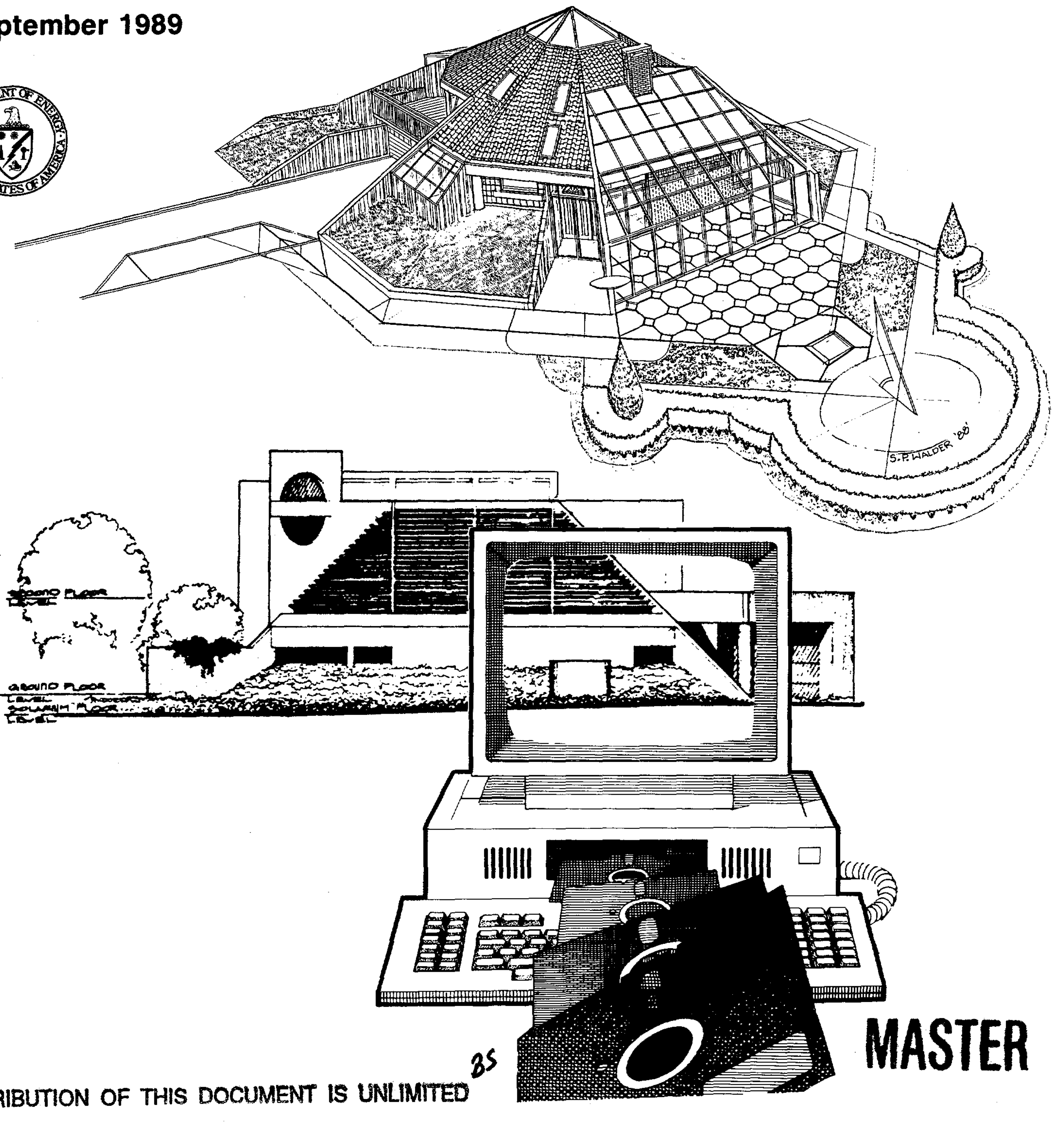
DOE/CE-0274
Volume 5 of 7

U.S. Department of Energy
Assistant Secretary
Conservation and Renewable Energy
Office of Buildings and Community Systems
Buildings Systems Division
Washington, DC 20585

Description of the Testing Process for the Automated Residential Energy Standard (ARES)

In Support of Proposed Interim Energy Conservation Voluntary Performance Standards for New Non-Federal Residential Buildings

September 1989



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ACKNOWLEDGMENTS

A number of organizations and individuals contributed to the preparation of this document. Funding for the project was provided by the Department of Energy (DOE), Office of Buildings and Community Systems under the direction of John Millhone. Program management and contract monitoring at DOE was provided by Stephen Walder. Technical recommendations in this report were prepared by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Technical Evaluation Committee for Special Project 53. That committee consisted of the following persons:

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David Conover of the National Conference of States on Building Codes and Standards provided invaluble expertise and insight throughout the development process. Joe Huang of Lawrence Berkeley Laboratory conducted the numerous computer simulations that form the basis for the energy analyses in the standard.

Michael R. Brambley and, previously, Raymond Reilly and Allen Lee served as project manager for the Voluntary Residential Standards Project at Pacific Northwest Laboratory (PNL). Victor Lortz wrote the software which embodies the proposed Standard and was primary author of the accompanying User's Guide. Z. Todd Taylor provided overall guidance and technical support for the analysis of the standard and assisted in preparation of the software User's Guide.

The software for this proposed voluntary standard has been used by the U.S. Department of Housing and Urban Development (HUD) in developing proposed new HUD mandatory standards for new manufactured housing. HUD funded work at PNL that was used jointly in HUD's new standard and in updates to the proposed DOE Voluntary Residential Standard.

PREFACE

The Energy Conservation for New Buildings Act of 1976, as amended, 42 U.S.C Section 6831 et. seq. requires the U.S. Department of Energy (DOE) to issue energy conservation standards for the design of new residential and commercial buildings. The standards will be mandatory only for the design of new federal buildings and will serve as voluntary guidelines for the design of new non-federal buildings.

The original recommendations for the non-federal residential standards were produced by the American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE) Special Projects Committee No. 53 under contract to Pacific Northwest Laboratory (PNL). Those recommendations were published in four volumes entitled Recommendations for Energy Conservation Standards for New Residential Buildings. DOE modified the original recommendations to accommodate an optional, more flexible economic analysis procedure. DOE also directed PNL to produce additional technical documentation for the software that embodies the standards and to assess the economic and environmental effects of the standards.

The final standards are documented in six publications in support of the Proposed Interim Energy Conservation Voluntary Performance Standards for New Non-Federal Residential Buildings:

- ARES 1.2 User's Guide (Automated Residential Energy Standard) - Explains the use of the ARES program to develop location-specific energy conservation requirements.

- Technical Support Documentation for the Automated Residential Energy Standard (ARES) - Explains the data and algorithms used by the ARES program to optimize energy-related features of new residences.

- Background to the Development Process for the Automated Residential Energy Standard (ARES) - Explains the background and philosophy of the standard development process.

- Technical Support Documentation for the Automated Residential Energy Standard (ARES) Data Base - Documents the assumptions and procedures used to develop the residential energy consumption data base in ARES.

- Description of the Testing Process for the Automated Residential Energy Standard (ARES) - Describes the process used by the development committee to initially test the ARES computer program.

- Economic Analysis - Describes an assessment of the likely impacts of the new standards on the nation's economy.

- Environmental Assessment - Describes an assessment of the likely impacts of the new standards on new home habitability, on institutions associated with residential construction, and on the economy in general.

CONTENTS

1.0 INTRODUCTION

Testing of the Standard recommendations was conducted in two parts. The first test examined the apparent equity and accuracy of the requirements that are generated by the procedures and data that support the Standard. The second test was performed to delineate problems that may exist with the points compliance procedure.

The scope of the tests was limited by schedule and financial considerations and intended only to uncover any substantive and obvious problems. Where errors were found that had an impact on the requirements, corrections were made. In addition, modifications were described that simplified the use, and improved the graphic quality of the Standard materials. Where time and resources allowed, these primarily cosmetic changes were implemented.

In the sections that follow, the scope of the tests, the method of analysis, the results, and the conclusions are discussed. In general, the first test indicated that the requirements generated by the Standard procedures and formulae appear to yield reasonable results, although some of the cost data provided as defaults in the Standard should be reevaluated. The second test provided experience that was useful in modifying the points compliance format, but did not uncover any procedural issues that would lead to unreasonable results.

These conclusions are based on analysis using the Automated Residential Energy Standard (ARES) computer program, developed to simplify the process of standards generation. Time and resource constraints prohibited assessing the accuracy of the ARES program in reproducing the results of the algorithms (selected or created by the SP-53 committee) that determine the Standard's requirements. These assessments were, however, made during the software development stages at Pacific Northwest Laboratory (PNL), and are documented in the project files.

2.0 TESTING THE PROCESS FOR GENERATING THE STANDARD'S REQUIREMENTS

This test sought to assess the procedures and data used in generating the Standard's requirements. The test was qualitative as opposed to quantitative. The intent was not to rigorously evaluate the numeric accuracy of the algorithms and standard development procedures. Rather the test was conducted to determine whether the requirements they generate, through running the ARES program, appear to be "reasonable" and provide regionally equitable results.

In cases where the resulting requirements were suspect, probable causes were identified and, if the required changes were minor, they were implemented. Suggested changes that were implemented prior to publication of this document are not recorded herein. None of the problems identified in this test required substantial changes to the Standard materials.

For five geographically and climatically disparate locations the ARES program was run, yielding Standard requirements for select housing types and energy types (see Appendix A). The requirements for the five locations - Fort Lauderdale, FL, South Bend, IN, Spokane, WA, Syracuse, NY and Tucson, AZ - were generated using local energy and energy conservation measure costs provided by the National Association of Home Builders National Research Center[a] as modified by the SP-53 committee (see ECM Costs Position Paper[b]).

Requirements were generated for the housing and energy types listed in table 2.1. A summary of the results follows.

(a) An Economic Data Base in Support of SPC 90.2: Costs of Residential Energy, Thermal Envelope and HVAC Equipment, NAHB National Research Center, ASHRAE Research Project 494-RP, December 1986.

(b) The position papers of SP-53 are to be published in Background to the Development Process for the Automated Residential Energy Standard (ARES) in support of the Proposed Interim Energy Conservation Voluntary Performance Standards for New Non-Federal Residential Buildings.

Location/ Table No./Housing Type(1)	Equipment Type (Heating/Cooling) Oil/ DX Clg.	N. Gas/ DX Clg.	LP Gas/ DX Clg.	Elec/ DX Clg.	Heat Pump
Fort Lauderdale, FL					
1a. Manufactured housing			o	o	o
1b. Single Family Detached			o	o	o
1c. Multi-Family Attached			o	o	o
South Bend, IN					
2a. Manufactured housing	o		o	o	
2b. Single Family Detached	o			o	o
Spokane, WA					
3a. Manufactured housing			o	o	o
3b. Single Family Detached				o	o
3c. Multi-Family Attached				o	o
Syracuse, NY					
4a. Single Family Detached	o	o			o
4b. Multi-Family Attached	o	o			o
Tucson, AZ					
5a. Manufactured housing		o	o		
5b. Single Family Detached		o	o		o
5c. Multi-Family Attached		o	o		o

(1) Table No. refers to the tables in Appendix A of this volume that contain the results of the computer runs.

Table 2.1 Summary of Test Runs Performed

General Observations

1. Low-E Glazing in the Basic Package - The Low-E glazing options appear to be cost-effective in most locations. This result is a reflection of the improved performance at little extra first cost. The Low-E option, in providing a more stringent energy target, places an inequitable burden on home construction where this product is not available.

   The Low-E glazing option may be particularly difficult to acquire in the manufactured housing market (e.g. see results for Fort Lauderdale, FL). One possible rectifying action would be to default Low-E glazing to a "disallow" status for purposes of the optimization but, retain it as an option in the points and package compliance paths.

2. Unrealistic Glazing Options - In some instances the Triple Glazing without Thermal Breaks and the Single Glazing with Thermal Breaks may be selected in the optimization analysis for the basic package. These two options are atypical and unavailable in many housing markets. It is recommended that these options be eliminated from the Standard's materials or defaulted to a "disallow" status and not included in the optimization.

3. High Mechanical Equipment Efficiency - In a number of locations the required efficiency levels for the mechanical equipment appear high, particularly in the case of manufactured housing. These levels are expected to be the result of the assumed first costs. Further corroborating analysis is appropriate here.

4. Cross Regional Requirements - One observation that deems further analysis is inconsistent selection of ECMs across regions. For example, the single family detached housing envelope requirements are more stringent in Syracuse than South Bend, while the mechanical equipment requirements are higher in South Bend (see Oil Furnace results). Additional analysis is justified to delineate the reasons for these discontinuous results.

5. House Type Comparison - In most instances the default data yield similar requirements for single and multifamily housing and different and less stringent requirements for manufactured housing. This finding is not surprising given the somewhat higher costs to achieve stringent levels of conservation in manufactured versus site built housing and the

degradation in insulation performance due to compression in manufactured homes. This finding argues a case for providing thermal requirements that differ by housing type.

3.0 TESTING THE POINTS COMPLIANCE METHOD

An example of the use of the points compliance method was developed to test the clarity of the procedure and completeness of the descriptive material and to determine the reliability of the results for homes that differ physically from the basic prototypes used to generate the energy data base. In developing the example a number of observations were made concerning the graphic presentation and the descriptive material. The recommended modifications were implemented prior to issuance of the final version of the Text of the Standard.

Where appropriate, wording changes were made and descriptions modified to reflect terms in common usage in the building industry without sacrificing numeric accuracy nor the integrity of the language. While the test indicated that the method is complete and clear it is recommended that, prior to publication, the Points Path be subjected to a Beta type test for further refinement.

The test consisted of developing Point tables for single family detached housing in South Bend, Indiana, with Oil space heating and direct expansion cooling. (The package requirements associated with this set of conditions are provided on Table 2.b.) It was then assumed that compliance was to be demonstrated for a two-story, center hall colonial home in South Bend, Indiana, with the following physical characteristics:

Floor Area:	2504 sq. ft.	Air Infiltration:	Tight Package
Ceiling Area:	1224 sq. ft.	HVAC Efficiency	
Opaque Wall Area:	2088 sq. ft.	Heating:	AFUE 88%
Fenestration Area		Cooling:	SEER 10.0
Total:	248 sq. ft.	DHW System:	Two Panel Active Solar
North:	50 sq. ft.		
East:	120 sq. ft.		
South:	25 sq. ft.		
West:	53 sq. ft.		
Basement Type:	UnheatedBasement		
Basement Floor Area:	1280 sq. ft.		

Based on that analysis, a number of graphic and procedural revisions were made. These were implemented prior to the release of the final Text of Volume I and are not reported here. In addition, the following observations were made:

1. The procedure is generally easy to follow and, while it is a considerable departure from current compliance procedures, the added degree of design flexibility is a distinct advantage.
2. As would be anticipated, the results are particularly sensitive to certain design decisions, such as selecting the "tight" level of air infiltration, a high level of mechanical equipment efficiency and the specification of a solar domestic hot water system. While the magnitude of the points associated with these options may be in the correct proportion relative to the other options, their use could allow compliance with relatively low levels of envelope insulation.
3. In compliance the same type of space conditioning equipment must be specified for both the Design and Target homes. This procedure assures that reductions in thermal integrity cannot be made simply by assuming that the Target home has electric resistance heat and the Design home has a heat pump.

This check and balance is not possible with the domestic hot water point computation. The target for the DHW system is set by the federally mandated minimum which provides values only for electric resistance. Specification of a heat pump water heater allows a credit against space conditioning conservation measures. This issue requires further consideration in the future.

APPENDIX A

BASIC STANDARD REQUIREMENT ANALYSES FOR FIVE CITIES

APPENDIX A - BASIC STANDARD REQUIREMENT ANALYSES FOR FIVE CITIES

Table 1a. Comparison of Energy Conservation Measures for Fort Lauderdale, FL

Housing Type: Manufactured Housing

Energy Conservation Measure (ECM)	Heating Equipment Type L-P Gas Furnace	Electric Furnace	Heat Pump
Ceiling Insulation:	R-11	R-11	R-11
Wall Insulation:	R- 7	R-11	R- 7
Floor Insulation			
Crawl:	R- 7	R-11	R- 7
Slab:			
Heated Basement:			
Unheated Basement:			
Fenestration			
Window Type:	Double Low-E Sun	Double Low-E Sun	Double Low-E Sun
Max. Window Area:	12 %	12 %	12 %
Min. South Window:	0 %	0 %	0 %
Infiltration:	Average	Average	Average
Equipment Efficiency			
Heating:	AFUE 78 %	100 %	HSPF 7.3
Cooling:	SEER 10	SEER 10	SEER 10

Table 1b. Comparison of Energy Conservation Measures for Fort Lauderdale, FL

Housing Type: Single Family Detached

Energy Conservation Measure (ECM)	Heating Equipment Type L-P Gas Furnace	Electric Furnace	Heat Pump
Ceiling Insulation:	R-30	R-30	R-30
Wall Insulation:	R-11	R-11	R-11
Floor Insulation			
Crawl:	R- 0	R-11	R- 0
Slab:	R- 0	R- 0	R- 0
Heated Basement:	R- 0	R- 0	R- 0
Unheated Basement:	R- 0	R- 0	R- 0
Fenestration			
Window Type:	Double Low-E Sun	Double Low-E Sun	Double Low-E Sun
Max. Window Area:	12 %	12 %	12 %
Min. South Window:	0 %	0 %	0 %
Infiltration:	Average	Average	Average
Equipment Efficiency			
Heating:	AFUE 78 %	100 %	HSPF 7.3
Cooling:	SEER 10	SEER 10	SEER 10

Table 1c. Comparison of Energy Conservation Measures for Fort Lauderdale, FL

Housing Type: Multi-Family Attached

Energy Conservation Measure (ECM)	Heating Equipment Type: L-P Gas Furnace	Electric Furnace	Heat Pump
Ceiling Insulation:	R-19	R-19	R-19
Wall Insulation:	R-11	R-13	R-11
Floor Insulation			
Crawl:	R- 0	R-11	R- 0
Slab:	R- 0	R- 0	R- 0
Heated Basement:	R- 0	R- 0	R- 0
Unheated Basement:	R- 0	R- 0	R- 0
Fenestration			
Window Type:	Double Low-E Sun	Double Low-E Sun	Double Low-E Sun
Max. Window Area:	12 %	12 %	12 %
Min. South Window:	0 %	0 %	0 %
Infiltration:	Average	Average	Average
Equipment Efficiency			
Heating:	AFUE 78 %	100 %	HSPF 7.3
Cooling:	SEER 10	SEER 10	SEER 10

Assumptions: Fort Lauderdale, FL

1. ECM costs and economic parameters: ARES default values.
2. Local energy costs: L-P Gas ($/gallon) - 0.788
   Electricity ($/KWatt-hr) - 0.083 (winter)
   - 0.088 (summer)
3. Prevalent foundation type: Manufactured Housing - Crawl space
   Single Family Detached - Crawl space
   Multi-Family Attached - Crawl space

Table 2a. Comparison of Energy Conservation Measures for South Bend, IN

Housing Type: Manufactured Housing

Energy Conservation Measure (ECM)	Heating Equipment Type: Oil Furnace	L-P Gas Furnace	Electric Furnace	Heat Pump
Ceiling Insulation:	R-19	R-19	R-33	R-19
Wall Insulation:	R-19	R-19	R-19	R-19
Floor Insulation				
Crawl:	R-19	R-19	R-28	R-19
Slab:				
Heated Basement:				
Unheated Basement:				
Fenestration				
Window Type:	Triple w/o TB	Double Low-E	Double Low-E	Double Low-E
Max. Window Area:	12 %	12 %	12 %	12 %
Min. South Window:	0 %	0 %	0 %	0 %
Infiltration:	Average	Average	Average	Average
Equipment Efficiency				
Heating:	AFUE 85 %	AFUE 90 %	100%	HSPF 7.3
Cooling:	SEER 10	SEER 10	SEER 10	SEER 10

Table 2b. Comparison of Energy Conservation Measures for South Bend, IN

Housing Type: Single Family Detached

Energy Conservation	Heating Equipment Type		
Measure (ECM)	Oil Furnace	Electric Furnace	Heat Pump
Ceiling Insulation:	R-30	R-60	R-30
Wall Insulation:	R-23	R-26	R-23
Floor Insulation			
Crawl:	R-19	R-30	R-30
Slab:	R- 5 (2 ft.)	R-10 (4 ft.)	R-10 (4 ft.)
Heated Basement:	R- 5 (4 ft.)	R-10 (4 ft.)	R- 5 (4 ft.)
Unheated Basement:	R-13	R-30	R-19
Fenestration			
Window Type:	Triple w/o TB	Triple Low-E	Triple w/o TB
Max. Window Area:	12 %	12 %	12 %
Min. South Window:	0 %	0 %	0 %
Infiltration:	Average	Average	Average
Equipment Efficiency			
Heating:	AFUE 95 %	100 %	HSPF 8.5
Cooling:	SEER 10	SEER 10	SEER 11

Assumptions: South Bend, IN

1. ECM costs and economic parameters: ARES default values.
2. Local energy costs: Oil ($/gallon) - 0.987
   L-P Gas ($/gallon) - 0.788
   Electricity ($/KWatt-hr) - 0.064 (winter)
   - 0.062 (summer)
3. Prevalent foundation type: Manufactured Housing - Crawl space
   Single Family Detached - Unheated Basement
   Multi-Family Attached - Unheated Basement

Table 3a. Comparison of Energy Conservation Measures for Spokane, WA

Housing Type: Manufactured Housing

Energy Conservation Measure (ECM)	Heating Equipment Type: L-P Gas Furnace	Electric Furnace	Heat Pump
Ceiling Insulation:	R-19	R-19	R-19
Wall Insulation:	R-19	R-19	R-11
Floor Insulation			
Crawl:	R-19	R-22	R-19
Slab:			
Heated Basement:			
Unheated Basement:			
Fenestration			
Window Type:	Double Low-E	Double Low-E	Double w/o TB
Max. Window Area:	12 %	12 %	12 %
Min. South Window:	0 %	0 %	0 %
Infiltration:	Average	Average	Average
Equipment Efficiency			
Heating:	AFUE 90 %	100 %	HSPF 7.3
Cooling:	SEER 10	SEER 10	SEER 10

Table 3b. Comparison of Energy Conservation Measures for Spokane, WA

Housing Type: Single Family Detached

Energy Conservation Measure (ECM)	Heating Equipment Type: Electric Furnace	Heating Equipment Type: Heat Pump
Ceiling Insulation:	R-30	R-30
Wall Insulation:	R-26	R-23
Floor Insulation		
Crawl:	R-30	R-13
Slab:	R-10 (4 ft.)	R- 5 (2 ft.)
Heated Basement:	R-10 (4 ft.)	R- 5 (4 ft.)
Unheated Basement:	R-30	R-13
Fenestration		
Window Type:	Double Low-E	Triple w/o TB
Max. Window Area:	12 %	12 %
Min. South Window:	0 %	0 %
Infiltration:	Average	Average
Equipment Efficiency		
Heating:	100 %	HSPF 7.3
Cooling:	SEER 10	SEER 10

Table 3c. Comparison of Energy Conservation Measures for Spokane, WA

Housing Type: Multi-Family Attached

Energy Conservation Measure (ECM)	Heating Equipment Type	
	Electric Furnace	Heat Pump
Ceiling Insulation:	R-30	R-30
Wall Insulation:	R-23	R-23
Floor Insulation		
Crawl:	R-30	R-13
Slab:	R-10 (4 ft.)	R- 5 (2 ft.)
Heated Basement:	R-10 (4 ft.)	R- 5 (4 ft.)
Unheated Basement:	R-30	R-11
Fenestration		
Window Type:	Double Low-E	Triple w/o TB
Max. Window Area:	12 %	12 %
Min. South Window:	0 %	0 %
Infiltration:	Average	Average
Equipment Efficiency		
Heating:	100 %	HSPF 7.3
Cooling:	SEER 10	SEER 10

Assumptions: Spokane, WA

1. ECM costs and economic parameters: ARES default values.
2. Local energy costs: L-P Gas ($/gallon) - 0.788
   Electricity ($/KWatt-hr) - 0.031 (winter)
   - 0.032 (summer)
3. Prevalent foundation type: Manufactured Housing - Crawl space
   Single Family Detached - Unheated Basement
   Multi-Family Attached - Unheated Basement

Table 4a. Comparison of Energy Conservation Measures for Syracuse, NY

Housing Type: Single Family Detached Housing

Energy Conservation Measure (ECM)	Heating Equipment Type: Oil Furnace	Nat. Gas Furnace	Heat Pump
Ceiling Insulation:	R-30	R-30	R-30
Wall Insulation:	R-26	R-23	R-26
Floor Insulation			
Crawl:	R-30	R-30	R-30
Slab:	R-10 (4 ft)	R- 5 (2 ft)	R-10 (4 ft)
Heated Basement:	R-10 (4 ft)	R- 5 (4 ft)	R-10 (4 ft)
Unheated Basement:	R-30	R-19	R-30
Fenestration			
Window Type:	Double Low-E	Triple w/o TB	Double Low-E
Max. Window Area:	12 %	12 %	12 %
Min. South Window:	0 %	0 %	0 %
Infiltration:	Average	Average	Average
Equipment Efficiency			
Heating:	AFUE 90 %	AFUE 90 %	HSPF 9.8
Cooling:	SEER 10	SEER 10	SEER 12

Table 4b. Comparison of Energy Conservation Measures for Syracuse, NY

Housing Type: Multi-Family Attached Housing

Energy Conservation Measure (ECM)	Heating Equipment Type: Oil Furnace	Nat. Gas Furnace	Heat Pump
Ceiling Insulation:	R-30	R-30	R-30
Wall Insulation:	R-23	R-23	R-26
Floor Insulation			
Crawl:	R-30	R-30	R-30
Slab:	R-10 (4 ft.)	R- 5 (2 ft.)	R-10 (4 ft.)
Heated Basement:	R-10 (4 ft.)	R-10 (4 ft.)	R-10 (4 ft.)
Unheated Basement:	R-30	R-13	R-30
Fenestration			
Window Type:	Double Low-E	Triple w/o TB	Double Low-E
Max. Window Area:	12 %	12 %	12 %
Min. South Window:	0 %	0 %	0 %
Infiltration:	Average	Average	Average
Equipment Efficiency			
Heating:	AFUE 80 %	AFUE 80 %	HSPF 7.3
Cooling:	SEER 10	SEER 10	SEER 10

Assumptions: Syracuse, NY

1. ECM costs and economic parameters: ARES default values.
2. Local energy costs: Oil ($/gallon) - 1.113
   Natural Gas ($/therm) - 0.593
   Electricity ($/KWatt-hr) - 0.078 (winter)
   - 0.063 (summer)
3. Prevalent foundation type: Single Family Detached - Unheated Basement
   Multi-Family Attached - Unheated Basement

Table 5a. Comparison of Energy Conservation Measures for Tucson, AZ

Housing Type: Manufactured Housing

Energy Conservation Measure (ECM)	Heating Equipment Type: Nat. Gas Furnace	Heating Equipment Type: L-P Gas Furnace
Ceiling Insulation:	R-19	R-19
Wall Insulation:	R-11	R-13
Floor Insulation		
Crawl:	R-19	R-19
Slab:		
Heated Basement:		
Unheated Basement:		
Fenestration		
Window Type:	Double Low-E Sun	Double Low-E Sun
Max. Window Area:	12 %	12 %
Min. South Window:	0 %	0 %
Infiltration:	Average	Average
Equipment Efficiency		
Heating:	AFUE 78 %	AFUE 78 %
Cooling:	SEER 10	SEER 10

Table 5b. Comparison of Energy Conservation Measures for Tucson, AZ

Housing Type: Single Family Detached

Energy Conservation Measure (ECM)	Heating Equipment Type: Nat. Gas Furnace	L-P Gas Furnace	Heat Pump
Ceiling Insulation:	R-30	R-30	R-38
Wall Insulation:	R-19	R-23	R-23
Floor Insulation			
Crawl:	R-11	R-19	R-13
Slab:	R- 0	R- 5 (2 ft.)	R- 0
Heated Basement:	R- 0	R-10 (4 ft.)	R- 5 (4 ft.)
Unheated Basement:	R- 0	R-11	R- 0
Fenestration			
Window Type:	Double Low-E Sun	Double Low-E Sun	Double Low-E Sun
Max. Window Area:	12 %	12 %	12 %
Min. South Window:	0 %	0 %	0 %
Infiltration:	Average	Average	Average
Equipment Efficiency			
Heating:	AFUE 78 %	AFUE 80 %	HSPF 7.3
Cooling:	SEER 10	SEER 10	SEER 10

Table 5c. Comparison of Energy Conservation Measures for Tucson, AZ

Housing Type: Multi-Family Attached

Energy Conservation Measure (ECM)	Heating Equipment Type: Nat. Gas Furnace	L-P Gas Furnace	Heat Pump
Ceiling Insulation:	R-30	R-30	R-38
Wall Insulation:	R-19	R-19	R-23
Floor Insulation			
Crawl:	R-11	R-11	R-13
Slab:	R- 0	R- 0	R- 0
Heated Basement:	R- 5 (4 ft.)	R- 5 (4 ft.)	R- 5 (4 ft.)
Unheated Basement:	R- 0	R- 0	R- 0
Fenestration			
Window Type:	Double Low-E Sun	Double Low-E Sun	Double Low-E Sun
Max. Window Area:	12 %	12 %	12 %
Min. South Window:	0 %	0 %	0 %
Infiltration:	Average	Average	Average
Equipment Efficiency			
Heating:	AFUE 78 %	AFUE 78 %	HSPF 7.3
Cooling:	SEER 10	SEER 10	SEER 10

Assumptions: Tucson, AZ

1. ECM costs and economic parameters: ARES default values.
2. Local energy costs: Natural Gas ($/therm) - 0.478
   L-P Gas ($/gallon) - 0.788
   Electricity ($/KWatt-hr) - 0.071 (winter)
   - 0.071 (summer)
3. Prevalent foundation type: Manufactured Housing - Crawl space
   Single Family Detached - Slab-on-Grade
   Multi-Family Attached - Slab-on-Grade

APPENDIX B

SAMPLE POINTS COMPLIANCE ANALYSIS

APPENDIX B - SAMPLE POINTS COMPLIANCE ANALYSIS

This appendix contains a worked example of the point system. ARES was run for a single family detached house in Washington, DC, with gas space heating and direct expansion cooling. The house was assumed to be a two story center hall home with the following characteristics:

Floor Area:	2504 sq. ft.
Ceiling Area:	1224 sq. ft.
Opaque Wall Area:	2088 sq. ft.
Fenestration Area	
Total:	248 sq. ft.
North:	50 sq. ft.
East:	120 sq. ft.
South:	25 sq. ft.
West:	53 sq. ft.
Foundation Type:	Unheated Basement
Basement Floor Area:	1280 sq. ft.

All page numbers that follow refer to Section 5 of the Text of the Standard (Volume I of this set).

ARES Version 1.2
Release date: 3/ 8/89

Prescriptive Compliance Packages

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Created 8/30/1989 8:13:01

Table 4-3a Prescriptive Compliance Package

Housing Type: Single Family Detached
Jurisdiction: District of Columbia
Heating Type: Gas Furnace
Description : Basic Single Family Gas Furnace Package

Component	Requirement
Ceiling Insulation	R-30
Wall Insulation	R-23
Floor over Crawlspace Insulation	R-30
Floor over Basement Insulation	R-11
Basement Wall Insulation	R-5_4ft
Slab Insulation	R-5_2ft
Window Type	Double_w/o_TB
Max window area/floor area	12.0% Max Total
Minimum south window area	0.0% Min South
Infiltration	Normal
Heating Efficiency	AFUE_85%
Cooling Efficiency	SEER_10

Table 4-3b Prescriptive Compliance Package

Housing Type: Single Family Detached
Jurisdiction: District of Columbia
Heating Type: Electric Furnace
Description : Basic Single Family Electric Furnace Package

Component	Requirement
Ceiling Insulation	R-38
Wall Insulation	R-26
Floor over Crawlspace Insulation	R-30
Floor over Basement Insulation	R-30
Basement Wall Insulation	R-10_4ft
Slab Insulation	R-10_4ft
Window Type	Double_Low-E
Max window area/floor area	12.0% Max Total
Minimum south window area	0.0% Min South
Infiltration	Normal
Heating Efficiency	Elec_Resistance
Cooling Efficiency	SEER_10

Table 4-3c Prescriptive Compliance Package

Housing Type: Single Family Detached
Jurisdiction: District of Columbia
Heating Type: Heat Pump
Description : Basic Single Family Heat Pump Package

Component	Requirement
Ceiling Insulation	R-30
Wall Insulation	R-13
Floor over Crawlspace Insulation	R-30
Floor over Basement Insulation	R-13
Basement Wall Insulation	R-10_4ft
Slab Insulation	R-5_2ft
Window Type	Double_Low-E
Max window area/floor area	12.0% Max Total
Minimum south window area	0.0% Min South
Infiltration	Normal
Heating Efficiency	HSPF 7.3
Cooling Efficiency	SEER 10.0

Table 4-3d Prescriptive Compliance Package

Housing Type: Single Family Detached
Jurisdiction: District of Columbia
Heating Type: Gas Furnace
Description : R-19 Walls for Gas

Component	Requirement
Ceiling Insulation	R-30
Wall Insulation	R-19
Floor over Crawlspace Insulation	R-30
Floor over Basement Insulation	R-11
Basement Wall Insulation	R-5_4ft
Slab Insulation	R-5_2ft
Window Type	Double_Low-E
Max window area/floor area	12.0% Max Total
Minimum south window area	0.0% Min South
Infiltration	Normal
Heating Efficiency	AFUE_78%
Cooling Efficiency	SEER_10

ARES Version 1.2
Release date: 3/ 8/89

Point System (Section 7)

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Created 8/30/1989 8:13:01

Table 5-2 TARGET Ceiling Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Heating Equipment Type	Multiplier Heating	Multiplier Cooling
Oil	N/A	N/A
Natural Gas	37	11
L. P. Gas	N/A	N/A
Electric Res.	29	9
Elec. Heat Pump	37	11

Table 5-3 DESIGN Ceiling Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

R-value		Multiplier	
At least	but less than	Heating	Cooling
R-11	R-19	81	24
R-19	R-30	57	17
R-30	R-38	37	11
R-38	R-49	29	9
R-49	R-60	23	7
R-60	--	20	6

Table 5-4 TARGET Wall Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Heating Equipment Type	Multiplier Heating	Multiplier Cooling
Oil	N/A	N/A
Natural Gas	55	9
L. P. Gas	N/A	N/A
Electric Res.	48	8
Elec. Heat Pump	84	14

Table 5-5a DESIGN Frame Wall Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

R-value		Multiplier	
At least	but less than	Heating	Cooling
R-11	R-13	99	16
R-13	R-19	84	14
R-19	R-23	68	11
R-23	R-26	55	9
R-26	--	48	8

Table 5-5b DESIGN Mass Wall Insulation Multipliers
Medium Weight (40 to 110 lb/sf)

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

R-value		Multiplier	
At least	but less than	Heating	Cooling
R-0_Medium_Wt	R-5_Medium_Wt	291	32
R-5_Medium_Wt	R-10_Medium_Wt	137	13
R-10_Medium_Wt	R-15_Medium_Wt	82	7
R-15_Medium_Wt	R-30_Medium_Wt	58	4
R-30_Medium_Wt	--	30	1

Table 5-5c DESIGN Mass Wall Insulation Multipliers
Heavy Weight (greater than 110 lb/sf)

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

R-value		Multiplier	
At least	but less than	Heating	Cooling
R-0_Heavy_Wt	R-5_Heavy_Wt	289	29
R-5_Heavy_Wt	R-10_Heavy_Wt	136	11
R-10_Heavy_Wt	R-15_Heavy_Wt	81	5
R-15_Heavy_Wt	R-30_Heavy_Wt	57	3
R-30_Heavy_Wt	--	30	0

Table 5-5d DESIGN Solid Wood (Log) Wall Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Nominal Thickness (inches)		Multiplier	
At least	but less than	Heating	Cooling
6_inch_Log	8_inch_Log	124	17
8_inch_Log	10_inch_Log	95	13
10_inch_Log	12_inch_Log	78	11
12_inch_Log	--	66	10

Table 5-6 TARGET Floor/Foundation Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Heating Equipment Type	Heating Multiplier: Slab	Heating Multiplier: Crawl Space	Heating Multiplier: Unheated Basement	Heating Multiplier: Heated Basement
Oil	N/A	N/A	N/A	N/A
Natural Gas	138	0	29	452
L. P. Gas	N/A	N/A	N/A	N/A
Electric Res.	0	0	0	382
Elec. Heat Pump	138	0	20	382

Heating Equipment Type	Cooling Multiplier: Slab	Cooling Multiplier: Crawl Space	Cooling Multiplier: Unheated Basement	Cooling Multiplier: Heated Basement
Oil	N/A	N/A	N/A	N/A
Natural Gas	1	39	27	40
L. P. Gas	N/A	N/A	N/A	N/A
Electric Res.	9	39	33	28
Elec. Heat Pump	1	39	28	28

Table 5-7a DESIGN Slab Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Insulation at least 2 feet deep:

R-value		Multiplier	
At least	but less than	Heating	Cooling
R-0	R-5_2ft	375	0
R-5_2ft	R-10_2ft	138	1
R-10_2ft	--	94	2

Insulation to depth of footing:

R-value		Multiplier	
At least	but less than	Heating	Cooling
R-0	R-5_4ft	375	0
R-5_4ft	R-10_4ft	70	6
R-10_4ft	--	0	9

Table 5-7b DESIGN Floor-Over-Crawlspace Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

R-value		Multiplier	
At least	but less than	Heating	Cooling
R-0	R-11	208	30
R-11	R-13	39	38
R-13	R-19	26	38
R-19	R-30	18	39
R-30	--	0	39

Table 5-7c DESIGN Floor-Over-Unheated-Basement Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

R-value		Multiplier	
At least	but less than	Heating	Cooling
R-0	R-11	113	8
R-11	R-13	29	27
R-13	R-19	20	28
R-19	R-30	11	30
R-30	--	0	33

Table 5-7d DESIGN Basement Wall Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Insulation at least 4 feet deep:

R-value		Multiplier	
At least	but less than	Heating	Cooling
R-0	R-5_4ft	725	86
R-5_4ft	R-10_4ft	452	40
R-10_4ft	--	382	28

Insulation at least 8 feet deep:

R-value		Multiplier	
At least	but less than	Heating	Cooling
R-0	R-5_8ft	725	86
R-5_8ft	R-10_8ft	361	37
R-10_8ft	--	240	22

Table 5-8 TARGET Air Infiltration Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Heating Equipment Type	Multiplier Heating	Multiplier Cooling
Oil	N/A	N/A
Natural Gas	143	17
L. P. Gas	N/A	N/A
Electric Res.	143	17
Elec. Heat Pump	143	17

Table 5-9 DESIGN Air Infiltration Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Infiltration Package *	Multiplier Heating	Multiplier Cooling
Normal	143	17
Tight	101	12

*(see Section 5.2.5 of Standard)

Table 5-10 TARGET Glazing Layers and Sash Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Heating Equipment Type	Multiplier Heating	Multiplier Cooling
Oil	N/A	N/A
Natural Gas	75	1
L. P. Gas	N/A	N/A
Electric Res.	39	1
Elec. Heat Pump	39	1

Table 5-11 DESIGN Glazing Layers and Sash Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Glazing Type	Multiplier Heating	Multiplier Cooling
Single_w/o_TB	1148	22
Double_w/o_TB	625	12
Double_TB	473	9
Triple_TB	373	7
Single_Heat_abs	1148	22
Double_Heat_abs	625	12
Triple_Heat_abs	473	9
Double_Low-E	322	6
Triple_Low-E	252	5

Table 5-12 TARGET Fenestration Area and Orientation Points

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Heated Floor Area (sf)	Points: Gas Furnace Heating	Gas Furnace Cooling	Electric Furnace Heating	Electric Furnace Cooling	Heat Pump Heating	Heat Pump Cooling
Less than 500	28	24	23	19	23	19
500 to 750	42	36	34	29	34	29
750 to 1000	55	48	45	39	45	39
1000 to 1250	67	61	55	49	55	49
1250 to 1500	79	74	65	59	65	59
1500 to 1750	91	87	75	70	75	70
1750 to 2000	102	101	85	80	85	80
2000 to 2250	112	114	94	91	94	91
2250 to 2500	122	128	102	102	102	102
2500 to 2750	132	142	111	113	111	113
2750 to 3000	141	157	119	124	119	124
3000 to 3250	149	172	127	135	127	135
3250 to 3500	157	186	134	147	134	147
3500 to 3750	165	202	142	158	142	158
3750 to 4000	172	217	148	170	148	170
4000 to 4250	178	232	155	182	155	182
4250 to 4500	184	248	161	194	161	194
4500 to 4750	190	264	167	207	167	207
4750 to 5000	195	281	173	219	173	219
5000 to 5250	199	297	178	232	178	232
5250 to 5500	204	314	183	244	183	244
Greater than 5500	204	314	183	244	183	244

Table 5-13 DESIGN Fenestration Area and Orientation Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

	Shading Coefficient					
	1.0 to 0.8		0.79 to 0.5		less than 0.5	
Orientation	Heat	Cool	Heat	Cool	Heat	Cool
North	35	26	27	21	17	13
Northeast	46	33	36	26	22	16
East	56	40	45	32	28	20
Southeast	77	40	61	32	38	20
South	98	39	77	31	48	19
Southwest	76	44	60	34	37	21
West	55	48	43	38	27	23
Northwest	45	37	35	29	22	18
Northwest	45	37	35	29	22	18

Typical Shading Coefficients:

Single_w/o_TB	1.000
Double_w/o_TB	0.880
Double_TB	0.880
Triple_TB	0.740
Single_Heat_abs	0.750
Double_Heat_abs	0.660
Triple_Heat_abs	0.560
Double_Low-E	0.710
Triple_Low-E	0.600

Table 5-14 DESIGN Overhang Multipliers

Jurisdiction: District of Columbia

	Overhang Ratio (L/H)			
	0.000 to 0.548	0.549 to 0.999	1.0 to 1.999	2.0 and above
Heating				
North	10	10	10	10
NorthEast	10	10	10	9
East	11	9	8	6
SouthEast	12	9	7	5
South	12	8	6	3
SouthWest	12	9	7	5
West	11	9	8	6
NorthWest	10	10	10	9
Cooling				
North	10	10	10	10
NorthEast	11	9	8	8
East	11	9	7	6
SouthEast	12	8	7	6
South	13	9	8	8
SouthWest	12	8	7	6
West	11	9	7	6
NorthWest	11	9	8	8

Table 5-15 DESIGN Glazing Area and Orientation Points

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Heating F-Factor	Heating Points	Cooling F-Factor	Cooling Points
Less than 190	19	Less than 90	9
190 to 380	40	90 to 180	18
380 to 570	61	180 to 270	28
570 to 760	83	270 to 360	37
760 to 950	105	360 to 450	47
950 to 1140	129	450 to 540	57
1140 to 1330	153	540 to 630	67
1330 to 1520	178	630 to 720	77
1520 to 1710	205	720 to 810	87
1710 to 1900	231	810 to 900	97
1900 to 2090	259	900 to 990	108
2090 to 2280	288	990 to 1080	118
2280 to 2470	317	1080 to 1170	129
2470 to 2660	347	1170 to 1260	140
2660 to 2850	378	1260 to 1350	151
2850 to 3040	410	1350 to 1440	162
3040 to 3230	443	1440 to 1530	174
3230 to 3420	476	1530 to 1620	185
3420 to 3610	510	1620 to 1710	197
3610 to 3800	545	1710 to 1800	209
3800 to 3990	581	1800 to 1890	221
3990 to 4180	618	1890 to 1980	233
4180 to 4370	656	1980 to 2070	245
4370 to 4560	694	2070 to 2160	257
4560 to 4750	734	2160 to 2250	270
4750 to 4940	774	2250 to 2340	282
4940 to 5130	815	2340 to 2430	295
5130 to 5320	856	2430 to 2520	308
5320 to 5510	899	2520 to 2610	321
5510 to 5700	942	2610 to 2700	334
5700 to 5890	987	2700 to 2790	348
Greater than 5890	987	Greater than 2790	348

Table 5-16 TARGET and DESIGN Base Load Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

Foundation Type	Multiplier Heating	Multiplier Cooling
Crawlspace	1	-27
Unheated Basement	9	-27
Heated Basement	36	-27
Slab	34	-35

Table 5-17 TARGET HVAC Equipment Points

Heating Equipment Type	Heating Multiplier Ducted	Heating Multiplier Hydronic	Heating Multiplier Baseboard	Cooling Multiplier Ducted	Cooling Multiplier Hydronic
Oil	N/A	N/A	N/A	N/A	N/A
Natural Gas	67	66	N/A	67	66
L. P. Gas	N/A	N/A	N/A	N/A	N/A
Electric Res.	225	220	216	67	66
Heat Pump	95	93	N/A	67	66

Table 5-18 TARGET and DESIGN HVAC Equipment Multipliers

Housing Type: Single Family Detached
Jurisdiction: District of Columbia

	Heating Equipment Type					Cooling
	Oil	Gas	LPG	Elec. Res.	Heat Pump (Heating)	DX, Heat Pump (Cooling)
Ducted	N/A	5729	N/A	21364	696	672
Hydronic	N/A	5612	N/A	20928	682	658
Baseboard	--	--	--	20510	--	--

Table 5-19 TARGET Domestic Hot Water Points

Water Heating Fuel	TARGET POINTS
Oil	27235
Gas	16406
LPG	30974
Electric	35229

Table 5-20 DESIGN Domestic Hot Water Factor

Water Heating Fuel	DESIGN DHW FACTOR
Oil	13454
Gas	8925
LPG	16850
Electric	33280

Table 5-21 TARGET and DESIGN Solar Domestic Hot Water Points

Space Heating Fuel	TARGET POINTS	DESIGN POINTS					
		Active		Integral		Thermosyphon	
		1-Panel	2-Panel	1-Panel	2-Panel	1-Panel	2-Panel
Oil	27235	24150	21708	24640	22665	24133	22038
Gas	16406	14359	12740	14685	13374	14348	12958
LPG	30974	27111	24053	27725	25251	27089	24465
Electric	35229	27598	21558	28811	23925	27556	22373

Table 5-1. Point Computation Summary Form

Component	Source Equation	TARGET Heating	TARGET Cooling	DESIGN Heating	DESIGN Cooling
Ceiling Insulation	5-1,5-2	45	13	45	13
Wall Insulation	5-3,5-4	115	19	175	29
Floor Insulation	5-5,5-6	37	35	26	36
Air Infiltration	5-7,5-8	358	43	253	30
Glazing Layers	5-9,5-10	+ 189	+ 3	+ 155	+ 3
SUBTOTAL 1	Note (a)	743	113	654	111
Glazing Orientation	5-11,5-12	- 132	+ 142	- 205	+ 118
SUBTOTAL 2	Note (b)	611	255	449	229
Base Points	5-13	± +23	± -68	± +23	± -68
SUBTOTAL 3	Note (c)	634	187	472	161
HVAC Efficiency Heating Cooling	5-14,5-15	x 67	x 67	x 65	x 67
TOTAL HEATING AND COOLING POINTS	Note (d)	42478	+ 12529	30680	+ 10787
TOTAL SPACE CONDITIONING POINTS	Note (e)	55007		41467	
Domestic Hot Water Points	5-16,5-17	+ 16406		+ 12740	
TOTAL POINTS	Note (f)	71413		54207	

Complies

Notes for Table 5-1:

a) Sum the points in each column to obtain entries for the four SUBTOTAL 1 boxes.

b) Subtract the Glazing Layers Heating points and add Glazing Layers Cooling points to obtain entries for the four SUBTOTAL 2 boxes.

c) Sum the Base Points and SUBTOTAL 2 to obtain SUBTOTAL 3 entries. Note: Some Base Points may be negative. In this case, subtract them from SUBTOTAL 2.

d) Multiply Heating SUBTOTAL 3 by HVAC Heating Points to obtain TOTAL HEATING POINTS. Multiply Cooling SUBTOTAL 3 by HVAC Cooling Points to obtain TOTAL COOLING POINTS.

e) Sum TOTAL HEATING and TOTAL COOLING POINTS to obtain TOTAL SPACE CONDITIONING POINTS.

f) Sum TOTAL SPACE CONDITIONING POINTS and Domestic Hot Water Points to obtain TOTAL POINTS.

5-3 Ceiling Insulation Points Computation

The equations below are provided to determine the number of Ceiling Insulation, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Ceiling Insulation

TARGET HOME:

	Ceiling Area		TARGET Mult.				TARGET POINTS	
Heating:	1224	x	37 (TARGET Htg. Mult. (Table 5-2))	=	45288 /1000	=	45	(5-1a)
Cooling:	1224	x	11 (TARGET Clg. Mult. (Table 5-2))	=	13464 /1000	=	13	(5-1b)

DESIGN HOME: R-30

	Ceiling Area		DESIGN Mult.				DESIGN POINTS	
Heating:	1224	x	37 (DESIGN Htg. Mult. (Table 5-3))	=	45288 /1000	=	45	(5-2a)
Cooling:	1224	x	11 (DESIGN Clg. Mult. (Table 5-3))	=	13464 /1000	=	13	(5-2b)

5-4 Wall Insulation Point Computation

The equations below are provided to determine the number of Wall Insulation, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Wall Insulation

TARGET HOME: TARGET POINTS

	Wall Area		TARGET Mult.				Points	
Heating:	2088	x	55 (TARGET Htg. Mult. (Table 5-4))	=	114840 /1000	=	115	(5-3a)
Cooling:	2088	x	9 (TARGET Clg. Mult. (Table 5-4))	=	18792 /1000	=	19	(5-3b)

DESIGN HOME: R-13 DESIGN POINTS

	Wall Area		DESIGN Mult.				Points	
Heating:	2088	x	84 (DESIGN Htg. Mult. (Table 5-5))	=	175392 /1000	=	175	(5-4a)
Cooling:	2088	x	14 (DESIGN Clg. Mult. (Table 5-5))	=	29232 /1000	=	29	(5-4b)

5-5 Floor/Foundation Insulation Point Computation

The equations below are provided to determine the number of Floor/Foundation, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Floor/Foundation Insulation (Unheated Basement)

TARGET HOME: TARGET POINTS

Heating: 1280 (Component Size*) x 29 (TARGET Htg. Mult. (Table 5-6)) = 37120 /1000 = 37 (5-5a)

Cooling: 1280 (Component Size*) x 27 (TARGET Clg. Mult. (Table 5-6)) = 34560 /1000 = 35 (5-5b)

DESIGN HOME: R-13 DESIGN POINTS

Heating: 1280 (Component Size*) x 20 (DESIGN Htg. Mult. (Table 5-7)) = 25600 /1000 = 26 (5-6a)

Cooling: 1280 (Component Size*) x 28 (DESIGN Clg. Mult. (Table 5-7)) = 35840 /1000 = 36 (5-6b)

* Enter the area (sqft) for a floor over a crawlspace or unheated basement. Enter the perimeter length (ft) for slabs and heated basements.

5-6 Air Infiltration Points Computation

The equations below are provided to determine the number of Air Infiltration, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Air Infiltration

TARGET HOME:

	Floor Area		Multiplier				Target Points	
Heating:	2504	x	143 (TARGET Htg. Mult. (Table 5-8))	=	358072/1000	=	358	(5-7a)
Cooling:	2504	x	17 (TARGET Clg. Mult. (Table 5-8))	=	42568 /1000	=	43	(5-7b)

DESIGN HOME: (Tight Package)

	Floor Area		Multiplier				Design Points	
Heating:	2504	x	101 (DESIGN Htg. Mult. (Table 5-9))	=	252904/1000	=	253	(5-8a)
Cooling:	2504	x	12 (DESIGN Clg. Mult. (Table 5-9))	=	30048 /1000	=	30	(5-8b)

5-7 Fenestration Layers and Sash Material Points Computation

The equations below are provided to determine the number of Fenestration Layers and Sash Material, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Window Layers and Sash Material

TARGET HOME: TARGET POINTS

Heating: 2504 (Floor Area) x 75 (TARGET Htg. Mult. (Table 5-10)) = 187800/1000 = 188 (5-9a)

Cooling: 2504 (Floor Area) x 1 (TARGET Clg. Mult. (Table 5-10)) = 2504 /1000 = 3 (5-9b)

DESIGN HOME: (Double w/o TB) DESIGN POINTS

Heating: 248 (Window Area) x 625 (DESIGN Htg. Mult. (Table 5-11)) = 155000 /1000 = 155 (5-10a)

Cooling: 248 (Window Area) x 12 (DESIGN Clg. Mult. (Table 5-11)) = 2976 /1000 = 3 (5-10b)

5-8 Glazing Area and Orientation Point Computation

The equations below are provided to determine the number of Glazing Area and Orientation Design Heating and Cooling Points. Values for the Target Heating and Cooling Points, and the Design Multipliers (Option and Overhang) are provided by the ARES Computer Program.

TARGET Point Calculation - Fenestration Area and Orientation

TARGET HOME: TARGET POINTS

Heating: 2504 (Floor Area) 132 (Table 5-12) (5-11a)

Cooling: 2504 (Floor Area) 142 (Table 5-12) (5-11b)

DESIGN Point Calculation - Fenestration Area and Orientation

DESIGN HOME: HEATING CALCULATION

Orientation	Glazing Area		Energy Option Multiplier (Table 5-13)		Overhang Multiplier (Table 5-14)		Fenestration Factor (F)
North	50	x	35	x	10	/ 100 =	175
Northwest		x		x		/ 100 =	
East	120	x	56	x	11	/ 100 =	739
Southeast		x		x		/ 100 =	
South	25	x	98	x	12	/ 100 =	294
Southwest		x		x		/ 100 =	
West	53	x	55	x	11	/ 100 =	321
Northwest		x		x		/ 100 =	

+

Total HEATING Fenestration Factor (F) 1529

DESIGN Points: 205 (5-12a)
(Table 5-15)

DESIGN HOME: COOLING CALCULATION

Orientation	Glazing Area		Energy Option Multiplier (Table 5-13)		Overhang Multiplier (Table 5-14)		Fenestration Factor (F)
North	50	x	26	x	10	/ 100 =	130
Northwest		x		x		/ 100 =	
East	120	x	40	x	11	/ 100 =	528
Southeast		x		x		/ 100 =	
South	25	x	39	x	13	/ 100 =	127
Southwest		x		x		/ 100 =	
West	53	x	48	x	11	/ 100 =	280
Northwest		x		x		/ 100 =	

+

Total COOLING Fenestration Factor (F) 1065

DESIGN Points: 118 (5-12b)
(Table 5-15)

5-9 Base Load Computation

The equations below are provided to determine the number of Base Load Heating and Cooling Points. Values for the Heating and Cooling Multipliers are provided by the ARES Computer Program.

Point Calculation - Base Load

	Floor Area		Multiplier (Table 5-16)				TOTAL POINTS	
Heating:	2504	x	9 (Heating Multiplier)	=	22536/1000	=	23	(5-13a)
Cooling:	2504	x	-27 (Cooling Multiplier)	=	-67608/1000	=	-68	(5-13b)

5-10 HVAC Equipment and System Efficiency Point Computation

The equations below are provided to determine the number of HVAC Systems, Target and Design, Heating and Cooling Points. Values for Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Mechanical Equipment

TARGET HOME: (Ducted Gas Furnace) w/ DX AC

	TARGET POINTS (Table 5-17)	
Heating:	67	(5-14a)
Cooling:	67	(5-14a)

DESIGN HOME:

	Equipment Multiplier (Table 5-18)		Efficiency Indicator		DESIGN POINTS	
Heating:	5729	÷	88 (AFUE)	=	65	(5-15a)
Cooling:	672	÷	10 (SEER)	=	67	(5-15b)

5-11 Domestic Hot Water Point Calculation

Values for the Target DHW Points and Design and Target Points for demonstrating compliance using Solar DHW System, are provided by the ARES Computer Program. The ARES Computer Program is also used to determine the DHW Multiplier in calculating the Design DHW Points.

Point Calculation - Nonsolar Domestic Water Heating

TARGET HOME:

TARGET POINTS

~~16406~~ (Table 5-19) (5-16a)

NA

DESIGN HOME:

DESIGN POINTS

______ DHW Multiplier (Table 5-20) ÷ ______ Energy Factor = ______ (5-16b)

Point Calculation - Solar Domestic Water Heating

TARGET HOME:

TARGET POINTS

16406 (Table 5-21) (5-17a)

DESIGN HOME:

(Active, 2-Panel system)

DESIGN POINTS

12740 (Table 5-21) (5-17b)