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DOE/NBS Forum on Testing and Rating Procedures for Consumer Products October 2-3, 1985

Robert D. Dikkers, Editor

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Building Technology
Building Equipment Division
Gaithersburg, MD 20899

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

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1 - INTRODUCTION

1.1 Background

Part B of Title III of the Energy Policy and Conservation Act (EPCA) (Public Law 94-163), as amended by the National Energy Conservation Policy Act (NECPA) (Public Law 95-619) creates the Energy Program for Consumer Products (Other Than Automobiles). The consumer products subject to this program (also referred to as "covered products") are: refrigerators and refrigerator-freezers; freezers; dishwashers; clothes dryers; water heaters; room air conditioners; home heating equipment; television sets; kitchen ranges and ovens; clothes washers; humidifiers and dehumidifiers; central air conditioners; and furnaces.

Under the Act the program consists essentially of three parts: testing, labeling and mandatory minimum energy efficiency standards. The Department of Energy (DOE), in consultation with the National Bureau of Standards (NBS), is required to establish test procedures for each of the covered products. The purpose of the test procedures is to provide for test results which reflect the energy efficiency, energy use, or estimated annual operating costs of each of the covered products. Test procedures have been prescribed relating to all products. The Federal Trade Commission (FTC) is required by the Act to prescribe rules governing the labeling of the covered products. These rules are to require that each particular model of a covered product bear a label that indicates its annual operating cost and the range of estimated annual operating costs for other models of that product. At the present time, there is an FTC rule requiring labels for the following products: room air conditioners, furnaces, clothes washers, dishwashers, water heaters, freezers, refrigerators and refrigerator-freezers.

1.2 Forum Objectives

In regard to the testing part of the Energy Program for Consumer Products mentioned above, DOE and NBS organized and conducted a forum at NBS on October 2-3, 1985. The objectives of this forum were:

(1) To provide a line of communication between test procedure users and test procedure developers;

(2) To provide an opportunity for participants to present technical and research issues concerning DOE test procedures that need to be addressed; and

(3) To assist DOE and NBS in establishing a future agenda for the development and/or revision of testing and rating procedures.

1.3 Forum Organization and Format

Based on registration information received prior to the forum, it was decided to limit the forum discussions to the following consumer products:

- Heat Pumps and Air-Conditioners
- Furnaces, Boilers and Household Heaters

- Water Heaters

- Refrigerators, Refrigerator-Freezers and Freezers.

Accordingly, following a brief general opening session, the forum was divided into four concurrent sessions covering the above products. In each of these sessions, opening presentations were made on current and planned DOE/NBS research activities and potential technical and research issues.* Detailed discussions were then held in each group to finalize a list of technical and research issues and to develop recommendations for future consideration and action by DOE and NBS. A summary of the issues and recommendations developed were presented at the closing session of the forum. The various presentations, discussions, conclusions and recommendations for the four product areas are reviewed in Section 2 through Section 5 of this report. A brief summary of the conclusions and recommendations is presented in Section 6.

The agenda for the forum is contained in Appendix A and a preliminary list of technical and research issues which was circulated prior to the forum is included in Appendix B. A final registration list comprises Appendix C.

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* Exception: During the opening presentations, the groups on heat pumps and air conditioners and furnaces/boilers/household heaters were combined.

2 - HEAT PUMPS AND AIR CONDITIONERS

David R. Tree
Purdue University
and
Joseph A. Pietsch
Consultant

2.1 Introduction

During the introductory session (Session II-A) for the heat pump and air conditioning (HPAC) discussion group,* two presentations were given. Dr. David A. Didion of the National Bureau of Standards (NBS) discussed the problems and activities of NBS relating to rating of mixed-matched air conditioning systems. The other presentation by Dr. David R. Tree, Purdue University, was divided into two parts: The first part discussed new advances in heat pump and air conditioner (HVAC) design that may not be covered by the present rating procedure (Fig. 1). The second part discussed problems or potential problems with the present rating procedure for present-day equipment (Fig. 2). The main emphasis of the second session (Session III) was to make sure all issues and related problems were raised and discussed in an open and frank manner. During the last session (Session IV), the group focused on trying to prioritize the issues discussed in the other sessions.

The problems and activities of the HPAC group are divided into three categories and activities prioritized within each category. The three categories are: 1) Problems and actions related to the existing rating procedure; 2) New and/or innovative design of heat pumps and air conditioners that may not be covered by the present rating procedure; and 3) Problems and activities relating to developing a rating procedure for mixed-match coil systems that are not covered by a third party certification program.

Some attempts were made to try to prioritize between categories, but without much success. The group felt that the top priorities in each category were important and needed to be solved. The discussion suggested that most manufacturers considered the rating procedures for mixed-match coil systems as the number one priority. There are obvious reasons for this. We are now living with (and have for some time), the problems associated with using the present rating procedure and still obtaining "meaningful" results. The problems related to rating of new designs is not yet here, but the problems of rating mixed-match coils are here and have been for some time. Many have concerns with the present situation relative to the rating of mixed-match coil systems.

2.2 Existing Rating Procedure

During all the discussions about the heat pumps and air conditioners rating procedure, it was assumed that American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 116, with its continuous

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* Participants in this discussion group are listed in Appendix D.

Figure 1

Advancements in Heat Pump Design*

That May Need Further Research Work
to Develop Rating Standard

1. Smart Controls
2. Variable Speed Compressors
3. More Than One Refrigerant Systems
4. Multi-Evaporator Systems
5. External or Engine Driven Heat Pumps
6. Ground Assist Water Source Heat Pumps

Figure 2

Problems With Existing Standard*

That Still Need Attention

1. Instrumentation:

   - o How good is good enough?
   - o Does instrumentation exist that will give accuracy we need?
   - o Two phase mass flow rate measurements

2. Calibration Devices:

   - o Rooms
   - o Air flow measuring devices
   - o Mass flow rate of two phase refrigerant

3. Repeatability:

   - o Closer tolerances
   - o Standard test stand

4. Measurements:

   - o Wet coil
   - o Refrigerant migration during start up and shut down
   - o Cycle time and rate

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* Presented by David R. Tree

indoor air flow during compressor off time, would be adopted by DOE. Thus, those problems related to the dampers in the present rating procedure were not discussed. This list of problems in order of priority are:

1. Annual hour usage of air conditioning
2. Indoor air flow requirements and correction factors
3. Enhancement factor approach to rating systems
4. Continuous air flow problems
5. Repeatability
6. Wet coil testing

2.2.1 Compressor Operating Hours

The current value used is 1000 full load compressor hours. A recent NBS study, "A Review of Energy Use Factors for Selected Household Appliances," by J. Greenberg, B. Reeder and S. Silberstein, NBSIR 85-3220, August 1985, which was distributed at the meeting recommends 1150 hours. This report was challenged by some participants. Some data was presented by one participant that indicated that improvement in design of air conditioners may have reduced, not increased, the 1000 full load compressor hours. In attendance at the meeting were several people who were involved in the study that recommended the 1000 hours and one NBS staff member who conducted the present study. It was felt that this issue was of such importance that a separate ad hoc group was organized to discuss this problem.

The heat pump-air conditioning group considered this problem to be the number one issue relating to the present rating procedure and recommended that NBS, DOE and ARI take whatever actions are needed to solve the problem.

2.2.2 Indoor Air Flow

In regard to indoor air flow, there were three concerns: a) the sensible to latent cooling ratio as a result of air flow rate, evaporator size, evaporator temperature, and the needed ratio due to changes in building construction (more insulation and less infiltration); b) needed air flow rate to provide comfort and odor control because of building construction changes; and c) due to equipment design changes, are the default values of indoor fan power input and the resulting energy added to the air stream representative of current design and installation practices?

2.2.3 Enhancement Factors

Since the beginning of the present DOE rating procedures, the question has always been asked, "Is there a way to get the same information and still reduce the testing burden?" This question again became the third priority for the existing standard.

The specific question that the group would like to have answered is: "Is it possible to conduct only one steady state test (i.e., test A), have a default value for the degradation coefficient, and have 'Enhancement Factors,' for various devices which increase efficiency?"

2.2.4 Continuous Air Flow

ASHRAE Standard 116 requires maintaining air flow over the indoor coil during the entire cycling test. Some manufacturers are experiencing problems with this test condition when testing various devices which prevent refrigerant migration during the compressor off part of the cyclic test. These devices should increase efficiency but the continuous air flow test as outlined in ASHRAE Standard 116, does not give these results. This problem must be investigated further, and if indeed, the present test procedure does not give credit to energy saving devices, it must be modified.

2.2.5 Repeatability

Whenever a third party certification program is being used, repeatability of tests becomes a very important item. There were several questions concerning repeatability raised and discussed. The main ones were:

- Test tolerances
- Equipment tolerances
- Accuracy of air flow rate measuring device.

There are some questions as to the accuracy of the present device used to measure air flow rates over the coils. It appears that nozzle location and/or number of nozzle used can affect the results.

It is not new, but the question was raised again at this meeting, "Should there be a standard indoor test box?" This recommendation was made several years ago by ETL Testing Laboratories and they even recommended the design of such a box.

2.2.6 Wet Coil Test

If a reliable cyclic wet coil test could be designed, the two dry coil tests (C&D) could be replaced by one wet cyclic test. This would reduce the number of tests and simplify the equipment needed to condition the indoor test room. Results of efforts to develop such a test outside the United States are now becoming available in published articles. NBS should follow these activities.

Two other subjects received some discussion. They were: 1) the ability to measure two-phase mass rate of flow; and 2) refrigerant migration during start-up and shut-down of the cyclic test. It was the opinion of this group that these two topics did not cause any problems with using the present rating procedure, but that additional knowledge in these areas would be very useful. The participants encouraged DOE, ASHRAE, Air-Conditioning and Refrigeration Institute (ARI), etc. to provide funds for such research.

2.3 New Product Innovations

During the discussion sessions, many new product developments were identified which may require changes or additions to the test procedures. These developments were then rank-ordered on the expected impact on the market place from a chronological standpoint. They are:

1. systems with variable pumping rate (other than two-speed) compressors;

2. systems with "smart controls" incorporated into the system;

3a(tie) system which combine space conditioning and domestic water heating;

3b(tie) water-source heat pumps with alternative heat sources/sinks (for example ground assist heat pumps);

3c(tie) multi-evaporator split systems;

6. engine driven heat pumps;

7. systems having zoning capacity incorporated into the product;

8. absorption systems; and

9. multi-refrigerant systems.

All systems listed under 1, 2, and 3 are starting to appear or soon will appear in the market place. Mr. McCabe stated in the opening session, that DOE should try to anticipate problems and solve them so that there would be fewer needs to have "exceptions to the rule." The first five (1, 2, 3a, 3b, and 3c) under new product innovations listed above are excellent examples of problems DOE needs to consider and have answered before there is a need for "exceptions to the rule." It is the recommendation of this group that DOE give high priority to these systems.

It should be pointed out that the ASHRAE 116 will allow testing of multi-evaporator systems as single zone systems. Zoning was felt to be more of a system (ducting, building design and controls) characteristic than a unit characteristic and to be outside the scope of the test procedure.

At present, ARI has a standard for rating ground water source heat pumps. With minor modification this standard could be applied to all types of water source heat pumps. Thus, it appears that items 1, 2, and 3a are the items needing the most research.

The group felt that the probability in the near future of needing test procedures for items 6, 8 and 9 was very small and should not be considered at this time.

Although the group felt that zoning and multi-evaporator split systems were adequately dealt with by the present standard, all agreed that additional research into how these devices affect performance and comfort are needed. The group strongly recommended that DOE and ASHRAE fund additional research in these areas.

2.4 Mixed-Matched Systems

The majority of the time in Session III was spent in discussing mixed-matched system rating procedures. After considerable research in this matter, NBS has concluded that at present, in order to rate a mixed system,

the minimum requirements are:

1) The manufacturer of the mixed evaporator coil to be supplied to operate with another manufacturer's condensing unit must obtain rating data of the condensing unit and physical data for the matched evaporator. In many cases, this will require the mixed evaporator coil manufacturer to have access to a sample of the matched evaporator unit. This requirement could be financially burdensome to a small manufacturer, especially if the matched evaporator units must be purchased.

2) Obtain the following ratios:

   a) coil capacity ratio;

   b) blower capacity ratio;

   c) refrigerant flow ratio; and

   d) experience factor ratio for energy saving design or innovations.

See Appendix E for further explanation of these ratios.* There are some energy saving designs such as suction superheat control and off-cycle refrigerant migration controls that need to be considered in the mixed coil systems. It is the present thinking of NBS that such devices could be taken into consideration by allowing experience/enhancement factors for these design features.

It is strongly stressed by some of the evaporator coil manufacturers, that this type of rating procedure would be very costly and in some cases prohibitively expensive for them.

The prioritized list developed by the HPAC group for mixed-matched coil systems was:

1) develop methods of rating mixed-matched coil systems based on the above discussion for air conditioning systems;

2) expand procedure developed in item 1 to heat pumps;

3) develop for air conditioning systems a method for testing and rating condensing units and evaporator units separately so that combined ratings comparable to those obtained by the existing rating procedure could be determined from published rating information of each unit; and

4) extend concept of item 3 to heat pumps.

Not discussed in any of the sessions but presented to the authors and NBS staff after the meeting to accomplish items 3 and 4 above was the following recommendation. Design a series of standard evaporator units and

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* Editor's Note: Also see "Rating Procedure for Mixed Air Source Unitary Air Conditioners and Heat Pumps Operating in the Cooling Mode," Piotr A. Domanski, NBSIR 86-3301, February 1986.

condensing units. All condensing units would be rated using the appropriate standard evaporator unit and all evaporator units would be rated using the appropriate standard condensing unit. Even though this proposal was not part of the formal meeting, the authors recommend that DOE and NBS include this proposal in their considerations.

The formalized procedure for rating mixed coil systems may be limited to those raters who do not participate in a third party certification program. It was suggested that if that is the case, the need for procedures disappears if it were a requirement for all raters to participate in such program.

2.5 Conclusions

From the discussions at this forum, it can be concluded that for rating of heat pumps and air conditioners:

1. We have learned to use and live with the present rating procedure for present-day equipment and only minor problems still exist.

2. New designs and/or innovations in heat pump and air conditioners that may not be covered by the present rating procedure are or soon will be appearing on the market place. The two most pressing are variable speed compressors and "smart controls."

3. The rating of mixed coil systems is the most immediate problem. At present, it appears that a testing and rating procedure to cover these systems may not be simple and therefore financially burdensome to coil manufacturers.

3 - FURNACES, BOILERS AND HOUSEHOLD HEATERS

Jack H. Hollingsworth
Consulting Engineer

3.1 Introduction

Two presentations pertaining to furnaces, boilers and household heaters were given during the introductory session (Session II-A). Mr. Esher R. Kweller, NBS, summarized recent and current pertinent research activities being conducted at NBS in support of the DOE Appliance Energy Standards Program. Mr. Jack H. Hollingsworth presented current information concerning testing and rating procedures for furnaces and boilers which would serve as a background for the group discussions* during Sessions III and IV. Mr. Hollingsworth's background remarks are contained in the following section.

3.2 Background Remarks

I would like to set the stage for our session this afternoon by first reviewing the background leading up to where we currently stand on testing and rating procedures for furnaces and boilers and how that relates to the overview of technical and research issues we will be discussing.

As you are well aware, DOE initiated through NBS the development of furnace and boiler test procedures that led to the present DOE rulings. Paralleling this, with DOE/NBS support, ANSI/ASHRAE Standard 103 was developed and issued in 1982, which provided a commercial standard that could be, and now is, referenced in the federal rulings.

Early on in the development of Standard 103, the Standard Project Committee (SPC) recognized the need for further research that would take us beyond the product envelope into the building systems envelope. This prompted ASHRAE Technical Committee (TC) 6.3 to propose a research project on "Dynamic Seasonal Performance of Forced Warm Air Heating Systems Installed in Residences." This led to ASHRAE Special Project 43, sponsored jointly by ASHRAE, DOE and the Gas Research Institute (GRI) and to an award of a contract with Battelle Laboratories three years ago. The objectives of the project have been to provide information on dynamic and seasonal performance that would not only form the basis for refinements to existing test procedures, but also provide inputs to the ASHRAE Handbook on system performance. While the scope includes the interaction of key system components as they affect seasonal system efficiency, this initial project is limited to single zone warm air heating systems incorporating conventional upflow furnaces, condensing and non-condensing power combustion furnaces.

Test measurements of energy associated with flue losses, duct losses, infiltration and building envelope loses have been evaluated in both a single and two-story home. Effects of furnace sizing, stack dampers, intermittent ignition devices, and thermostat set-back have been evaluated

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* Participants in this discussion group are listed in Appendix D.

in terms of energy requirements. The main thrust has been the development and field validation of a computer simulation model. It appears the model is now adequately validated so that a matrix of handbook cases can be provided to compare energy use for different system configurations and modes of operation in a prescribed house. The handbook information, and the computer model should be available to all of us next year.

ASHRAE TC 6.3 again, with DOE and GRI support, is currently proposing an extension of the comfort heating research program to expand the capability of the SP 43 computer program. This would include zone control and extended work on duct losses.

As we address technical and research issues this afternoon, we should keep in mind there are seasonal efficiency issues dominated by the product envelope, and conversely, those that are dominated by the building system envelope. There is the third area where product design strategy for efficiency improvement is dependent on a proper marriage with the building system design strategy and mode of operation to be effective. Up to this point in time, DOE testing and rating procedures have gone a long way toward quantifying seasonal efficiency related to the first area - the product envelope. It is a more difficult task to quantify the affects of building system variables and their inter-relation with the product envelope. The outputs from the SP43 project will be a good step forward in this direction.

You received a preliminary list of technical and research issues with the notice of this forum. The concerns that have been most often expressed to me generally fall into the category of one of the first three issues on the preliminary list. These are:

1. Should Annual Fuel Utilization Efficiency (AFUE) be modified to account for both the fossil fuel and electrical consumption of furnaces and boilers?

   There are specific proposals addressing this from the Gas Appliance Manufacturers Association (GAMA) and others to which DOE has responded negatively, but with the understanding that the issue is open for further consideration. I can add this has been an issue of some considerable discussion in SPC 103 meetings and needs resolution.

2. Should the annual cost of operation be extended to include system effects (e.g., multizone operation of the central system); or adjustment factors as being developed under the SP 43 project?

   This, together with the first issue is a meaty subject. The manufacturer of a product that has the potential to measurably reduce seasonal energy consumption when the product is installed with a system design that takes advantage of that potential looks for up-front credit that can be easily recognized by the consumer. Because it is site and system specific, it is not easy to give credit without qualifications.

   A similar problem exists, to somewhat lesser degree, with the issue of energy descriptors accounting for both fossil fuel and electric energy consumption. Energy cost ratios change with time, and are site

specific. The questions become:

Are we technically in the position to define, with reasonable accuracy, adjustment factors that will account for different system configurations, sites and modes of operation? If not, what additional information is needed? And then, how do we present this to the consumer?

Are we in the position now to give the consumer something other than an AFUE number - a revised rating that accounts for electrical energy consumption in at least a generalized way that is meaningful to the consumer - and, force the product designer to give the same attention to electrical energy consumption as he now gives to fossil fuel consumption?

3. What DOE/NBS studies, if any, should be conducted to assist the current ASHRAE activities to develop a test procedure that determines the efficiency of combination heating and hot water appliances?

There will be a meeting of SPC 124 Friday on this issue. I expect our discussions today should be limited because of that.

In addition to these three primary issues, we will review, as necessary, current DOE test procedures and related ASHRAE Standard 103 proposed amendments.

I should state here, the currently active SPC 103 revisions committee has, this past week, presented to the ASHRAE Standards committee a revised standard which we can anticipate will be issued for open review in the near future. The proposed new standard includes all DOE amendments adopted in the March 28, 1984 issue of the Federal Register. Also included on the agenda are the subjects of vent damper test procedures, current DOE waivers, and the subject of converting the current DOE Fortran computer program to Basic language.

3.3 Technical and Research Issues

A summary of the technical and research issues raised in Sessions III and IV and the discussions that resulted are presented in the following sections.

3.3.1 Energy Efficiency Descriptor

The need for a means of including electric energy consumption as well as fossil fuel in the measure of utilization efficiency was a majority expression. However, there was no consensus on a method of accomplishing this. Round table discussions on this issue included the following considerations:

- GAMA proposed "SEUF" (Seasonal Energy Utilization Factor) descriptor in lieu of present AFUE descriptor;
- Adverse impacts of changing from the well-established AFUE number to a new rating descriptor;

- Retention of AFUE with a modifier to recognize electric energy consumption; and

- Redesign of Federal Trade Commission (FTC) fact sheets to emphasize total annual energy cost

3.3.2 System Effects

Efficiency rating adjustment factors accounting for effects of system design variables (e.g., multizone operation) raised the following discussion items:

- Limitations of providing performance information dependent on installation parameters and consumer use;

- Limitation of DOE testing and rating beyond the appliance envelope;

- Definition of appliance accessories that are part of the appliance envelope; and

- DOE supported ASHRAE role in research and development of a computer simulation model to assess the dynamic interactions and performance of entire heating systems and control strategies.

The group acknowledged that total system design and control strategies can heavily influence energy utilization. However, it was also acknowledged that appliance testing and rating procedures could not be extended beyond the inclusion of specified accessories supplied with the appliance by the manufacturer.

3.3.3 Combination Heating/Water Heating Appliances

In view of the ASHRAE SPC 124 meeting on this specific subject to follow this forum, discussion was limited and recommendations deferred. Discussion indicated the FTC fact sheets should clarify that AFUE and operating cost applies to the space heating function only.

3.3.4 Proposed Test Procedures for Stack Dampers

The proposed DOE tracer gas test method was reviewed and recognized by all participants as an acceptable and needed improvement.

3.3.5 Fan Time Delay

Revisions to the test procedures to accommodate furnace designs where the originally specified fixed time delay is not appropriate was acceptable to all without comment.

3.3.6 Status of ANSI/ASHRAE Standard 103

ASHRAE SPC 103 members present reported the status of proposed amendments, including the following:

- Incorporates all DOE amendments adopted in the March 28, 1984 Federal Register;

- o Incorporates DOE proposed test procedure revisions for the fan time delay;

- o Incorporates editorial changes based on recommendations made by Robert Wise, NBS, and

- o Does not yet include DOE proposed tracer gas test method for stack dampers.

3.3.7 Direct Heating Equipment

The status of testing and rating procedures was reviewed with specific attention given to:

- o The completeness of current procedures for assigned factors (i.e., tables for Dp);

- o Extension of procedures for condensing furnaces to include direct heating appliances.

There was consensus agreement that both of the above items should be on the DOE/NBS agenda for extension and revision of procedures.

3.3.8 Current Waivers

Following discussion, it was agreed there are no outstanding waivers of concern, and that waivers are not an issue.

3.3.9 Computer Programs

Use of the current computer programs related to DOE test procedures, and the issue of conversion of the programs from FORTRAN to BASIC language were discussed. The opinion was expressed by some attendees, without adverse comment, that the cost of annual fuel consumption portion of the program was of little value. There was no expression of need to convert from FORTRAN to BASIC language.

3.4 Conclusions and Recommendations

As a result of the round table discussions, the group established the following conclusions and recommendations relating to the furnaces, boilers and household heaters.

3.4.1 Energy Efficiency Descriptor

It was acknowledged by all that the current AFUE number has short comings in that it does not recognize electric energy consumption. However, it was recommended that the AFUE number be retained, and that other means of describing electric energy consumption be explored.

It was further recommended that a proposal be made to FTC to redesign the fact sheet's format to emphasize total electric and fossil fuel annual energy consumption cost.

3.4.2 System Effects

It was concluded that the DOE testing and rating procedures could not be extended beyond the appliance envelope, but there is the need to better define appliance accessories that can be accepted as part of the envelope.

It was further concluded that test procedures are not applicable to system designs such as zone control where the system performance is user dependent.

A recommendation was made to record an expression of need for DOE to continue their support of ASHRAE research projects related to seasonal performance of central forced-warm-air heating systems.

3.4.3 Combination Heating/Water Heating Appliances

It was recommended that FTC fact sheets state that AFUE and operating cost for combination boiler/water heater appliances applies to the space heating function only.

3.4.4 Test Procedures for Stack Dampers

A recommendation was made that the proposed amendments to ANSI/ASHRAE Standard 103 be withheld from presentation to the ASHRAE Standards Committee until the DOE tracer gas test method for stack dampers is incorporated in the amendments.

3.4.5 Direct Heating Equipment

In regard to direct heating equipment, it was recommended that: (1) the testing and rating procedures be examined for completeness of assigned factors and (2) the testing and rating procedures for condensing furnaces be extended to include direct heating appliances.

3.4.6 Current Waivers

The group concluded that there are no current waivers of issue.

3.4.7 Computer Programs

It was concluded there is no consensus of need for conversion of programs from FORTRAN to BASIC language.

3.4.8 DOE/NBS Workshops

A recommendation was made that an expression of need be recorded for scheduling periodic test methods and procedures workshops (in concert with industry associations, such as GAMA, ARI, etc.) to educate and update technical personnel in all areas of involvement.

3.5 Priorities

With reference to the above conclusions and recommendations, the following priorities are suggested for developing and revising testing and rating procedures and related items:

Priority 1. Test Procedures

- o Expand procedures to include combination space heating/water heating equipment. (DOE/NBS directed)

- o ASHRAE adoption of DOE proposed stack damper test method. (ASHRAE SPC 103 directed)

- o Assigned factors for space heaters (DOE/NBS directed)

- o Revise condensing type space heaters. (DOE/NBS directed)

Priority 2. Energy Descriptor (FTC Labelling)

- o Revise format of FTC fact sheets to emphasize total energy consumption. (GAMA directed)

- o Clarify FTC fact sheets regarding AFUE rating for combination appliances. (DOE/NBS directed)

4 - WATER HEATERS

Robert E. Cook
Consultant

4.1 Introduction

During the opening session on water heaters (Session II-B), presentations were made by Mr. James E. Harris, NBS, and Mr. Robert E. Cook, Consultant. Mr. Harris reviewed recent water heater tests conducted at NBS. Mr. Cook presented a review of critical issues related to water heater testing and rating procedures (Section 4.2) -- many of these issues have been raised as a result of the proposed DOE rules contained in the February 8, 1984 Federal Register. Following these presentations, there were wide ranging "give and take" discussions by all participants*. These discussions helped to refine the main issues (Section 4.3) and establish the conclusions and recommendations presented in Section 4.4.

4.2 Critical Issues

A summary of the critical issues pertaining to water heater testing and rating procedures as presented by Mr. Cook is contained in the following sections.

4.2.1 Testing Water Heaters by the Same Procedure

a. The suggested "actual" operating temperature range (58 F - 135 F) should resolve the test difference provided to accommodate thermal compensating dip tubes. It should be a satisfactory temperature range for heat pump water heaters and should assure that other designs, when tested by a uniform test will reflect actual performance under use conditions.

b. The proposed simulated use test could apply to any tank type water heater - or water heater that employs a storage tank. (Tank type heater recovery mode allows the burner to reach a steady state performance.) This test requires modification to give meaningful results for instantaneous type water heaters (boiler or geyser type) as the burner efficiency during short draws must be addressed in this type of fuel fired water heater.

c. One test should provide comparability between types of heaters. Inlet, outlet and ambient air temperatures should represent typical operating conditions:

	Present Test	Proposed Test
Inlet water	55 F (70 F for test)	58 F
Outlet water	135 F (160 F for test)	135 F
Ambient air	55 F (75 F for test)	65 F

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* Participants in this discussion are listed in Appendix D.

Observe that under present test procedures, the stored water temperature is 160 F and room ambient is 75 F; a temperature difference of 85 F. Under the proposed test, the temperatures will be 135 F and 65 F; an air to water temperature difference of 70 F.

Product development objectives would focus on expected operating conditions, rather than test conditions. For ease of testing, where needed, alternate temperatures could be permitted and be corrected to standard by approved methods.

4.2.2 Heat Trap Allowance*

A fixed heat trap allowance misrepresents actual standby heat loss of the unit. Unrestricted, uninsulated 1/2" pipe on an electric water heater in a standby mode will have the following heat loss:

Horizontal pipe	4.4 watts (15 Btu/H)
Vertical (infinite)	7.0 watts (24 Btu/H)
Typical basement	7.0 watts (24 Btu/H)

Testing water heaters with the heat trap (if any) supplied by the heater manufacturer would reflect actual performance of the heat trap/heater combination.

Properly designed and installed heat traps can provide rapid excellent payback for the consumer. It is recalled that in the 1950's a NEMA electric water heater was designed with a built-in heat trap - usually within the jacket.

4.2.3 Average Daily Hot Water Use

The average gallons per day use is presently set at 64.3 gallons. Various utility and other studies tend to confirm a figure in that range. Changing only a couple of gallons per day could present confusion with little offsetting benefit.

Hot water use does vary by family size, however. Is some "family use" selection scale needed to prevent selection of a "most efficient" but perhaps too small a heater?

4.2.4 DOE/NBS Role

In addition to the statutory requirement, how can DOE and NBS interface with the private sector in standards development?

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*References:

1. Schultz, William W., "Efficiencies of Electric Service Water Heating Systems: Measurements and Modelling," Purdue University Thesis, Department of Mechanical Engineering. December 1977.

2. Harris, James E., "Test Results and A Recommended Test Procedure for Heat Traps," NBSIR 84-2851. March 1984.

3. ETL Testing Laboratories. Consumption comparisons for GAMA.

Present policy encourages cooperation with the private sector in the development and use of standards.

Some areas of cooperation might be:

- Continue to participate in the voluntary standards project committees.
- Use NBS facilities or contractors to confirm or disprove test concepts and procedures proposed for voluntary standards.
- Provide feedback to industry on NBS time table relative to projects so that issues and tests that need to be accomplished can be addressed by others without duplication of effort.
- Develop public domain PC software that will assist in test routines.

4.3 Technical and Research Issues

The various issues which were addressed (and discovered) during the water heater group discussions are reviewed in following sections.

4.3.1 Standardized Terms

A minor point - yet important to the discussion was the realization by many that various sections and/or groups use different terms to describe certain things; or use the same term to describe totally different functions. It was agreed that standardized terms need to be adopted and defined. It was suggested that the ASHRAE Terminology Committee could address this issue, then have government and industry adopt those standardized terms.

4.3.2 Average Hot Water Use

Some questions were raised on this issue. There was agreement (with one exception) that the current figure (64.3 gallons per day) was a valid average for a household. There is substantial research evidence that supports the present figure. Any minor adjustment (i.e., 60 gallons per day) would have little merit.

The principle discussion centered on the problems of:

- Various family sizes and therefore different needs.
- Should the fixed gallonage be replaced with a more flexible number related to family size?
- Water heater size, especially the need to provide selection criteria for offpeak water heating applications.
- Is the label information misleading - should the dollar emphasis on the label be replaced with an (Energy Factor) (EF) or some similar number?

4.3.3 Test Temperatures

If all types of water heaters are to be tested with a test that is as uniform as possible so that results from one type of heater to another can be fairly compared, the tests should be run at temperatures that reflect actual operating temperatures rather than the elevated temperatures that were selected for ease of testing.

4.3.4 Present Recovery Test Versus Simulated Use Test

The present recovery test is suitable for most tank type water heaters. It may not be valid for large mass water heaters, and is not valid for heat pump water heaters and instantaneous water heaters. It appears that a simulated use test, properly designed, could be applied to all types of water heaters.

4.3.5 Draw Rate

Should the draw rate remain at the presently prescribed 5 gallons per minute (GPM) or should it be some other rate?

Draw rates can effect first hour ratings.

Draw rates are more critical for instantaneous water heaters than for storage type water heaters.

Perhaps 3 GPM would be a suitable figure.

4.3.6 Piping, Insulation, Heat Trap Allowance

If test procedures are to be developed that treat all designs equally and fairly, and in addition are technically accurate, the piping arrangement must be adaptable to all types of water heaters without favoring any.

Presently prescribed insulation of piping must be reconsidered and the merits of fixed allowances for heat traps needs review.

4.3.7 Burden of Test Procedures

The test procedures should be as free of cost burden as possible.

Some public domain PC software to assist in testing might further this objective.

Any new test procedures need to be phased in over time to prevent disruption and excess cost to both manufacturers and consumers.

4.4 Conclusions and Recommendations

The conclusions and recommendations presented below were adopted with agreement of all participants in the water heater group discussions.

4.4.1 Priorities

Priority conclusions and recommendations established were as follows:

a. The February 8, 1984 Federal Register proposed rule on water heaters should NOT be implemented!

b. Develop a common test that will fairly and accurately test and compare - in so far as possible - all types of water heaters.

c. Cost data on the FTC label should be replaced with a measure that is less misleading and better guides the selection process.

d. There is a need for agreed upon standard terms.

e. DOE/NBS needs to provide support in a number of areas.

Specific comments on these priorities are reviewed in the following sections.

4.4.2 February 8, 1984 Proposed Rule

Implementing the February 8, 1984 proposal would only delay and confuse the effort to proceed with the major changes recommended by the forum.

4.4.3 Common Test

A common test should include a number of elements (as discussed below).

a. Consider a simulated use test in place of the present recovery test. It should include a draw schedule with standby. The draw schedule needs configurations that establish:

   - o frequency
   - o time
   - o rate(s) (GPM)

   Perhaps the simulated daily use test should be related to the capacity of the water heater. Perhaps multiple ratings could be accomplished or recognized by calculation. Some consideration must be given to the comparison, test and rating of off-peak water heaters.

b. Test temperatures can be those temperatures in NBSIR 85-3220 with the proviso that alternate test temperatures can be used and corrected to standard with a specified correction method and test confirmation. However, the allowable room temperature range specified in NBSIR 85-3220 is too great and should be tightened.

c. Test Setup

   Piping. The piping should be adaptable to various styles/types of water heaters.

Consider a modification to the ASHRAE 118P approach to piping setup for testing. Nipple height, etc. needs specification (perhaps 6" or 12").

There should be no insulation on piping or relief valve (unless supplied as part of the water heater by the manufacturer).

The heater should be tested only with accessories (i.e., heat traps, insulation) furnished as standard by the manufacturer.

No fixed, arbitrary credit (Jc & Jh) should be given. Use actual test results.

Venting. The existing setup needs modification. Category 1 and 2* (non-positive vent pressure) water heaters can be tested under the present language.

Category 3 and Category 4* (positive vent pressure) and direct vent heaters should be tested with the manufacturer's recommended hookup. Where manufacturers have several recommended alternative hookups, select that system that provides the greatest standby loss for the test.

* The categories referenced are those categories in ANSI/Z21.13 (August, 1985 Review and Comment Text) Part IV.

Temperature Measurement. If all types of water heaters are to be tested some alternative to the presently prescribed six thermocouple drop stick must be provided to measure water temperatures.

4.4.4 FTC Label

a. It is suggested that the present emphasis on operating cost ($) that highlights the present FTC label be replaced with some other measure.

- o $ is sometimes confused as cost of the unit.
- o $ is not representative of the consumption of different size families.
- o $ is not the same for various area fuel costs.
- o $ changes each time new fuel rates are issued; therefore, old water heaters in stock are different from later models.

Consider: Use of low - standard - high EF depending on water heater size or family requirements. The present comparison bar should continue to reflect the Energy Factor.

b. First hour rating needs review. There is a need for a hot water capability measure. Review the present 1st hour rating test and address how it can reflect low or no water volume water heater performance.

Review those types of water heaters where storage acts as a reserve and the energy source is not available on demand, such as:

- o Solar
- o Off-peak electric
- o Desuperheater water heaters
- o Perhaps some boiler systems

Perhaps some combination test must be developed to address the various types of water heaters (and water heating systems) if we are striving for a goal to develop a test method and FTC label that will address "all types" of water heaters.

4.4.5 Standard Definitions

The requirement for a definition of standard terms should not be dismissed. Part of the early concerns during the forum disappeared when participants learned what was really intended.

4.4.6 NBS/DOE Role

a. The waiver process needs to be streamlined and speeded up so that new innovative designs can enter the market without delay or penalty. Perhaps a voluntary technical group can assist in the review - have confirming tests performed or witnessed (by NBS or other appropriate agency) and issue recommendations to DOE. Place a requirement on the petitioner to supply adequate data so that it can be checked and verified.

b. Speed-up the rule making procedure.

c. NBS needs to continue their work to develop a suitable simulated use test that can be used for all types of water heaters.

d. NBS needs to run tests to assess the impact of suggested new/revised test procedures or ratings, the time required and the test reproducibility.

e. NBS should determine the actual heat loss from insulated versus bare T&P valves during the test.

f. DOE and NBS technical personnel should continue to participate in the voluntary standards project committees.

g. The NBS facilities should be used to confirm/disprove test concepts and procedures proposed for voluntary standards.

h. NBS should provide feedback on what tests they can and cannot do (due to time and budget constraints) in order to eliminate unnecessary duplication of effort.

i. Develop public domain software that will assist in test procedures. It should be written in BASIC language.

j. There is a need for an educational video to explain the new test procedures when adopted.

5 - REFRIGERATORS, REFRIGERATOR-FREEZERS AND FREEZERS

J. Benjamin Horvay
Consulting Engineer

5.1 Introduction

The introductory session (Session II-C) for the group discussions on refrigerators, refrigerator-freezers and freezers was opened with remarks by Robert A. Wise, NBS. Mr. Wise reviewed a history of pertinent test procedures, and past and future NBS research activities. Following his remarks, Mr. J. Benjamin Horvay presented the following questions with regard to the present DOE test procedures, based on the preliminary list of technical and research issues (Appendix B) and various inputs from industry:

- Is there a satisfactory correlation with actual field condition results?
- Are the various types of refrigerated appliances and subsystems adequately covered?
- Is the thermocouple calibration, presently specified, too restrictive?
- Test results according to foreign (Japanese) testing standards deviate significantly from those obtained by U.S. standards, to the disadvantage of the American products. Should this be of concern?

Mr. Horvay urged the participants not only to identify and verbalize these and other issues relating to the present test procedures, but also to attempt to assess the magnitude of the potential changes. This would be helpful in deciding whether the existing standards should be amended or if major revisions are needed.

If major revisions are needed to the existing test procedure, the question is, who should develop these new procedures, and how should this work be financed? Mr. Horvay suggested the following potential participants: ASHRAE, AHAM, DOE/NBS. Finally, he discussed the possible objectives and limitations of any new testing procedures.

The following added concerns were expressed by the participants with regard to the current test procedure*:

- Do the results properly reflect the response of the appliance to various usage conditions in the field (such as freezing rate)?
- Does the present test procedure adequately cover the various types of defrost systems?
- Is the humidity condition of the ambient air correctly reflected in the response of the various defrost systems?

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* Participants in this discussion group are listed in Appendix D.

- Could an "average" environmental condition be devised to assist in the establishment of the frequency of defrost initiation?

5.2 Technical and Research Issues

Based on discussions in the opening session, it was quite clear that most participants considered the validity (correlation of performance characteristics as determined under laboratory conditions with actual field performance) of the present test procedure as the primary issue on hand. This issue has already confronted ASHRAE Technical Committee 7.1 (Domestic Refrigerators, Freezers and Water Coolers) resulting in an ASHRAE sponsored research project at the University of Missouri-Kansas City, titled "Determination of the Validity of Refrigerator/Freezer Energy Testing". With concurrence from ASHRAE, Professor William Stewart, a participant in the Forum, and the principal investigator of the aforementioned research project, reviewed the status of the work at the University of Missouri. The present phase is basically the design of an experiment that may be conducted, in the laboratory and in the field, at some later date. The data available from published information is insufficient to confirm or to challenge the validity of the present test procedure.

The participants agreed that the ASHRAE research project is most pertinent to the question on hand, and that DOE involvement would be desirable. Furthermore, it was the consensus that one should not consider changes to the present test procedures until the determination of validity has been completed.

The next issue discussed was that of determining the effect of defrosting schemes on the energy consumption of refrigerators. Two alternate approaches were proposed:

1. Laboratory simulation to determine the effect of defrosting on the energy consumption during field usage.

2. A standardized field test procedure that could quickly determine the impact on energy consumption of various design modifications, not only defrost schemes but also other new innovations that might emerge.

Both of these approaches represent monumental tasks, yet it was the consensus of the participants, that unless a solution is found, test procedure users, developers and enforcers will be faced with unending frustrations when trying to introduce or evaluate innovative new designs.

The last issue discussed in considerable detail involved the discrepancy between U.S. and foreign test procedures and results. Of particular concern to industry representatives, was the indiscriminate use of energy consumption data that has been generated by various national test procedures when comparing one refrigerator to another. Implied in these comparisons is the technical superiority of the foreign product, while more often than not, it is the result of the difference in test procedure. It was the consensus of the participants that it would behoove DOE/NBS to get involved in this issue, so that an authoritative assessment of the differences between the more significant testing standards can be made available to the public. Of course, if there are genuine technological innovations incorporated into some of the foreign products, it would be of

great benefit to industry and to the consumer if such innovations would be recognized and made public by this process.

5.3 Conclusions and Recommendations

The following three major issues were identified relating to the test procedures of refrigerated appliances:

1. The validity (i.e., correlation of performance characteristics as determined under laboratory conditions with actual field performance) of the present test procedure has been questioned.

2. The present testing procedure does not cover adequately new defrosting schemes recently introduced.

3. Energy consumption, when determined according to foreign testing standards, often deviates significantly from that obtained by the U.S. procedure, more often than not, to the disadvantage of the American product.

Recommendations concerning three issues are outlined below.

Primary Issue: Validity of the Present Test Procedure

- DOE/NBS review the Research Project: "Determination of the Validity of Refrigerator/Freezer Energy Testing" sponsored by ASHRAE at the University of Missouri.

- DOE organize the overall effort to determine test procedure validity in cooperation with Association of Home Appliance Manufacturers (AHAM), ASHRAE, electric utilities, and all other interested parties willing to contribute financially, or otherwise.

- Consideration for changes to test procedures, with regards to correlation, be delayed until the determination of validity is completed.

- If changes to test procedures are warranted, recommendations for these changes be spearheaded by AHAM at the appropriate time.

Secondary Issue: Effect of Defrosting Schemes on the Energy Consumption of Refrigerators

- DOE/NBS establish a laboratory simulation of the effect of adaptive defrosting on the energy consumption of refrigerators in field usage and/or

- DOE/NBS develop a standardized field test procedure that can readily determine the impact on energy consumption of various design modifications.

NOTE: It is fully recognized that these tasks are of major magnitude and will probably involve extensive research, considerable creativity, and significant funding. Yet, it was the collective opinion of the participants, no matter how difficult it will be to find a solution, this problem will not go away.

Secondary Issue: Discrepancy Between U.S. and Foreign Test Procedures and Results

- DOE/NBS coordinate efforts with other interested agencies and organizations to expeditiously quantify the differences in energy consumption of refrigerators when tested according to U.S. versus Japanese and other significant foreign test procedures, so that the discrepancies can be properly attributed to technological advances and/or differences in test procedures.

6 - SUMMARY

The major conclusions and recommendations developed within each of the discussion groups are briefly summarized in the following sections. For additional details and background information, interested readers should refer to Sections 2 through 5.

6.1 Heat Pumps and Air Conditioners

The rating of mixed-matched coil systems is the most immediate problem which needs to be addressed. A method for testing and rating condensing units and compressor units separately should be developed so that combined ratings comparable to those obtained by the existing rating procedure could be determined from published rating information of each unit.

In regard to new designs and/or innovations in heat pumps and air conditioner designs, the two most important areas that may not be covered by the present rating procedure are: (1) variable speed compressors and (2) smart controls.

The problems identified with the present testing and rating procedures for heat pumps and air conditioners are relatively minor.

6.2 Furnaces, Boilers and Household Heaters

The following items (listed in priority order) were recommended:

Testing and Rating Procedures

- Expand procedures to include combination space heating/water heating equipment.
- Incorporate the DOE proposed stack damper test method into ASHRAE Standard 103.
- Revise procedures for direct heating appliances in regard to assigned factors (tables for Dp) and condensing type units.

Energy Descriptors (FTC Labelling)

- Revise format of FTC fact sheets to emphasize total energy consumption.
- Clarify FTC fact sheets regarding AFUE rating for combination appliances.

6.3 Water Heaters

Priority conclusions and recommendations established by the participants in the water heater discussion group were as follows:

(1) The Federal Register proposed rule on heat pump water heaters (February 8, 1984) should not be implemented because its implementation would only delay and confuse the efforts to proceed with major changes recommended by the forum.

(2) A common test that will fairly and accurately test and compare - in so far as possible - all types of water heaters should be developed. Consideration should be given to a simulated use test in place of the present recovery test.

(3) Cost data on the FTC label should be replaced with a measure that is less misleading and better guides the selection process.

(4) There is a need to develop standardized terms. It was suggested that ASHRAE could address this issue.

(5) DOE/NBS needs to provide support in a number of areas including: speeding up the waiver process and rule making procedures; continuing development of a suitable test for all types of water heaters; continuing participation in voluntary standards project committees, etc.

6.4 Refrigerators, Refrigerator-Freezers and Freezers

The primary issue identified by the refrigerated appliance discussion group was the validity (i.e., correlation of performance characteristics as determined under laboratory conditions with actual field performance) of the present test procedure. It was recommended that DOE/NBS continue to follow the ASHRAE project being conducted at the University of Missouri and DOE should organize an overall effort to determine test procedure validity in cooperation with AHAM, ASHRAE, electric utilities and all other interested parties.

Two secondary issues were also identified. The first issue was the effect of defrosting schemes on the energy consumption of refrigerators. It was recommended that DOE/NBS establish a laboratory simulation of the effect of adaptive defrosting and develop a standardized field test procedure. The second issue was the discrepancy between U.S. and foreign test procedures and results. It was recommended that DOE/NBS coordinate efforts with other interested agencies and organizations to expeditiously quantify the energy consumption of refrigerators when tested according to U.S. versus Japanese and other significant foreign test procedures, so that the discrepancies can be properly attributed to technological advances and/or differences in test procedures.

6.5 Future DOE/NBS Workshops

A recommendation was made that DOE/NBS should consider scheduling (in concert with industry associations such as GAMA, ARI, etc.) periodic workshops on testing and rating procedures in order to educate and update technical personnel in all areas of involvement. The need for an educational video to explain new test procedures when adopted was also identified.

Appendix A

DOE/NBS FORUM
ON
TESTING AND RATING PROCEDURES
FOR CONSUMER PRODUCTS

October 2-3, 1985
National Bureau of Standards
Gaithersburg, Maryland

October 2, 1985 (Wednesday)

8:30 a.m. Registration & Coffee (Lecture Room A, Administration Bldg.)

SESSION I
(Lecture Room A)

Robert D. Dikkers, Forum Chairman
Group Leader, Combustion Equipment
Building Equipment Division
Center for Building Technology, NBS

9:00 a.m.	Welcome	Richard N. Wright, Director Center for Building Technology, NBS
9:10 a.m.	Forum Objectives	Michael J. McCabe, Chief Test and Evaluation Branch Building Equipment Division Office of Building Energy R&D Department of Energy
9:25 a.m.	Break	

SESSION II-A
(Lecture Room A)

9:30 a.m. Test Procedures for Heat Pumps and Air Conditioners

o Current and Planned Research	David A. Didion, Group Leader Thermal Machinery Building Equipment Division Center for Building Technology, NBS
o Technical and Research Issues	David R. Tree Professor, Mechanical Engineering Ray W. Herrick Laboratories Purdue University West Lafayette, IN
o Discussion	

10:40 a.m. Break

11:00 a.m. Test Procedures for Furnaces, Boilers and Household Heaters

o Current and Planned Research	Esher R. Kweller Combustion Equipment Group Building Equipment Division Center for Building Technology, NBS
o Technical and Research Issues	Jack H. Hollingsworth Consulting Engineer South Laguna, CA
o Discussion	

SESSION II-B
(Room B157, Bldg. 225)

9:45 a.m. Test Procedures for Water Heaters

o Current and Planned Research	James E. Harris Combustion Equipment Group Building Equipment Division Center for Building Technology, NBS
o Technical and Research Issues	Robert E. Cook Consultant Kankakee, IL
o Discussion	

SESSION II-C
(Room B221, Bldg. 226)

9:45 a.m. Test Procedures for Refrigerators, Refrigerator-freezers and Freezers

o Current and Planned Research	Robert A. Wise Combustion Equipment Group Building Equipment Division Center for Building Technology, NBS
o Technical and Research Issues	J. Benjamin Horvay, P.E. Consulting Engineer Louisville, KY
o Discussion	

12:15 p.m. LUNCH (on your own) NBS Cafeteria

SESSION III
(Concurrent Sessions for discussion of technical and research issues)

1:30 p.m.	o Furnaces, Boilers and Household Heaters	Room A340, Bldg. 220
	o Heat Pumps and Air Conditioners	Lecture Room A, Admin. Bldg.
	o Water Heaters	Room B157, Bldg. 225
	o Refrigerators, Refrigerator-freezers and Freezers	Room B221, Bldg. 226
3:00 p.m.	Break	
3:20 p.m.	Concurrent Discussion Sessions (continued)	
5:00 p.m.	Adjournment	
5:15 p.m.	Bus to Quality Inn (Administration Bldg.)	

October 3, 1985 (Thursday)

SESSION IV
(Concurrent discussion sessions to prioritize technical and research issues)

8:30 a.m.	o Furnaces, Boilers and Household Heaters	Room A340, Bldg.220
	o Heat Pumps and Air Conditioners	Lecture Room A, Admin. Bldg.
	o Water Heaters	Dining Room C, Admin. Bldg.
	o Refrigerator, Refrigerator-freezers, and Freezers	Dining Room A, Admin. Bldg.
10:00 a.m.	Coffee Break	NBS Cafeteria

SESSION V
(Lecture Room A, Admin. Bldg.)

Robert D. Dikkers, Forum Chairman

10:30 a.m.	Reports on Technical and Research Issues for Various Products	
	o Furnaces, Boilers and Household Heaters	Jack H. Hollingsworth

	o Heat Pumps and Air Conditioners	David R. Tree
	o Water Heaters	Robert E. Cook
	o Refrigerators/Freezers	J. Benjamin Horvay
12 noon	Concluding Remarks	Michael J. McCabe, DOE
12:15 p.m.	Adjournment	
1:30 p.m. to 3:30 p.m.	Optional Tours of NBS Thermal Machinery Laboratories (Building 226) and Combustion Equipment Laboratories (Building 202)	(Individuals interested in tour, should sign up at registration desk by 10:30 a.m., October 3)

Appendix B

Preliminary List of Technical and Research Issues to be discussed at the DOE/NBS Forum on Testing and Rating Procedures for Consumer Products

October 2-3, 1985

I. Furnaces and Boilers

1. Should AFUE be modified to account for both the fossil fuel and electrical consumption of furnaces and boilers?

2. Should the annual cost of operation be extended to include system effects (e.g., multizone operation of the central system; integrated appliances; adjustment factors as being developed by Battelle Laboratory)?

3. What DOE/NBS studies, if any, should be conducted to assist the current ASHRAE activities to develop a test procedure that determines the efficiency of combination heating and hot water appliances?

4. Review of current DOE test procedures including:

   a. tracer gas test method for stack dampers;
   b. revision of fan delay time;
   c. status of ASHRAE Standard 103 amendments.

5. Should the current FORTRAN computer programs relating to the DOE test procedures be rewritten in the BASIC language?

II. Household Heaters (other than furnaces and boilers)

1. Is the simplified AFUE rating method adequate for newer high efficiency products?

2. Should current DOE test procedures be revised to include provisions for condensing heaters?

3. Review of current work to develop test procedures for catalytic heaters (i.e., provisions for unreacted fuel).

III. Heat Pumps and Air Conditioners

1. Evaporator coil testing and/or rating for mix-match air conditioners.

   a. Are the current catalogues (e.g., Bohn, McQuay, etc.) consistent with each other and representative of other manufacturer's coils?

b. Is testing of individual coil design essential or is theoretical prediction possible?

c. Can existing test procedures be simplified for comparative results only (i.e., Qmix/Qmatch)?

d. How do the enhanced surfaces effect this overall rating problem?

2. What is the impact of expansion devices on mix-match coil ratings?

a. Interchangeable devices (i.e., match coil has TXV and mixed has cap tube).

b. Device in series (e.g., orifice ahead of high pressure distributor and multiple parallel cap tubes downstream).

3. Is heat pump mix-match test and rating procedure necessary? If so, what are its unique problems?

4. Should mix-match have limits on the capacity ratio range for reliability purposes?

5. Should there be a rating procedure for the following:

a. Zoning of multi-evaporator system?

b. Heat pump/hot water integrated system?

c. Variable speed?

6. Should there be a humidity criteria for air conditioner testing in general (i.e., new fast responding humidity sensors have been developed)?

7. Should a wet coil cycle test be considered to simplify the air conditioning test procedure (i.e., the Japanese are supposedly developing one)?

8. Central Air Conditioners - Annual Hours of Use. The current value used is 1000 full load compressor hours. A recent NBS study recommends 1150 hours. What should be done to confirm this value or determine a more representative value?

IV. Water Heaters

1. What provisions should be included to allow for efficiency and energy consumption comparisons of all types of water heaters at different usage rates (i.e., models designed for installations requiring more than 64.3 gallons of hot water per day are presently penalized by the energy factor calculation)?

2. Should piping and temperature/pressure relief valve be insulated during testing?

3. Are revisions needed for the recovery efficiency testing of high mass water heaters?

4. Should the current 90° temperature rise specified for water heating testing be revised? Should the actual temperature rise be used in the energy factor calculation?

5. What should be done to determine a more representative daily hot water usage value?

6. Should procedures be developed to permit all water heaters to be tested in the same manner insofar as practical or possible?

7. Review of current work to develop test methods for residential instantaneous water heaters.

8. Should DOE/NBS develop computer software for water heater efficiency testing?

V. Refrigerators, Refrigerator-freezers, and Freezers

1. Test procedure validity.

   a. Is the present correlation factor of 1.0 for all units except freezers an acceptable number?

   b. Should there be other classes with other correlation factors?

   c. Should there be other classes that have modified test methods?

   d. Should the test method be changed to provide better correlation with actual field conditions results?

   e. Should field testing be initiated to provide the data needed to resolve these questions and again to confirm the adequacy any proposed new test procedure?

   f. Is the thermocouple calibration presently specified too restrictive?

   g. Participation of ASHRAE, AHAM, DOE, and NBS in the resolution of the above questions?

2. Foreign test procedures.

   a. Should test results resulting from the use of foreign test procedures be compared to DOE results to evaluate the possibilities of improving uniformity of testing requirements?

3. Adaptive defrost controls.

   a. Will adaptive control designs inherently provide for external initiation of a defrost period?

b. Should a water vapor frost source test be evaluated for testing ADC and perhaps other types of defrost control designs?

c. How extensive does a field test need to be to evaluate an ADC correlation factor?

Appendix C

FINAL REGISTRATION LIST

DOE/NBS FORUM
ON
TESTING AND RATING PROCEDURES
FOR CONSUMER PRODUCTS

October 2-3, 1985

Mr. David R. Abrey
New York State Energy Office
2 Rockefeller Plaza
Albany, NY 12223
518/473-4879

Mr. Charles Adams
Lennox Industries, Inc.
1600 Metrocrest
Carrollton, TX 75006
214/245-2525

Mr. Stephan P. Amicone
New Yorker Steel Boiler Co.
Route 309
Colmar, PA 18915
215/822-0114

Dr. Swiki Anderson
Swiki Anderson & Associates, Inc.
Phillips Industries Inc.
1516 Shiloh
Bryan, TX 77803
409/779-6068

Mr. Edward Baily
Carrier Corporation
P.O. Box 4800
Syracuse, NY 13221
315/433-4737

Mr. John Batey
Brookhaven National Laboratory
6100 Empire State Building
New York, NY 10001
212/564-5800

Mr. Sam Beach
Chief Engineer
Greenville Products
Division of White Consolidated
635 W. Charles Street
Greenville, MI 48838
616/754-7131

Mr. Edward Becker
Amana Refrigeration, Inc.
Amana, IA 52204
319/622-2163

Mr. Joseph L. Behr
Alco Controls Division
P.O. Box 12700
St. Louis, MO 63141
314/569-4541

Mr. Walter H. Blanck, Jr.
AHAM
20 North Wacker Drive
Chicago, IL 60606
312/984-5841

Mr. John C. Bock
Bock Water Heaters
110 S. Dickinson Street
Madison, WI 53704
608/257-2225

Mr. R. H. Bohman
Amana Refrigeration, Inc.
Amana, IA 52204
319/622-2163

Mr. W. J. Bowen
Trane Company
6200 Troup Hy.
Tyler, TX 75711
214/581-3356

Mr. Ralph S. Bryant
Heil-Quaker Corporation
1136 Heil-Quaker Blvd.
P.O. Box 3005
Lavergne, TN 37086-1985
615/793-0450

Mr. Paul Buckley
Lennox Industries, Inc.
1600 Metrocrest
Carrollton, TX 75006
214/245-2525

Mr. D. J. Canclini
Rheem Manufacturing Company
P.O. Box 6444
Fort Smith, AR 72906-0444
501/646-4311

Mr. Roger Carlone
Virginia KMP Corporation
4100 Platinum Way
Dallas, TX 75237
214/330-7731

Mr. A. R. Carnevale
Bradford-White Corporation
200 Lafayette Street
Middleville, MI 49333
616/795-3364

Mr. Bruce Cleveland
Duotherm
508 Poplar
LaGrange, IN 46761
219/463-7602

Mr. Robert E. Cook
1435 Budd Blvd.
Kankakee, IL 60901
815/932-2257

Mr. J. L. Cox
Rheem Manufacturing Company
P.O. Box 6444
Fort Smith, AR 72906-0444
501/646-4311

Ms. Marie E. Dasher
Whirlpool Corporation
Highway 41 North
Evansville, IN 47727
812/426-4673

Mr. Dale Dassler
Comfortmaker, SynderGeneral Corporation
401 Randolph Street
Red Bud, IL 62278
618/282-6262

Mr. Paul F. Davis
The Williamson Company
3500 Madison Road
Cincinnati, OH 45209
513/731-1343

Mr. R. Denny
ARI
Suite 600
1501 Wilson Blvd.
Arlington, VA 22209
703/524-8800

Mr. Irvin L. Derks
Bard Manufacturing Company
P.O. Box 607
Bryan, OH 43506
419/636-4127

Dr. David A. Didion
Group Leader
National Bureau of Standards
B122, Building 226
Gaithersburg, MD 20899
301/921-2994

Mr. Robert D. Dikkers
Group Leader
National Bureau of Standards
Building 226, Room B320
Gaithersburg, MD 20899
301/921-3285

Mr. Peter Domanski
National Bureau of Standards
Room B124, Bldg. 266
Gaithersburg, MD 20899
301/921-3532

Mr. Gordon D. Duffy
A-C, Heating, & Ref. News
P.O. Box 2600
Troy, MI 48007
313/362-3700

Mr. Donald R. Dupras
Williams Furnace Company
225 Acacia Street
Colton, CA 92324
714/825-0993

Mr. Phil Fairchild
Electric Power Research Inst.
3412 Hillview Avenue
P.O. Box 10412
Palo Alto, CA 94303

Mr. George C. Fanelli
Ford Products Corporation
Ford Products Road
Valley Cottage, NY 10989
914/758-8282

Mr. Robert D. Fischer
Battelle
505 King Avenue
Columbus, OH 43201
614/424-5326

Mr. Randy Forristal
Borg Warner
5005 Interstate Drive
Norman, OK 73069

Mr. Richard Fort
AGA Laboratories
8501 East Pleasant Valley Road
Cleveland, OH 44131
216/524-4990

Mr. Howard Geller
Associate Director
ACEEE
#535
1001 Connecticut Avenue, NW
Washington, DC 20036
202/429-8873

Prof. Victor W. Goldschmidt
Purdue University
West Lafayette, IN 47907
317/494-2132

Mr. Dirk Granberg
A.O. Smith Co.
Suite 600
10767 Gateway West
El Paso, TX 79935
915/595-1011

Mr. Joseph Greenberg
National Bureau of Standards
Building 226, Room B320
Gaithersburg, MD 20899
301/921-3285

Mr. Richard Greenhaus
Consumers Union
256 Washington Street
Mt. Vernon, NY 10553
914/667-9400

Mr. Russ Griffith
Copeland Corporation
Campbell Road
Sidney, OH 45365
513/498-3579

Mr. Wilbur L. Haag, Jr.
Rheem Mfg. Company
7600 S. Kedzie Avenue
Chicago, IL 60652
312/471-7825

Mr. James G. Hammond
Tecumseh Products Company
Compressor Manufacturers
100 E. Patterson Street
Tecumseh, MI 49286
517/423-8692

Mr. Richard J. Hanna
Bard Manufacturing Company
P.O. Box 607
Bryan, OH 43506
419/636-4127

Mr. James E. Harris
National Bureau of Standards
Building 202, Room 149
Gaithersburg, MD 20899
301/921-3304

Mr. Richard B. Harrison
Whirlpool Corporation
Highway 41 North
Evansville, IN 47727
812/426-4630

Mr. Charles A. Hastings
American Standard Inc.
Suite 408
2020 14th Street, North
Arlington, VA 22201
703/525-4015

Mr. Thomas L. Hildreth
Magic Chef Air Conditioning
851 West Third Avenue
Columbus, OH 43212
614/294-3547

Dr. James E. Hill
Division Chief
National Bureau of Standards
Building 226, Room 306
Gaithersburg, MD 20899
301/921-3465

Mr. Adam W. Hinge
New York State Energy Office
2 Rockefeller Plaza
Albany, NY 12223
518/473-4879

Mr. Jack H. Hollingsworth
22902 Via Cordova
South Laguna, CA 92677
714/499-2498

Ms. Sally Hooks
Edison Electric Institute
1111 19th Street, N.W.
Washington, DC 20036-3691
202/828-7510

Mr. Byron Horak
ETL Testing Labs.
Industrial Park
Cortland, NY 13045
607/753-6711

Mr. J. Benjamin Horvay
Consulting Engineer
613 Indian Ridge Road
Louisville, KY 40207
502/897-0836

Mr. George W. Hurl
The Coleman Company
3110 North Mead
Wichita, Kansas 67219
316/832-6542

Mr. Donald L. Hussong
Consolidated Industries Corp.
800 Sagamore Parkway South
P.O. Box 7800
Lafayette, IN 47903
317/447-1194

Mr. Ron Hutchison
Locke Stove Company
127 West 10th Street
Kansas City, MO 64105
816/421-1650

Mr. Sadik Imral
Intertherm, Incorporated
3345 Morganford Road
St. Louis, MO 63116
314/894-1829

Mr. Frank E. Jakob
Battelle
505 King Avenue
Columbus, OH 43201
614/424-5326

Mr. Robert W. Johnson
Whirlpool Corporation
Highway 41 North
Evansville, IN 47727
812/426-4610

Mr. Nick Johnson
Williams Furnace Company
225 Acacia Street
Colton, CA 92324
714/825-0993

Mr. Gary K. Jones
AIRMAX, Incorporated
P.O. Box 159
Gilmer, TX 75644
214/843-5666

Mr. Theodore Kapus
Department of Energy
Room GF217
Washington, DC 20585
202/252-9389

Mr. Esher R. Kweller
National Bureau of Standards
Building 226, Room B320
Gaithersburg, MD 20899
301/921-2627

Mr. Joseph A. Lane
Amtrol Incorporated
1400 Division Road
West Warwick, RI 02893
401/884-6300

Mr. J. P. Langmead
Gas Appliance Manufacturers Association
1901 North Moore Street
Arlington, VA 22209
703/525-9565

Mr. Eric Lannes
Hoyt Heater Company
P.O. Box 60129
Reno, NV 89506
702/972-3680

Mr. Peter W. Likes
Hussmann Corporation
12999 St. Charles Rock Road
Bridgeton, MO 63044
314/291-2000

Mr. Danny C. Lim
Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
202/252-9130

Mr. Robert M. Little
Tampa Electric Company
P.O. Box 111
Tampa, FL 33601-0111
813/228-1619

Mr. Bruce R. Maike
Magic Chef Air Conditioning
851 West Third Avenue
Columbus, OH 43212
614/294-3547

Mr. John D. Marran
Energy Kinetics, Incorporated
P.O. Box 407
Bernardsville, NJ 07924

Mr. Karl W. Mayer
Burnham Corporation
Hydronics Division
P.O. Box 3079
Lancaster, PA 17604
717/393-3181

Mr. Donald L. Mays
Consumers Union
256 Washington Street
Mount Vernon, NY 10553
914/667-9400

Mr. Michael J. McCabe
Department of Energy
Room GF217
Washington, DC 20585
202/252-9127

Mr. Bruce McCowan
Canadian Gas Association
55 Scarsdale Road
Ontario Canada M3B 2R3
416/447-6465

Mr. Peter Miller
Natural Resources Defense Council
25 Kearny Street
San Francisco, CA 94108

Mr. Marvin Muchmore
Red T Coil
5004 South Street
Nacogdoches, TX 75961
409/560-3553

Mr. Bill Mulroy
National Bureau of Standards
Room B124, Bldg. 226
Gaithersburg, MD 20899
301/921-3532

Mr. Melvin J. Myers
Director of Engineering
Peerless Heater Company
Div. of Peerless Industries, Inc.
Spring & Schaeffer Streets
Boyertown PA 19512
215/367-2153

Mr. James R. Nanni
Hydrotherm
Rockland Avenue
Northvale, NJ 07647
201/768-5500

Mr. Robert Napp
Borg Warner
5005 Interstate Drive
Norman, OK 73069

Ms. Beverly Kim Naylor
GAMA
1901 North Moore Street
Arlington, VA 22209
703/525-9565

Mr. Lorne Nelson
Honeywell
1985 Douglas Drive
Golden Valley, MN 55422
612/542-6743

Mr. R. W. Newell
Rheem Manufacturing Company
P.O. Box 6444
Fort Smith, AR 72906-0444
501/646-4311

Mr. Edwin A. Nordstrom
AMTROL Incorporated
14000 Division Road
West Warwick, RI 02893
401/884-6300

Mr. Steve R. Petersen
National Bureau of Standards
B120, Poly.
Gaithersburg, MD 20899
301/921-3701

Mr. H. M. Pham
Trane Company
6200 Troup Hy.
Tyler, TX 75711
214/581-3356

Mr. Herbert Phillips
Director of Engineering
ARI
Suite 600
1501 Wilson Blvd.
Arlington, VA 22209
703/524-8800

Mr. Joseph A. Pietsch
4319 Bobbitt Drive
Dallas, TX 75229
214/350-8209

Mr. Frank J. Powell
National Bureau of Standards
B220, Building 226
Gaithersburg, MD 20899
301/921-3637

Mr. W. Glenn Pracejus
The Williamson Company
3500 Madison Road
Cincinnati, OH 45209
513/731-1343

Mr. Fernando Preto
Energy, Mines & Resources Canada
555 Booth Street
Ottawa, Ontario K1A 0G1
613/996-4570-X182

Mr. William F. Raleigh
Teledyne Laars
13230 Saticoy Street
P.O. Box 3911
No. Hollywood, CA 91605
818/765-2277 X272

Mr. James A. Ranfone
GAMA
1901 North Moore Street
Arlington, VA 22209
703/525-9565

Mr. Robert W. Rankin
American Gas Association Laboratories
8501 E. Pleasant Valley Road
Independence, OH 44131
216/524-4990

Mr. Allan J. Reifel
Intertherm, Incorporated
3345 Morganford Road
St. Louis, MO 63116
314/771-2410

Mr. C. Keith Rice
Oak Ridge National Laboratory
Building 9102-1
P.O. Box Y
Oak Ridge, TN 37831
615/574-2016

Mr. F. L. Rivard
Greenville Products
Div. of White Consolidated
635 W. Charles Street
Greenville, MI 48838
616/754-7131

Mr. Russ Sasnett
General Electric
Building 3, Room 220
Appliance Park
Louisville, KY 40225
502/452-3261

Mr. Roger Sheridan
AGA Labs.
8501 E. Pleasant Valley Road
Cleveland, OH 44131
216/524-4990

Mr. Gary L. Sirois
Project Engineer
Peerless Heater Company
Division of Peerless Industries, Inc.
Spring & Schaeffer Streets
Boyertown, PA 19512
215/367-2153

Mr. Donald B. Smith
First Company
8273 Moberly Lane
Dallas, TX 75227
214/388-5751

Ms. Cyndy Snow
General Manager
AIRMAX, Incorporated
P.O. Box 159
Gilmer, TX 75644

Mr. Werner Specht
Rezpor
McKinley Avenue
Mercer, PA 16137
412/662-4400

Mr. Frank A. Stanonik
GAMA
1901 North Moore Street
Arlington, VA 22209
703/525-9565

Mr. Terry Statt
Department of Energy
Room GF217
Washington, DC 20585
202/252-9142

Dr. Bill Stewart
Univ. of Missouri - Kansas City
Truman Campus
Independence, MO 64050
816/254-3663

Mr. Erwin H. Strassemeyer
Empire Comfort Systems
P.O. Box 529
Belleville, IL 62222
618/233-7420

Mr. Gerry Sturgeon
General Electric
Building 3, Room 220
Appliance Park
Louisville, KY 40225
502/452-3261

Mr. Bodh R. Subherwal
BR Laboratories, Inc.
15542 Computer Lane
P.O. Box 1249
Huntington Beach, CA 92647
714/891-0206

Mr. Frank Suchomel
A.O. Smith Co.
Suite 600
10767 Gateway West
El Paso, TX 79935
915/595-1011

Mr. John Talbott
Department of Energy
Room GF217
Washington, DC 20585
202/252-9127

Mr. Stan Tomlinson
Heil-Quaker Corporation
1136 Heil-Quaker Blvd.
P.O. Box 3005
Lavergne, TN 37086-1985
615/793-0450

Prof. David R. Tree
Purdue University
The Ray W. Herrick Laboratories
West Lafayette, IN 47907
317/494-5694

Mr. George W. Ullrich
Audi Company
2100 North Central Avenue
Fort Lee, NJ 07024
201/585-9362

Mr. Robert "Dutch" Uselton
RB Uselton Engr. Co.
P.O. Box 855
Lancaster, TX 75146
214/227-4509

Mr. Otto Vago
State Industries, Inc.
By Pass Road
Ashland City, TN 37015
615/792-4371

Mr. James Vaughn, Jr.
Vaughn Mfg. Corp.
386 Elm Street
P.O. Box 431
Salisbury, MA 01950
617/462-6683

Mr. J. J. Verderber, Jr.
Rheem Manufacturing Company
P.O. Box 6444
Fort Smith, AR 72906-4311
501/646-4311

Mr. Bernie Warning
IEC
5000 S.W. 7th Street
Oklahoma City, OK 73125
405/947-7666

Mr. Rob Watson
Natural Resources Defense Council
25 Kearny Street
San Francisco, CA 94108

Mr. John T. Weizeorick
AHAM
20 North Wacker Drive
Chicago, IL 60606
312/984-5842

Mr. E. L. West
Bradford-White Corporation
200 Lafayette Street
Middleville, MI 49333
616/795-3364

Mr. Thomas Wetherington
Florida Power Corporation
P.O. Box 14042
St. Petersburg, FL 33733
813/866-5660

Mr. Larry Wethje
ETL Testing Labs.
Industrial Park
Cortland, NY 13045
607/753-6711

Mr. John R. Williams
AMF/Paragon Elect. Co.
606 Parkway Blvd.
P.O. Box 28
Two Rivers, WI 54241
414/793-1161

Mr. Robert A. Wise
National Bureau of Standards
Building 202, Room 149
Gaithersburg, MD 20899
301/921-3304

Mr. Michael W. Woodford
ARI
Suite 600
1501 Wilson Blvd.
Arlington, VA 22209
703/524-8800

Mr. John I. Woodworth
Hydronics Institute
35 Russo Pl.
P.O. Box 218
Berkeley Heights, NJ 07922
201/464-8200

Dr. Richard N. Wright
Director
National Bureau of Standards
Building 226, Room B250
Gaithersburg, MD 20899
301/921-3377

Mr. R. E. Ziebol
Trane Company
6200 Troup Hy.
Tyler, TX 75711
214/581-3356

Appendix D

List of Participants in Various Forum Discussion Sessions

I. Heat Pumps and Air Conditioners

Name	Organization
David Tree (Moderator)	Purdue University
David Didion	NBS
Swiki Anderson	Phillips Industries Inc.
Ted Baily	Carrier Corporation
Joseph L. Behr	Alco Controls
Ralph S. Bryant	Heil-Quaker Corporation
Paul K. Buckley	Lennox Industries
Dan Canclini	Rheem A/C Division
Roger Carlone	Virginia KMP
Jimmy Cox	Rheem Manufacturing Company
Richard Denny	ARI
Irvin Derks	Bard Manufacturing
Peter Domanski	NBS
Phil D. Fairchild	EPRI
R. C. Forristall	Borg Warner
Victor Goldschmidt	Herrick Laboratories
Russ Griffith	Copeland Corporation
Jim Hammond	Tecumseh Products
Charles Hastings	American Standard Incorporated
Tom Hildreth	Magic Chef Air Conditioning
Byron Horak	ETL Testing Labs
George W. Hurl	The Coleman Company
Sadik Imral	Intertherm Incorporated
Frank Jakob	Battelle Labs
Nick Johnson	Williams Furnace
Gary K. Jones	Airmax, Incorporated
Peter W. Likes	Hussmann Corporation
Marvin R. Muchmore	Red T Coil
Bill Mulroy	NBS
Bob Napp	Borg Warner
Lorne Nelson	Honeywell
Robert Newell	Rheem
Hung M. Pham	Trane Company
Herb Phillips	ARI
Joseph A. Pietsch	Pietsch Engineering
Glenn Pracejus	The Williamson Company
Keith Rice	ORNL
Don Smith	First Company
Cindy Snow	Airmax, Incorporated
Terry Statt	DOE
Dutch Uselton	RB Uselton Eng./Aspen
Bernie Warning	IEC
Mike Woodford	ARI
R. E. Ziebol	Trane Company

II. Furnaces, Boilers and Household Heaters

Name	Organization
Jack Hollingsworth (Moderator)	Consultant
Esher Kweller	NBS
Charles Adams	Lennox Ind.
Steve Amicone	New Yorker Steel Boiler Company
John Batey	Steven Winter Associates
Ed Becker	Amana Refrigeration
W. J. Bowen	Trane Company
Bruce Cleveland	Duo Therm
Paul F. Davis	Williamson Company
Don Dupras	Williams Furnace
Robert D. Fischer	Battelle-Columbus Labs
Richard Fort	American Gas Association
Dick Hanna	Bard Manufacturing Company
Adam Hinge	NY State Energy Office
Sally Hooks	EEI
Don Hussong	Consolidated Industries Corporation
Ron Hutchison	LSC/Locke Stove
Joseph Lane	Amtrol Incorporated
Danny C. Lim	U.S. DOE
Bruce Maike	Magic Chef
John Marraw	Energy Kinetics Incorporated
Karl W. Mayer	Burnham Corporation
D. Bruce McCowan	Canadian Gas Association
M. J. Myers	Purlen Heater Company
Jim Nanni	Hydrotherm
Kim Naylor	GAMA
Fernando Preto	EMR Canada
William F. Raleigh	Teledyne Laars
Jim Ranfone	GAMA
Allan Reife	Intertherm, Incorporated
Roger Sheridan	American Gas Association
Gary Sirois	Peerless Heater Company
Werner Specht	Reznor Company
Erwin Strassemeyer	Empire Climate Systems
Frank Suchomel	A. O. Smith
John M. Talbott	U.S. Department of Energy
Stan Tomlinson	Heil-Quaker
Jacob J. Verderber, Jr.	Rheem-Air Conditioning Division
John Woodworth	Hydronics Institute

III. Water Heaters

Name	Organization
Robert Cook (Moderator)	Consultant
Jim Harris	NBS
David R. Abrey	NYS Energy Office
John C. Bock	Bock Water Heaters
Bob Carnevale	Bradford - White

George C. Fanelli	Ford Products Corporation
Victor Goldschmidt	Herrick Labs (Purdue University)
Dirk Granberg	A.O. Smith Water Products
Joseph Greenberg	NBS
Richard Greenhaus	Consumer Reports
William Haag, Jr.	Rheem Manufacturing Company
Sally Hooks	EEI
Jack Langmead	GAMA
Eric Lannes	Hoyt Heater Company
Peter Miller	Natural Resources Defense Council
Ed Nordstorm	Amtrol Incorporated
Fernando Preto	EMR Canada
Bob Rankin	AGA Laboratories
Frank A. Stanonik	GAMA
Bodh R. Subherwal	BR Laboratories, Incorporated
Otto Vago	State Industries, Incorporated
Jim Vaughn, Jr.	Vaughn Manufacturing Company
Eugene West	Bradford - White
Thomas I. Wetherington	Florida Power Corporation
Larry Wethje	ETL

IV. Refrigerators, Refrigerators-Freezers and Freezers

Name	Organization
J. Benjamin Horvay (Moderator)	Consultant
Robert A. Wise	NBS
Sam Beach	Greenville Products
Walter H. Blanck	AHAM
Raymond H. Bohman	Amana Refrigeration Incorporated
Marie E. Dasher	Whirlpool Corporation
Robert D. Dikkers	NBS
Howard Geller	ACEEE
Richard B. Harrison	Whirlpool Corporation
Robert Johnson	Whirlpool Corporation
Donald L. Mays	Consumers Union
Michael J. McCabe	U.S. Department of Energy
Peter Miller	NRDC
Francis L. Rivard	Greenville Products
Russ Sasnett	General Electric Company
Terry Statt	U.S. Department of Energy
William Stewart	University of Missouri
Gerry Sturgeon	General Electric Company
George Ullrich	Audi Company
John T. Weizeorick	AHAM
John R. Williams	AMF/Paragon Elect. Company

Appendix E

The Determination of Evaporator Unit Performance Ratios Required for the Calculation of Mixed System Ratings

Joseph A. Pietsch
Consultant

The procedures for determining system performance ratings of mixed systems from system ratings of tested-matched systems employing the same condensing unit requires the determination of several performance ratios relating the mixed system evaporator to the tested-matched system evaporator. This has been studied at length by NBS and they have concluded that the minimum information required is as follows:

- Coil capacity ratio
- Blower power ratio
- Expansion device refrigerant flow ratio (fixed devices only)
- Experience factor ratios
  - Suction superheat control
  - Off-cycle refrigerant migration control
  - Other

These ratios can be determined in a variety of ways with varying degrees of accuracy. Effort will continue to be applied to develop alternatives and to appraise their suitability from both accuracy and practical standpoints. Also effort will be directed to determine the degree of accuracy required to achieve acceptable projections of system performance.

Methods for determining these ratios identified to date include:

Coil Capacity Ratio

Evaporator Testing - Testing to determine the evaporator capacity of the mixed evaporator at its specified air flow and the tested-matched coil at its specified airflow at some standard rating condition.

Coil Performance Curves - Information on the details of an evaporator (tube diameter, tube pattern, number of tube rows, fins per inch and fin detail) can be obtained from examining the coil or in some cases from manufacturer's printed literature. With the additional knowledge of the air flow across the coil, the evaporator performance can be determined by utilizing performance curves generated from tests of representative coils within a coil family. For some configurations these curves are available from coil manufacturers but the information is not always consistent. In most cases, they do not consider the effects of variations in internal tube circuitry. Methods for defining tube circuitry and its effects on evaporator performance should be developed to improve the accuracy of this approach. These methods could include analytical procedures, simplified test methods or combinations of testing and calculation procedures. Indoor airflow quantity is sometimes available from printed manufacturer's literature. Another approach is to use a nominal 400 to 450 cfm/ton if the actual airflow is not known.

Evaporator Capacity Prediction Model - Some sophisticated computer models of evaporator performance develop performance characteristics on a tube-by-tube basis which allows for circuitry considerations. NBS has developed such a model, but it needs to be verified.

Blower Power Ratio

Evaporator Unit Testing - Tested-matched system evaporator units and mixed evaporator units which contain an indoor blower motor can be tested for power input with a simple wattmeter test.

Default Values - For coil-only systems, if the indoor airflow is known, the blower power can be determined utilizing the default value of 0.365 watt per cfm prescribed in the standard. If both the tested-matched system and the mixed system utilize coils-only, the blower power ratio is the ratio of the indoor airflows.

Manufacturer's Literature - Many manufacturers provide printed performance literature which provides the blower watts input for evaporator blower motors. Some manufacturers may provide the horsepower rating of the blower motor which can be used to establish a crude estimate of blower watts.

Expansion Device Refrigerant Flow Ratio (fixed devices only)

Measurement of Physical Dimensions - The physical dimensions of fixed expansion devices used in the tested-matched system and the mixed system can be measured and the relative flow rates determined through the use plotted performance curves or calculated by formula.

Flow Rate Measurements - Air (or other gasses) flow tests can be run on the tested-matched system expansion device and the mixed system expansion device at a fixed pressure drop to determine the relative flow of each device. The ratio of flow of the expansion in a refrigeration system can be approximated by the flow ratio obtained by the airflow test.

Experience Factor Ratios

Analysis of Rating Data - An analysis of rating data where the only difference between the rated systems is variations in hardware which affect factors such as suction superheat control and off-cycle refrigerant migration control, could yield patterns which quantify the value of the specific hardware difference. Strong correlations of existing rating data would support the extension of same performance differences to other systems which have similar hardware differences.

Computer Simulations - Sophisticated models of air conditioning systems can identify the magnitude of performance differences caused by changes in hardware which affect performance. Prescribed values based on the computer simulations can be verified by spot checks against existing rating data of systems with the same hardware differences.

Sources of Information

The procedures for projecting the performance of mixed system require the rater to have a knowledge of certain evaporator unit parameters for both

the mixed evaporator unit and the tested-matched evaporator unit. This information can be obtained in a variety of ways. They include:

Directly from the manufacturer of the evaporator unit. This path is not always available since the manufacturer may consider some or all of the needed information to be proprietary.

From manufacturer's published product data. Selected evaporator unit information is provided in published product data which is generally available to engineers, distributors and installing contractors.

Some evaporator unit parameters can be determined by physical examination of a sample of the evaporator unit.

Some evaporator unit parameters can be determined by actual tests of the evaporator unit and/or its components.

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5. AUTHOR(S)

Robert D. Dikkers, Editor

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

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U.S. Department of Energy
Office of Building Energy Research & Development
Building Equipment Division
Washington, DC 20585

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

One hundred thirty-four persons participated in a Forum on Testing and Rating Procedures for Consumer Products held at the National Bureau of Standards (NBS), Gaithersburg, Maryland, on October 2-3, 1985. The objectives of the forum, which was planned in cooperation with various industry associations, were: (1) to provide a line of communication between test procedure users and test procedure developers; (2) to provide an opportunity for participants to present technical and research issues concerning Department of Energy (DOE) test procedures that need to be addressed; and (3) to assist DOE and NBS in establishing a future agenda for the development and/or revision of testing and rating procedures. The report summarizes discussions, conclusions and recommendations developed by the forum participants for the following consumer products: heat pumps and air conditioners; furnaces, boilers, and household heaters; water heaters; refrigerators, refrigerator-freezers and freezers.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Air conditioners; boilers; consumer products; energy efficiency; Energy Policy and Conservation Act; furnaces; heat pumps; refrigerator-freezers; testing and rating procedures; water heaters.

13. AVAILABILITY

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