AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIR-CONDITIONING ENGINEERS, INC.
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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: May 14, 1996

TC/TG/TRG TITLE: Energy Calculations

DATE OF MEETING: February 20, 1996 LOCATION: Atlanta

MEMBERS PRESENT	**YEAR APPTD**	**MEMBERS ABSENT**	**YEAR APPTD**	**EX-OFFICIO MEMBERS & ADDIT'L ATTENDANCE**
Henry Amistadi	1992	James Axley	1992	See attached Sheet
Chip Barnaby	1995	Carol Gardner	1992	
Michael Brandemuehl	1993	Joe Huang	1992	
Drury Crawley	1993	David E. Knebel	1994	
Dan Fisher	1994	Ed Sowell	1994	
Philip Haves	1994	Michael Witte	1994	
Ron Jarnagin	1992			
Les Norford	1994			
George Reeves	1995			
Robert Sonderegger	1994			
Jeff Spitler	1995			
Rich Wruck	1992			

DISTRIBUTION

ALL MEMBERS OF THE TC/TG/TRG

RESEARCH & TECHNICAL COMMITTEE CHAIRMAN: Gordon Reistad

R&T SECTION HEAD: Terry Townsend

LIAISONS:

Program: James H. Norman Journal: John H. Stanley

Handbook: George Reeves

MANAGER OF TECHNICAL SERVICES: B.W. Ward

MANAGER OF RESEARCH: William A. Seaton

ADDITIONAL DISTRIBUTION:

ASHRAE TC/TG/TRG ACTIVITIES SHEET

DATE: May 14, 1996

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**
San Diego, CA Atlanta, GA	6/24/95 2/17/96	San Antonio, TX Philadelphia, PA	6/25/96 1/28/97

TC/TG/TRG SUBCOMMITTEES

Function	**Chairman**
Component Models	Dan Fisher
Simulation	Jeff Spitler (Phil Haves, effective before San Antonio)
Applications and Inverse Methods	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 9			
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)

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*

Last Name	First Name	E-Mail
Addison	Marlin	msa@essinc.com
Amistadi	Henry	amistadi@maine.com
Bahnfleth	Bill	wpb5@psu.edu
Barnaby	Chip	cbarnaby@wrightsoft.com
Black	Al	
Brandemuehl	Mike	michael.brandemuehl@colorado.edu
Claridge	David	claridge@esl.tamu.edu
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Taylor	Russ	taylor@dilbert.me.uiuc.edu
Thomaston	Bill	
Todorovic	Bravko	
Walton	George	gwalton@nist.gov
Wruck	Richard	rich.wruck@hbc.honeywell.com
Yuill	Gren	gkyarc@engr.psu.edu

*** In order to preserve the e-mail addresses for all attendees, this is actually a complete list of attendees. It includes the voting members of the committee listed on page 1.**

Appendix 1

RESEARCH PROJECTS -- CURRENT

Project Title	Contractor	Comm.Chm.	At Meeting
RP-665 Preparation of a Toolkit for Primary HVAC System Energy Calculations	Universite de Liege	Barnaby	Yes
RP-665 Preparation of a Toolkit for Primary HVAC System Energy Calculations - Editing portion	Yuill (awarded at meeting)	Mitchell	Yes
RP-669 Ice-On-Pipe Brine Thermal Storage System		Knebel	?
RP-717 Attic Energy Calculation Model	Holometrix, Inc.	Jarnagin	Yes
RP-787 Sensitivity Study to Determine Parameters for Floor and Ceiling Plenum	University of Kansas	Spitler	Yes
RP-839 Development of a Component Model Translator for the Neutral Model Format	KTH	Barnaby	Yes
865-RP Development of Accuracy Tests for Mechanical System Simulation	Penn State/Texas A&M (awarded at meeting)	Walton	Yes

Appendix 2

TECHNICAL PAPERS FROM SPONSORED RESEARCH

January 1994

629-RP Brandemuehl, M.J.; Gabel, S. Development of a toolkit for secondary HVAC system energy calculations ASHRAE Transactions v 100 n 1 1994. p 21-32

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

June 1995

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

Appendix 3

TC/TG/TRG SPONSORED SYMPOSIA

Title, When Presented

FUTURE:

San Antonio - June 1996:

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

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

PAST:

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:

PAST:

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
6:00 - 8:30 PM, Tuesday, February 20, 1996

158W Georgia World Congress Center
Atlanta, Georgia

AGENDA

1.	Roll Call and Introduction	Spitler
2.	Accept Agenda and Approve Minutes of San Diego Meeting	Barnaby
3.	Announcements	
4.	Membership, July 1996 - July 1997	Sonderegger
5.	Subcommittee Report	
	5.1 Component Models	Fisher
	665-RP Primary Toolkit	Barnaby
	5.2 Simulation	Spitler / Haves
	717-RP Attic Model/Radiant Barrier Systems	Jarnigan
	787-RP Sens. Study to Determine Parameters for Floor and Ceiling Plenum Models	Spitler
	5.3 Applications and Inverse Methods	Haberl
	865-RP Dev. of Accuracy Tests for Mech. System Simulations	Walton
	5.4 Ad Hoc Neutral Model Format (NMF)	Norford
	839-RP Dev. of a Component Model Translator for the NMF	Barnaby
	5.5 Research	Sonderegger
	951-URP (Passive Cooling)	Haves
	5.6 Handbook	Kreider
	5.7 Program	Haberl
	San Antonio	

TC 4.7 Minutes

February 20, 1996

1. The meeting was called to order at 6:30 p.m. Role was called with 10 out of 18 members present. Two more would eventually arrive to make the total 12.

2. Chip Barnaby made several announcements. Journal is looking for back-to-basics articles. R&T is looking for technology transfer ideas. Deadline for room assignments for San Antonio is March 29. All subcommittee chairs should bug Chip to make sure he gets the necessary rooms. Chip's address has changed:

   Chip Barnaby
   394 Lowell St.
   Lexington, MA 02173
   Voice:(617)862-8719
   FAX: (617)861-2058
   cbarnaby@wrightsoft.com

   Key dates are on the back of the agenda.

3. Our section head, Terry Townsend briefly addressed the committee.

4. Les Norford motioned to approve the agenda, Dan Fisher seconded. Minutes were approved unaminously

5. Knebel motioned to approve the San Diego Minutes, Sonderegger seconded. Minutes were approved unaminously.

6. Sonderegger announced changes in membership. Carol Gardner, Henry Amistadi, Jim Axley, Joe Huang, Ron Jarnagin, and Rich Wruck are rolling off after the San Antonio meeting. Coming on the committee will be Jeff Haberl, George Walton, Fred Winkelman, Bill Bahnfleth, Per Sahlin, Sandy Klein. Phil Haves has taken on chairmanship of simulation subcommittee to replace Jeff Spitler; Bill Bahnfleth will be program chair.

7. Dan Fisher presented the component models subcommittee report, attachment #1 and the draft work statement for the loads toolkit, attachment #2. The loads toolkit work statement is planned to be submitted at San Antonio. Phil Haves, Mike Brandemuehl, Marlin Addison agreed to review the work statement and return comments by May 1.

   John Mitchell, for the 665-RP PMSC presented proposals for 665-RP editing project. (Fixed price contract to edit the 665-RP Primary Systems Toolkit.) Crawley proposed, Norford seconded that the contract be awarded to Yuill. Motion carried 9 yes, 0 no, 0 abstained, chairman voted (One member was out of the room) Anticipated completion is June 1996.

   The chair appoints Mitchell, Hittle, Spitler, Barnaby to the 665-RP PMSC.

8. Spitler reported on Simulation Subcommittee meeting

   787-RP: (Impact of Return Air and Supply Air Plenums on Space Cooling Loads) PMSC recommends approval. The project was aimed at determining sensitivities of plenum models to parameters such as convective heat transfer coefficients and detail of the radiation model. In only a few cases did any variable cause more than a 2% change in the peak cooling load when the variable was varied by one

order of magnitude. The primary conclusion from the PMSC's view point is that no further experimental research is needed at this time. PMSC met with contractor. Spitler moves Norford seconds that TC4.7 approve the final approves final report subject to few minor wording changes agreed upon between PMSC and contractor. Some questions as to what the changes were. [Jarnagin, Amistadi enter room]. 12 yes, 0 no, 0 abstentions, chair not voting. Motion carries.

717-RP Attics: Jarnagin reporting. Project had been behind on account of problems independent of the work. Now the work is complete and the report is ready, as are copies of the software.
Jarnagin moves that TC 4.7 approve a no-cost extension through July 30, 1996 Spitler seconds. 12 yes, 0 no, 0 abstentions, chair not voting. Motion carries.

A draft work statement on advanced zone models is being revised by Kevin Knapmiller. Input was solicited from the committee. Some input had been volunteered at the subcommittee meeting – see minutes.

No progress on Cumali WS.

Extensive general discussion on role of TC 4.7, especially simulation, in ASHRAE. Merger of DOE-2 and BLAST considered.

Program: Will have two forums: Priorities for Near-Term Developments in Building Simulation Programs (Haves), Fast Multizone Models for System Optimization (Lebrun)

URP-951: will be discussed during research.

Amistadi reported that TC1.5 has submitted a work statement regarding guidelines for ASHRAE research containing software as a deliverable. TC1.5 requests that we appoint a PMSC member to assist with project management. The chair appointed Dru Crawley to act in this capacity.

Hunn wanted to know if mass transfer would be considered for the work statement that Knapmiller is working on.

9. Jeff Haberl presented the Applications and Inverse Methods subcommittee report (Attachment #4) WS-930, which had been returned by R&T was discussed. WS-930 will be revised for vote in San Antonio. Some discussion of the long-term research plan was held.

   George Walton reported on 865-RP Development of Accuracy Tests for Mechanical System Simulation, which had gone out for bid since the last meeting.(PMSC Witte, Walton, Amistadi) Three bids were received. The PMSC recommended the low bidder . Norford proposed, Reeves seconded, that the contract be awarded to Penn State/Texas A&M. ($53,000) 10 yes, 0 no, 0 abstained, CNV. (Jarnagin, Brandemuehl out of the room) PMSC Walton (chair), Judkoff, Maeda, Knebel.

10. Ad Hoc NMF subcommittee report; presented by Norford. (Minutes will be sent by subcommittee secretary.) Discussion of extensions to current version of NMF was held.

    Chip Barnaby presented the report of the 839-RP PMSC. (Development of a Component Model Translator for the NMF.) Work is essentially complete. Includes translator, final report, source code documentation, NMF Handbook, library of component models, and paper. Very high quality. Barnaby moved, Haves seconded approval of the final report. 11 yes, 0 no, 0 abstentions, CNV.

    Translator, etc. is available to be downloaded at: instructions in attachment #5.

11. Sonderegger presented the research report; one item. URP-951 was received and reviewed by an ad-hoc subcommittee Haves, Judkoff, and Fisher. Judkoff presented the committee's review; they did not

recommend funding the proposal. Haves moved that the proposal be rejected; Fisher seconded. 11 yes 0 no 0 abstentions CNV.

Judkoff announced he had a couple more work statement drafts which will be submitted to the Simulation Subcommittee.

12. Jan Kreider presented the report (Attachment #6) of the handbook committee. Simulation program history section is likely to be detailed. Location of the heat balance material Ch. 26 vs. Ch. 28. Tentatively it will be in Ch. 26. Ground loss material location is being decided between TC 4.1, TC 4.4, and TC 4.7. To be resolved. A schedule of the draft review dates is attached. Mitchell, Knebel, Hunn, and Hittle have agreed to review the chapter, in addition to the voting membership.

    Reeves moved, Amistadi seconded "That TC4.7 approve in concept the draft HOF chapter 28, subject to the editorial concerns listed in the hand book subcommittee minutes." 11 yes 0 no 1 abstention CNV

13. Jeff Haberl gave the program committee report. One complete symposium package has been submitted The Great Energy Predictor Shootout II. The other symposium External Environmental Impacts was submitted was not complete, and will probably be deferred to Philadelphia. Larry Degelman agreed to help Sue Reilly get the symposium package completed successfully. Two forum packages have been submitted for San Antonio. (Priorities for Near-Term Developments in Building Simulation Programs (Haves), Fast Multizone Models for System Optimization (Lebrun))
    Haves moves, Norford seconds, 11 yes, 0 no, 0 abstentions CNV to approve the following program plan:

    San Antonio priorities
    Priority 1 The Great Energy Predictor Shootout II; Priority 2 Haves forum; Priority 3 Lebrun forum

    Philadelphia priorities
    User Tools for Building Simulation (?); External Environmental Impacts (Reilly) 3 Status and Future Research Directions of How Monitored Data Should be used to Identify System Parameters (Reddy)

14. Dru Crawley discussed the BLAST/DOE 2 merger. The new program will use the "best of" both programs. Hooks to HVACSIM+ and SPARK will remain intact.

15. Ron Judkoff presented a brief report (Attachment #7) on SPC140P. One suggestion was that SPC 140P become a standing committee. The inter-model comparison subcommittee has a 70-80% complete translation of BESTEST to ASHRAE standard format. The analytical test (systems) subcommittee should now make accelerated progress now that there is a contractor for 865-RP. A draft empirical tests work statement has been written and will be distributed. A draft analytical test (loads) one-pager has been written and will be distributed. (One pagers are included as Attachment #8a and Attachment #8b)

16. Old business. Barnaby reported on IBPSA. IBPSA held a very successful conference in Madison, WI in August 1995. Regionalization continues. Another international conference is scheduled for Prague, Czech republic in 1997.

    Reeves reported on the status of BPC 14P.

    Amistadi reported on the status of SPC 152. John Leber mentioned that the research path should probably be taken out of the standard.

    Brandemuehl reported on the ad hoc professional development committee. (No energy analysis PDS courses currently being offered.) A meeting will be scheduled for San Antonio. Potential members are solicited.

17. Barnaby brought up the issue of "Long Range Vision". Some discussion will be held in the simulation subcommittee in San Antonio. We're at the end of the rope ^H^H^H^H road with the monolithic simulation codes. Come to the simulation subcommittee meeting.

    Dru Crawley mentioned the ibpsa-futures mailing list as another venue for discussing the future of building simulation.

    Les Norford suggested the third Sunday session be chopped since it conflicts with subcommittee meetings.

    Yuill restated that he would like nominations for awards.

18. Haves moved, Brandemuehl seconded that the meeting be adjourned. It was unanimously approved at 8:30 p.m.

Minutes

TC 4.7 Component Models Subcommittee

February 19, 1996

1. The meeting was called to order at 6:42 p.m., after Applications and Inverse Methods coasted to an end. Present were Fisher, Spitler, Witte, Sommer, Walton, Sonderegger, Barnaby, Mingsheng Liu, Kathleen Fraser.

2. Dan Fisher presented the draft of the work statement "Preparation of a Toolkit for Building Loads Calculations". Significant changes since the last draft include explicit statement that the toolkit would be based on the heat balance method, the programming language is FORTRAN 90, the background indicating TC4.1's interests has been strengthened. Minor changes include specification of surface temperatures, removal of moisture capacitance.

   A lengthy discussion on the work statement and group editing session followed. The changes focused on the need to simplify scope of work so that the project would be feasible. A revised work statement will be prepared for distribution to the full committee.

3. Chip Barnaby gave an update on 665-RP. An RFP was approved to do some editing on the final document. Four proposals are in hand; the PMSC will meet before the full committee and make a recommendation.

4. Chip Barnaby gave an update on 839-RP (NMF Translator). The project is essentially done; the quality is excellent and the PMSC will recommend approval at this meeting.

5. Chip Barnaby presented a "one-pager" *Development of Analytic Tests for Building Loads Algorithms* which would support the SPC-140P work. It will be passed to Haberl and Judkoff for further revisions.

6. Dan Fisher presented a "one-pager" produced by TC 4.6, *Anticipating the Effect of Lighting Controls on Building Controls and Energy Use*. An inconclusive discussion of the meaning of the document followed. It was decided to "DEEP-6" the one-pager.

7. Dan Fisher brought up another idea regarding an experimental project to survey different building types to determine actual diversity factors for internal heat gains. Chip Barnaby maintains that a significant amount of work has been done under the category of "Load Research". Sonderegger suggested that a small survey project might be useful to uncover and process recent research data into a form useful to ASHRAE. Dan Fisher will draft a "one-pager" for the next meeting.

8. Dan Fisher requested that thought be given to how toolkits might be maintained in a more formal fashion than just "e-mailing Mike Brandemuehl." One idea is to put comments/corrections on the WWW.

9. Meeting was adjourned at 8:04.

Work Statement

From
TC 4.7, Energy Calculations
TC 4.1, Loads Calculations

Preparation of a Toolkit for Building Load Calculations

February 20, 1996

Send comments to d-fisher@uiuc.edu by May 1, 1996

Background

Engineers now have ready access to powerful desktop computers and an ever enlarging library of packaged software for performing many types of calculations related to HVAC design and analysis. However, there is a need for a compendium of models for calculation of building heat transfer and loads so the engineer can efficiently and accurately use the available computer power to solve immediate problems.

In the past, ASHRAE has offered publications devoted to energy calculation techniques [1-2]. These publications are still widely used in spite of their age. Replacement publications are badly needed by engineers and students involved in calculation of building loads and energy use.

TC 4.7 has undertaken research that is improving this situation. First, an Annotated Guide to Models and Algorithms Relating to HVAC Equipment has been prepared under research project 530-RP [3]. This guide provides an annotated list of readily available material that assists in HVAC model development. Second, the research project 629-RP [4] documents actual calculation techniques for representing secondary (air side) HVAC components along with appropriate fundamental methods. Third, a similar project 665-RP [5] is nearing completion and documents additional methods suitable for primary HVAC components such as chillers and boilers. Fourth, 741-RP (co-sponsored with TC 4.1) produced a thorough annotated guide to models and algorithms relating to building load calculations. The current workstatement specifies work to document loads-related models and algorithms. This will result in the publication of a replacement for Energy Calculations 1 [1] and will complete the 10 year documentation effort initiated by T.C. 4.7.

An important goal of this project is to unify where possible the techniques used for sizing calculations and those used for energy calculations. With the sponsorship of 515-RP which may yield improved conduction transfer function models for building elements and the sponsorship of 875-RP, Advanced Methods for Calculating Peak Cooling Loads, TC 4.1 has strongly signaled its intention to move in the direction of fundamentally based cooling load procedures. At the most basic level, the equations used for sizing calculations are the same as those used for energy calculations. Thus, T.C. 4.1 and T.C. 4.7 are in agreement on the need for a library of fundamental procedures.

Justification of Need

The techniques for calculation of building loads have evolved significantly since the publication of Energy Calculation 1 in 1976. Several large public domain hourly simulation codes have been implemented since then (e.g. DOE-2, BLAST, and TARP), and many years of experience have been accumulated by users and developers of those

codes. Now that virtually every engineer has access to sufficient computing power to execute models of this type, the time has come to assemble an up-to-date and coherent set of load calculation component models.

An additional need addressed by this workstatement is the identification, evaluation and collection of the common techniques used for both energy calculations and peak load calculations (equipment sizing). TC 4.1 and TC 4.7 have always promulgated closely related techniques. The joint sponsorship of this work is an explicit effort to capitalize on that commonality.

Objective

The objective of this project is to prepare computer software and associated documentation that implements available models and algorithms for calculating:

1. Space heat gains and losses due to all pertinent sensible and latent modes.

2. The space conditioning load (defined as the rate of heat addition or extraction required to maintain a specified space temperature profile).

3. Surface temperatures and space temperature when it is not specified.

Scope

Collect, implement in FORTRAN 90, document, and verify algorithms for building load calculations. The included algorithms should draw heavily from the sources identified in the 741-RP Annotated Guide. New model development should be undertaken only after explicit approval from the PMSC.

The input requirements of the zone algorithm generally determine the outputs required from the component algorithms. Thus, the zone algorithm "sets the style" for the entire Toolkit. The Toolkit will include only heat balance based zone models. A key aspect of this project is assessing the relationship between the heat balance algorithm (or solution technique) and the fundamental equations required to calculate zone loads and temperatures. The test procedure must evaluate not only the accuracy of a solution technique, but also its stability over the expected range of inputs.

In a Toolkit of this type, clarity should take precedence over efficiency. Both component and room models should be retained in the most basic form possible. Complete variable definitions and model descriptions are essential.

The following areas should be covered in the Toolkit --

1. Fundamentals:

   - Required weather data and sky models.

   - Sun position and solar incident angle.

   - Shading effect of building wings, overhangs, and simple fixed objects.

   - Solar intensity on an arbitrarily oriented surface.

   - Psychrometric routines from A Toolkit for Secondary HVAC System Energy Calculations [5].

   - Outside surface heat transfer coefficients including dependence on orientation, wind speed, and roughness.

2. Load components (sensible and latent, as appropriate):

   - One dimensional wall and roof elements.
   - Ground coupled floor, foundation and basement wall elements including two dimensional and three dimensional models.
   - Glazing losses and gains including angle of incidence dependencies for solar gains.
   - Infiltration and natural ventilation (correlation models and air flow network models).
   - Internal gains (lighting, people, equipment, process gains, etc.).

3. Room model:

   - Short wavelength radiation distribution.
   - Long wavelength radiation distribution.
   - Convective transfer under still and moving air conditions.
   - Internal mass, including both building elements (e.g. partitions) and contents (e.g. furniture).
   - Interface with HVAC system (thermostat and control models).
   - Moisture balance (first order model).

The specific project tasks are as follows:

1. Develop, with advice from the monitoring committee, a technique for presenting the algorithms, including a listing of the FORTRAN 90 code statements, the test input and output data, and sufficient discussion to allow others to understand the calculation approach. The presentation technique should build on the formats used in the Secondary HVAC Toolkit (629-RP) and the Primary HVAC Toolkit (RP-665). References should be provided for each algorithm.

2. Collect, implement in FORTRAN 90, and verify loads-related algorithms for the areas enumerated above.

3. Develop test data sets that establish correct operation of each algorithm. The test inputs and outputs are to be included in the Toolkit publication.

4. Prepare complete draft versions of the Toolkit software and manual.

5. Coordinate third-party testing and review of the Toolkit software and manual. See Other Information for Bidders below.

6. Produce a final, camera-ready original of the publication in a format satisfactory to both the monitoring committee and to ASHRAE Special Publications.

7. Produce an PC compatible diskette containing code and test data developed for the project.

8. Prepare a brief final report documenting the methods used in conducting the project and identifying areas where additional research is needed.

9. Prepare a technical paper and research note, as required by ASHRAE research policy.

Level of effort

Project duration: 32 months (spanning 6 ASHRAE meetings). Person months principal investigator: 6 - 12; person months assistants: 24. Estimated value: $150,000

Other Information for Bidders

1. Bidders should include in their proposal an explicit third-party testing plan. Experience in other Toolkit projects indicates that thorough testing can only be accomplished on a funded basis. Masters level graduate students are well qualified to perform testing tasks. An essential aspect of any testing plan is independence: the testers must have no direct involvement in the development of the Toolkit manual or software.

2. In their proposals, bidders should present their qualifications with respect to software development in addition to those related to engineering and building science.

References

1. *Energy Calculations 1 -- Procedures for Determining Heating and Cooling Loads for Computerized Energy Calculations, Algorithms for Building Heat Transfer Subroutines.* ASHRAE, 1976.

2. *Energy Calculations 2 - Procedures for Simulating the Performance of Components and Systems for Energy Calculations.* ASHRAE (out of print).

3. 530-RP Final Report (*An Annotated Guide to Models and Algorithms For Energy Calculations Relating to HVAC Equipment*). ASHRAE.

4. Brandemuehl, M. J., S. Gabel and I. Andresen. 1993. A Toolkit for Secondary HVAC System Energy Calculations. Atlanta, GA: ASHRAE.

5. 665-RP Toolkit and Final Report. In draft form, to be completed in 1995.

6. 741-RP Annotated Guide and Final Report. ASHRAE.

7. Press, W. H. et al. *Numerical Recipes -- The Art of Scientific Computing.* Cambridge: The Cambridge University Press, 1986.

8. 342-RP, 359-RP, 472-RP, 515-RP, and 626-RP reports.

Workstatement Contributors

TC 4.7: C. Barnaby; TC 4.7 D. Fisher; TC 4.1 C. Pedersen

Minutes

TC 4.7 SimulationSubcommittee

February 19, 1996

1. The meeting was called to order at 8:12 pm Present were Fisher, Spitler, Witte, Sommer, Walton, Sonderegger, Barnaby, Liu, Rock, Ober, Wilkes, Norford, Addison, Knapmiller, Haves, Fraser

2. 717-RP Attic Modeling status report: Brief report by Dave Ober. Extension until April 30, 1996. Draft report in circulation. Code reviewed by Dan Fisher. Noted need for complete variable lists, suggested code clean-up in several places and suggested that a more detailed convection model (RP-529 and RP-664) be included to complement the "Vent-4 model". Comments will be sent to Ken Wilkes.

3. 787-RP Impact of Return Air and Supply Air Plenums on Space Cooling Loads status report: Brief presentation by Brian Rock. Project essentially complete. Jeff Spitler noted that the research showed that further research need not be done. The plenum is relatively insensitive to the model parameters. Brandemuehl asked for an estimate of the effect of the "worse case combination of variables (sensitivity analysis varied one variable at a time). Spitler noted that most combinations will also have little effect on the load. Norford echoed Spitler's concern that further research should not be recommended since it is not indicated by the results. PMSC recommends approval with minor modifications. Barnaby asked if simple models in BLAST and DOE-2 are adequate. Spitler confirmed that sufficient accuracy could be obtained with simple model. Haves noted that project was originally conceived to determine whether or not experimental research was needed. Spitler confirmed that experimental work is not needed. Spitler and Walton requested that the program and the models be included in the record.

4. Discussion of Work Statement, Imperfectly Mixed Room Models for Practical Environmental Calculations: Kevin Knapmiller reported no progress on editing the work statement. He noted that the work statement was deficient in that TC 4:10 was not included and that the work statement lacked the "political finesse" to gain acceptance by R&T. Spitler noted that there were definite benefits in cooperation in terms of obtaining R&T approval. Spitler suggested that Knapmiller re-write work statement and send workstatement to ad-hoc committee. Knapmiller agreed to send revised work statement by April 30 to Haves, Walton, Lebrun, Spitler, etc. Haves suggested that we need to converge on technical content before we worry about "spin". Kevin's opinion was that the technical content was quite good, but lacked the "political content". Sonderegger suggested that the workstatement needed less not more technical content. He suggested that the workstatement was pushing the edge of what ASHRAE could accept.

5. Discussion of Work Statement, Goal Oriented Model Synthesis for Simulation: Spitler noted that this work statement really couldn't progress without Zulfi Cumali, who is not present.

6. Spitler gave synopsis of BLAST-DOE2 merger project. Dru Crawley at DOE is spearheading the effort. A Workshop at Madison in August 1995 focused on the next generation of building energy simulation tools. Phil Haves noted that the simulation world was in a state of flux and that ASHRAE was in a position to provide a forum for discussion on the future of building energy simulation. Barnaby noted that the direction of the committee requires some thought. Spitler noted that Dru Crawley should be asked to give a brief report to the full committee. Marlin Addison noted that a "users" workshop was planned and suggested that it wouldn't be that difficult to set this up as a forum for San Antonio. Marlin also reported that several members of 6.5 had heard of the "shotgun" wedding and wondered if 4.7 was involved. Spitler and Barnaby will get a forum set up. Witte suggested that Dru be encouraged to write a Journal article informing the ASHRAE membership of plans and status of project. Addison suggested that 4.7 could provide technical oversight to the project. A discussion ensued on the relationship of the loads toolkit to the merger project and possibility of moving to a more modular structure. Norford suggested that time be blocked out next meeting to discuss forward looking

simulation structures and methods.

7. Lebrun gave a brief presentation on the need for Fast Multizone Models for System Optimization. Primary aspect to simplify concept for interpretation purposes. Recommended that high priority be given to modeling. Spitler noted that forum was not submitted properly and could be resubmitted. Haves suggested that the need is not there—that calculations already procede quickly. Lebrun stated that the problem was that an enormous amount of detail was currently required to obtain a relatively poor result. A lengthy discussion ensued on the usefulness of fast-multizone systems. Spitler concluded the discussion by stating that a forum will be scheduled. Jean Lebrun will work on a one-pager.

8. Spitler reviewed program for San Antonio. The package for the External Environmental Impacts symposium has been delivered. (It contains 4 papers; 3 are approved; the 4th has been revised per mandatory review comments but has not been approved yet.)

9. Under New Business. Chip Barnaby reported that an unsolicited proposal URP-951 Cooling Load Calculations in Buildings Using Passive and Natural Systems received from TC 4.1. Fisher, Judkoff and Haves volunteered to review proposal and report to full committee on February 20.

10. Barnby presented TC Guidelines for Research Projects that Include Software Deliverables from Henry Amistadi. Amis tadi is seeking TC endorsement of project.

11. Spitler announced that Phil Haves will take over the simulation sub-committee, effective after this meeting.

12. Meeting adjourned at 9:48 pm.

MINUTES

TC 4.7 Subcommittee on Applications and Inverse Methods
Monday, February 19, 1996, 5:00 to 6:30 p.m.
Weston Peachtree Plaza Hotel, Rm 1203
Chair: Jeff Haberl

REVISED AGENDA

1. Introductions (all)
2. Discussion of the minutes from June 1995 meeting (all)
3. Status report on Work Statements (Haberl, Krarti)
   WS “Calibrated Computer Models”...rewrite (Haberl).
   WS 930 “Toolkit for ANNs...”..reject by R&T rewrite (Krarti)
4. Long Range Research Plan (Haberl)
5. Old Business
6. New Business
7. Adjourn

ATTENDING THE MEETING:

Jeff Haberl, Texas A&M, 409-845-6065
George Walton, NIST, 301-975-6421
Robert Sonderegger, SRC Systems, 510-848-8400
Agami Reddy, Texas A&M, 409-845-9213
Liu Mingsheng, Texas A&M, 409-862-1234
Kelly Kissock, University of Dayton, 513-229-2852
Chip Barnaby, Wrightsoft, 617-862-8719
Moncef Krarti, University of Colorado, 303-492-3387
Jan Kreider, University of Colorado, 303-492-3915
Michael Witte, GARD Analytics, 847-699-3254
Klaus Sommer, University of Cologne, klaus.sommer@vt.fh-koeln.de
Jeff Spitler, Oklahoma State University, spitler@osuunx.ucc.okstate.edu

GENERAL DISCUSSION

Haberl opened the meeting at 5:05 p.m. followed by introductions. The minutes from the June 1995 meeting were then discussed.

MOTION: To approve the minutes from the June 1995 meeting (Sonderegger, 2nd by Walton), approved.

Haberl then reviewed the agenda for the Atlanta meeting and suggested that given the short time constraint that the WS be discussed first followed by the long range research plan, old business, new business. All agreed.

Barnaby asked that the sub-committee review the TC 4.7 agenda and prepare to have a quick (i.e., 15 minute) discussion for Tuesday so that the meeting could end as scheduled.

DISCUSSION OF WS “DEVELOPMENT OF PROCEDURES FOR ASSESSING HOW WELL BUILDING SIMULATION PROGRAMS ARE CALIBRATED TO MEASURED DATA...”

Discussion then began on the WS “Development of procedures for assessing how well building simulation programs are calibrated to measured data...” by Haberl. Haberl

reviewed the history of this WS, including the fact that this WS had been sent back by TC 4.7 for a rewrite with the instructions that the intent of the WS be changed from "procedures for calibrating" to "procedures for assessing the calibration". Haberl mentioned to the subcommittee that the WS had been through a quick rewrite to make the requested changes.

The subcommittee took a few minutes to read the WS.

Sonderegger asked for clarification on the intention of the WS. He felt that the current WS was still not clear as to what the EXACT intention was. He also questioned the need for the statement "All computer code will be documented according to the recommendations of ASHRAE's TC 1.5 - Computer Applications"

Haberl reminded the subcommittee that TC 1.5 has requested R&T to send this statement out with all research proposals. Sonderegger said that he was unaware of such orecommendations".

Sonderegger suggested cutting the first two paragraphs from the WS and fixing the sentence fragment in the last paragraph of the introduction and spell checking. He also suggested that the output not be just graphs, but possibly analysis techniques, RMSE, R^2, etc.

Witte asked if there were commercially available programs that could do this today. Haberl said that there were very expensive programs for doing this on UNIX and MS Windows platforms but that he was unaware of any specific programs.

Haberl mentioned to the subcommittee that he was suggesting that co-sponsorship be dropped from the WS because this was causing a logistics nightmare. TC 1.5 research meets on Sunday, and the TC 1.5 main meeting is on Monday. Which means that the WS that is discussed at the TC 1.5 subcommittee is not the same as that discussed at the Monday 5:00 - 6:30 p.m. TC 4.7 A&I meeting. Haberl said that he had discussed this with TC 1.5 research and that they didn't have any objections with dropping the co-sponsorship.

Barnaby asked that further clarification of the intent "assessing how well..." be added.

Kissock wanted to know how such a toolkit was going to be used if the intention of the calibration was unknown. Haberl mentioned that the intention was to produce a toolkit that could be used for many different purposes. Kissock suggested that this be clarified in the next rewrite.

Sonderegger asked if the emphasis needed to be only hourly simulation, why not daily, monthly or annual calibration. Sonderegger said that the WS needed to make this more clear -- in its current form it may not be biddable since this was not clear. Haberl agreed to include this in the next rewrite.

Liu questioned that one toolkit could be used by different simulation programs. Haberl said that the intention of the toolkit was to use columnar ASCII data and to demonstrate on two simulation programs. Liu said that this needed to be made more clear. Haberl agreed to do this.

Haberl said that the title needed to be changed to “Calibration... of whole-building simulation programs...” to make it clear that this is not referring to component simulations.

ACTION: The subcommittee tasked Haberl to rewrite the WS with the comments from the above discussion and have it ready for review in San Antonio. Haberl agreed to this.

ACTION: Sonderegger and Witte offered to provide help with reviewing the WS to be rewritten by Haberl provided that it was done in a timely manner.

ACTION: The subcommittee also requested that copies of the WS be made available to members of the subcommittee prior to the meeting so that they had time to read it and come prepared to discuss it. Haberl agreed to develop a process to accomplish this, perhaps post copies of the ASCII WS on the TC 1.5 ftp server.

DISCUSSION OF WS 930 “DEVELOPMENT OF A TOOLKIT FOR PREDICTING BUILDING THERMAL AND ELECTRICITY USE FROM MEASURED DATA USING NEURAL NETWORKS” (KRARTI).

Discussion then proceeded to WS 930 “Development of a toolkit for predicting building thermal and electricity use from measured data using neural networks” (Krarti).

The subcommittee took a few minutes the WS and then Krarti reviewed the history of the WS and his response to the rejection notice by R&T (see attached).

Liu questioned the need for certain statements in the background regarding the use of calibrated simulations. Haberl suggested that Liu and Krarti work out the wording of this, providing that Liu can supply Krarti the proper references.

The first statement by R&T was “What does this do that MATLAB and ARMAS don’t do”. Krarti explained his response (see attached).

The second statement by R&T was “Needs more word-smithing”. Krarti said that he had taken another look at the WS.

The third statement “Who pays for the third party testing”. Krarti said that he had added a statement to clarify that the proposal should set aside some money from the proposal for independent testing.

There was quite a bit of discussion about this. The subcommittee agreed that this was an important issue, and mentioned the fact that HVAC01 and HVAC02 had been tested by graduate students under the guidance of TC4.7 members.

The subcommittee recommended that this statement be replaced with “the proposal should describe an adequate procedure for the testing of the software...” or something to that effect. Krarti agreed to this.

Item #4 from R&T was then discussed “Not clear that the ”ANNs” are the way to go”. There was quite a bit of discussion about regarding the fact that the whole concept of “inverse methods” was new to ASHRAE and that perhaps it might be worthwhile for more education to take place since many of the current members of R&T were not aware of inverse methods and/or ANNS.

Krarti said that he had added additional material to the WS that helped to clarify this.

Haberl suggested that Krarti provide a discussion of the count of ANN papers on display at the Atlanta ASHRAE bookstore and include a discussion of the fact that there is not standardization regarding how the ANNs are constructed, tested, and documented. Krarti agreed that this might help the WS.

Witte questioned the need for an ANN toolkit. He felt that the WS was trying to resolve once and for all which ANNs were best for what purpose. He suggested more programs and/or symposiums on ANNs. Krarti mentioned that there were already many ANN papers in the ASHRAE literature and that perhaps it was time for a toolkit.

Haberl reminded the subcommittee that the intent of the WS was to produce a toolkit that would be similar to HVAC01 or HVAC02, and that when these toolkits were developed there were already existing codes that had portions of the various programs in them but that there was no ASHRAE toolkit that would make available such tools to ASHRAE members.

Witte suggested that the phrase oin a form that would be immediately useful to ASHRAE members be added. He also pointed out the current WS did mention that it was going to find the obest” method. Krarti agreed that this would need revision.

ACTION: The subcommittee tasked Krarti to rewrite the WS with the above discussion in mind and have it ready to discuss by San Antonio. Witte, Kissock and Walton agreed to help Krarti in this task.

ACTION: Sonderegger asked that at San Antonio if discussion could go first on the WS#8 “Development of procedures for inverse method building energy analysis” (Krarti) since perhaps this might be a better way of warming up R&T before hitting them with an ANN WS. Haberl agreed to this. Krarti handed out copies of this for review and discussion at San Antonio.

DISCUSSION ON THE LONG RANGE WORK PLAN

Haberl recommended to the subcommittee that all co-sponsorships be dropped from the one-pagers since this was causing too much confusion and work in corresponding the to other Research subcommittees.

Witte suggested that co-sponsorship was important the one-pager stage on a case by case basis. He recommended continuing only with those that needed it. Haberl agreed to do this.

Haberl read through the list of one pagers.

MOTION: To adjourn the meeting (Spitler, 2nd by Sonderegger). Carried.

The meeting was adjourned at 6:40 p.m.

NOTE: A copy of the A&I long range research titles is attached. Copies of the one pager will be posted on the ftp server.

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

#1 Development of accuracy tests for mechanical system simulations (Haberl).
STATUS: Passed by R&T...out for bid.
#2 Development of a procedures for predicting building thermal and electricity use from measured data with artificial neural networks (Krarti/Kreider).
STATUS: WS Rejected by R&T. Comments forwarded to Krarti. Krarti to rewrite by Atlanta.
#3 Development of procedures for assessing how well hourly building energy simulation programs are calibrated to measured energy and internal environmental data. (Haberl).
STATUS: WS rejected by 4.7, Haberl to rewrite for discussion in Atlanta.
#4 Development of procedures for inverse method building energy analysis (Krarti).
STATUS: WS by Krarti discussed at San Diego, Krarti will revise and bring 10 copies to Atlanta for discussion.
#5 Development of a procedures for preparing weather data for use with building energy analysis programs (Cumali,Haberl). STATUS: One Pager, Cumali to write WS.
#6 Development of procedures for analyzing energy savings from HVAC and Lighting Retrofits using an inverse bin method and main meter, before/after data (Kammers, Haberl).
STATUS: One Pager, Kammers to write WS.
#7 Development of procedures for baselining energy use at large central plants (Schwedler, Haberl). STATUS: One Pager. Schwedler to write WS.
#8 Develop self-describing information exchange methods for computer programs used in HVAC industry for analysis, design and evaluation (Cumali). STATUS: One pager.

#9 Development of procedures for determining in-situ performance of large air-handing
units. STATUS: DROPPED...forwarded to TC 9.6.
#10 Development of levels for determining simulation time steps. STATUS: One pager.
#11 Development of procedures for empirically analyzing energy use from small commercial and residential buildings using monthly utility billing data and daily weather data. (Haberl) STATUS: New one pager.
#12 Modification of inverse bin method calculations to include procedures for calculating
latent, thermal, and solar effects (Haberl). STATUS: One pager

The Neutral Model Format

a Simulation Model Source Language for Tool Developers

Per Sahlin, KTH, Stockholm
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The calculation engines of the most widely spread building simulation tools were, almost without exception, developed during the seventies. The challenge then was to perform a multizone hourly simulation over a year within acceptable execution times. These programs are therefore highly optimized to perform well on a selected class of problems. If you want to do something slightly different, you are often out of luck. Changing the built-in models is generally beyond reach for anybody but the code developers. Today, person-time rather than machine-time is the limiting factor, and the flexibility of truly modular programs, such as TRNSYS, has proved to be invaluable. Consequently, significant research efforts are invested in model development for TRNSYS and for more recently developed modular simulation environments. Unfortunately, moving models between different environments or solvers, such as TRNSYS, HVACSIM+, ALLAN.Simulation, CLIM 2000, ESACAP, IDA, SPARK, EKS etc., is still a tedious and error prone handicraft.

NMF is a suggested standard for a component model source format, aiming at complete automation of model implementation in several target environments. A translator parses NMF model descriptions and generates environment code, e.g. TRNSYS TYPE subroutines.

An NMF model is essentially a strictly structured way of stating equations, variables and component model boundaries. An equation based language facilitates - given current numerical and computer algebra techniques - automatic generation of algorithmic model descriptions as required by, e.g., TRNSYS. Reverse translation, i.e. from algorithmic to equation based code, is not generally feasible.

As of today, research translators have been written for SPARK and ESACAP. A production quality translator for TRNSYS, HVACSIM+, and IDA has been developed at KTH in Stockholm, mainly based on ASHRAE funding. Several component model libraries have been directly developed in NMF. Others have been manually translated into NMF, e.g. the IEA Annex 10 & 17 group of models. An ASHRAE subcommittee of Technical Committee 4.7 has assumed responsibility for the NMF definition, pending further standardisation efforts.

A beta version for Windows of the ASHRAE translator can be downloaded as a self-extracting file

ftp://urd.ce.kth.se/pub/rp839/nmfwin.exe (remember to transfer as binary)

With the translator delivery comes also the NMF reference report and handbook (in rtf and postscript) as well as a large number of sample NMF component models. The translator is a 32-bit application. To run it under Windows 3.x, a 32 bit extension from Microsoft must be installed. A copy of this Win32s extension is also, for convenience, located in the same directory (file pw1118.exe.)

An e-mail list for NMF has been established on the U.K. mailbase facility. To join the IBPSA-NMF list send an e-mail message to

mailbase@mailbase.ac.uk

The Subject line is irrelevant, but the body of the message should read

join ibpsa-nmf <Yourfirstname> <Yourlastname>

Let us now turn to the details of NMF. Internal component model behavior is described by a combination of algebraic and ordinary differential equations. Equations may be written in any order and in the form

<expression> = <expression>;

NMF only states equation models, while solution of equations is, in some cases, left to the target environment (e.g. IDA, or SPARK), or the NMF translator in others (e.g. TRNSYS, or HVACSIM+).

NMF supports model encapsulation through a link concept, i.e. models may only interact via variables appearing in LINK statements. To enhance and encourage model plug compatibility, links and variables are globally typed. The idea is that a basic list of such types should be included in each revision of the standard, but that users may add to the list as need arises. A selection of such global types is:

```
QUANTITY_TYPES

/* type name  unit         kind */

  Area        "m2"         CROSS
  Control     "dimless"    CROSS
  Density     "kg/m3"      CROSS
  Factor      "dimless"    CROSS
  HeatCap     "J/(K)"      CROSS
  HeatCapA    "J/(K m2)"   CROSS
  HeatCapM    "J/(kg K)"   CROSS
  HeatCond    "W/(K)"      THRU
  HeatFlux    "W"          THRU
  HeatFlux_k  "kW"         THRU
  Temp        "Deg-C"      CROSS

LINK_TYPES

/* type name  variable types... */

/* generic   (arbitrary, arbitrary,...) implicitly defined */
  Q          (HeatFlux)
  T          (Temp)
  PMT        (Pressure, MassFlow, Temp)
  PMTQ       (Pressure, MassFlow, Temp, HeatFlux)

  MoistAir   (Pressure, MassFlow, Temp, HumRatio)
  BidirFlow  (Pressure, MassFlow, Enthalpy, HeatFlux)
```

A quantity type includes a physical unit and information about potential (across) or flow (through) type. A link type is simply an ordered list of quantity types. Let us now look at an example of an NMF model of a wall using the heat equation in one dimension.

```
ABSTRACT
“A 1D finite difference wall model. One homogeneous layer.
```

```
TQ interfaces on both sides.”

EQUATIONS
/* space discretized heat equation, for
   extreme nodes */
  c_coeff * T’[1] = Taa - 2.*T[1] + T[2] ;
  c_coeff * T’[n] = T[n - 1] - 2. * T[n] + Tbb ;

/* .. and for internal nodes*/
  FOR i = 2, (n -1)
    c_coeff * T’[i] = T[i - 1] - 2. * T[i] + T[i + 1];
  END_FOR ;

/* boundary equations */
  0 = -Ta + .5 * (Taa + T[1]) ;
  0 = -Tb + .5 * (T[n] + Tbb) ;
  0 = -Qa + d_coeff * (Taa - T[1]) ;
  0 = -Qb + d_coeff * (Tbb - T[n]) ;

LINKS
/*type   name      variables ....  */
  TQ     a_side    Ta, POS_IN Qa ;
  TQ     b_side    Tb, POS_IN Qb ;

VARIABLES
/* type    name  role  description*/
  Temp     T[n]  OUT  “temperature profile”
  Temp     Ta    OUT  “a-side surface temp”
  Temp     Tb    OUT  “b-side surface temp”
  Temp     Taa   OUT  “a-side virtual temp”
  Temp     Tbb   OUT  “b-side virtual temp”
  HeatFlux Qa    IN   “a-side entering heat”
  HeatFlux Qb    IN   “b-side entering heat”

MODEL_PARAMETERS
/* type    name  role  description  */
  INT      n     SMP  “number of temp layers”

PARAMETERS
/*type     name  role     description*/

/* supplied parameters */
  Area      a       S_P   all area”
  Length    thick   S_P   “wall total thickness”
  HeatCondL lambda  S_P   “heat transfer coeff”
  Density   rho     S_P   “wall density”
  HeatCapM  cp      S_P   “wall heat capacity”

/* computed parameters */
  generic   d_coeff C_P   “lambda*a/dx”
```

```
  Length    dx      C_P   "layer thickness"
  generic   c_coeff C_P   "rho*cp*dx*dx/(lambda*3600.)"


PARAMETER_PROCESSING
  dx := thick / n ;
  c_coeff := rho * cp * dx * dx / (lambda * 3600.) ;
  d_coeff := lambda * a * dx ;

END_MODEL
```

To enable direct model translation to input-output oriented environments (e.g. TRNSYS or HVACSIM+), variable declarations have a role attribute indicating IN for given variables and OUT for calculated ones.

Variables and parameters may be vectors or matrices. A parameter must remain constant throughout a simulation. Links may also be vectors, thus allowing models with variable number of ports. Vector and matrix dimensions are governed by a special type of parameter, model parameters. Regular and model parameters are divided into two categories, user supplied and computed, the algorithmic computation of which is described in the parameter processing section. Arbitrary foreign functions in Fortran 77 or C may be defined, either globally or locally within a model. Special functions are defined to handle discontinuities, hysteresis, linearization, and errors.

If NMF seems interesting, please try the translator and join the ibpsa-nmf list on Mailbase. Please send comments and error reports to plurre@engserv.kth.se

MINUTES - TC 4.7 HANDBOOK SUBCOMMITTEE MEETING

February 19, 1996

The Handbook Subcommittee met and was joined by our Handbook Liaison, George Reeves. The final chapter 28 draft had been distributed prior to the Winter meeting by JFK. The conclusion of the meeting was that the chapter be approved for content with some changes in layout and level of detail. The chair of TC 4.7 will place the chapter on the agenda on this basis. G. Reeves noted that the handbook ms due date had been extended.

Various comments were made by those in attendance. The commented upon areas included:

1. Location of simulation program history section and chronological "roadmap."
2. Level of detail needed for primary and secondary toolkit coverage.
3. TC 4.7 has included a loads section in the current chapter because of the absence of handbook material from TC 4.1, the responsible TC for the loads chapters. J. Spitler will coordinate with TC 4.1 to determine the status of loads material for the 1997 HOF.
4. M. Krarti presented a subsection on ground coupling loads.
   If not included in TC 4.1 chapters, it will be included in Chap. 28 since it is based on TC 4.7-funded research and because it is both an energy and loads calculation procedure.
5. A table with supporting text will be added drawing the distinction between peak loads and annual energy calculations. The methods are very similar in principle but parametric inputs (e.g., solar gain, air change, film coefficients) differ from peak load values in many cases.

   The following schedule was approved.

1. All comments on present draft to JFK by 2/29/96.
2. JFK will distribute final revision on 3/30/96.
3. Final comments to JFK by 4/30/96.

All of the dates are final. JFK will not accept any comments after the two noted dates above. All comments must be in writing or by e-mail (kreider@bechtel.colorado.edu) to be considered.

_____

Jan F. Kreider, Handbook Subcommittee Chair

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1617 COLE BLVD **FAX: 303-384-7540**
GOLDEN CO 80401
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DATE: 2/19/96

CHAIRMAN'S SUMMARY MINUTES
SPC-140 SMOT FOR BUILDING ENERGY SOFTWARE
ATLANTA 2/19/96
R. Judkoff

Correspondance Since Last Meeting

- Letter from Jeff Haberl to Dru Crawley on BLAST and DOE vs hand calculation example.
- The RFP for 865-TRP.
- Letter from Robert Gansler, EPRI HVAC&R Center seeking additional information on 865-TRP.
- Letter from Bill Seaton asking for the record of questions and responses on 865-TRP.
- Letter from R. Judkoff to Bill Seaton and R Gansler indicating that no specific inquiries were received, and therefore no clarifications to the RFP were issued.

GENERAL

Dru Crawley suggested that we attempt to become a standing committee so that we can add sections to the Standard Method of Test as the research projects related to those sections are completed. Dru agreed to discuss this with the appropriate ASHRAE authorities.

Jeff Haberl suggested that R Judkoff ask Ken Gillespie Jr about the policy for standards on importing "approved" reports whole into a standard. If the IEA BESTEST Report could be imported whole into the SMOT, this would reduce the work required immensely.

MEMBERSHIP

C. Barnaby (producer category) has requested to resign from the committee due to conflicts with other activities. B. Wilcox (producer category) has expressed interest in becoming a member of the committee. Kathleen Fraser (producer category) has also expressed interest in becoming a member of the committee.

INTERMODEL COMPARISON BASED TESTS

NREL produced a second draft of the Standard Method of Test. This draft identifies where each applicable section of the IEA BESTEST would fit into the Standards format developed by Dru Crawley for the last meeting. NREL will distribute this draft for review, once the cut and paste mechanics are completed.

- Publication of HERS BESTEST.
- HERS BESTEST cited as the basis for software certification in DOE NOPR 10CFR-437, "Residential Energy Efficiency Ratings.
- Adoption by New Zealand of BESTEST as the basis for certifying code compliance software.
- Use of BESTEST by Canada Department of Natural Resources to test HOT2000.

ANALYTICAL TESTS (HVAC SYSTEMS)

After three rejections, R&T approved 865-WS, "Development of a Reference Set of Analytical Solutions for Mechanical Systems Simulation Test Cases." George Walton chaired the 865-TRP contractor selection committee, and will have a recommendation for TC-4.7.

Jeff Haberl reported that the discrepancy between BLAST and DOE for the first mechanical system example problem was corrected. BLAST and DOE now agree closely, but disagree with the hand calculation by about 20% for a simple VAV system.

George Walton indicated that we will need to establish a time for the 865-TRP project committee to meet. The time slots immediately before and after the SPC-140 time slot were suggested as favorable alternatives.

EMPIRICAL DATA SETS

A discussion on the merits of the PASSYS data sets from European Economic Community research occurred. This led to a discussion of the general need for high quality data sets suitable for validation of whole building energy simulation programs. Jeff Haberl mentioned a data set from Doug Dale at the University of Alberta, Edmonton. R. judkoff mentioned several potential data sets from Europe. It was agreed that a research project should be defined to evaluate existing data sets for this purpose. R. Judkoff of NREL agreed to write a one page work statement summary in time for the June meeting. Bruce Wilcox thought that TC-4.9 would want to co-sponsor the research project. Also, Mike Macdonald (ORNL) reported that TC-9.6 is interested in data sets for occupied buildings. This project would focus on data sets for unoccupied test buildings to examine the physics models within the building energy simulation programs.

ANALYTICAL TESTS (BUILDING FABRIC)

It was agreed that a research project should be defined to create a set of analytical solutions to test the solution methods within whole building energy simulation programs. Jeff Haberl attempted to construct a one page work statement during the subcommittee breakout. However, this generated a lot of discussion and questions. The committee requested that R. Judkoff construct a "straw-man" 1 page work summary statement for review by the committee prior to the June meeting.

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PRELIMINARY RESEARCH WORK STATEMENT

DEVELOPMENT OF AN ANALYTIC TEST SUITE FOR WHOLE BUILDING ENERGY SIMULATION PROGRAMS

Analytical Verification is defined as a process in which the output from a program, subroutine, or algorithm is compared to the result from a known analytical solution, or a universally accepted numerical solution, for isolated heat transfer mechanisms under simplified and constrained boundary conditions. Analytical verification tests the mathematical solution algorithm for a specific heat transfer mechanism within a program. It does not test how well the algorithm models physical reality. Analytical verification is one part of a three part validation approach which forms the basis for the Standard Method of Test for Building Energy Software being developed under SPC-140. The other two parts of the validation methodology include:

- Empirical Validation in which the calculated results from a program, subroutine, or algorithm are compared to monitored data from a real structure, test cell, or laboratory experiment.

- Comparative Testing in which a program is compared to itself or to other programs. The comparative approach includes "sensitivity testing" and "intermodel comparisons."

The purpose of this project is to produce a suite of analytical tests that can be easily implemented by program users, and producers. In previous work a number of analytical tests were derived and implemented at NREL (Wortman, Burch, Judkoff) including: wall conduction under steady state conditions, mass charging and decay due to a step change in temperature, glazing heat transfer, mass charging and decay due to solar radiation, and infiltration heat transfer. Several other researchers have also proposed analytical solutions (Bland, Bloomfield, Stefanizzi, Van de Perre, and Verstreit). Although many such analytical tests are possible in theory, the utility of a test depends on how easily it can actually be implemented in the context of the typical input capabilities associated with a variety of whole building simulation models. In this project the contractor would review the existing literature on analytical verification of whole building energy simulation computer programs. The contractor would then create a suite of easily implemented tests. The contractor would document the tests by producing a detailed set of modeling specifications for each test, and by producing the target results for each test. The contractor would also be required to prove that the tests can be implemented by testing several whole building energy simulation programs with time steps of one hour or less. The contractor would adhere to the following format for documenting the tests.

Description:	a brief description of the test and its purpose.
Input:	Building description and weather data. Common building designs and weather sequences shall be shared among multiple tests to the extent possible to simplify the testing process.
Output:	Identifies modeling results that are to be produced. These will generally be zone or component loads, heat flows and/or temperatures at hourly, daily, monthly and/or annual intervals.
Quantitative Results:	Tabulated numerical results. Variants may be presented as required to cover common modeling differences, such as combined vs separate calculation of radiant and convective surface heat transfer.
Qualitative Results:	The expected output behaviour described in non-numerical fashion where applicable.
Derivation:	Full documentation of how the target results are obtained in sufficient detail to allow verification, extension, and modification.

The contractor will develop the most parsimonious suite of tests that covers as many of the heat transfer mechanisms associated with the building fabric. These can be comprised of existing tests in the literature, or new tests developed by the contractor.

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PRELIMINARY RESEARCH WORK STATEMENT

DEVELOPMENT OF AN EMPIRICAL VALIDATION TEST SUITE FOR WHOLE BUILDING ENERGY SIMULATION PROGRAMS

Empirical Validation is defined as a process in which the calculated results from a program, subroutine, or algorithm are compared to monitored data from a real structure, test cell, or laboratory experiment. Empirical Validation provides a bottom line test of a model and its solution algorithms against an approximate truth standard within experimental uncertainty. Empirical Validation allows only a limited sampling of the parameter space because of the expense of gathering high quality and complete data sets. Empirical Validation is one part of a three part validation approach which forms the basis for the Standard Method of Test for Building Energy Software being developed under SPC-140. The other two parts of the validation methodology include:

- Analytical Verification in which the output from a program, subroutine, or algorithm is compared to the result from a known analytical solution, or a universally accepted numerical solution, for isolated heat transfer mechanisms under simplified and constrained boundary conditions. Analytical verification tests the mathematical solution algorithm for a specific heat transfer mechanism within a program. It does not test how well the algorithm models physical reality.

- Comparative Testing in which a program is compared to itself or to other programs. The comparative approach includes "sensitivity testing" and "intermodel comparisons." Comparative testing allows extensive sampling of the parameter space.

Together these three techniques comprise a powerful validation method.

The purpose of this project is to a) evaluate the literature on existing data sets that have been produced specifically for validating whole building energy simulation programs, and b) to assemble at least one data set into an empirical validation test package that can be easily used by software users and producers. The evaluation would involve the following criteria:

SUITABILITY OF THE TEST OBJECT: The data must be from a single zone test cell or building that was unoccupied and operated as a controlled experiment during the period of data collection. The test object should be de-coupled from the ground, have no attic, have a convective heating system and a relatively well mixed air volume. The test object must have a minimum internal heat capacitance of_____, and be strongly solar driven with a south glass area at least 15% of the floor area. The thermal and optical characteristics of the object must be well defined with no unknown heat transfer paths. The infiltration air exchange must have been measured with a well calibrated continuous tracer gas monitoring system. The test object must have been run in at least a heating temperature controlled mode using electric heaters and a distribution system entirely contained within the insulated envelope. Additionally, a period in which the object was run in a free-floating temperature mode would be considered advantageous.

Minimum required measurements:
- Outdoor ambient dry-bulb hourly integrated temperature (properly shaded and ir shielded aspirated sensor).
- Outdoor hourly integrated wind speed measured 6ft above the roof of the building.

- Hourly integrated global horizontal solar radiation, hourly integrated direct normal solar radiation measured with a properly calibrated pyrheliometer or hourly integrated diffuse radiation measured with a properly calibrated shadow band pyranometer.
- The ground reflectivity around the building.
- The solar albedo of all surfaces.
- The ir emittance of all surfaces.
- The zonal indoor spatially averaged and hourly integrated dry-bulb temperature.
- The hourly integrated electric power usage for heating, indoor lighting, and fans (lights and fans to be completely contained within the insulated envelope of the building).
- Hourly integrated infiltration rate.
- Hourly integrated outdoor barometric pressure.
- Hourly integrated outdoor wet-bulb temperature.
- Hourly integrated indoor wet-bulb temperature.

Other desireable measurements
- Global solar incident radiation in the plane of all windows.
- Global solar transmitted radiation in the plane of all windows.
- Surface temperatures, and temperature rakes through building elements.
- Heat flux transducer measurements through building elements.

The contractor would be responsible for processing weather data into standard electronic TMY format readable by most hourly simulation programs. The contractor would be responsible for assembling a complete description of the test object and its various test modes in a form suitable for unambiguous input to most hourly simulation programs. The contractor would be responsible for formatting the hourly and summed energy consumptions, and indoor temperatures in a convenient form for easy comparison of modeled results to measured results.

ASHRAE TC 4.7 1996-1997 Long Range Research Plan

Approved by **TC** 4.7 in San Diego
FINAL June 27, 1995

TC Priority	**Subcommittee/ Title**	**Status**	**Principal Author**
0.	Development of a Test Suite for Calibrating Hourly Building Energy Systems Models	865-WS, rejected by R&T/PAS(SPC 140)	A&IM/Haberl
1.	Development of a Toolkit for Predicting Building Thermal and Electricity Use Using Artificial Neural Networks	WS in San Diego	A&IM/Krarti & Kreider
2.	Algorithms for Heating and Cooling Loads for Computerized Energy Calculations (Loads Toolkit)	WS for Atlanta	CM/Fisher
3.	Development of Analytical Tests for Building Envelope Algorithms	WS for Atlanta	A&JM/Barnrby (SPC 140)
4.	Development of a Toolkit for Inverse Method Building Energy Analysis	WS for Atlanta	A&IM/Krarti
5.	Advanced Zone Models	Draft WS for Atlanta	Simulation/Knapmiller
6.	Development of Computerized Proceduresfor Calibrating Hourly Building Energy Simulation Programs to Measured Energy Use and Internal Environmental Data	WS in San Diego	A&IM/Haberl
7.	Requirements and Availability of Data for Energy Calculations	DraftWS forAtlanta	CM & TC 1.5/Arnistadi
8.(HR)	Goal Oriented Model Synthesis for Simulations and and Design	Draft WS for Atlanta	Simulation/Cumali 1.5 Co-sponsor *HIGH RISK*
9.	Development of Procedures for Preparing Weather Data for Use with Building Energy Analysis Programs	Draft WS for Atlanta	A&IM/Cumali& Haberl