutes are Attachment 3.

11. Research. The following work statements were discussed:

    a. WS-930 *Development of Procedures for Predicting Building Thermal and Electricity Use from Measured Data Using Neural Networks* was discussed by Moncef Krarti Fisher moved, Haberl seconded, <u>that we accept the work statement with the Windows GUI work be removed from the work statement</u> 11-3-0 Chair not voting. Moncef Krarti will revise work statement accordingly. Barnaby appointed the following PES: **Haberl (chair) Brandemuehl, Witte**.

    b. *Building System Design Synthesis and Optimization,* a high risk work statement, was discussed by Phil Haves. Phil Haves moved, Norford seconded, <u>that TC 4.7 accept the work statement, *Building System Design Synthesis and Optimization*, to be forwarded to RAC subject to minor editorial changes to make more explicit the needed qualifications of the bidder</u>. The motion was amended by Haves that relevant software would be added, accepted by Norford, 12-1-1 Chair not voting. Barnaby appointed **Sonderegger (chair), Sowell, Knebel, Pedersen** as a PES.

    c. *Development of a Toolkit for Calculating Linear, Change-point Linear and Multiple-linear Inverse Building Energy Analysis Models* was presented by Jeff Haberl. Haberl moved, Knebel seconded <u>that the work statement be approved as written</u>. 10-1-3, Chair not voting. Barnaby appointed **Sonderegger, Kreider(chair), Krarti as PES**.

    d. *Development of a Toolkit for comparing the results of hourly building energy simulation programs against measured energy and internal environmental data* was presented by Haberl. Haberl moved, Winkelmann seconded <u>that the work statement be approved</u>. 11-1-2 Chair not voting. Barnaby appointed **Knebel, Winkelmann, Pedersen(chair)** as PES.

    e. *Analytical Verification Test Suite for Whole Building Energy Simulation Programs: Building Fabric* was presented by Joel Neymark. Haberl moved, Knebel seconded <u>that the work statement be approved, subject to minor editorial revisions</u>. 14-0-0, Chair not voting. Barnaby appointed **Walton (Chair), Judkoff, Winkelmann, Neymark, Fisher**, as PES.

    f. *Methodology for Estimating the Impacts of Interior Lighting and Plug Load Efficiency Improvements on Space-Conditioning Energy Use* was presented by Joe Huang. Haberl moved that the work statement be approved, Walton seconded. 1-12-1, motion failed.

12. Dru Crawley presented a draft long range research plan. Crawley moved, Norford seconded <u>that the long range plan, amended as stated (Spreadsheet interface to NMF Model Libraries replace item 8), with appropriate modifications to make it confirm to ASHRAE procedures, be approved</u>. 14-0-0 Chair not voting. The approved research plan is attached as Attachment 4.

13. Norford reported that the handbook committee was in an *inter regnum*. Volunteers to read and comment on the chapter were sought. **Walton, Hittle, Bahnfleth** answered the call.

14. Joe Huang reported on the Program plan. Some discussion followed. The Program plan is Attachment 5.
15. Joel Neymark reported on the SPC-140P meeting. The minutes are Attachment 6.

16. Chip Barnaby reported on the status of the copyright of the toolkits. The upshot is that derived works should be freely distributable. Dru and Chip will continue to follow this.

17. Doug Hittle reported on the status of educational outreach. A possibility would be to have a ASHRAE educational seminar (3 hour short course type of thing). Doug Hittle will continue to pursue this.

18. Dru Crawley reported in ibpsa-USA.

19. Jon Leber reported on SPC152

20. Jeff Haberl reported on GPC-14P

21. Haves moved to adjourn, Brandemuehl seconded. Unanimously approved. Meeting adjourned at 8:35 p.m.

TC 4.7 Simulation and Component Models Subcommittee

June 30, 1997

Minutes

1. The meeting was called to order at 7:47 p.m. A list of attendees is attached below.
2. The agenda was briefly discussed, with Phil Haves requesting discussion of the just-won't-die Imperfectly Mixed Zone Models work statement.
3. Program was discussed next, as when it's at the end of the agenda, we never get to it. A possible suggestion for a symposium in Chicago - *Application of Heat Balance Methods to Energy and Thermal Load Calculations*- was given by the chair. **Chip Barnaby** agreed to chair it with help from **Dan Fisher** finding authors.

   A second symposium **-** *Recent Innovations in HVAC System Modeling***-** for Toronto. The idea was abandoned. An alternative is a seminar.
4. Discussion of the long range research plan. It was commenced by passing out drafts of 6 work statements, which was somewhat chaotic. A lengthy discussion followed. The work statements are summarized in the table below, along with the subcommittee's ranking.

Ranking	Title (*Action*)	Responsible Parties
1	Building System Design Synthesis and Optimization (High Risk) *Will be brought to full committee tomorrow.*	Haves, Norford, Flake
2	Modular Simulation of Building Envelope Performance *Fisher will provide scope of work for Loads Toolkit to authors. Authors will revise.*	Haves, Sahlin, Winkelmann, Walton
3	Compilation of Diversity Factors and Schedules for Energy and Cooling Load Calculations	Sommer
4	Modeling Two- and Three-dimensional Heat Transfer Through Composite Wall and Roof Assemblies in Hourly Energy Simulation Programs	Huang, Strand
Endorse	A Thermal and Moisture Transport Database for Common Building and Insulating Materials	TC 4.4
Back-burner	Determination of "Effective Moisture Penetration Depth (EMPD)" for typical building materials and operating conditions and its implementation in an hour-by-hour energy simulation program	Swami, **Brandemuehl** will do a forum on what the needs are.

5. A lengthy discussion on the merits of the two moisture work statements ensued. *The subcommittee requests that full committee recommend endorsement of TC4.4 work statement.* A forum, scheduled for San Francisco and chaired by Mike Brandemuehl, will inform the committee on the advisability of proceeding with the EMPD modeling work statement.
6. The subcommittee also recommended that the work statement titled *Building System Design Synthesis and Optimization* be presented to the full TC for approval. All other work statements require additional revision.

7. The meeting was adjourned at 9:50 p.m..

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George Walton	NIST	gwalton@nist.gov
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MINUTES

TC 4.7 Subcommittee on Applications and Inverse Methods
Monday, June 30, 1997, 6:00 - 7:30 p.m.
Marriott Tufts Room
Chair: Jeff Haberl

AGENDA

1. Introductions (all)
2. Discussion of the minutes from January 1997 (all)
3. Status report on Work Statements (all)
   - WS "Procedures for Inverse Building Energy Analysis Methods..." (Krarti/Haberl)
   - WS "Calibrated Computer Models"...(Haberl).
   - WS "Devel. of Anal. Fabric Model Tests"...(Judkoff).
   - WS 930 "Toolkit for ANNs..."...(Krarti)
   - WS "Methodology Development for Lighting/HVAC Interact..." (Huang)
4. Approval of the Long Range Research Plan (all)
5. Old Business (all)
6. New Business (all)
7. Adjourn

ATTENDING THE MEETING:

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Klaus Sommer, Koeln	
Rod Dougherty, Landis & Staefa	rod.dougherty@us.landisstaefa.com

GENERAL DISCUSSION

Haberl opened the meeting at 6:10 p.m. All agreed that they should read the WS until more people came in since there were fewer people at the meeting than expected.

Discussion then followed of WS “Development of an Analytical Verification Test Suite for Whole Building Energy Simulation Programs” by Ron Judkoff and Joel Neymark.

MOTION to approve the WS (Krarti/Judkoff), approved.

ACTION: Judkoff and Neymark then agreed to edit the WS and bring to the full committee meeting.

Discussion then proceeded to the WS “Development of A Toolkit for Calculating Linear, Change-point Linear, and Multiple-linear Inverse Building Energy Analysis Models”, by Jeff Haberl and Moncef Krarti.

MOTION to approve the WS (Krarti/Buhl), approved.

ACTION: Haberl agreed to edit the WS and bring copies to the 4.7 main meeting.

During the discussion a number of person(s) entered the room. Introductions were then made and the discussion then turned to the approval of the minutes from Philadelphia.

MOTION: to approve the minute from Philadelphia (Krarti/Judkoff), approved.

Discussion then proceeded to the WS “Development of toolkit for comparing the results of hourly building energy simulation programs against measured energy and internal environmental data.” by Haberl.

MOTION: to approve the WS (Krarti/Reddy), approved.

ACTION: Haberl agreed to edit the WS and bring copies to the 4.7 main meeting.

Discussion then proceeded to the WS “Development of A Toolkit for Predicting Building Thermal and Electrical Use From Measured Data Using Neural Networks” by Krarti.

MOTION: to approve the WS (Buhl/Krarti), approved.

ACTION: Krarti agreed to edit the WS and bring copies to 4.7 for a vote.

Discussion then proceeded to the WS “Methodology for Estimating the Impacts of Interior Lighting and Plug Load Efficiency Improvements on Space-conditioning Energy use”, by Huang

MOTION to approve the WS (Buhl/Krarti), approved.

ACTION: Joe Huang agreed to edit the WS and bring copies to 4.7.

Discussion the moved along to the long range research plan which is attached.

MOTION to adjourn (Haberl/Reddy). Subcommittee meeting adjourned at 7:30 p.m.

LONG RANGE RESEARCH PLAN FOR TC 4.7 APPLICATIONS & INVERSE METHODS: JUNE 1996 (IN ORDER OF A&IM PRIORITY)

A&IM RANK	STATUS	TITLE
#1	WS	Development of toolkit for calculating linear, change-point linear and multiple-linear inverse building energy analysis models. (Haberl/Krarti). .
#2	WS	Development of toolkit for comparing the results of hourly building energy simulation programs against measured energy and internal environmental data (Haberl).
#3	WS	Development of an Analytical Validation Test Suite for Whole-building Energy Simulation Programs -- Building Fabric (Judkoff/Neymark)
#4 WS 930	WS	Development of a procedures for predicting building thermal and electricity use from measured data with artificial neural networks (Krarti/Kreider).
#5	WS	Methodology Development to Determine Impacts of Interior Lighting and Plug Load Efficiency Improvements in Conditioned Buildings (Huang).
#6	One Pager	Development of an Empirical Validation Test Suite for Whole-building Energy Simulation Programs -- Building Fabric (Judkoff, Huang)
#7	One Pager	Methodology Development to Extend RP 827 Semi-empirical Chiller Models to include Models for Screw Chillers, Air-conditioners, and Heat Pumps (Haberl)
#8	One Pager	Development of procedures for baselining energy use at large central plants (Haberl).
#9	One Pager	Development of a reference set of validated semi-empirical tests for primary and secondary HVAC equipment simulations. (Haberl, Judkoff)
#10	One Pager	Development of a procedures for preparing weather data for use with building energy analysis programs (Huang).
#11	One Pager	Develop self-describing information exchange methods for computer programs used in HVAC industry for analysis, design and evaluation (Cumali).

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

1 TITLE:
Development of toolkit for calculating linear, change-point linear and multiple-linear inverse building energy analysis models. (Haberl/Krarti). .

OBJECTIVE:
The objective of this research is to develop a toolkit for calculating inverse method building energy analysis. Such procedures would result in a toolkit which would be similar to ASHRAE's HVAC-01 and HVAC-02 toolkits in format and would contain algorithms and documented computer code for performing inverse method calculations. These procedures would exclude artificial neural networks and calibrated simulation models, and would be applicable to hourly, daily and monthly building energy use data.

SCOPE:
This research includes: (1) Thorough literature search into the current methods that are used to empirically analyze building energy use, (2) development of computer code for that performs inverse method calculations, and (3) assembly of such code into an ASHRAE Toolkit including the appropriate documentation.

BENEFIT:
The project will benefit ASHRAE membership as well as the general public as follows:
1. ASHRAE to develop a standard toolkit of inverse methods software.
2. Software suppliers as an aid for incorporating standard inverse building energy analysis programs.
3. Text book publishers for documenting inverse methods.
4. ASHRAE for developing more effective training programs for teaching engineers how to apply inverse calculation software.
5. Improving indoor air quality by providing ASHRAE members with software for performing inverse calculation software for analyzing IAQ.
6. Improving energy efficiency by providing ASHRAE members with inverse calculation software for calculating energy conservation savings.

ESTIMATED COSTS:	DURATION:
$95,000	18 calendar months

CONTRIBUTORS:
Moncef Krarti,
Jeff Haberl

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

2 TITLE:
Development of toolkit for comparing the results of hourly building energy simulation programs against measured energy and internal environmental data (Haberl).

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 ASHRAE's HVAC-01 and HVAC-02 toolkits in format and would contain algorithms and documented computer code for assessing how well computer simulations are calibrated to measured building energy data.

SCOPE:
This research includes: (1) performing a literature search to determine the different methods that are currently being used to calibrate hourly simulation programs, (2) development of standard procedures for performing the calibrations, and (3) documenting the procedures.

BENEFIT:
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's 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 COSTS:	DURATION:
$95,000	18 calendar months

CONTRIBUTORS: Jeff Haberl

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

3 TITLE:
Development of Analytical Validation Test Suite for Whole-building Energy Simulation Programs -- Building Fabric (Judkoff/Neymark).

OBJECTIVE:

The objective of this research is to create a reference set of steady-state analytical solutions for verifying building fabric heat transfer simulation. Such procedures would result to the accuracy tests developed by RP865. These procedures would be useful for verifying simulations of building fabrics or envelopes. ASHRAE has established the Standard Method of Test for Building Energy Software (SPC 140P SMOT) for developing procedures for testing the accuracy of building energy software. SPC 140P SMOT is to be based on two validation methods: (1) analytical tests and (2) inter-model comparisons.

SCOPE:

This research includes: (1) performing a literature search to determine the different methods that have been used to calculate the heat transfer across the building fabric. (2) development of standard set of accuracy tests for selected fabrics, and (3) documenting the procedures.

BENEFIT:
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 calculate heat flow across fabrics or envelopes.
2. Software suppliers as an aid for incorporating ASHRAE's procedures into their building energy analysis programs.
3. Text book publishers for documenting fabric calculations.
4. ASHRAE for developing more effective training programs for teaching engineers how to use computer simulation programs.
5. Improving energy efficiency by providing ASHRAE members with improved procedures for calculating heat transfer.

ESTIMATED COSTS:	DURATION:
$95,000	18 calendar months

CONTRIBUTORS:
Ron Judkoff

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

4 TITLE:
Development of procedures for predicting building thermal and electricity use from measured data using artificial neural networks.

OBJECTIVE:
The objective of this research is to develop and document procedures for predicting building thermal and electricity use which utilizes artificial neural networks, or connectionist methods. Such procedures would results in a toolkit would be similar to ASHRAE's HVAC-01 and HVAC-02 toolkits in format and would contain algorithms and documented computer code for performing artificial neural network predictions of building energy use.

SCOPE:
This research includes: (1) Development of computer code for that performing artificial neural network calculations, (2) assembly of such code into an ASHRAE Toolkit including the appropriate documentation.

BENEFIT:
The project will benefit ASHRAE membership as well as the general public as follows:
1. ASHRAE to develop a standard toolkit for artificial neural network calculations.
2. Software suppliers as an aid for incorporating artificial neural network calculations into building energy analysis programs.
3. Text book publishers for documenting artificial neural network methods.
4. ASHRAE for developing more effective training programs for teaching engineers how to apply artificial neural network calculations.
5. Improving indoor air quality by providing ASHRAE members with neural network software for analyzing IAQ.
6. Improving energy efficiency by providing ASHRAE members with neural network software for calculating energy conservation savings.

ESTIMATED COSTS:	DURATION:
$95,000	18 calendar months

CONTRIBUTORS:
Moncef Krarti,
Jan Kreider

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

5 TITLE:
Methodology Development to Determine Impacts of Interior Lighting and Plug Load Efficiency Improvements in Conditioned Buildings

OBJECTIVE:
The objective of this research is to expand upon the previous work by EPRI and others to develop a methodology whereby the thermal interaction of plug loads and lighting loads can be empirically estimated for the most common building and systems types based upon parametric computer simulations. 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 methods that are used to empirically determine the thermal interaction of retrofits to plug and lighting loads, (2) development of the necessary parametric computer simulations to determine a suite of test cases in representative cities of North America, and (3) assembly of the results into an easy to use nomograph and/or algorithm for use by engineers and architects to estimate the thermal interaction without using simulation.

BENEFIT:
The project will benefit ASHRAE membership as well as the general public as follows:
1. ASHRAE to develop a standard methods for assessing the thermal interaction.
2. Software suppliers as an aid for incorporating such standard methods into estimation programs.
3. Text book publishers for documenting such methods.
4. ASHRAE for developing more effective training programs for teaching engineers and architects how to apply such methods.
6. Improving energy efficiency by providing ASHRAE members with improved methods.

ESTIMATED COSTS:	DURATION:
$95,000	18 calendar months

CONTRIBUTORS: Jor Huang, Jeff Haberl

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

6 TITLE:
Development of Empirical Validation Test Suite for Whole-building Energy Simulation Programs -- Building Fabric (Judkoff/Neymark).

OBJECTIVE:

The objective of this research is to create a reference set of empirical accuracy tests for verifying building fabric heat transfer simulation. Such procedures would expand the result to the accuracy tests developed by RP865. These procedures would be useful for verifying simulations of building fabrics or envelopes. ASHRAE has established the Standard Method of Test for Building Energy Software (SPC 140P SMOT) for developing procedures for testing the accuracy of building energy software. SPC 140P SMOT is to be based on two validation methods: (1) analytical tests and (2) inter-model comparisons.

SCOPE:

This research includes: (1) performing a literature search to determine the different empirical methods that have been used to check the accuracy of building simulations, (2) development of standard set of accuracy tests for selected fabrics, and (3) documenting the procedures.

BENEFIT:
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 calculate heat flow across fabrics or envelopes.
2. Software suppliers as an aid for incorporating ASHRAE's procedures into their building energy analysis programs.
3. Text book publishers for documenting fabric calculations.
4. ASHRAE for developing more effective training programs for teaching engineers how to use computer simulation programs.
5. Improving energy efficiency by providing ASHRAE members with improved procedures for calculating heat transfer.

ESTIMATED COSTS:	DURATION:
$95,000	18 calendar months

CONTRIBUTORS:

Ron Judkoff

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

7 TITLE:
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:	DURATION:	CONTRIBUTORS:
$95,000	18 calendar months	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.

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

8 TITLE:
Development of a procedure for baselining energy use at large central plants.

OBJECTIVE:
The objective of this research is to develop and document a procedure that will baseline the energy use at large central plants. This would include the capability of developing a baseline at large central plants that serve many buildings and that contain multiple interconnected chillers, boilers, heat exchangers, electrical generation equipment, etc. This system would be capable for normalizing for different operational strategies, addition or subtraction of building stock, weather conditions and other variables such as equipment loading, etc. This type of baseline procedure is intended to be used to measure savings from retrofits to equipment in central plants. Such a procedure could then lead to a toolkit that would be similar to ASHRAE's HVAC-01 and HVAC-02 toolkits in format and would contain algorithms and documented computer code for preparing weather data for use by the most widely used building analysis programs.

SCOPE:
This research includes: (1) performing a literature search to determine the previous work that has been accomplished in this area, (2) developing an baseline calculation procedure, and (3) validating the procedure with measured data from an actual central plant, and (3) documenting the procedure in the appropriate ASHRAE report.

BENEFIT:
The project will benefit ASHRAE membership as well as the general public as follows:
1. ASHRAE to develop a standard procedure for baselining large central plants.
2. Software suppliers as an aid for incorporating ASHRAE's baseline procedure into their building energy analysis programs.
3. Text book publishers for documenting ASHRAE's baseline procedure.
4. ASHRAE for developing more effective training programs for teaching engineers how to baseline large central plants.
5. Improved energy efficiency by providing ASHRAE members with a procedure to baseline large central plants.

ESTIMATED COSTS:	DURATION:
$95,000	18 calendar months

CONTRIBUTORS:

Jeff Haberl

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

9 TITLE:

Development of a reference set of validated semi-empirical tests for primary and secondary HVAC equipment simulations.

BACKGROUND
ASHRAE research project RP865 is developing a reference set of analytical tests for air-side HVAC simulations. To complete the validation of a general purpose HVAC simulation program a reference set of test is now needed for the primary and secondary HVAC equipment simulations, including: pumps, coils, chillers, air-conditioners, boilers, furnaces, etc.

OBJECTIVE:
Using the previously developed work including the results from RP865, and the HVAC 01 and HVAC 02 toolkits as a guide develop a reference set of semi-empirical tests for primary and secondary HVAC equipment simulations.

SCOPE:
This research includes: (1) documenting relevant publications regarding semi-empirical models for primary and secondary HVAC systems (i.e., pumps, blowers, chillers, boilers, etc.), (2) locate a set of valid experimental data for validating the semi-empirical models and validate the models, (3) develop a set of procedures that can be used to use the semi-empirical models to perform an accuracy test on the commonly used primary and secondary HVAC systems.

BENEFIT:
The project will benefit ASHRAE membership as well as the general public as follows:
1. ASHRAE to develop a standard method of applying inverse bin method calculations that include latent cooling, thermal mass, and solar effects.
2. Software suppliers as an aid for developing inverse bin method calculations that are capable of measuring latent cooling, thermal mass and solar effects.
3. Text book publishers for developing more accurate inverse methods for evaluating actual building performance data.
4. ASHRAE for developing more effective training programs for teaching engineers how to apply inverse bin methods.

ESTIMATED COSTS:	DURATION:
$75,000	18 calendar months

CONTRIBUTORS:
Jeff Haberl
Ron Judkoff

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

10 TITLE:
Development of procedures for preparing weather data for use with building energy analysis programs.

OBJECTIVE:
The objective of this research is to develop and document a toolkit that will prepare weather data from varying sources (i.e., NWS, local measured data, etc.) for use by building energy analysis programs such as DOE-2, BLAST, ASEAM, etc. Such a toolkit would be similar to ASHRAE's HVAC-01 and HVAC-02 toolkits in format and would contain algorithms and documented computer code for preparing weather data for use by the most widely used building analysis programs.

SCOPE:
This research includes: (1) performing a literature search to determine the different sources, format, methods of electronic transfer, and quality of weather information (e.g., NWS, solar, and other weather data bases), (2) performing a literature search to determine the different methods that are in use for preprocessing weather data for use by DOE-2, BLAST, ASEAM, PRISM and other programs and/or packing into TRY, TMY, WYEC-2, or BIN format, (2) development of computer codes for performing the weather data preprocessing, and (3) assembly of such code into an ASHRAE Toolkit including the appropriate documentation.

BENEFIT:
The project will benefit ASHRAE membership as well as the general public as follows:
1. ASHRAE to develop a standard toolkit for processing weather data into a format that is useful for building energy analysis programs.
2. Software suppliers as an aid for incorporating ASHRAE's processed weather data into their building energy analysis programs.
3. Text book publishers for documenting weather data processing routines.
4. ASHRAE for developing more effective training programs for teaching engineers how to preprocess weather data for building energy analysis programs.
5. Improved energy efficiency by providing ASHRAE members with improved weather data for analyzing existing buildings.

ESTIMATED COSTS:
$95,000

DURATION:
18 calendar months

POTENTIAL CO-SPONSORS
TC 4.2

CONTRIBUTORS:
Jeff Haberl

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

11 TITLE:
Develop self-describing information exchange methods for computer programs used in HVAC industry for analysis, design and evaluation.

OBJECTIVE:
The objective of this research is to develop methods of self description for input and output from computer programs to enable unhindered communication among them.

SCOPE:
The scope of this research will focus on two selected areas: a) Hydronic Systems.
b) Energy Analysis.

This research includes: 1) Classification of input and output data, 2) definition of data models, 3) development/selection of methods of self description, 4) test of the developed methodology, 5) code that permits the data exchange for the two selected areas, 6) description of the methodology and code so that it can be applied to computer programs of interest by ASHRAE members.

BENEFIT:
The project will benefit ASHRAE membership as well as the general public as follows:
1) Help solve the data incompatibility problem among computer programs.
2) Facilitate computer aided design work done by ASHRAE members.
3) Make translation of data from detailed to simple computer programs.
4) Permit use of a variety of programs from the same input/output.
5) Save significant amounts of time in design, analysis, and evaluation of projects requiring use of multiple programs,
6) Improve energy efficiency and cost by permitting use of many different programs in design work from different vendors,
7) Permit greater flexibility of data representation without imposing constraints of standards on data format or content.

ESTIMATED COSTS:	DURATION:
$75,000	18 calendar months

CONTRIBUTORS: Zulfi Cumali, Jeff Haberl

Minutes
TC 4.7 ad hoc Subcommittee on the NMF

Boston
Tuesday July 1, 1997

1. The agenda for this meeting and the minutes of the Philadelphia were approved.
2. No announcements.

3. Old Business:

3.1 E-mail (attached) from Per Sahlin citing recent developments was distributed and discussed. The upshot is that there is significant usage, including library development, in Europe.

3.2 Chip Barnaby indicated that ASHRAE staff has agreed that our NMF translator is to be freely used. Derived products will be allowed without ASHRAE royalties. Apparently, we have nothing but e-mail from Seaton and Comstock to testify to this policy, but Chip and Dru Crawley will follow the matter to be sure the policy is formalized or at least followed. In the meanwhile, we will continue to allow free Web distribution.

4. New Business:

4.1. Forum report:
The Forum on "How should ASHRAE Computer Models be Expressed?" was held at the Boston meeting. A brief review of currently used model expression formats by ASHRAE research contracts, and the Neutral Model Format (NMF) was followed by open discussion. Response from 25 attendants was plentiful and interesting. There were widely differing points of view, ranging from those wanting nothing more than a clear, narrative explanation of models to those wanting computer algorithms. The latter were in the minority, however. Perhaps the most interesting outcome was strong support for expression in some spreadsheet compatible form. The idea of an NMF to spreadsheet translator was broached and well received.

Evaluation forms rated the forum Excellent or Good.

4.2 Research agenda

4.2.1 Modular simulation work statement

The work statement on modular loads simulation was discussed. The consensus was that it should remain with the Simulation Subcommittee where it originated and have some NMF slant. The contractor should be required to implement the methods developed the constructs currently available in NMF when the project is under way. If the contractor finds the semantics too limited or the syntax awkward, changes will be proposed. This subcommittee will participate in monitoring the project.

4.2.2 Spreadsheet interface to NMF libraries

As a result of the Forum, a work statement will be developed to allow spreadsheet users to conveniently use NMF libraries. Several possible approaches were discussed, including models and the translator being transformed into DLLs. It was generally agreed that this work should make use of the present translator front end, perhaps using the intermediate output file. Perhaps Visual Basic (VBA) and C could be emitted,

either of which could be converted to DLLS and/or spreadsheet
macros or functions.

Fred Buhl, Chip Barnaby, and Ed Sowell will write the work statement
for San Francisco. Ed will provide a short description
for the 4.7 research plan.

4.2.3 Neutral System Models
Phil Haves suggested that we should provide for neutral system models.
Ed pointed out that may require a seamless hierarchy, i.e.,
no difference in syntax between models and submodels, which
is not (or may not be) present in the syntax proposed by
Bring and Sahlin in the defining IBPSA paper. Ed will try
to initiate a discussion group on the matter using the IBPSA-NMF
mail list. All present will be added to the list and
are encourage to participate. We will put the issue
on the San Francisco agenda.

5. Program

5.1 Phil Haves will chair a seminar on "What can Modular
Simulation Environments do Today." This will be targeted
for San Francisco, if possible. TC 1.5 will be invited
to cooperate.

The meeting adjourned at 5:50PM.

Minutes prepared by Ed Sowell.

Attendance:

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Ed Sowell  Cal State Univ. Fullerton   sowell@fullerton.edu
Fred Buhl  Lawrence Berkeley Nat'l. Lab  buhl@gronk.lbl.gov
Rod Dougherty  Landis & Staefa         rod.dougherty@us.landisstaefa.com
Ram Laks   Dunham Bush                 thermapp@rica.net
Vic Hanby  Loughborough Univ.          v.i.hanby@lboro.ac.uk
Mingsheng Liu Texas A&M Univ.          mingshen@esl.tamu.edu
Chip Barnaby  Wrightsoft        cbarnaby@wrightsoft.com
Dan Clark    Carrier Corp.             dan.clark@carrier.utc.com
Tor Malmstrom  KTH              tgm@ce.kth.se
Phil Haves   Loughborough Univ.        p.haves@lboro.ac.uk
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Attachments:
>From - Thu Jul 03 09:01:51 1997
Received: from kth.se (kth.se [130.237.72.201]) by dns.fullerton.edu
(8.6.12/8.6.9) with ESMTP id EAA06771 for <sowell@fullerton.edu>; Wed, 25 Jun
1997 04:38:46 -0700
Date: Wed, 25 Jun 1997 13:14:49 +0200
From: Per Sahlin <plurre@engserv.kth.se>
Organization: KTH, Building Sciences

To: sowell@fullerton.edu
Subject: Re: Boston

Ed,

I have to go to Amsterdam tomorrow, so today is my last chance to
do any ASHRAE related work. I have continued to work on Phil's
WS about Modular Loads Simulation, giving it an NMF slant in
line with Chips idea. I will circulate the result later today.

Here is a list of activities with NMF relevance that
you might be interested in:

- Jari Hyttinen and Mika Vuolle of HUT, Finland, has made a translation of the secondary toolkit into NMF, tested each component individually (using IDA) and have made a number of system models. This library is available at http://www.hut.fi/Units/HVAC/nmf.html

- KTH is developing a large model library for general thermal building simulation. The library contains very detailed (full radiosity network, vertical temperature gradient, non-linear film coefficients) as well as traditional heat balance zone models (MRT, fixed coefficients). Units such as water and electric radiators, chilled ceilings etc. are included with individual massflow controllers. The ASHRAE secondary systems models may be used, but simplified AHU components are also included that require a minimum of parameters. At the moment, only a very simple chiller and a boiler model are available for the primary system. All water and air circuits contain pressure in order to model,e.g., natural ventilation or circult balancing. The library is currently under validation, but whole year runs using realistic weather data (climate processing and shading is also included) has been done. The working version of the library is maintained at ftp://urd.ce.kth.se/pub/idacenmf. The models are documented individually, but very little overview material is currently available.

- KTH is developing a web structure for global access to individual NMF resources (translators and libraries). Hopefully, this will come "on-line" in September.

- Paul Williams of the TRNSYS team has made a small NMF library for solar systems and tested it using the ASHRAE translator.

- CSTB has a position available for a master student to work on NMF editors and library tools within the ISE environment. Contact Werner Kielholz <werner@cstb.fr> for info.

- Bris Data has issued some 28 revisions of its NMF translator during the spring. A lot of work is going on in terms of NMF algorithmic models, weakly coupled subproblems and related issues. (http://www.brisdata.se)

Good luck at the meeting! I'm available on Monday if you want any last minute discussions (or work done).

Cheers,

Per

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-----------------------------------------------------------------
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ASHRAE TC 4.7 Energy Calculations
1998-1999 Research Plan
1 July 1997

Rank	Title	*Status*	Subcommittee and Responsible Parties
1	**Development of Toolkit for Calculating Linear, Change-Point Linear and Multiple-Linear Inverse Building Energy Analysis Models**	TC approved WS in Boston	A&IM Haberl, Krarti
2	**Building System Design Synthesis and Optimization**	(*HIGH RISK*) TC approved WS in Boston	S&CM Haves, Norford, Flake
3	**Development of Toolkit for Comparing Results of Hourly Building Energy Simulation Programs against Measured Energy and Internal Environmental Data**	TC approved WS in Boston	A&IM Haberl
4	**Development of Analytical Validation Test Suite for Whole-building Energy Simulation Programs – Building Fabric**	TC approved WS in Boston	A&IM Judkoff, Neymark
5	**Modular Simulation of Building Envelope Performance**	TC approved WS in Boston (WS-930)	S&CM Haves, Sahlin, Winkelmann, Walton
6	**Development of Procedures for Predicting Building Thermal and Electricity Use from Measured Data Using Artificial Neural Networks**	Draft WS for San Francisco	A&IM Krarti, Kreider
7	**Modeling Two- and Three-dimensional Heat Transfer through Composite Wall and Roof Assemblies in Hourly Energy Simulation Programs**	Draft WS for San Francisco	S&CM Huang, Strand
8	**Method for Accessing NMF Models in a Spreadsheet Environment**	Draft WS for San Francisco	NMF Buhl, Barnaby, Sowell
9	**Compilation of Diversity Factors and Schedules for Energy and Cooling Load Calculations**	Draft WS for San Francisco	S&CM Sommer
10	**Develop Methodology to Determine Impacts of Interior Lighting and Plug Load Efficiency Improvements in Conditioned Buildings**	Draft WS for San Francisco	A&IM Huang

Program Plan

Location: San Francisco (Jan 1998)
Type: Seminar
Moderators: Phil Haves and Ed Sowell
Title: "Beyond Spreadsheets: Using equation solvers and modular simulation environments for energy calculations"

Type: Forum
Moderator: Mike Brandemuehl
Title: "Who needs moisture calculations in energy simulations ?"

Location: Toronto (Jun 1998)
Type: Symposium
Moderator: Michael Witte
Title: "Accuracy Tests for Simulation Models"

Type: Symposium
Moderator: Robert Sonderreger
Title: "Baseline Calculations for Measurement and Verification of Energy and Demand Savings"

Location: Chicago (Jan 1999)
Type: Symposium
Moderator: Chip Barnaby
Title: "Application of Heat Balance Methods to Energy and Thermal Load Calculations"

NATIONAL RENEWABLE ENERGY LABORATORY (NREL) **PHONE: 303-384-7520**
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USA **DATE:** 7/02/97
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MINUTES
SPC-140 SMOT FOR BUILDING ENERGY SOFTWARE

BOSTON 6/30/97

R. Judkoff

ATTACHMENTS

A. Agenda
B. Discussion Material
C. Attendance List/Mailing List

CORRESPONDANCE SINCE LAST MEETING

February 3, 1997 (approx.): Jan 27, 1997 meeting minutes distributed to TC 4.7.
May 10, 1997 (approx.): Conference call discussion materials distributed.
May 12, 1997: Conference call (see appropriate minutes).
June 23, 1997: Meeting materials distributed.

GENERAL

Regarding ASHRAE technical program, the committee discussed that the symposium on validation methods is delayed until the Summer 1998 meeting. Authors that have agreed to participate in the symposium are: Guyon (empirical validation at Electricité de France), Haberl and Yuill (TRP-865 analytical verification, possibly separate papers), Judkoff and Neymark (BESTEST comparative validation).

INTERMODEL COMPARISON BASED TESTS

A new "List of Comments and Questions" (see Attachement B) was distributed to the committee members a few days before the meeting, and a proposed Foreword was distributed at the meeting. These included revisions to various sections of Working Draft 96/1 based on previous committee comments.

Committee Discussion

A quorum was established with 6 of 10 voting members present. Wilcox later arrived after minutes approval. Witte later arrived during discussion of foreword.

The agenda for the meeting is provided as Attachment A

Approval of Prior Minutes

Motion (Walton): Accept Minutes of January 1997 Meeting.
2nd (Crawley):

Vote: Yes = 5, No = 0, Abstain = 1 (chair)
Absent = (Fraser, Maeda, Wilcox, Witte)

Motion (Walton): Accept Minutes of May 1997 Conference Call.
2nd (Crawley):

Vote: Yes = 5, No = 0, Abstain = 1 (chair)
Absent = (Fraser, Maeda, Wilcox, Witte)

Foreword

The committee discussed the foreword that was distributed. Note, although the foreword is not part of the standard and may be written by the chair, the chair requested comments from the committee. General comments included:

- there should be more discussion of a full validation methodology (comparative, analytical and empirical tests)
- the place holder sections for each type of test should be specifically referenced.

Other specific revisions were noted directly on a copy of the Foreword and will be included in the new version.

Note, section numbers listed below relate to those of Working Draft 96/1.

Section 3.1 Description of the Test Cases

The committee decided to revise the grouping of cases as follows:

a. Base Case (see 3.1.1.1)
b. Basic Tests
   - Low Mass (see 3.1.1.2)
   - High Mass (see 3.1.1.3)
   - Free Float (see 3.1.1.4)
c. In-Depth Tests (see 3.1.1.5)

It was also agreed that for the In-Depth tests the terms "Series-A" and "Series-B" would be replaced with appropriate listing of case numbers (i.e. "Cases 195-320" and "Cases 395-440, 800, 810").

Section 3.2 Modeling Approach

Haberl asked how "solar time" as referred to in Section 3.2.1 was modeled. After some discussion, Judkoff and Neymark agreed to review the results of IEA BESTEST and determine whether results actually applied weather data and required component schedules based on solar time or standard time. The conclusions of this review will be reported back to the committee.

Section 3.3.3 Comparing Your Output to Other Results

The introductory paragraph of Section 3.3.3 needs to revised to replace "The programs used to generate the example results have already been subjected to extensive testing" with a reference to the informational appendix about production of example results. A sentence is to be added to the production-of-example-results appendix indicating when programs used to generate example results were subjected to extensive testing. Additionally, we need to verify that the appendix discussion includes that test results were generated by expert users, and that there was cross checking of input decks to minimize the potential for user errors; if these statements aren't there then include them.

In Section 3.3.3.1, the committee reversed a previous decision and decided to remove definitions of "agree" and "disagree". Witte suggested, with agreement from others, that we should instead give the following list of things to look for when comparing results:

- magnitude of results for individual cases
- magnitude of difference between cases (e.g. Case 610 - Case 600)
- same direction (sign) of difference between cases.

The committee agreed that Section 3.3.3.2 should be rephrased as: "To help the user identify what algorithm in the tested program is causing specific differences between programs, diagnostic flow charts are provided as informational Appendix B.tk."

NREL agreed to incorporate above comments related to Section 3 and submit revised language for a letter ballot or conference call.

Proposed Standard Output Format

After some discussion, the committee agreed to the proposed standard output format included in the handout (see attachment B). The committee also agreed that the full spreadsheet for recording user simulation results will be included on a diskette accompanying the standard; a printed appendix of the spreadsheet does not need to be included.

Ground Coupling

After some discussion, the committee agreed to delete the case description and results for Case 990 regarding ground coupling, but that the section will be left as a placeholder.

Wrap up

After completion of the ground coupling discussion attendence fell below quorum. The remaining group of voting members (Judkoff, Sonderegger, Walton, Winkelmann and Witte) provided a general impression of the following:

- The section on diagnostic logic will be moved from a normative appendix to an informational appendix

- The standard output format is a normative appendix

- Keep placeholder sections for:

+ Analytical Verification Tests
+ Empirical Validation Tests
+ Ground Coupling within the Comparative Tests

- The objective for the next 6 months is to have a draft ready for a vote regarding public review at the San Francisco meeting

- There should be a conference call very soon to finish discussion of the handout distributed just prior to this meeting.

- Future discussion materials should be sent by email when possible.

NREL will organize a follow up conference call for July.

ANALYTICAL TESTS (865-TRP HVAC SYSTEMS)

Jeff Haberl (Texas A&M) met with the Project Monitoring Subcommittee (Judkoff, Knebel, Walton (chair)) at 1:15p, monday 6/30/97 for further review. Gren Yuill (Pennsyvania State University) was absent due to recovering from surgery. For details of the meeting contact George Walton.

ANALYTICAL TESTS (BUILDING FABRIC)

Judkoff and Neymark submitted a work statement to the Applications and Inverse Methods (A&IM) Subcommittee of TC 4.7. The workstatement is entitled, "Analytical Verification Test Suite for Whole Building Energy Simulation Programs: Building Fabric". A&IM made comments, and accepted the work statement for submittal to TC 4.7 pending incorporation of comments. A revised version was submitted to TC 4.7. TC 4.7 unanimously approved it for submittal to ASHRAE Research pending minor revision. Those revisions have been incorporated and sent to Dru Crawley.

EMPIRICAL DATA SETS (BUILDING FABRIC)

No progress was made on the work statement.

Attachment A - Meeting Agenda

PRELIMINARY AGENDA - SPC 140
Monday June 30, 1997, 2:15PM - 6:15PM, "University of Massachusetts Exhibit Hall", Room 6, 3rd Level, Marriott Hotel

- Communications since previous meeting

- Announcements

- Program: Seminar or ? for San Fran or ? (Joe Huang)

- Agenda mods from the floor

- Approval of Previous MInutes
  + January meeting
  + May conference call

- Discussion of "List of Comments and Questions"
  + proposed rewrite of sections 3.1, 3.2, and introductory portion of Sec. 3.3 of Working Draft 96/1
  + proposed standard output format and included examples
  + resolve what to do with Case 990 (ground coupling)
  + committee ok on text content of the following informational appendices
    - Example Results
    - Diagnosing the Results Using the Flow Diagrams
    - Production of Example Results
  + Table of Contents
        - Formalize that diagnostic flow is an informational appendix
        - Formalize that standard output format is a normative appendix
      - Forward
      - For categories of tests "basic" replaces "preliminary", "in-depth" replaces "diagnostic"
        - Include or exclude placeholder sections for other types of tests.
      - Discuss Next Steps to Achieve a Draft for the Committee to Vote on Regarding Public Review. We propose:
  + Incorporate committee comments
  + Clean up existing "tk"s, etc
  + ASHRAE (Sara Deppen) to review format
  + Distribute to Committee for vote.

Attachment B - Discussion Materials

LIST OF COMMENTS AND QUESTIONS

This list summarizes the questions included in the following pages, and indicates the page where the question and information supporting the question are listed. Within the attachment questions are preceded by "■" and underlined.

note: throughout, "tk" means "to check" and is a convenient search sequence.

TABLE OF CONTENTS by Question

■ (p.19) Regarding proposed revised table of contents, ok? Main substance here is regarding normative appendices versus informative appendices. Other renumbering is to more closely match other ASHRAE SMOTs (e.g. for establishing AFUE and SEER).

■ (p.19) The new standard output format is proposed to be a normative appendix, ok?

■ (p.19) Other SMOTs like for determining AFUE and SEER do not have a forward, in light of this do we want to have one?

■ (p.19) Test categories are now called "basic" replacing "preliminary", and "in-depth" replacing "diagnostic", ok?

■ (p.19) Do we need to include empirical and analytical testing headers as place holders in this standard or leave those test procedures for another SPC (or for the future SSPC) to address? It may be less confusing without them, and since the research for these other sections is not yet completed, it may not be possible to keep them.

■ Per our meeting and conf call discussions, the material below just indicates that tests are provided, and then we give a general description of the tests. We are silent regarding which tests a user must run. We have also referenced a standard output format, but we only require they enter results for simulated cases (again not stating which cases they must simulate). Based on this, are you all ok with the proposed content of Secs 3.1, 3.2, and 3.3.

■ Is the 3.1.1 description of cases good enough or do we need simplified version of Tables B-1A and B-1B which would specifically list each case and what it tests? Note, we've referred users to appendix B for the detailed version already?

3. Comparative Tests

3.1 Description of Test Cases.

The following cases are provided for analyzing and diagnosing building energy simulation software using software-to-software comparisons. The comparative test allows different building simulation programs, representing different degrees of modelling complexity, to be tested.

3.1.1 The cases are grouped as:

a. Base Case (see 3.1.1.1)
b. Low Mass Basic Tests (see 3.1.1.2)
c. High Mass Basic Tests (see 3.1.1.3)
d. Free Float Basic Tests (see 3.1.1.4)
e. In-Depth Tests - series A (see 3.1.1.5)
f. In-Depth Tests - series B (see 3.1.1.6).

Quantities varied for the cases are summarized in informational Appendix B (**Tables B-1Atk and B-1Btk)**.

3.1.1.1 The base building is a low mass, rectangular single zone with no interior partitions.

3.1.1.2 Low mass basic tests analyze the ability of software to model building envelope loads in a low mass configuration with the following variations: window orientation, shading devices, setback thermostat, and night ventilation.

3.1.1.3 High mass basic tests analyze the ability of software to model building envelope loads in a high mass configuration with the following variations: window orientation, shading devices, setback thermostat, night ventilation, a sunspace, and ground coupling **(tk)**.

3.1.1.4 Free float basic tests analyze the ability of software to model zone temperature in both low mass and high mass configurations with and without night ventilation.

3.1.1.5 In-depth series-A tests analyze the ability of software to model building envelope loads in a bang-bang thermostat control configuration with the following variations: no windows, opaque windows, exterior infrared emittance, interior infrared emittance, infiltration, internal gains, exterior shortwave absorptance, south solar gains, interior shortwave absorptance, window orientation, shading devices, and thermostat setpoints. These are a detailed set of diagnostic tests designed to isolate the effects of specific algorithms. However, some of the cases may be incompatible with some building energy simulation programs.

3.1.1.6 In depth series-B tests analyze the ability of software to model building envelope loads in a deadband thermostat control configuration with the following variations: no windows, opaque windows, infiltration, internal gains, exterior shortwave absorptance, south solar gains, interior shortwave absorptance, and thermal mass. This series of diagnostic tests is designed to be compatible with more building energy programs. However, the diagnosis of software using this test series is not as precise as in the in-depth series-A tests.

3.2 Modelling Approach

3.2.1 All references to time in this specification are to solar time, and assume that: *hour 1 = the interval from midnight to 1am*. Do not use daylight savings time, or holidays for scheduling.

3.2.2 In some instances the specification will include input values that do not apply to the input structure of your program. When this occurs, disregard the non-applicable inputs and continue. Such inputs are in the specification for those programs that may need them.

3.2.3 If your program includes the thickness of walls in a three-dimensional definition of the building geometry, then wall, roof, and floor thicknesses should be defined such that the interior air volume of the building remains as specified (6m x 8m x 2.7m = 129.6m^3) Make the thicknesses extend exterior to the currently defined internal volume.

3.2.4 Where options exist within a simulation program for modeling a specific thermal behavior, document which option was used in the output report (see section **tk**).

3.2.5 Where options exist for initialization or preconditioning (iterative simulation of an initial time period until temperatures and/or fluxes stabilize at initial values), document which option was used in the output report (see section **tk**).

3.3 How to Perform the Comparative Tests.

3.3.1 Building Simulation Input Specifications.

Procedures for inputing data for the various cases along with specific output requirements are provided case by case in Sections **3.4tk** through **3.9tk**. **[tk note, sections will be changed again] Tables B-1Atk and B-1Btk (Appendix Btk**) provide an informational overview for all the test cases and contain information on those building parameters that change from case to case; this summary is recommended for preliminary review of the tests, but do not use it for defining the cases. In some instances (e.g. Case 620, **section tk**), a case developed from modifications to Case 600 (**section 3.4tk**) will also serve as the base case for other cases.

3.3.2 Reporting results

A standard output report format is included in Appendix **A.tk**. Information required for this report includes:

a. software name and version number
b. documentation of modeling methods used when alternative methods are available in the software.
c. results for simulated cases.

3.3.3 Comparing Your Output to Other Results

The user may choose to compare output to the example results provided in **Appendix B.3tk**, or the user may choose run the test sequence for other programs and compare output among those. Example results are included as informational Appendix **B.tk**. The programs used to generate the example results have already been subjected to extensive testing.

For the convenience to users who wish to plot or tabulate their results along with the reference results, an electronic version of the reference results has been included with the file RESULTS2.WK1 **(tk filename)** on the accompanying diskette. Documentation regarding RESULTS2.WK1 **(tk filename)** has been included with the file and is printed out in **Appendix B.8tk**.

3.3.3.1 Comparative results are considered to be in agreement when:

a. results for a single case are of similar magnitude, and

b. results for the difference between cases (e.g. Case 610 **-** Case 600) are either both positive or both negative, and of similar magnitude.

3.3.3.2 For results that are not in agreement, diagnostic flow charts are provided as informational Appendix **B.tk.** Instructions provided in Appendix **B.tk** are designed to help the user identify what algorithm in the tested program is causing the disagreement.

■ Below is proposed standard output report based on 5/97 conf call along with some examples of how users would present information regarding use of alternative algorithms (note the modeling notes could get long for some software, e.g. BLAST). Yea or nay?

■ Also do we need to print out entire spreadsheet form in the appendix? would prefer to just keep it on the diskette, but print out instructions for filling it out.

STANDARD 140P OUTPUT FORM

INSTRUCTIONS: See 140POUT1.TXT on the diskette provided with the standard.

(tk - instructions to be based on Appendix H in IBTEST markup for SPC140 SMOT, also will add example per below)

SOFTWARE:

VERSION:

DOCUMENT BELOW THE MODELING METHODS USED IF ALTERNATIVE MODELING METHODS OR ALGORITHMS ARE AVAILABLE IN YOUR SOFTWARE (see instructions for example format):

Simulated Effect:

Optional Settings or Modeling Capabilities:

Setting or Capability Used:

Simulated Effect:

Optional Settings or Modeling Capabilities:

Setting or Capability Used:

(Include more alternative feature descriptions using this format if applicable to the test)

tk spc140 - proposed examples below ok? Note these sections could get lengthy depending on the number of modeling options a code applies. BLAST and DOE2 have a number of other options than what are listed here for examples. Also, i think that if we start having folks write anything detailed about the differences in the models themselves, it adds extra unnecessary work as all that's really necessary is enough discussion for another competent modeler to be duplicate the results.

STANDARD 140P OUTPUT FORM

INSTRUCTIONS: See 140POUT1.TXT on the diskette provided with the standard.

SOFTWARE: *BLAST 3.0*

VERSION: *Level 193*

DOCUMENT BELOW THE MODELING METHODS USED IF ALTERNATIVE MODELING METHODS OR ALGORITHMS ARE AVAILABLE IN YOUR SOFTWARE (see instructions for example format):

Simulated Effect:

Convective heat transfer and radiative exchange related to both interior and exterior surfaces
Optional Settings or Modeling Capabilities (from simplest to most detailed):

HEAT BALANCE = 0
HEAT BALANCE = 1
HEAT BALANCE = 2

Setting or Capability Used:

HEAT BALANCE = 2

Simulated Effect:

Interior solar distribution

Optional Settings or Modeling Capabilities (from simplest to most detailed):

SOLAR DISTRIBUTION = 0
SOLAR DISTRIBUTION = 1

Setting or Capability Used:

SOLAR DISTRIBUTION = 1

STANDARD 140P OUTPUT FORM

INSTRUCTIONS: See 140POUT1.TXT on the diskette provided with the standard.

SOFTWARE: *DOE2.1E*

VERSION: *W54*

DOCUMENT BELOW THE MODELING METHODS USED IF ALTERNATIVE MODELING METHODS OR ALGORITHMS ARE AVAILABLE IN YOUR SOFTWARE (see instructions for example format):

Simulated Effect:

Thermal behavior of windows

Optional Settings or Modeling Capabilities:

1) "Shading Coefficient"
2) GLASS-TYPE-CODE £ 11
3) GLASS-TYPE-CODE ‡ 1000
 3A) Existing window used from W4LIB.DAT
 3B) Custom window developed and added to W4LIB.DAT

Setting or Capability Used:

3B) GLASS-TYPE-CODE ‡ 1000 with custom window developed and added to W4LIB.DAT

■ Given the discussion below, what does the committee want to do with Case 990 regarding ground coupling?

Ground coupling notes - 6/16/97

Case 990 has always been a problem with IEA BESTEST as the state of the art in simulating ground coupling is the least well developed of all the heat transfer mechanisms tested in IEA BESTEST. In this vein, the most detailed criticism we've received is from NRCan and includes:

■ Methodology used in DOE2 and BLAST simulations regarding supression of delta T ground while maintaining full Latta and Boileau pathlengths is essentially double counting to suppress ground heat loss.

■ While use of Latta and Boileau method (as was done properly with the SERIRES/SUNCODE simulations) is ok for design calculations, that method understates annual heat loss estimations. NRCan recommends use of the Mitalas method, or even more detailed numerical methods.

■ The 10°C ground temperature included in the spec. is possibly inconsistent with assumptions made in more detailed ground heat transfer models (e.g. HOT 2000). Possiblities to revise this are:

- delete the ground temperature from the weather data (software that uses the annual average air temp can still use the listed value of 9.71°C for that value, and software that automatically calculates appropriate ground temps will come up with its own values anyway)
- specify a soil depth for which the deep ground temperature applies (however, we don't readily know how to do this)

Given these issues, here are some options:

■ delete the current BLAST and DOE2 results for Case 990, and either rerun them or not as time allows

■ delete all the results, but leave the case description either revised or not

■ delete the ground temp from the case description, but leave the annual average air temp

■ delete Case 990 entirely, and develop a better ground coupling case description later which could be applied to a future version of the SMOT

■ leave case description and results as is (no chnages)

■ leave as is but add results from another program which models ground coupling in greater detail (e.g. HOT2000)

■ form a small subcommittee to make a recommendation

■ other.

Since Kathleen (who will not be able to attend the meeting) was involved in discussions between NREL and NRCan last year regarding ground coupling in IEA BESTEST, and specifically running HOT2000 thru IEA BESTEST, we obtained comments from her. Her comments summarize to:

"For SPC 140, my advice is to improve the ground coupling cases or don't include them at all."

"If we decide not to include 990, SPC140 should still remind readers that heat loss to the ground can have a major impact on the heating and cooling loads in a residential building."

"If we decide to include 990, the following improvements would be required:

1. widen the range of reference results whether by re-running the reference programs such that they better model ground coupling or run a program that better models ground heat transfer, and
2. describe how the reference programs were used to model ground coupling to give users advice as to how they should model it in their programs."

"As for the ground temperature:
I most definitely think that the 10C ground temperature should be removed from the weather summary (Table A-1) and from the Case 990 description. You may wish to advise users to use the average ambient air temperature as the ground temperature if that's what their program requires."

■ Yea or nay for the proposed content of informational appendix regarding example results general discussion?

B.Resultstk Example Results (informational appendix, tk was formerly App. A.3)

The example results from the reference programs are presented here in tabular and graphic form. These results can be used for a comparison with the software being tested. Alternatively, a user can run a number of different programs through the Standard Method of Test and draw comparisons from those results independently or in conjunction with the results listed here. In either case when making comparisons the user should, as a minimum, emply the diagnostic logic presented in **Appendix B.Diagtk**.

Although the programs used to generate example results have been extensively tested, the example results do not represent truth. There is no truth standard in this type of exercise. For any given case, a program which yields values in the middle of a range of example results should not be perceived as better or worse than a program which yields values at the borders of a range. The range of differences between results for a given case represent algorithmic differences among computer programs. The existence of a difference in results between a tested program and the results listed here does not necessarily mean a program is faulty. However, investigating the source(s) of the difference(s) is worthwhile, as the collective experience of the authors of this Standard indicate that when programs show major disagreement with these results, it is often because there is a an error in the software or a questionable algorithm.

For the convenience to users who wish to plot or tabulate their results along with the reference results, an electronic version of the reference results has been included with the file RESULTS2.WK1 **(tk filename)** on the accompanying diskette. Documentation regarding RESULTS2.WK1 **(tk filename)** has been included with the file and is printed out in **Appendix B.8tk** for convenience.

For a summary of how reference results were developed see **Appendix resultsinfotk (informational)**. For more detailed information about the reference results see IEA BESTEST (**tk ref).**

Several pages have been left blank intentionally so that related graphs are on facing pages. **tk if this is still true**.

■ Regarding informational diagnostic logic appendix, to be consistent with recent discussions and proposed Sec. 3, again we are silent on what tests a user must run, or what order to run the tests in. Given that:

- formally vote that this diagnostic flow is an informational appendix.
- yea or nay for proposed content?

B.Diagtk Diagnosing the Results using the Flow Diagrams (Formerly Appendix A.4, and is now informational (tk formalize as informational))

B.Dtk.1 General Description. Figures 4tk through 7tk contain a set of flow diagrams that serve as an expert system for diagnosing the cause of disagreeing results that may arise from using this test. These flow diagrams list the feature(s) being tested, thus indicating which algorithms may be responsible if problems are encountered.

B.Dtk.2 Comparing Tested Software Results to Other Example Results.

B.Dtk.2.1 "Example results" are either results presented in **Appendix B.resultstk** or other user generated results.

B.Dtk.2.2 Check your program for agreement (see **Section tk**) with example results for both the absolute outputs and the sensitivity (or "delta") outputs. For example when comparing to the example results shown in **Appendix B.tk**, for Case "610 **-** 600" in the "low mass basic" flow diagram (**Figure 4tk**), the program results are compared with both the Case 610 example results (**Figure B.tk**) and the Case 610 **-** 600 reference sensitivity results **(Figure B.tk**).

B.Dtk.2.3 Compare all available output types specified for each case that can be produced by your program. This includes appropriate solar radiation, free float, and hourly results if your software is capable of producing that type of output. A disagreement with any one of the output types may be cause for concern.

B.Dtk.2.4 There are some cases where it is possible to proceed even if problems were uncovered in the previous case. For example, in Case 610, inability to model a shading overhang would not effect the usefulness of the program for modelling buildings with unshaded windows. Thus the flow diagram has an extra arrow connecting Case 610 and Case 620, which denotes that you may proceed regardless of the results for Case 610. Where cases are connected by a single arrow, a satisfactory result is required in order to proceed to the next case. For example, in Case 620, the inability to model transmitted radiation through an unshaded east window renders the program practically useless for whole building energy analysis. Thus, there is no sense in proceeding until the disagreement is reconciled.

B.Dtk.3 If Tested Software Results Disagree With Example Results. If the tested program shows disagreement (as defined in **Section tk**) with the example results, then re-check the inputs against the specified values. Use the diagnostic flow diagrams to help isolate the problem. If no input error can be found then look for an error in the software. If an error is found, then fix the problem, and rerun the tests. If in the engineering judgement of the user the disagreement is due to a legitimate difference in algorithms between the tested software and the example results or other tested software then continue with the next test case.

B.Dtk.4 Low Mass and High Mass Basic Tests. The first flow diagram **(Figure 4tk)** begins with the base building (Case 600). If your program output agrees satisfactorily with other example results for Case 600 then check other output according to the flow diagram. Once the low-mass basic cases have been checked, proceed with the high**-**mass basic (900-series) cases **(Figure 6tk)**.

B.Dtk.5 In-Depth Tests. These tests provide detailed diagnostics. The "in-depth test" flow diagram (**Figure 5tk**) indicates two possible diagnostic paths, A1 through A11 or B1 through B10. Selecting path A versus path B depends on the capabilities of your program. Path A is the preferable diagnostic path. Use Path A if the software being tested is literal enough in its treatment of building physics to allow input of those cases. Otherwise, Path B will still help to identify the algorithmic source of problems, but less definitively because of interacting effects.

B.Dtk.6 Mass Interaction Tests. Further diagnostic information can be obtained regarding thermal mass interactions using the diagnostic logic flow diagram of **Figure 7tk**. When disagreement among results occurs, this diagram sometimes returns to the low mass diagnostics (**Figure 5tk**) even though the program may have already showed agreement in the low mass basic tests. The reason for this is that the high mass cases may reveal disagreements that the low mass cases did not expose because:

- The disagreement is more readily detectable when mass is present
- The disagreement was not previously detectable because of compensating errors
- The disagreement was not previously detectable because of other unknown interactions.

B.Dtk.7 Example. A program shows agreement with Case 600, but shows large disagreement with the example results annual cooling load predictions for Case 610. **Figure 4tk** suggests a potential problem with the shading algorithm and directs the user to look at the sensitivity results for shading as represented by the difference between the output values from Cases 600 and 610. The flow diagram indicates the probable cause of disagreement is in the shading algorithm and directs the user to diagnostic A12. Diagnostic A12 will either confirm shading as the problem, or direct the user to additional diagnostics if the shading algorithm is okay. The logic is sequential in that to show disagreement with 610-600 and to show agreement with A12 indicates compensating errors in some of the basic heat transfer algorithms. To show disagreement with both 610-600 and A12 confirms a shading algorithm problem.

Other examples of how the diagnostic tests were used to trace and correct specific algorithmic and input problems in the programs used to produce example results of **Section B.tk** are given in IEA BESTEST **(tk ref).**

tk search on "A.4" refs (previous appendix # for this) in text and change as appropriate.

■ regarding background for selecting example result software and excluding some of the results presented in IEA BESTEST, ok?

Appendix B.resultsinfotk: Production of Example Results

The full discussion of example results is included in IEA BESTEST (tk ref). Portions of that discussion have been included here.

The programs used to generate the example results are described in **Table B-results1tk**. Under the "computer program" column, the first entry in each cell is the proper program name and version number. The entries in parentheses are the various names and abbreviations for the programs used for labeling in some of the figures, tables, and text in this Standard.

Table B-Results1tk. Computer Programs, Program Authors, and Producers of Reference Results

Computer program	**Authoring organization**	**Reference results produced by**
BLAST-3.0 level 193 v.1 (BLAST-US/IT)	CERL,[a] United States (U.S.)	NREL,[b] U.S. Politecnico Torino, Italy
DOE2.1D 14 (DOE2)	LANL/LBNL,[c] U.S.	NREL, U.S.
ESP-RV8 (ESP-DMU)	Strathclyde University, United Kingdom (U.K.)	De Montfort University, U.K.
SERIRES/SUNCODE 5.7 (SRES/SUN)	NREL/Ecotope, U.S.	NREL, U.S.
SERIRES 1.2 (SRES-BRE)	NREL/BRE,[d] U.S./U.K.	BRE, U.K.
S3PAS	University of Sevilla, Spain	University of Sevilla, Spain
TASE	Tampere University, Finland	Tampere University, Finland
TRNSYS 13.1 (TSYS-BEL/BRE)	University of Wisconsin, U.S.	BRE, U.K. Vrije Universiteit (VUB) Brussels, Belgium

[a]CERL U.S. Army Construction Engineering Research Laboratories
[b]NREL National Renewable Energy Laboratory
[c]LANL/LBNL Los Alamos National Laboratory/Lawrence Berkeley National Laboratory
[d]BRE Building Research Establishment

To minimize the potential for user error, we encouraged more than one modeler to develop input files for each program. This was done for BLAST, SERIRES, and TRNSYS. Where disagreement in the inputs or results was found, we requested the two modelers to resolve the differences. Where only a single modeler was involved, we strongly recommended that inputs be carefully checked by another modeler familiar with the program.

B.resinftk.1 Selection of Programs for Producing Example Results

The criteria for selection of programs used for producing example results required that:

- A program be public domain in the sense that a large portion of its development was government sponsored and that source code be available

- The program be a true simulation based on hourly weather data and calculational time increments of one hour or less.

B.resinftk.2 Exclusion of Specific Results

Specific results from IEA BESTEST used to develop example results were excluded according to a specific set of rules.

Rule 1) Where there is known to be a specific, identifiable, documented deficiency in a program which impacts the results for specific cases, and not for any other cases, the results for those cases were excluded.

Rule 2) If a fundamental bug, or algorithmic error is suspected which affects many of the results from a particular program, then all the results from that program were excluded.

Rule 3) A significantly outlying result for a particular case must be explained/justified by the modeler, or corrected by the modeler with an explanation of the physical basis for the correction, or it was excluded.

Application of these rules resulted in the elimination of:

- ■ SERIRES 1.2 (SERIRES-BRE) for setting ranges related to peak loads
- ■ TASE results related to East and West shading devices (cases 630 and 930)
- ■ various diagnostic results as noted in **Table B-diagtk**.

SERIRES/BRE peak loads results were excluded because the implementation of SERIRES 1.2 for producing example results did not explicitly model a pure convective thermostat as called for in **Section 3.3.1.9tk**. A convective thermostat is one that responds to pure interior air temperature (does not respond directly to infrared radiation from interior surfaces). The mathematical representation of the thermostat control temperature in the SRES-BRE results is closer to a radiant temperature than an air temperature. This can have a significant effect on peak load prediction in certain cases. In the SERIRES/SUNCODE 5.7 (SRES/SUN) results, the pure convective thermostat is modeled by reducing the combined radiative/convective interior film coefficient from 8.29 W/m^2K to a convection-only film coefficient of 3.16 W/m^2K. The modelers then slightly increased the conductivity of the wall and roof insulation materials, and increased the resistance of the floor insulation materials so that the building air-to-air heat transmission coefficient remained equivalent to that specified in **Tables 3-1tk** and **3-11tk**. For more discussion about this, see IEA BESTEST Sec 2.5.3.3. **(tk ref).**

TASE results related to east and west shading devices (cases 630 and 930) were also eliminated from range setting, based on communications with the modeler.

For diagnostic cases 195 to 440 and 800 to 810, we used results only from those reference programs capable of explicitly modeling the effect in question. The most difficult cases were those that required variation of exterior and/or interior infrared emissivity (ε), and those that required variation of interior shortwave absorptivity (α). Thus, for cases that specified interior $\varepsilon = 0.1$, exterior $\varepsilon = 0.1$, or interior $\alpha = 0.1$ (cases 195, 200, 210, 220, 280, 440, and 810), the decision to include a program's results was based on the modeling approach described by each modeler (see IEA BESTEST, **tk ref**). Where explicit modeling of the effect was internal to the program, or where the modeler documented a credible method equivalent to explicit modeling of the effect, the results were included. **Table B-diagtk** shows those effects responsible for eliminating some of the programs (no = eliminated).

For case 210, we required at least some sort of interior radiosity network and the ability to explicitly vary interior emissivity. ESP, BLAST, TRNSYS, and TASE were the only programs able to meet these requirements. The TRNSYS modelers were able to do case 210 (interior $\varepsilon = 0.1$) by varying the Stefan-Boltzmann Constant within the context of a simplified radiosity network. The SERIRES modelers were able to do cases 280, 440, and 810 (cavity albedo) by externally calculating the fraction of shortwave radiation absorbed by interior surfaces based on shape factors and absorptivities (SERIRES/SUNCODE), or area weighting and absorptivities (SERIRES/BRE). Most of the programs were capable of explicitly modeling the remainder of the diagnostic cases.

Table B-diagtk. Ability of Participating Computer Programs to Explicitly Model Diagnostic Cases That Vary Selected Radiative Properties

Computer program	**Exterior ε = 0.1**	**Interior ε = 0.1**	**Interior α = 0.1**
BLAST–3.0 level 193 v.1	No*	Yes	Yes
DOE2.1D14	No	No	No
SERIRES/SUN-CODE 5.7	No	No	Yes
SERIRES1.2	No	No	Yes
ESP–RV8	Yes	Yes	Yes
S3PAS	No	No	No
TRNSYS 13.1	No	Yes	Yes
TASE	No	Yes	Yes

*Just prior to final publication of IEA BESTEST **(tk ref)**, the BLAST Support Office notified the BLAST modelers of the undocumented commands for invoking BLAST's most detailed algorithm for handling of exterior surface infrared radiation exchange. This information was not available in time to revise the reference results.

■ Regarding proposed revised table of contents, ok? Main substance here is regarding normative appendices versus informative appendices. Other renumbering is to more closely match other ASHRAE SMOTs (e.g. for establishing AFUE and SEER).

■ The new standard output format is proposed to be a normative appendix, ok?

■ Other SMOTs like for determining AFUE and SEER do not have a forward, in light of this do we want to have one?

■ Test categories are now called "basic" replacing "preliminary", and "in-depth" replacing "diagnostic", ok?

■ Do we need to include empirical and analytical testing headers as place holders in this standard or leave those test procedures for another SPC (or for the future SSPC) to address? It may be less confusing without them, and since the research for these other sections is not yet completed, it may not be possible to keep them.

Proposed Revised Table of Contents

tk have attempted to redefine this following SMOTs for AFUE (ANSI/ASHRAE 103-1993) and SEER (ANSI/ASHRAE 37-1988) with sections regarding Instruments and Apparatus excluded. Changes do not have much effect on content.

Forward *(not yet written)* **tk delete forward?**

- *explain who are the expected users of the standard and how it will assist them*
- *give a simple summary of how standard could be used*
- *explain why this should be considered a standard method of test*

1. Purpose

2. Scope

3. Definitions, Abbreviations and Acronyms, Symbols

4. Classifications
    - *may not need this section unless we need to classify types of simulation software being tested, tk ASHRAE later.*

5. Methods of Test
    - background, introduces the different kinds of tests

    5.1 Comparative tests
    - *add something like is in HERS BESTEST about the fact that the reference programs have already been subjected to extenxive analytical, empirical and intermodel testing*

5.2 Empirical data tests
5.3 HVAC Calculations *(to be removed?)*
5.4 Analytic examples
- *if we decide to delete place holder sections then introductory sections of section 6 (6.1, 6.2, 6.3, 6.4) may go here instead, tk ASHRAE later*

6. Comparative Test Procedure
6.1 General description of test cases
- *tk add a table or tables summarizing the cases and what they test, or is current discussion (see "3.1.1" of handout) ok?*

6.2 Modelling approach: rules for performing the tests
6.3 How to perform the comparative tests
6.4 Case 600: Base case
6.4.1 Ground coupling
6.4.2 Infiltration
6.4.3 Internally generated heat
6.4.4 Opaque surface radiative properties
6.4.5 Exterior combined radiative and convective surface coeff.
6.4.6 Interior combined radiative and convective surface coeff.
6.4.7 Transparent window
6.4.8 Interior Solar distribution
6.4.9 Mechanical system assumptions
6.4.9.1 Thermostat control strategies
6.4.9.2 Equipment characteristics
6.5 Low mass basic tests
6.5.1 Case 610: South shading
6.5.2 Case 620: East/West window orientation
6.5.2.1 Window orientation
6.5.2.2 Interior solar distribution
6.5.3 Case 630: East/West shading
6.5.4 Case 640: Thermostat setback
6.5.5 Case 650: Night ventilation
6.6 High mass basic tests
6.6.1 Case 900: High mass base building
6.6.2 Case 910: South shading
6.6.3 Case 920: East/West window orientation
6.6.4 Case 930: East/West shading
6.6.5 Case 940: Thermostat setback
6.6.6 Case 950: Night ventilation
6.6.7 Case 960: sunspace
6.6.7.1 Back zone
6.6.7.2 Sun-zone/back-zone common wall
6.6.7.3 Sune-zone
6.6.7.4 Interior solar distribution in sun-zone

[tk jn - change main text to reflect new numbering and title revisions]

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