Title
DOE-2 REFERENCE MANUAL

Author
Horak, H.L.

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DOE – 2

SUPPLEMENT

Version 2.1D

Simulation Research Group
Center for Building Science
Applied Science Division
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

June 1989

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DISCLAIMER

IMPORTANT MESSAGE

This package of updates to the DOE-2 documentation brings the previously published materials (with the exception of the *Users Guide*) up to Version 2.1D of the DOE-2 program. The user may verify that the program being used is 2.1D by checking the first page of the output and also the upper right hand heading of any output page of the computer printout.

Volume I

DOE-2 BDL Summary and *Users Guide*

Replace the old *BDL Summary,* Version 2.1C, dated May 1984, with the enclosed 2.1D version. This revised document contains an integrated listing of all of the DOE-2 commands and keywords. It also has a listing and brief description of all of the summary and verification reports, and a listing of the DOE-2 materials library. The *Users Guide* is not being updated.

Volume II

DOE-2 Sample Run Book

Replace the old *DOE-2 Sample Run Book,* Version 2.1C, dated May 1984, with the enclosed 2.1D version.

Volume III

DOE-2 Supplement

Replace the old *DOE-2 Supplement,,* Version 2.1C, dated May 1984, with the enclosed 2.1D version. The new Supplement incorporates documentation for the 2.1B, 2.1C, and 2.1D versions of the program; it is to be used in conjunction with the *DOE-2 Reference Manual.*

DOE-2 Reference Manual, Part 1

Follow the instructions in **UPDATE TO THE DOE-2 REFERENCE MANUAL,** next page.

CBS/ICE Users Guide

Documentation for the CBS/ICE program, which is part of the DOE-2.1D PLANT program, may be ordered from the University of Texas at Austin. Phone (512) 471-7792 for information or write:

The CBS/ICE Program
Center for Energy Studies
Balcones Research Center
10100 Burnett Road
Austin, TX 78758

UPDATE TO THE DOE-2 REFERENCE MANUAL

1. Replace the title page with the enclosed revised title page dated June 1989.

2. The *DOE-2 Supplement*, Version 2.1D, contains instructions for using the new 2.1B, 2.1C, and 2.1D features and enhancements to existing commands and keywords. In order to alert readers to the existence of new commands, keywords, and meanings, and to direct them to the *Supplement*, it is necessary to amend the *DOE-2 Reference Manual* in the following manner:

   - Insert the enclosed sheets A, B, C, D, and E immediately before the Table of Contents for II BDL, III LOADS, IV SYSTEMS, V PLANT and VI ECONOMICS, respectively.

   - In the *DOE-2 Reference Manual*, highlight or otherwise emphasize each of the commands and keywords listed in the columns "Existing Command" and "Associated Keyword" on sheets A, B, C, D, and E. This will act as a signal that more information concerning the command/keyword can be found in the *Supplement*.

DOE – 2

REFERENCE MANUAL

(Version 2.1D)

Part 1

Group Q-11, Solar Energy Group
Los Alamos National Laboratory
Los Alamos, NM 87545

Simulation Research Group
Applied Science Division
Lawrence Berkeley Laboratory
Berkeley, CA 94720

Edited by Don A. York, Charlene C. Cappiello, Karen H. Olson, and Kathleen Ellington

June 1989

Sheet A. – BDL

The following commands have been upgraded or added in the DOE-2.1B, DOE-2.1C, and DOE-2.1D versions of the program. They should be noted or high-lighted in the body of the text to indicate the existence of new keywords. Please consult the *The DOE-2 Supplement* for discussion and use of these new features.

RM Page	Existing Command	Associated Keyword	New Commands/ Keywords	*Suppl.* Page
II.15	INPUT	—	INPUT–UNITS OUTPUT–UNITS	1-27
	and			
	PARAMETRIC–INPUT	—	INPUT–UNITS OUTPUT–UNITS	1-27
—	—	—	FUNCTION command ASSIGN command CALCULATE command END–FUNCTION command	1-1

Sheet B. – LOADS

The following commands/keywords have been upgraded or added in the DOE-2.1B, DOE-2.1C, and DOE-2.1D versions of the program. They should be noted or high-lighted in the body of the text to indicate the existence of new commands, keywords, and meanings. Please consult the *DOE-2 Supplement* for discussion and use of the new features. Refer to the Supplement page numbers listed below.

RM Page	Existing Command	Associated Keyword	New Commands/ Keywords	*Suppl.* Page
III.30	BUILDING–LOCATION	—	X–REF Y–REF	2-63
		—	ATM–MOISTURE ATM–TURBIDITY	2-33
		—	SHIELDING–COEF TERRAIN–PAR1 TERRAIN–PAR2 WS–TERRAIN–PAR1 WS–TERRAIN–PAR2 WS–HEIGHT	2-74
		—	FUNCTION DAYL-FUNCTION	1-1
III.35	BUILDING–SHADE	—	SHADE–VIS–REFL SHADE–GND–REFL	2-33
		—	FIXED–SHADE command SHADE–SCHEDULE	2-63
III.42	SPACE–CONDITIONS	LIGHTING–TYPE LIGHT–TO–SPACE	LIGHT–TO–OTHER LIGHT–HEAT–TO LIGHT–TO–RETURN LIGHT–RAD–FRAC	2-69
		INF–METHOD	HOR–LEAK–FRAC NEUTRAL–LEVEL FRAC–LEAK–AREA	2-63
		—	DAYLIGHTING and associated keywords	2-33
		—	SUNSPACE	2-1
		—	AREA/PERSON	ii
III.80	CONSTRUCTION	—	WALL–PARAMETERS and WALL–PARAMETERS command	2-1 and 2-60

RM Page	Existing Command	Associated Keyword	New Commands/ Keywords	*Suppl.* Page
III.87	GLASS–TYPE	GLASS–CONDUCTANCE	INSIDE–EMISS	2-77
		—	VIS–TRANS	2-33
		GLASS–TYPE–CODE	Value = 0	2-1
III.94	SPACE	MULTIPLIER	FLOOR–MULTIPLIER	2-81
		—	FUNCTION	1-1
		—	DAYL–ILLUM–FN	1-1
		—	DAYL–LTCTRL–FN	1-1
III.100	EXTERIOR–WALL	—	SHADING–SURFACE	2-63
			INSIDE–VIS–REFL	2-33
		—	TROMBE–WALL command	2-60
		—	INSIDE–SOL–ABS	2-1
		—	FUNCTION	1-1
III.107	WINDOW	—	MAX–SOLAR–SCH SUN–CTRL–PROB CONDUCT–TMIN–SCH WIN–SHADE–TYPE VIS–TRANS–SCH GLARE–CTRL–PROB INSIDE–VIS–REFL	2-33
		—	Overhang and fin keywords	2-63
		—	SOL–TRANS–SCH	2-1
		—	OPEN–SHADE–SCH	2-31
		—	FUNCTION WINDOW–SPEC–FN	1-1
		SKY–FORM–FACTOR GND–FORM–FACTOR	automatically calculated when overhang or other shading device is present	2-68

RM Page	Existing Command	Associated Keyword	New Commands/ Keywords	*Suppl.* Page
III.110	DOOR	—	INSIDE–VIS–REFL	2-33
		—	Overhang and fin keywords	2-63
		—	FUNCTION	1-1
III.113	INTERIOR–WALL	—	INT–WALL–TYPE	2-81
		—	INSIDE–VIS–REFL	2-33
		—	X Y Z AZIMUTH INSIDE–SOL–ABS	2-1
III.118	UNDERGROUND–WALL	—	INSIDE–VIS–REFL	2-33
		—	INSIDE–SOL–ABS	2-1
		—	FUNCTION	1-1
III.123	LOADS–REPORT	VERIFICATION	LV–L and LV–M code-words	C-18
		SUMMARY	LS–G through LS–L code-words	C-38
		—	REPORT–FREQUENCY	1-25
		—	HOURLY–DATA–SAVE	1-26

Sheet C. – SYSTEMS

The following commands/keywords have been upgraded, added, or deleted in the DOE-2.1B, DOE-2.1C, and DOE-2.1D versions of the program. They should be noted or high-lighted in the body of the text to indicate the existence of new commands, keywords, and meanings. Please consult the *DOE-2 Supplement* for discussion and use of the new features.

RM Page	Existing Command	Associated Keyword	New Commands/ Keywords	*Suppl.* Page
IV.180	CURVE–FIT	—	OUTPUT–MIN OUTPUT–MAX	3-21
IV.188	ZONE–AIR	AIR–CHANGES/HR CFM/SQFT		3-23
		—	SS–VENT–SCH SS–VENT–T–SCH SS–VENT–CST SS–VENT–WND SS–VENT–TEMP SS–VENT–LIMIT–T SS–VENT–KW SS–FLOW–SCH SS–FLOW–T–SCH	2-1
IV.193	ZONE–CONTROL	HEAT–TEMP–SCH BASEBOARD–CTRL THROTTLING–RANGE		3-21
IV.198	ZONE	MIN–CFM–RATIO	MIN–CFM–SCH	3-22
		MULTIPLIER	FLOOR–MULTIPLIER	2-81
		BASEBOARD–RATING		3-21
		—	TROM–VENT–SCH	2-60
		—	INDUCED–AIR–ZONE TERMINAL–TYPE REHEAT–DELTA–T	3-1
		—	REFG–ZONE–LOAD and associated keywords	3-6
		—	ZONE-FANS command	3-1
		—	FUNCTION	1-3
IV.203	SYSTEM–CONTROL	HEATING–SCHEDULE COOLING–SCHEDULE		3-22
		MIN–HUMIDITY MAX–HUMIDITY		3-23
		ECONO–LIMIT–T	ECONO–LOW–LIMIT	3-23

RM Page	Existing Command	Associated Keyword	New Commands/ Keywords	*Suppl.* Page
IV.215	SYSTEM–AIR	SUPPLY–CFM		3-23
			MIN–AIR–SCH	3-22
			VENT–TEMP–SCH	3-19
			VENT–METHOD	3-33
			MAX–VENT–RATE	
			HOR–VENT–FRAC	
			FRAC–VENT–AREA	
			OPEN–VENT–SCH	
IV.221	SYSTEM–FANS	—	NIGHT–VENT–CTRL	3-19
			NIGHT–VENT–SCH	
			NIGHT–VENT–DT	
			NIGHT–VENT–RATIOS	
		NIGHT–CYCLE–CTRL	— and ZONE–FANS–ONLY code-word	3-19 and 3-1
		FAN–SCHEDULE	Value = -999.0	3-17
IV.237	SYSTEM–EQUIPMENT	~~ELEC–HEAT–CAP~~	HP–SUPP–HT–CAP	3-15
		~~MAX–ELEC–T~~	HP–SUPP–SOURCE	
		—	REFG–KW–FTCOND	3-6
			REFG–KW–FPLR	
			TWR–RFACT–FRT	
			TWR–APP–FRFACT	
		—	New default curves	3-26
		—	T8–FWB1WB6	3-29
		—	T8PL–FWB1WB6	
		—	HR8–FWB1WB6	
		—	HR8PL–FWB1WB6	
		—	QREG–FWB1WB6	
		—	QREGPL–FWB1WB6	
IV.257	SYSTEM	RETURN–AIR–PATH		2-69
		SYSTEM–TYPE	PIU codeword	3-1
			PTGSD codeword	3-29
		HEAT–SOURCE	HEAT–PUMP codeword	3-15
		—	HUMIDIFIER–TYPE	3-23
		—	REFG–SIZING–RAT and assoc. keywords	3-6
		—	FUNCTION	1-3

RM Page	Existing Command	Associated Keyword	New Commands/ Keywords	*Suppl.* Page
IV.267	PLANT–ASSIGNMENT	—	FUNCTION	1-3
IV.269	SYSTEMS–REPORT	SUMMARY	SS–K through SS–O code-words	C-84
			REFG code-word	3-6
		—	REPORT–FREQUENCY	1-25
	—	—	HOURLY–DATA–SAVE	1-26
	—	—	SUBR–FUNCTIONS command	1-5

A command, keyword, or code-word with lines through it indicates that it has been removed from the program. If there is a replacement, it appears in the column to its immediate right.

Sheet D. – PLANT

The following commands/keywords have been upgraded, added, or deleted in the DOE-2.1B, DOE-2.1C, and DOE-2.1D versions of the program. They should be noted or high-lighted in the body of the text to indicate the existence of new or changed commands, keywords, and meanings. Please consult the *DOE-2 Supplement* for discussion and use of these new features.

RM Page	Existing Command	Associated Keyword	New Commands/ Keywords	*Suppl.* Page
V.22	PLANT–PARAMETERS	~~ELEC–GEN/MODE~~	COGEN–TRACK–MODE COGEN–TRACK–SCH MIN–TRACK–LOAD DIESEL–TRACK–MODE DBUN–MIN–HEAT	4-1
		~~MAX–DIESEL–EXH~~ ~~MAX–GTURB–EXH~~ ~~STURB–SPEED~~	—	
		—	DIESEL–GEN–EFF DIESEL–EXH–EFF DIESEL–J/L–EFF GTURB–GEN–EFF GTURB–EXH–EFF STURB–MECH–EFF	4-8
		—	CCIRC–SIZE–OPT HCIRC–SIZE–OPT CCIRC–PUMP–TYPE HCIRC–PUMP–TYPE CCIRC–MIN–PLR HCIRC–MIN–PLR	4-13
		—	ABSORG–HIR ABSORG–HCAPR ABSORG–FUEL ABSORG–HEAT–XEFF	4-16
		—	ENG–CH–COP ENG–CH–REC–EFF ENG–CH–FUEL ENG–CH–COND–TYPE ENG–CH–IDLE–RATIO	4-19
V.38	EQUIPMENT–QUAD	~~DIESEL–LUB–FPLR~~ ~~DIESEL–JAC–FPLR~~ ~~DIESEL–STACK–FU~~	—	4-8
		~~GTURB–EXH–FT~~ ~~GTURB–I/O–FT~~ ~~GTURB–STACK–FU~~ ~~GTURB–TEX–FT~~		
		ABSOR1–HIR–FPLR	—	

		—	DIESEL–I/O–FPLR DIESEL–EXH–FPLR DIESEL–TEX–FPLR DIESEL–JCLB–FPLR GTURB–CAP–FT GTURB–I/O–FPLR GTURB–EXH–FPLR GTURB–TEX–FPLR STURB–ENTH–FPIX STURB–I/O–FPLR	
		—	ABSORG–CAP–FT ABSORG–HIR–FT ABSORG–HIR–FPLR ABSORG–HIR1–FTI ABSORG–HCAP–FQC	
		—	ENG–CH–CAP–FT ENG–CH–COP–FPLR1 ENG–CH–COP–FPLR2 ENG–CH–COP–FT ENG–CH–HREJ–FPLR ENG–CH–HREJ–FT ENG–CH–COP–FTS ENG–CH–COP–FPLRS	
V.52	LOAD–ASSIGNMENT	—		4-1
V.66	HEAT–RECOVERY		—	4-1
V.83	~~ENERGY–COST~~		ENERGY–RESOURCE command	4-14
V.100	PLANT–REPORT	VERIFICATION SUMMARY	~~PV–D~~, ~~PV–H~~ code-words ~~PS–J~~ code-word	4-14
		—	REPORT–FREQUENCY	1-25
		—	HOURLY–DATA–SAVE	1-26
V.115	SOLAR–EQUIPMENT	The solar equipment program has been replaced by the ice storage program. Please refer to the "CBS/ICE Users Guide", available from the University of Texas at Austin, Center for Energy Studies, Balcones Research Center, 10100 Burnett Road, Austin, TX 78758.		

A command, keyword, or code-word with lines through it indicates that it has been removed from the program. If there is a replacement, it appears in the column to its immediate right.

Sheet E. – ECONOMICS

The following commands/keywords have been added or upgraded in the DOE-2.1B, DOE-2.1C, and DOE-2.1D versions of the program. They should be noted or high-lighted in the body of the text to indicate the existence of new commands, keywords, and code-words. Please consult the *DOE-2 Supplement* for discussion and use of these new features.

RM Page	Existing Command	Associated Keyword	New Commands/ Keywords	*Suppl.* Page
—	—	—	DAY–CHARGE–SCH command	5-1
			WEEK–SCHEDULE command	
			SCHEDULE command	
			ENERGY–COST command	
			CHARGE–ASSIGNMENT command	
			COST–PARAMETERS command	
VI.12	ECONOMICS–REPORT	VERIFICATION SUMMARY	EV–B code-word ES–D, ES–E, ES–F code-words	

THE DOE–2 USER NEWS

DOE-2: A COMPUTER PROGRAM FOR BUILDING ENERGY SIMULATION

PUB-439
Vol. No.
Version 2.1D

The Simulation Research Group at Lawrence Berkeley Laboratory publishes a quarterly newsletter, the *DOE-2 User News.* The newsletter offers articles of interest on DOE-2, bug fixes, updates to documentation, a directory of program-related software, etc. To be put on the *User News* distribution list, please fill in your name and address below and mail this form to:

Ms. Jan Carter
National Energy Software Center
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439
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LBL—8706 Suppl., Rev. 5

DOE – 2

SUPPLEMENT

Version 2.1D

Simulation Research Group
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TABLE OF CONTENTS

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* indicates new feature in DOE-2.1D

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* indicates new feature in DOE-2.1D

SYSTEMS

PLANT

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* indicates new feature in DOE-2.1D

SYSTEMS Verification Reports

PLANT Verification Reports

PLANT Summary Reports

ECONOMICS Verification Reports

ECONOMICS Summary Reports

INTRODUCTION

This publication updates the 2.1C version of the **DOE-2 Supplement** and is a companion volume to the *DOE-2 Reference Manual*, Version 2.1A, dated May 1981. It contains detailed discussions and instructions for using the new features and enhancements introduced into the 2.1B, 2.1C, and 2.1D versions of the program. It assumes a thorough understanding of the DOE-2 Reference Manual, and is not intended for stand-alone use by new users of the program.

Asterisks next to articles in the Table of Contents indicate that these are associated with new features in version DOE-2.1D, to distinguish them from the previous 2.1B and 2.1C material.

Appendix A to this volume is an updated listing of all of the Hourly Report Variables available in the program. This new listing replaces the three individual lists found in the *DOE-2 Reference Manual* under the HOURLY–REPORT command at the end of LOADS, SYSTEMS, and PLANT.

Appendix C is an updated description of the verification and summary reports available in the program. It replaces Chapter VII, Reports, in the *DOE-2 Reference Manual.*

In addition to the *DOE-2 Reference Manual* and this *DOE-2 Supplement*, there are four other publications that provide information on DOE-2. The *DOE-2 BDL Summary*, Version 2.1D, contains an integrated listing of all of the DOE-2 commands and keywords together with their abbreviations, defaults, minimums, and maximums. The *DOE-2 Sample Run Book*, Version 2.1D, contains DOE-2 inputs and output examples for a variety of buildings. The *DOE-2 Engineers Manual*, Version 2.1A, describes the equations and algorithms used in the DOE-2 calculations. The quarterly *DOE-2 User News* contains articles on building performance modeling, new DOE-2 features, bug fixes, and documentation ordering information; it also has a directory of DOE-2 related software and services.

ACKNOWLEDGMENTS

The desiccant cooling, engine-driven chiller, and gas-fired absorption chiller models in DOE-2.1D were developed in collaboration with Robert Henninger of the GARD Division of the Chamberlain Manufacturing Corporation and Douglas Kosar of the Gas Research Institute, with support from the Gas Research Institute.

CBS/ICE, the component-based ice storage model in DOE-2.1D, was developed by Scott Silver, Jerold Jones, John Peterson, Andre Milbitz, and Bruce Hunn of the Center for Energy Studies of the University of Texas at Austin, with support from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Steven D. Gates, was the principal consultant for the Plant Cogeneration and the Refrigerated Case Work algorithms in DOE-2.1C.

We also wish to express our appreciation for the work done by the RAMSES Group, University of Paris-South in Orsay, France, on the metrification of DOE-2.

MISCELLANEOUS CHANGES

Version 2.1D

The following minor changes in DOE-2 have been made in addition to the major enhancements described later in this Supplement.

Changes to BDL

(1) The default for ABORT is now ERRORS instead of CAUTIONS.

(2) The default for DIAGNOSTIC is now WARNINGS instead of COMMENTS.

(3) DOE-2 now accepts "tabs" input using your editor. In past versions, the program would give an error message whenever it encountered a tab.

(4) DOE-2 now accepts both lower and upper case letters in all commands, keywords, values, and symbols. Previously, only upper case letters were permitted. It will also accept lower and upper case letters in u-names but will treat the form in which they are entered as unique. For example, a u-name entered as "Zone-1" would not be recognized if it was later referenced as "ZONE-1".

Changes to LOADS

(1) The number of RUN–PERIODS allowed has been increased from 12 to 15.

(2) The start and stop dates that the program uses for daylight savings in the U.S. will now be determined by the year of the RUN–PERIOD. For years prior to 1987, the start date will be the last Sunday in April and the end date will be the last Sunday in October. For 1987 and later, the start date will be the first Sunday in April and the end date will remain the last Sunday in October.

(3) The number of SCHEDULES allowed has been increased as follows:

DAY–SCHEDULES is now 80 instead of 60;

WEEK–SCHEDULES is now 80 instead of 60;

SCHEDULES is now 60 instead of 40.

(4) Under SPACE–CONDITIONS we have added a new keyword, AREA/PERSON, which eliminates calculating the NUMBER–OF–PEOPLE for each space.

(5) In the LOADS hourly report for VARIABLE–TYPE = u-name of WINDOW, the heat gain due to solar energy absorbed in the glass and conducted into the space has been moved from variable #17, *Conduction heat gain through window*, to variable #15, *Heat gain by solar radiation through window* (See Appendix A, p. A.13). This change has *not* been made to the glass loads given in the Summary Reports (LS–B, LS–C, LS–E and LS–F); in these reports, as before, "Glass Conduction" includes solar absorbed in the glass and

conducted into the space, and "Glass Solar" is transmitted solar only.

(6) The inputs for internal heat gains allowed for UNCONDITIONED and PLENUM spaces need to be clarified:

All SPACE–CONDITIONS keywords are allowed in *both* UNCONDITIONED *and* PLENUM spaces.

See **Changes to SYSTEMS** for SYSTEMS keywords that are applicable to UNCONDITIONED and PLENUM zones.

Changes to SYSTEMS

(1) The keywords in SYSTEMS that apply to UNCONDITIONED and PLENUM zones are as follows:

Keyword	UNCONDITIONED	PLENUM
MULTIPLIER	YES	YES
BASEBOARD–RATING	NO	YES
DESIGN–HEAT–T	YES	YES
DESIGN–COOL–T	YES	YES
HEAT–TEMP–SCH	NO	YES
COOL–TEMP–SCH	NO	YES
BASEBOARD–CTRL	NO	YES
THROTTLING–RANGE	NO	YES
SIZING–OPTION	YES	YES
EXHAUST–CFM	NO	YES
ZONE–FAN–CFM	NO	YES
Residential Ventilation Keywords	YES	YES

(2) Report SS-J now shows the *peak integrated cooling load for a 24-hour period* as well as the day of the year that it occurs (which may not be the same day as the peak one-hour cooling load). This 24-hour integrated value should be of help in sizing thermal energy storage systems. One word of caution, however: the user should still look to see if there are hours of "loads not met", and if there are, increase the capacity of the system until they are minimized.

(3) The default for SIZING–OPTION for *ALL* system types is now NON–COINCIDENT. The reason for this change is the substantial reduction in lighting levels and better window treatment that most designers use today. When automatic sizing is done in DOE-2 SYSTEMS, the low peak sensible loads cause air flows that are so low that DOE-2 reports many hours of "loads not met". Most inexperienced users cannot understand why DOE-2 gives these unexpected results, and the problem is only exacerbated when using SIZING–OPTION = COINCIDENT. If the number of hours with "loads not met" is still too high with SIZING–OPTION = NON–COINCIDENT, the user should increase air-side system capacity by setting SIZING–RATIO greater than 1.0.

(4) The default RETURN–AIR–PATH = DIRECT for system types SZRH, MZS, TPIU, FPIU, HVSYS, and PZS remains as before. However, all systems that normally pick up heat gain from return air light fixtures now default to RETURN–AIR–PATH = DUCT.

Changes to PLANT

The DOE-2.1C version of PLANT was substantially upgraded to include (1) a very sophisticated approach to the allocation of loads to electrical generators and chillers for cogeneration, (2) simpler functional forms for the input/output relationships of these generators, and (3) variable-speed, optionally-sized pumps. The calculation of energy costs has been shifted from PLANT to ECONOMICS so that income from the sale of electricity produced by on-site generators is now possible. The PLANT routine now creates a file of 8760 hours of energy use and ECONOMICS reads this file to calculate energy costs that involve time-of-day and ratcheted demand charges. See, p. 5.1, **EXPANDED TREATMENT OF ENERGY COSTS**, in this Supplement.

The DOE-2.1C options for the control of electrical generators are an extension of the work described in the documentation of DOE-2.1B. The keywords and techniques for invoking the 2.1B options (i.e. ELEC–GEN–MODE and the use of negative NUMBERs in a LOAD–ASSIGNMENT) have been eliminated.

The program feature of DIRECT–COOL, which refers to the strainer cycle and thermo cycle on centrifugals, has never been a satisfactory model. **We have removed this capability from DOE-2.**

References to past versions of DOE-2, e.g. DOE-2.1C, apply to that version and all later versions, unless otherwise stated. Where such specific references are made, it is to indicate to the user the program version in which a new feature first appeared.

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FUNCTIONAL VALUES IN LOADS AND SYSTEMS

The Functional Value feature allows users to modify the DOE-2 LOADS and SYSTEMS calculations without recompiling the program.

This feature is entirely optional; it should not be attempted by the beginning user.

There are two types of applications of Functional Values:

(1) Calculation of variables that influence the program results, thus allowing the user to modify or replace the algorithms used by the program without recompiling the program.

(2) Calculation of variables for reporting or debugging purposes.

Functional Values are input by the user in BDL. The user specifies the values to be calculated and where in the hourly simulation they are to be used. In order to use Functional Values, the user must have access to the LOADS and SYSTEMS simulation variables, their definitions, and the locations of the final calculation of their values. Appendix B in this Supplement contains flowcharts showing the calculational sequence and looping structure of LOADS and SYSTEMS. Note that not all of the LOADS and SYSTEMS subroutines are accessible. For the exact location of function access points, consult the Compiler Listing, described below, and look for CALLs to subroutine FINTL in LOADS and subroutine FINTS in SYSTEMS. To determine the location and method of calculation of accessible variables, the flowcharts should be used in conjunction with

1) the LOADS and SYSTEMS Global Variables Listings, which list the DOE-2 internal variables that are accessible to functions,

2) the Cross-Reference Listing of LOADS and SYSTEMS Global Variables, which shows where in each subroutine a variable is used or set,

3) the Compiler Listing of Subroutines That Contain Function Access Points, to determine the location and method of calculation of accessible variables, and

4) the Subroutine Call Tree.

These four listings are available as print files on the program tape; they reside on File 28, LDSDOC.SRC, and File 29, SYSDOC.SRC. Request your computer operations personnel to print out these files if you plan to use the Functional Values capability; these tools are essential to the use of the feature. See also the LOADS and SYSTEMS sections of the DOE-2 Engineers Manual for detailed algorithm descriptions.

Functions are referenced within the hourly loop of the program and, therefore, will be calculated each hour of the input run period.

The new commands and keywords associated with Functional Values are described below. The input sequence (for a function which modifies a window calculation in LOADS) looks like:

```
INPUT LOADS ..
     .
     .
W-1       =  WINDOW
               .
               .
                          FUNCTION=(*NONE*,*FNW-1*) ..  Invoke function calculation
                                                        for this window
             .
             .
END ..
             .
             .
               FUNCTION  NAME=FNW-1 ..
ASSIGN
             .  assign variable names
             .  ..
CALCULATE ..
  FORTRAN-like routine
END-FUNCTION ..
COMPUTE LOADS ..
```

Before reading the following descriptions it will be helpful to briefly review the LOADS and SYSTEMS function examples at the end of this section. Additional examples can be found in the DOE-2 Sample Run Book under the Medical Building and Daylighting sample runs.

FUNCTION

FUNCTION tells LOADS or SYSTEMS that the data to follow specify the characteristics of a function. Allowable number of FUNCTIONs is 100. Note: FUNCTIONs must be specified after the END command and before the COMPUTE LOADS or COMPUTE SYSTEMS command.

NAME specifies a unique user-assigned name for the function (up to 16 alphanumeric characters).

FUNCTION is also used as a *keyword* in LOADS for the BUILDING–LOCATION, SPACE, EXTERIOR–WALL, DOOR, WINDOW, and UNDERGROUND–WALL commands, and in SYSTEMS for the ZONE, SYSTEM and PLANT–ASSIGNMENT commands:

BUILDING–LOCATION, SPACE, EXTERIOR–WALL, DOOR, WINDOW, UNDERGROUND–WALL, ZONE, SYSTEM, PLANT–ASSIGNMENT

FUNCTION takes two arguments: *u-name1* and *u-name2*. Assigning u-name1 means that the calculation of the function with NAME = u-name1 will be done *before* the execution of the subroutine associated with the function (see LOADS, Example 3, below). Assigning u-name2 means that the calculation of the function with NAME = u-name2 will be done *after* the subroutine's execution (see LOADS, Example 1, below). If both u-names are assigned, the function with u-name1 will be calculated before, and the function with u-name2 will be calculated after the subroutine's execution (see LOADS, Example 6, below). If only one argument is specified, the other must be entered as *NONE*.

There are four optional keywords for special-use functions in LOADS:

BUILDING–LOCATION

DAYL–FUNCTION is the special function executed in LOADS subroutine DEXTIL. This subroutine determines the hourly exterior horizontal illuminance for the daylighting simulation.

SPACE

DAYL–ILLUM–FN is the special function executed in LOADS subroutine DINTIL. This subroutine determines the hourly daylight illuminance and glare index at each reference point in a space (see LOADS Example 4).

DAYL–LTCTRL–FN is the special function executed in LOADS subroutine DLTSYS. This subroutine determines the electric lighting reduction in response to daylight illuminance at each reference point in a space (see the Daylighting Example in the Sample Run Book).

WINDOW

WINDOW–SPEC–FN is the special function used in LOADS subroutines CALWIN, DCOF, DINTIL, and DREFLT. This function is used to alter variables involved in the daylighting calculation. WINDOW–SPEC–FN takes only *one* u-name, surrounded by asterisks, but without parentheses.

The following command allows functions to be executed in user-specified subroutines in the SYSTEMS program:

SUBR–FUNCTIONS

SUBR–FUNCTIONS tells SYSTEMS in which subroutines a function calculation is to be performed.

The SUBR–FUNCTIONS command has the following keywords:

BERNOU–1	DOUBLE–1	HVUNIT–1Z	SUM–3Z
CFMINF–0	EBAL–0	HVUNIT–2	SUM–4Z
CFMINF–1	EBAL–1	HVUNIT–3	SUM–5
CONCHN	ECONO–1	INDUC–0	SZCI–0
DAYCLS–1	ECONO–2	INDUC–1Z	SZCI–1Z
DAYCLS–2	ECONO–3	INDUC–2	SZCI–2
DAYCLS–3	ECONO–4	OPSTRT	TDVPIU–0
DAYCLS–4	FANPWR	PANEL–0Z	TDVPIU–1
DAYCLS–5	FCOIL–0	PANEL–1	TEMDEV–0
DAYCLS–6	FCOIL–1Z	PIU–0	TEMDEV–1
DDSF–0	FCOIL–2Z	PIU–1	TEMDEV–2
DDSF–1	FCOIL–3	PTAC–0	TEMDEV–3
DESFO–0	FTDEV	PTAC–1Z	TSOLVE–0
DESFO–1	FNSYS1–1	PTAC–2	TSOLVE–1
DESIGN	FNSYS1–2Z	RESYS–0	UNITH–0
DESIND–0	FNSYS1–3Z	RESYS–1Z	UNITH–1Z
DESIND–1	FNSYS1–4Z	RESYS–2Z	UNITH–2Z
DESPIU–0	FNSYS1–5	RESYS–3Z	UNITH–3
DESPIU–1	FURNAC	RESYS–4Z	UNITV–0
DKTEMP–0	HE	RESYS–5	UNITV–1Z
DKTEMP–1	HOURIN	SDSF–0	UNITV–2
DKTEMP–2	HPUNIT	SDSF–1	VARVOL–0
DKTEMP–3	HTPUMP–0Z	SSBASB	VARVOL–1Z
DOETRM–0	HTPUMP–1Z	SSFCOR	VARVOL–2
DOETRM–1	HTPUMP–2	SUM–1	VARVOL–3
DOUBLE–0	HVUNIT–0	SUM–2Z	

These keywords are named after SYSTEMS subroutines. They take only one u-name (that of a function) surrounded by asterisks, but without parentheses.

Example:

```
INPUT SYSTEMS ..
     .
     .
SUBR-FUNCTIONS   FCOIL-0    =    *FN0*
                 FCOIL-1Z   =    *FN1*
                 FCOIL-3    =    *FN3* ..
     .
     .
END ..

FUNCTION   NAME   =   FN0
     .
     .
END-FUNCTION ..
FUNCTION   NAME   =   FN1
     .
     .
END-FUNCTION ..
FUNCTION   NAME   =   FN3
     .
     .
END-FUNCTION ..
COMPUTE SYSTEMS ..
```

ASSIGN

ASSIGN Variables used within the function are declared through the use of the ASSIGN command. These assignments are made through the definition of *local variable names* (1 to 7-character names chosen by the user) or *table variable names.*

local variable name =

(1) simulation variable from the Global Variables Listing, which contains variables used in the DOE-2 LOADS and SYSTEMS programs. For example, in ASSIGN WS=WNDSPD, WS is the local variable name chosen by the user and WNDSPD is the simulation variable, selected from the Global Variables Listing, corresponding to windspeed.

(2) numeric value.

(3) previously defined PARAMETER name that is set equal to a numeric constant.

(4) the keyword **SCHEDULE–NAME** (u-name of a previously defined schedule) so that for the date and hour in question, the schedule value will be used within the function. This overwrites the value in the original SCHEDULE for that hour for the rest of the run. For example,

```
PEOP1 = SCHEDULE (.....) ..
        .
        .

SOUTH = SPACE    PEOPLE–SCHEDULE = PEOP1
                 FUNCTION = (*SPXX*,*NONE*)
        .
        .  ..
END ..

FUNCTION              NAME = SPXX ..
ASSIGN        Y = SCHEDULE–NAME(PEOP1)
        .
        .  ..
```

::

(5) the keyword **SCHEDULE**(global variable name) where the global variable name is that pointer found in the Global Variables Listing which corresponds to a previously defined SCHEDULE. The schedule value for the hour in question will be used (without overwriting the original value). Changing the example above, the input would be:

```
ASSIGN Y = SCHEDULE(KZPPL) ..
```

::

(6) previously defined PARAMETER name that is set equal to a SCHEDULE–NAME u-name. The schedule value for the hour in question will be used. For example,

```
PARAMETER    VTMULT = TVIS–SCH–1 ..
                .
                .
TVIS–SCH–1      =    SCHEDULE    THRU DEC 31 (ALL)(1,24)(.35) ..
                .
                .
WINDOW       VIS–TRANS–SCH = TVIS–SCH–1
             FUNCTION = (*WINXX*,*NONE*)
                       .
                       .
END ..

FUNCTION                  NAME = WINXX ..
ASSIGN       Y = SCHEDULE–NAME(VTMULT) ..
        .
        .  ..
```

or

table variable name =

values associated with the piecewise linear interpolation of curves defined through the keyword TABLE (see the following example).

TABLE

This keyword specifies x-y pairs of data points which define a curve that is to be piecewise linearly interpolated to enable the calculation of y-values, given x-values in the function. The x-values should be in increasing order. There is no limit on the number of pairs which define the curve. Also, each TABLE keyword should have its own ASSIGN command. Mixing of TABLE and the other ASSIGN forms is not permitted. The x-y arguments can be defined through the use of the DOE-2 PARAMETER technique if desired.

In the CALCULATE section of a FUNCTION, the utility routine PWL returns the y-value of the piecewise linear curve given the x-value and the table variable name, as shown in the following example:

```
FUNCTION  NAME = FN-1  ..
ASSIGN    X1 = simulation variable from Global Variables Listing
ASSIGN    TAB1 = TABLE (0.,10) (.2,20) (.4,30)
                       (.6,36) (.8,38) (1.0,40)   ..
   .
   .
CALCULATE  ..
      Y1 = PWL(TAB1,X1)
           .
           .
      END
END-FUNCTION  ..

----+----1----+----2----+----3----+----4----+----5----+----6----+
```

In this function, the value of Y1 is determined from the value of X1 by linear interpolation between the points (0.,10), (.2,20), etc., defined by TABLE. For example, if X1 = 0.1, then Y1 = 15. (If X1 is outside the range of x-values in TABLE, PWL linearly extrapolates to get the corresponding Y1 value.) See LOADS Example 4 for another example of using TABLE.

CALCULATE

CALCULATE

The CALCULATE command informs the LOADS program that the following statements, which are written in a pseudo-FORTRAN language, are to be used to define the function. The valid FORTRAN declarative and executable statements and operations are given in Table 1.1. Also presented is a subprogram called PWL which performs the piecewise linear interpolation discussed above under the ASSIGN command.

All statements following the CALCULATE command must begin in or after column 7, except for statement numbers which begin in column 1. Column 6 is used to designate the continuation of a statement as in standard FORTRAN. The executable statement END terminates the CALCULATE section and must be present. Variables used in the FUNCTION are all classified as real; other types do not exist. Integers may be used, but they will be treated as real.

END–FUNCTION

END–FUNCTION

This command informs the LOADS or SYSTEMS program that the function definition is complete.

TABLE 1.1

VALID FORTRAN STATEMENTS AND OPERATIONS

Arithmetic Operators	+, –, /, *, **, =, (,)		
Logical Operators	OR, AND, NOT, EQ, NE, GT, GE, LT, LE		
Executable Statements	CONTINUE	GO TO	RETURN
	END	IF	REWIND
	ENDFILE	PRINT	STOP(2)
		READ(1)	WRITE(3)

(1) unformatted or formatted

(2) For debugging only; program stops execution without printing reports

(3) unformatted or formatted

Declarative Statements	FORMAT	SUBROUTINE	
Standard Functions	ABS (x)	AMIN (x1, x2)	EXP (x)
	ALOG (x)	AMOD (x1, x2)	INT (x)
	ALOG10 (x)	ATAN (x)	SIN (x)
	AMAX (x1, x2)	COS (x)	SQRT (x)

Library Functions

ACCESS (ixaa) : ACCESS(ixaa) returns the value of AA(ixaa) from the program's blank common array.

GETAA (naa) : IX = GETAA(NAA) gets a block of memory (of NAA words) in the program's main blank common array (the AA, or IA array) for exclusive use by functions, and IX is set to value pointing to the beginning of the block. Any value can be stored inside this block by using

XX = STORE(XX, IX+ccc)

or

XX = ISTORE(XX, IX+ccc)

and may be retrieved by using

XX = ACCESS(IX+ccc)

or

XX = IACCESS(IX+ccc)

where ccc = between 0 and NAA–1.

H (dbt, humrat, press)	:	returns Specific enthalpy (BTU/LB) of air as a function of Drybulb temp (F), Humidity ratio (LBS-WTR/LBS-AIR), Pressure (IN-Hg).
IACCESS (ixia)	:	like ACCESS() but returns IA(ixia).
ISTORE (val, ixia)	:	X = ISTORE(X, IXIA) will convert the value of X into integer and then store it at IA(ixia) in program's blank common array.
PWL (table, x)	:	Piecewise linear interpolation function.
RAND (0)	:	RAND(0) returns a random number in the range [0,1].
STORE (val, ixaa)	:	X = STORE(X, IXIA) will store the value of X at AA(ixaa) in the program's blank common array.
V (dbt, humrat)	:	returns specific volume of air (LBS/CUFT) as a function of Drybulb temp (F), Humidity ratio (LBS-WTR/LBS-AIR).

Note : the following four library functions are available only in systems functions.

CVAL (MC , x, y)	:	evaluates the curve stored in the curve block pointed by MC. x and y are the independent variables.
RHFUNC (dbt, humrat, press)	:	returns Relative humidity (%) as a function of Drybulb temp (F), Humidity ratio (LBS-WTR/LBS-AIR), Pressure (IN-Hg)
WBFS (dbt, humrat, press)	:	returns Wetbulb temp (F) as a function of Drybulb temp (F), Humidity ratio (LBS-WTR/LBS-AIR), Pressure (IN-Hg) .
WFUNC (dbt, RelHum, press)	:	returns Humidity ratio (LBS-WTR/LBS-AIR) as a function of Drybulb temp (F), Relative Humidity (%), Pressure (IN-Hg).

LOADS Functional Value Examples

LOADS Example 1. This function prints out the incident solar radiation and outside surface temperature of an exterior wall.

```
EW1 = EXTERIOR-WALL
                                                      Applicable
          .                                           Exterior Wall
          .
          .

      FUNCTION = (*NONE*,*FNEW1*)    ..

 .
 .
 .

END ..

FUNCTION  NAME  = FNEW1  ..

ASSIGN
          QI = SOLI
          TO = T   ..

CALCULATE  ..

ote:  Begin the FUNCTION statements in column 7 or later)

      PRINT 100, QI,TO
100   FORMAT(1H ,2F12.3)
      END                  (required)

END-FUNCTION  ..

COMPUTE LOADS  ..

----+----1----+----2----+----3----+----4----+----5----+----6----+
```

LOADS Example 2. This function models a hypothetical ventilation system in which the infiltration airflow through a window is adjusted each hour to cancel the solar and conduction heat gain through the window.

```
WINDOW-1  = WINDOW
                                                          Applicable
                 .                                          Window
                 .
                 .
             FUNCTION = (*NONE*,*FNWIN1*)   ..
   .
   .
   .
END   ..
FUNCTION     NAME   = FNWIN1   ..
ASSIGN
             TO  = DBTR
             TS  = TZONER
             PR  = PATM
             QS  = QSOLG
             QC  = QCON
             CI  = CFMW     ..
CALCULATE    ..

C  Add solar gain and conductance through window

        X = QS + QC

C  If solar plus conduction gain is less than or equal to zero,
C  or outside warmer than inside, don't alter infiltration

        IF (X .LE. 0.0) GO TO 80
        IF (TO .GE. TS) GO TO 80

C  Calculate infiltration CFM

        DEN = PR/(.754*TZONER)
        CI  = X/(14.4*DEN*(TO-TS))
80      CONTINUE
        END

END-FUNCTION   ..
COMPUTE LOADS    ..

----+----1----+----2----+----3----+----4----+----5----+----6----+
```

LOADS Example 3. This function redefines the outside film heat transfer coefficient of an exterior wall so that wind direction is accounted for. It uses Kimura's algorithm to get local windspeed at the wall surface as a function of global windspeed (from the weather file) and orientation of wall with respect to the global wind direction (Kimura, *Scientific Basis of Air Conditioning,* 1977, p.85ff)

```
EW-2 = EXTERIOR-WALL
             .                                              Applicable
             .                                              Exterior Wall
             .
      FUNCTION = (*FNEW2*,*NONE*)   ..
  .
  .
  .
END  ..
FUNCTION NAME = FNEW2  ..
ASSIGN
          WS = WNDSPD
          WD = WNDDRR
          WA = XSAZM
          FU = FILMU   ..
CALCULATE  ..

      RWD = WA + 3.1415 - WD
      IF(RWD .GT. 3.1415) RWD = 6.283 - RWD

C  Convert global windspeed from knots to M/S
      VV = .553*WS

C  Get windspeed at wall surface
      IF(RWD .LT. 1.5708 .AND. VV .GT. 2.) VC = .25*VV
      IF(RWD .LT. 1.5708 .AND. VV .LE. 2.) VC = .5
      IF(RWD .GE. 1.5708) VC = .3 + .05*VV

C  Convert back to knots
      VC = 1.808*VC

C  Combined convective plus radiative air film conductance
C  for roughness = 3 (see Engineers Manual, p.III.59)
      FU = 1.90 + .38*VC
      END

END-FUNCTION  ..
COMPUTE LOADS  ..
----+----1----+----2----+----3----+----4----+----5----+----6----+
```

LOADS Example 4. This function calculates daylight levels in a space using coefficients obtained by the user from physical scale model measurements of the ratio of interior to exterior illuminance. In the function, the coefficients are multiplied by the hourly total exterior illuminance from sun and sky to give the interior daylight illuminance. The measured coefficients for solar altitudes of 0, 10, 30, 50, and 70 degrees are entered using TABLE.

Note 1. This function assumes there are no movable shading devices on the windows which would alter the interior illuminance depending on whether the shades were open or closed.

Note 2. This function does not re-calculate glare, so that the glare levels reported by the program should be ignored.

Note 3. This function is illustrative only; the coefficients in an actual case could also depend on other factors, such as solar azimuth, cloud cover, etc.

```
SPACE1 = SPACE
       .                                               Applicable
       .                                                  Space
    DAYLIGHTING = YES
       .
       .  other daylighting-related keywords
       .
    DAYL-ILLUM-FN = (*NONE*,*MODEL-DATA-FN*)     ..
 .
 .
 .
END  ..
FUNCTION   NAME = MODEL-DATA-FN  ..
ASSIGN
   RDNCC    = RDNCC              $ DIRECT NORMAL SOLAR RADIATION, $
                                 $ BTUH/SF $
   BSCC     = BSCC               $ SKY DIFFUSE SOLAR RADIATION $
                                 $ ON HORIZONTAL, BTUH/SF $
   RAYCOS3  = RAYCOS3            $ SINE OF SOLAR ALTITUDE $
   PHSUND   = PHSUND             $ SOLAR ALTITUDE IN DEGREES $
   ILLUM    = DAYLIGHT-ILLUM1    $ DAYLICHT ILLUMINANCE AT REF PT 1 $
                                 $ FOOTCANDLES (REF PT 2 NOT USED) $  ..
ASSIGN
   TAB1 = TABLE (0,0)(10,.005)(30,.007)(50,.0085) (70,.01)(90,.01)
CALCULATE  ..
```

```
C  Exterior horizontal illuminance from direct sun in footcandles
C  (=Lumens/SF).  Assumes that the luminous efficacy of direct
C  solar radiation = 100 Lumens/Watt = 29.3 Lumens/BTUH)
      IDIRH = RDNCC * RAYCOS3 * 29.3


C  Exterior horizontal illluminance  from sky.
C  (Assumes that the luminous efficacy of diffuse solar
C  radiation = 125 Lumens/Watt = 36.6 Lumens/BTUH.)
      IDIFH = BSCC * 36.6


C  Total exterior illuminance
      ITOTH = IDIRH + IDIFH


C  Interior daylight illuminance for current solar altitude
      ILLUM = PWL (TAB1,PHSUND) * ITOTH
      END

END-FUNCTION   ..
COMPUTE LOADS   ..

----+----1----+----2----+----3----+----4----+----5----+----6----+
```

LOADS Example 5: This function demonstrates looping logic.

```
SPACE1 = SPACE
        .                                               Applicable
        .                                                  Space
        .
    FUNCTION = (*NONE*,*SP-FN-TEST-1*)    ..
  .
  .
  .
END  ..
FUNCTION   NAME  = SP-FN-TEST-1  ..
ASSIGN
     DAY    = IDAY     MZ       = MZ
     HR     = IHR      MZEXT    = MZEXT
     LMX    = LMX      NEXTS    = NEXTS
     LMWI   = LMWI     QZTOT    = QZTOT
     MON    = IMO      S        = SCHEDULE(SCHED-1)
     MWI    = MWI      WIAREA   = WIAREA
     MX     = MX       XSQCOMP  = XSQCOMP
     MXWIN  = MXWIN    YR       = IYR
                       ZAREA    = ZFLRAR  ..
CALCULATE  ..

        PRINT 1
1       FORMAT(21H TEST OF SP-FN-TEST-1)
        PRINT 2, YR,MON,DAY,HR,S
2       FORMAT(1X,4F10.1,F8.2)
        PRINT 3, ZAREA,QZTOT
3       FORMAT(10X,6HZAREA=,F6.1,5X,6HQZTOT=,F8.1)


C  Initialize EXTERIOR-WALL pointer and counter.
       MX=MZEXT
       NX=0


C  Loop through EXTERIOR-WALLS.
100    NX=NX+1


C  Increment EXTERIOR-WALL count and exit
C  EXTERIOR-WALL loop if finished
       IF(NX .GT. NEXTS)GO TO 900
       PRINT 4, NX,XSQCOMP
4      FORMAT(30X,3HNX=,F3.0,8HXSQCOMP=,F10.1)
```

```
C   Initialize window pointer and counter.
                MWI=MXWIN
                NW=0

C   Increment window counter and exit window loop if finished
200             NW=NW+1
                IF(NW .GT. NWIN) GO TO 400
                     PRINT 5, NW, WIAREA
5                    FORMAT(40X,3HNW=,F3.0,3X,7HWIAREA=,F10.1)

C   Increment window pointer to get next window
                     MWI=MWI+LMWI
                     GO TO 200
400             CONTINUE

C   Increment EXTERIOR-WALL pointer to get next EXTERIOR-WALL.
      MX=MX+LMX
      GO TO 100
900   CONTINUE

C   Stop simulation at hour 9.
      IF(HR .EQ. 9) STOP
      END

END-FUNCTION   ..
COMPUTE LOADS   ..

----+----1----+----2----+----3----+----4----+----5----+----6----+
```

LOADS Example 6. This function is used to vary the shading coefficient of a window depending on the value, RTOT, of the total (direct plus diffuse) solar radiation incident on the window. If RTOT $\leq$ 10 Btuh/ft^2, the window is "clear" (shading coefficient = 0.8). As RTOT increases from 10 to 100 Btuh/ft^2, the window is darkens, reaching a shading coefficient of 0.2 at 100 Btuh/ft^2. For RTOT > 100 Btuh/ft^2, the shading coefficient remains at 0.2.

```
WINDOW-1 = WINDOW
                                                    Applicable
        .                                             Window
        .
        .
     FUNCTION = (*WSCSGC*, *PRINTQ*) ..
 .
 .
 .
END ..
FUNCTION NAME = WSCSGC ..
ASSIGN
    RTOT     = RTOT
    SHACO    = GSHACO
    GSHACOE  = GSHACO-EDTT ..
CALCULATE ..
C  Calculate shading coefficient
    SHACO = -0.00667*RTOT + 0.8667
    IF (RTOT.LE.10.) SHACO=0.8
    IF (RTOT.GE.100.) SHACO=0.2
       END
END-FUNCTION ..
FUNCTION NAME = PRINTQ ..
ASSIGN
    HR       = ISCHR
    IPRDFL   = IPRDFL
    SHACO    = GSHACO
    RTOT     = RTOT ..
CALCULATE ..
C  PRINTQ is used at the end of the subroutine's execution;
C  its purpose in this example is to verify values generated
C  by WSCSGC.  Don't print any values until building startup
C  is complete.  IPRDFL is a counter used for building startup.
C  When the building has cycled through three days, IPRDFL goes
C  to 0 (zero).  Print values between the hours of 6 and 21 only.
       IF(IPRDFL.GT.0.)RETURN
       IF((HR.LT.6.).OR.(HR.GT.21.))RETURN
```

```
C   Standard FORTRAN print statement
        PRINT 20,HR,RTOT,SHACO
   20   FORMAT(1X,3HHR=,F3.0,3X,5HRTOT=,F8.2,3X,6HSHACO=,F8.3/)
        END

END-FUNCTION   ..

COMPUTE LOADS   ..
----+----1----+----2----+----3----+----4----+----5----+----6----+
```

Note: More input/output examples may be found in the DOE–2 Sample Run Book under the Medical Building and Daylighting examples.

SYSTEMS Functional Value Examples

SYSTEMS Example 1:
In this example the return air temperature is used to reset the cold-deck supply air temperature to the reheat coils in a Reheat Fan System. Here, TRLAST is the last-hour value of the return air temperature, TR, which is stored by the function "SFN1".

```
INPUT SYSTEMS ..

SUBR-FUNCTIONS    DKTEMP-3=*DKTEMPF*   .. $ modifying subroutine DKTEMP at
                                          $ function access point DKTEMP-3

FS-SYS= SYSTEM     SYSTEM-TYPE=RHFS

                   FUNCTION=(*NONE*,*SFN1*) .. $ systems-after-function SFN1
                                               $ is used to save the value
                                               $ of TR to be used next hour
                                               $ by the function DKTEMPF

END ..
FUNCTION  NAME=DKTEMPF ..
$
$ This function resets the cold-deck temperature according to the
$ return air temperature.
$ The reset characteristic obeys the following piecewise linear
$ (PWL) relationship between TC and TR:
$
$    TC ^
$       |
$    70 +-----\
$       |      \
$    60 +       \
$       |        \
$    50 +         \-----
$       |
$       +-+---+---+---->
$         60  70  80   TR (deg F)
$
  ASSIGN  IHR=IHR  IDAY=IDAY  IMO=IMO  INILZE=INILZE ..
  ASSIGN  TR=TR    $ return air temp $
          TC=TC    $ cold-deck  temp $ ..
  ASSIGN  TRLAST = F-SYS-VAR1 .. $  where last-hour TR value is stored $
  ASSIGN  TCTR=TABLE (0,70) (70,70) (80,50) (100,50) .. $ for the PWL function $
                                                        $ of TC vs TR $
  CALCULATE ..
c--if TRLAST not available, do nothing
      IF ( TRLAST .EQ. 0. )    RETURN
c--compute cold-deck temperature
      TC = PWL( TCTR, TRLAST )
```

```
c
c--the following four lines can be un-commented to get debug print
c       IF ( INILZE .LT. 4 )     RETURN    { if initalization cycle, don't print }
c       IF ( (IDAY .NE. 7) .OR. (IMO .NE. 7) ) RETURN { print only one day =JUL 7 }
c       PRINT 1, IMO, IDAY, IHR, TC, TR
c     1 FORMAT(' DKTEMPF -- IMO,IDAY,IHR=',3f3.0,' TC=',f7.2,' TR=',f7.2)
        END

END-FUNCTION ..
FUNCTION  NAME=SFN1    ..
$ This function stores the value of the return air temperature (TR)
$ so that the function 'DKTEMPF' can use it next hour.
   ASSIGN  TR=TR   $ return air temp $
   ASSIGN  TRLAST = F-SYS-VAR1 .. $ where the last-hour TR value is stored $
   CALCULATE ..
c--store return air temperature
        TRLAST = TR
        END
END-FUNCTION ..
COMPUTE SYSTEMS ..
STOP ..

----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8---
```

SYSTEMS Example 2:
A drybulb economizer is modeled that sets the outside air fraction to minimum if the outside air temperature exceeds the return air temperature.

```
INPUT SYSTEMS ..
      .
      .
SUBR-FUNCTIONS    ECONO-2=*econoFNa*   ..  $ to modify subroutine ECONO at
                                           $ function access point ECONO-2
      .
      .
END  ..

FUNCTION  NAME=econoFNa                  ..
  ASSIGN     IHR=IHR   IDAY=IDAY   IMO=IMO   INILZE=INILZE
             PO       = PO                 $ outside-air fraction$
             TR       = TR                 $ return-air temp$
             POMXXX   = POMXXX             $ min outside-air-fraction$
             TAPPXX   = TAPPXX             $ requested mixed-air temp$
             DBT      = DBT                $ outside drybulb temp$
             ECONOLT  = ECONO-LIMIT-T      $ from BDL input$
             ECONOLL  = ECONO-LOW-LIMIT    $ from BDL input$
             MAXOA    = MAX-OA-FRACTION    $ from BDL input$
                ..

  CALCULATE ..
c--first compute PO to satisfy TAPPXX and limit it depending on bounds
      PO = POMXXX
      IF( ABS( DBT-TR ) .gt. 0.1 )
     1        PO = AMAX( POMXXX, (TAPPXX-TR)/(DBT-TR) )
      PO = AMIN( PO, MAXOA )
      IF( (ECONOLL .ne. 0) .and. (DBT .lt. ECONOLL) )  PO = POMXXX
      IF( (ECONOLT .ne. 0) .and. (DBT .ge. ECONOLT) )  PO = POMXXX
c--set oa fraction to min if oa temp greater than return air temp
      IF( DBT .GT. TR)  PO = POMXXX
c
c--the following six lines can be un-commented to get debug print
c     IF ( INILZE .LT. 4 )   RETURN     { if initialization cycle, don't print }
c     PRINT 1, IMO,IDAY,IHR, POMXXX,TAPPXX, ECONOLT, ECONOLL, MAXOA, PO
c    1        , TR, DBT
c 1   FORMAT( ' econoFN-- ',3f3.0,'  POMXXX,TAPPXX=',f5.2,f6.2,
c    1        '  ECONOLT=',f5.2,'  ECONOLL=',f5.2,'  MAXOA=',f5.2,
c    2        '  PO=',f5.2,'  TR=',f5.2,'  DBT=',f5.2 )
      END
END-FUNCTION ..
COMPUTE SYSTEMS    ..
STOP  ..

----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8---
```

SYSTEMS Example 3:
We model an enthalpy economizer that sets the outside air fraction to minimum if the outside air enthalpy is greater than a setpoint value.

```
INPUT SYSTEMS ..
      .
      .
SUBR-FUNCTIONS    ECONO-2=*econoFNb*   ..   $ modifying subroutine ECONO at
                                            $ function access point ECONO-2
      .
      .
END   ..

FUNCTION  NAME=econoFNb   ..

  ASSIGN    IHR=IHR  IDAY=IDAY  IMO=IMO  INILZE=INILZE  ..
  ASSIGN    ENTHSET = 30                $ setpoint for outside air enthalpy stat $
            ENTHAL  = ENTHAL            $ outside air enthalpy $
            PO      = PO                $ outside-air fraction $
            TR      = TR                $ return-air temp      $
            TAPPXX  = TAPPXX            $ requested mixed-air temp $
            POMXXX  = POMXXX            $ min outside-air fraction $
            DBT     = DBT               $ outside drybulb temp $
            ECONOLT = ECONO-LIMIT-T     $ from BDL input $
            ECONOLL = ECONO-LOW-LIMIT   $ from BDL input $
            MAXOA   = MAX-OA-FRACTION   $ from BDL input $

  CALCULATE  ..
c--first compute PO to satisfy TAPPXX and limit it depending on bounds
      PO = POMXXX
      IF( ABS( DBT-TR ) .gt. 0.1 )
     1         PO = AMAX( POMXXX, (TAPPXX-TR)/(DBT-TR) )
      PO = AMIN( PO, MAXOA )
      IF( (ECONOLL .ne. 0) .and. (DBT .lt. ECONOLL) )  PO = POMXXX
      IF( (ECONOLT .ne. 0) .and. (DBT .ge. ECONOLT) )  PO = POMXXX
c--now set oa fraction to minimum if oa enthalpy exceeds setpoint
      IF( ENTHAL .gt. ENTHSET )  PO = POMXXX
c
c--the following six lines can be un-commented for debug print
c     IF ( INILZE .lt. 4 )   RETURN     { if initialization cycle, don't print }
c     PRINT 1, IMO,IDAY,IHR, POMXXX,TAPPXX, ECONOLT, ECONOLL, MAXOA, PO
c    1          , TR, DBT
c 1   FORMAT( ' econoFN-- ',3f3.0,'  POMXXX,TAPPXX=',f5.2,f6.2,
c    1      '  ECONOLT=',f5.2,'  ECONOLL=',f5.2,'  MAXOA=',f5.2,
c    2      '  PO=',f5.2,'  TR=',f5.2,'  DBT=',f5.2 )
      END
END-FUNCTION  ..
COMPUTE SYSTEMS   ..
STOP  ..

----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8---
```

HOURLY REPORT FREQUENCIES AND SUMMARIES

There is a keyword in the LOADS–REPORT, SYSTEMS–REPORT, and PLANT–REPORT commands that allows the user to control the frequency at which hourly report data are printed.

REPORT–FREQUENCY may be set to HOURLY (the default), DAILY, MONTHLY, or YEARLY. If REPORT–FREQUENCY is not specified, the program will generate reports with the same format as before except that summary values (minimum, maximum, total, and average) will be printed at the end of each day and month, and at the end of the run period specified in the REPORT–SCHEDULE. When REPORT–FREQUENCY is set to DAILY, the hourly data are suppressed and only summary values are printed for each day and at the end of the month and run period. Similarly, when REPORT–FREQUENCY is set to MONTHLY, only the summary statistics for months and the run period are printed. Specifying frequency equal to YEARLY results in a single summary report covering the entire run period. Only scheduled hours are included in the summaries.

Example:

```
LOADS–REPORT       VERIFICATION = (LV-A)
                   SUMMARY = (SS-A,SS-E)
                   REPORT–FREQUENCY = DAILY  ..

REPORT–BLOCK
       .
       . ..

HOURLY–REPORT
       .
       . ..
```

- -

When REPORT–FREQUENCY is used in conjunction with the HOURLY–REPORT keyword, OPTION = PLOT, only the TOTAL values are plotted. If REPORT–FREQUENCY is not specified, i.e., hourly data are printed, the plots are unchanged.

Note that some averages may be misleading, e.g., the average solar altitude if the schedule contains nighttime hours during which the solar altitude values are zero.

Example output may be found in the DOE-2 Sample Run Book under the Daylighting and Sunspace examples.

SAVING FILES OF HOURLY OUTPUT FOR POSTPROCESSING

An option has been added to DOE-2.1D to create binary files of hourly report data. These files can then be read by a user-provided postprocessor program that does statistical analysis or manipulates the data to produce customized tables, graphs, histograms, etc.

To use this option, specify HOURLY–DATA–SAVE=YES in the LOADS–REPORT, SYSTEMS–REPORT, and/or PLANT–REPORT commands. This will automatically set REPORT–FREQUENCY equal to MONTHLY. Specify only one HOURLY–REPORT for each program section (LOADS, SYSTEMS, and/or PLANT). For each HOURLY–REPORT you can use up to 30 REPORT–BLOCKS with up to a total of 64 VARIABLE–LIST items. The hourly report data will be written in binary form to the file CECDT*n*.BIN. One record is written for each hour. The record begins with the month, day, and hour (as in the printed hourly reports, the hour is not corrected for daylight savings). It continues with item 1 from the first REPORT–BLOCK specified in the HOURLY–REPORT command, then item 2, through all items of the first REPORT–BLOCK, and so on through all REPORT–BLOCKS. The header information from the hourly reports is written to a formatted (human-readable) file, CECPRO.FMT, and to a binary file, CECHR*n*.BIN. These files contain the hourly report title information, variable type and type number, variable list item number, FORTRAN format specifications and the units of the item. They also contain the DOE-2 run title, data of the run, weather file name, the number of hours of data, the number of items, and the program section number. (The program section number, IPRO, is 1 for LOADS, 2 for SYSTEMS, and 3 for PLANT.) CECDT*n*.BIN and CECHR*n*.BIN are written once per program section and *n* is then incremented.

METRIC OPTION

With the metric option it is possible to enter and have reported out numerical values in metric units. In addition, metric output units can be requested from an English unit input deck, and vice versa. The metric units employed by DOE-2 are those used by professionals in Europe; they differ slightly from those of the International System of Units. The ranges and defaults have been calculated from the DOE-2 English ranges and defaults. The table at the end of this section indicates the unit conversion from English to metric.

To invoke the metric option, specify the following keywords in the **INPUT** or **PARAMETRIC–INPUT** command at the beginning of each subprogram:

INPUT–UNITS informs the particular subprogram of the type of units being input. It takes the codewords ENGLISH and METRIC; ENGLISH is the default. Units are always reported as a COMMENT in the echo of the LOADS input.

OUTPUT–UNITS instructs the subprogram to report out in the unit-type specified. It takes the codewords ENGLISH and METRIC; ENGLISH is the default. Units are always reported as a COMMENT in the echo of the LOADS input.

Rule 1. Subprograms LDL, SDL, PDL, and EDL always default to English units. Therefore if the user wants metric throughout, he/she must specify INPUT–UNITS = METRIC at each level, *including* parametric runs. The program calculations are always performed in English units and all files are passed or saved in English. BDL converts metric input to English, and the Report Generators convert English to metric output. Therefore, it is also possible to switch from one unit system to the other, between subprograms, in a single run.

Rule 2. The error message "INCONSISTENCY IN BDLLIB UNIT" will result if INPUT–UNITS=METRIC but BDLLIB, the DOE-2 library, is in English units. To avoid the error, be sure BDLLIB is metric (or, if BDLLIB is not being used, delete it).

The LIBRARY–INPUT LOADS command also takes the keyword **INPUT–UNITS**, which specifies the type of units used in a library run.

Rule 1. An individual library can contain only one type of units.

Rule 2. If INPUT–UNITS = METRIC, the preassembled DOE-2 library cannot be accessed (see LAYERS and CONSTRUCTION commands), nor can it be augmented.

The metric conversion of DOE-2 was the result of the combined efforts of the RAMSES Group of the University of Paris (South) in Orsay, France, and the Simulation Research Group of Lawrence Berkeley Laboratory.

As a convenience to metric users, synonyms have been developed for keywords which contain English units as an integral part of their names. For instance, to avoid confusion in a metric input deck, LIGHTING–W/SQFT may be specified as its metric equivalent, LIGHTING–W/AREA (abbreviated as L–W–A). The following table gives the equivalent metric term which can be substituted wherever the English term is encountered in a keyword. These synonyms will also appear in the diagnostics and output reports, if the user specifies OUTPUT–UNITS = METRIC.

English	**Metric**	**Metric Abbrev.**
BTU/HR	POWER	P
CFM	FLOW	F
FCFM	FFLOW	FF
SQFT	AREA	A
THERMS	POWER	P

In addition to these synonymous keywords, there are several keywords *unique* to the metric option. Ordinarily, the values assigned to SCHEDULE commands are pure numbers (i.e., dimensionless) and do not require conversion. The two exceptions are temperature and solar radiation values. In order for BDL to convert these two types of values to metric, the DAY–SCHEDULE command *must* contain explicit directions to do so. Therefore, the following two keywords have been added under the DAY–SCHEDULE command in LOADS and SYSTEMS. In SYSTEMS, only the keyword TEMPERATURES applies.

TEMPERATURES

replaces the keyword VALUES and is required for schedules that take temperatures as input. The range is from -50.0 to 100.0°C, and there is no default. The abbreviation is TEMP. If specified in an English input deck, this keyword will have no effect.

RADIATIONS

replaces the keyword VALUES and is required for schedules that take intensity of solar radiation as input. At present, the only schedule which requires this keyword is that which is assigned to MAX–SOLAR–SCH, if this keyword is specified under the WINDOW command. (See Section "Daylighting" in this Supplement for use of this keyword.) The range is from 0.0 to 1200.0 W/m^2, and there is no default. The abbreviation is RADT. (If specified in an English input deck, this keyword will have no effect.)

For example:

```
DS1 = DAY–SCHEDULE   HOURS = (1,6)    TEMPERATURES  = (16)
                     HOURS = (7,18)   TEMPERATURES  = (21)
                     HOURS = (19,24)  TEMPERATURES  = (16) ..
DS2 = DAY–SCHEDULE   HOURS = (1,24)   RADIATIONS    = (420) ..
```

where these DAY–SCHEDULES are then assigned to WEEK–SCHEDULEs and SCHEDULEs.

Rule 1. All schedules that take °C temperatures as input must be associated with a DAY–SCHEDULE of the form:

HOURS = (. . .) TEMPERATURES = (. . .).

Rule 2. RADIATIONS should only be specified if MAX–SOLAR–SCH is input in the WINDOW command.

Rule 3. Since the TEMPERATURES and RADIATIONS keywords are required for schedules accepting non-dimensionless values, these DAY–SCHEDULEs *cannot* be nested. E.g.,

S1 = SCHEDULE THRU DEC 31 (ALL) HOURS = (1,24) TEMP = (21) . .

will produce an ERROR message since the only keyword allowed in nested SCHEDULEs is THRU; DAY–SCHEDULE must be explicitly input.

Under the SPACE–CONDITIONS command, the English keyword RES–INF–COEF has been *replaced*, for metric input only, by three keywords:

RES–INF–CST has a range from 0.0 to 20.0 (mixed units), and the default is 0.252.

RES–INF–WND has a range from 0.0 to 39.0 sec/meter, and the default is 0.0488.

RES–INF–TEMP has a range from 0.0 to 36.0 K^{-1}, and the default is 0.0151.

where

infiltration = RES–INF–CST + (RES–INF–WND × windspeed) + (RES–INF–TEMP × ΔT)

In the LOADS–REPORT command there is a report entitled

LV–M DOE–2 UNITS TABLE

which is the English/metric conversion table reproduced herein. Also note that LV–G, the schedules verification report, reports out schedules in ENGLISH units only.

In SYSTEMS, under the DAY–RESET–SCH command, the following four keywords are to be used, in the metric option only, when specifying ratios. As with temperatures, if ratios are input, all four of the keywords are required.

SUPPLY–HI–R
SUPPLY–LO–R
OUTSIDE–HI–R
OUTSIDE–LO–R

These represent output ratios to be used instead of the temperature values SUPPLY–HI,SUPPLY–LO,OUTSIDE–HI, and OUTSIDE–LO, respectively. Values of temperatures and ratios cannot be used interchangably in the metric option. Ranges are from 0.0 to 1.0, and there are no defaults.

In SYSTEMS and PLANT, under the CURVE–FIT command, the keyword:

INPUT–TYPE specifies the type of DATA being input for independent variables. It takes the codewords NON–DIMENSIONAL and TEMPERATURES; NON–DIMENSIONAL is the default. If TEMPERATURES is specified, then the values are assumed to be in °C.

Rule 1. In PLANT, under the EQUIPMENT–QUAD command, the quadratics, TWR–RFACT–FRT and TWR–APP–FRFACT, must be fitted from English input data.

Rule 2. Under the CONNECT command, if an input-name is connected to a CONSTANT value, the value must be entered in the same units as specified in the keyword OUTPUT–UNITS in the INPUT PLANT command (DOE-2.1B only; the Solar Simulator has been removed from DOE-2.1C).

Rule 3. In the Solar Simulator, whenever the keyword EFF–COEF is applicable to a component, the coefficients must be entered in ENGLISH units (DOE-2.1B only).

This report is provided for use with the metric option. It gives the conversion factors used to convert the English minimums, maximums, and default values for metric input and output.

LV–M DOE–2 UNITS TABLE (excerpt)

English	*multiplied by*	Metric	English	*multiplied by*	Metric
Btu	.292875	W-hr	gallons/min/ton	1.078	liters/min/kW
Btu/°F	1897.8	Joule/K	hr-ft^2-°F/Btu	.176228	m^2-K/W
Btu/ft-°F	6226.48	Joules/m-K	(hr-ft^2-°F/Btu)^2	.0310563	(m^2-K/W)^2
Btu/ft^2-°F	20428.4	Joules/m^2-K	inch	2.54	cm
Btu/hr-°F	.527178	W/K	inch mercury	33.8638	mbar
Btu/hr-ft^2-°F	5.67446	W/m^2-K	inch water	25.4	mm-water
Btu/hr-ft-°F	1.7296	W/m-K	knots	.51444	m/sec
Btu/hr-ft^2	3.15248	W/m^2	kW/cfm	.5885	kW/m^{3}hr
Btu/lb	.645683	W-hr/kg	lbs	.45359	kg
Btu/lb-°F	4183.83	Joule/kg-K	lb/ft^2	4.8824	kg/m^2
cfm	.4719	l/sec	lb/ft^3	16.01846	kg/m^3
cfm/ft^2	18.288	m^3/hr-m^2	lbs/in^2-gage	68.94757	mbar-gage
ΔT°F	.555556	ΔT°C	lbs/kW	.65359	kg/kW
footcandles	10.76391	lux	mph	.44704	m/sec
footlamberts	3.426259	candela/m^2	therms	25.0	thermies
ft	.3048	m	units/gal/min	.26417	units/liter/min
ft^2	.092903	m^2	units/in	.3937	units/cm
ft^3	.0283168	m^3	W/ft^2	10.76392	W/m^2
ft^3/min	1.69901	m^3/hr	1/R	1.7999	1/K
gallon	3.78541	liter	1/knots	1.94386	sec/m

INPUT MACROS

(and General Library Features)

Input Macros

A new feature called "Input Macros" has been added to the Building Description Language in DOE-2.1D. This feature increases the flexibility of BDL. It is intended for advanced users who are already familiar with preparing BDL input. The basic capabilities are:

(1) Incorporating external files containing pieces of BDL into the main BDL input stream. This is also called the "General Library" feature.

(2) Selectively accepting or skipping portions of the input.

(3) Defining a block of input with parameters and later referencing this block.

(4) Performing arithmetic and logical operations on the input.

(5) Input macro debugging and listing control.

These capabilities are invoked in BDL by using *macro commands*. Macro commands are preceded by ## to distinguish them from regular BDL commands. After execution by the BDL processor, macro commands produce regular lines of BDL input that are shown in the BDL echo print. Following are descriptions of the macro commands associated with the above capabilities. **A detailed example of input macros is given at the end of this section. The user should look at this example before reading the macro command descriptions.**

(1) Incorporating external files

##include {includefilename}

This command puts all of the lines in an external file into the BDL input stream starting right after the command line. The name of the file that is included is the concatenation of {prefixpathname}, entered using **##fileprefix**, and {includefilename}. The lines in the external file will be listed in the BDL echo so that the user can see exactly what is being included. When all the lines in the external file have been read in, input reverts back to the original input file at the line following the **##include** command.

##fileprefix {prefixpathname}

specifies a pathname that will be prefixed to the filename given in an **##include** command. The **##fileprefix** command allows commonly-used include files to be kept in a directory other than the directory in which the current DOE-2 input file resides.

Example: on VAX/VMS, the combination

##fileprefix DRC2:[GUEST.LIBRARY]

##include SCHEDULES.INP

will include into the BDL stream the file whose full name is

DRC2:[GUEST.LIBRARY]SCHEDULES.INP

##includesilent {includefilename}

This command is identical to **##include**, except that the lines in the included file will not be listed in the BDL echo.

##nosilent

Overrides the listing suppression of **##includesilent**. Used for debugging purposes only. After **##nosilent**, all following **##includesilent** commands are treated as **##include** commands.

Example: Assume the following files contain the indicated lines:

Main input file: input1.inp	External file: file2.inp
line 1a	line 2a
##include file2.inp	line 2b
line 1b	line 2c
line 1c	

The end result of processing the **##include** command will be:

```
line 1a    (from input1.inp)
line 2a      (from file2.inp)
line 2b      (from file2.inp)
line 2c      (from file2.inp)
line 1b    (from input1.inp)
line 1c    (from input1.inp)
```

External files can also contain **##include** commands, as shown in the following example:

Main input file: input1.inp	First external file: file2.inp	Second external file: file3.inp:
line 1a	line 2a	line 3a
##include file2.inp	line 2b	line 3b
line 1b	**##include** file3.inp	line 3c
line 1c	line 2c	line 3d

The end result of processing the **##include** commands will be:

```
line 1a     (from input1.inp)
line 2a       (from file2.inp)
line 2b       (from file2.inp)
line 3a          (from file3.inp)
line 3b          (from file3.inp)
line 3c          (from file3.inp)
line 3d          (from file3.inp)
line 2c       (from file2.inp)
line 1b     (from input1.inp)
line 1c     (from input1.inp)
```

Note: Up to nine **##include** commands can be nested. However, there should be no recursion; this is an example of a recursion.

file1.inp contains **##include** file2.inp

file2.inp contains **##include** file1.inp

(2) Selectively accepting or skipping lines of input

The **##if** series of commands is used to selectively accept or skip lines of input according to the following sequence:

##if {condition1}
line1a
line1b
....

##elseif {condition2}
line2a
line2b
....

##elseif {condition3}
line3a
line3b
....

##else
line*N*a
line*N*b
....

##endif

Then the lines that will be included into the BDL stream are:

line1a
line1b
.... } if {condition 1} is TRUE,

and

line2a
line2b
.... } if {condition 2} is TRUE,

and

line3a
line3b
.... } if {condition 3} is TRUE,

.
.
.

or

line*N*a
line*N*b
.... } if {condition 1}, {condition 2}, {condition 3} are all FALSE.

There are six different **##if...** commands:

Command			Result
##ifdef	{macro name}	:	if macro name defined include following lines
##ifndef	{macro name}	:	if macro name NOT defined include following lines
##if	{condition}	:	if condition is TRUE include following lines
##elseif	{condition}	:	if condition is TRUE include following lines
##else		:	indicates the else part of the if block
##endif		:	indicates the end of the if block

Notes:

{macro name} is explained in (3), below.

{condition} is 0 or BLANK meaning FALSE, and any other character meaning TRUE.

##ifdef and **##ifndef** do not have corresponding **##elseif** commands, but they do have corresponding **##else** and **##endif** commands.

(3) Defining blocks of input

The **##def** command allows a block of input text to be defined and given a name. The block of text can then be inserted anywhere in the BDL stream by simply referencing the name of the block. (This process is called "macro expansion".) The block can have parameters (also called arguments) that can be given different values each time the block is referenced.

The syntax of the **##def** command is as follows:

```
         unique name
             |
             |          zero or more arguments        -- macro text
             |            |     |     |     |          |
             |            |     |     |     |          |
             ↓            ↓     ↓     ↓     ↓          ↓
  ##def   macro-name  [ arg1  arg2, arg3  ... ]     text line 1
 ↑          ↑        ↑ ↑    ↑     ↑     ↑         ↑
 |--        |  ------| |    |-    |    -|         |
    |       |   |      |       |  |  |            |-- one or more spaces
    |       |   |      |       |  |  |
 one or more space(s)-|     space(s) or ,
```

Example: Define a macro with name "all_ones":

```
##def all_ones    SCHEDULE    THRU DEC 31
                              (ALL) (1,24) (1.0) ..

##enddef
```

Then, in the BDL input stream, when we say :

```
SCHED1=   all_ones[]   ..
                    ↑
                    |-----  the square braces
                            are required
```

the result is equivalent to:

```
SCHED1 = SCHEDULE    THRU DEC 31
                     (ALL) (1,24) (1.0) ..
```

Macro definitions may have one or more arguments; the maximum number of arguments is 32. When a macro with arguments is referenced, its arguments must be given values.

Example: Define a macro with name "sched" and argument "x":

##def sched[x] SCHEDULE THRU DEC 31 (ALL) (1,24) (x)

##enddef

Then, when we put the following in the BDL input stream

SCHED2 = sched[.20] ..
SCHED3 = sched[.33] ..

the result is equivalent to:

SCHED2 = SCHEDULE THRU DEC 31 (ALL) (1,24) (.20) ..
SCHED3 = SCHEDULE THRU DEC 31 (ALL) (1,24) (.33) ..

Macro names must be unique (except see **##set1** below); i.e., when a macro name is defined it cannot be defined again.

The macro definition commands are the following:

##def macro-name **[arg1,..,arg*n*]** macro-text

Defines a macro with the name "macro-name" and arguments "arg1" through "arg*n*". "Macro-text" is one or more lines of text.

##enddef

Indicates the end of the macro definition initiated by **##def**.

##def1 macro-name **[arg1,..,arg*n*]** macro-text

This is the same as **##def** but there is only one line of text so that the terminating command **##enddef** is not required.

##set1 macro-name macro-text

Like **##def1** but has no arguments and macro-text is evaluated before storing. "Macro-text is evaluated" means that if macro-text contains other macros, these macros will be expanded, and the expanded text becomes the macro-text defined by **##set1**.

```
Example:     ##def1   xx    123
             ##set1   yy    xx[]

      is equivalent to:
             ##set1   yy    123
```

##set1 can also be used to redefine macro-name.

```
Example:     ##set1   x     0
               .
               .
               .
             ##set1   x     #[x[]+1]
```

(4) Arithmetic Operations

The built-in macro called **#eval**[ ] can be used to perform arithmetic, literal, and logical operations. It can be abbreviated to #[ ].

#eval[**X OP Y**] or #[**X OP Y**]

Gives the result X OP Y. The allowed values for X, OP, and Y, and the corresponding result are shown in the following table.

X	OP	Y	Result
number	+	number	number
number	−	number	number
number	*	number	number
number	/	number	number
SIN	OF	number (degrees)	number
COS	OF	number (degrees)	number
TAN	OF	number (degrees)	number
SQRT	OF	number	number
ABS	OF	number	number
ASIN	OF	number	number (degrees)
ACOS	OF	number	number (degrees)
ATAN	OF	number	number (degrees)
string1	//	string2	string "string1string2"
string1	///	string2	string "string1 string2"
string	EQS	string	logical
string	NES	string	logical
logical	AND	logical	logical
logical	OR	logical	logical
0	NOT	logical	logical
number	EQ	number	logical
number	NE	number	logical
number	GT	number	logical
number	GE	number	logical
number	LT	number	logical
number	LE	number	logical

Example

#eval[1 + 2] when expanded becomes 3.

#eval[1 + **#eval**[2 * 3]] when expanded becomes 7.

Example

#set1 city Washington

TITLE LINE–1 #["large office" // city[ ]]

gives

TITLE LINE–1 "large office Washington"

The following example illustrates the use of **#eval** inside **#if**-commands:

##**if** #[city[ ] EQS "Chicago"]

##**if** #[#[city[ ] EQS "Chicago"] and #[occup[ ] NES "low"]]

Notes:

1. For logical values:

   False = 0 or BLANK,

   True = any other character

2. A string must be enclosed inside a pair of double quotes if it contains BLANKs or reserved characters like [ ] ( ) , * =

   E.g., "abc *def" String == ??

3. String concatenation operators // and /// produce quoted strings.

   E.g., #[large /// office] gives "large office"

(5) Macro debugging and listing control

##list

DEFAULT; turn on listing; echo of input lines on the OUTPUT file is enabled.

##nolist

Turn off listing; echo of input lines on the output file is disabled.

##show

Start printing expanded line on output file. After this command, if a macro expansion was done, the expanded line is printed on the output file. In this way we can see the end result of macro expansions, which is the input as seen by the BDL processor.

##noshow

DEFAULT; stop printing expanded line on output file.

##showdetail

Start printing each macro expansion. After this command, every time a macro expansion is done the result of the expansion is printed. This can produce lots of output.

##noshowdetail

DEFAULT; stop printing each macro expansion.

##traceback

DEFAULT; give full traceback when printing an error message. After this command, if there is a BDL error, a full traceback of the macro expansions in progress is printed.

##notraceback

Don't give full traceback when printing an error message.

##write

Start writing expanded text into file 22. This is similar to **##show** except that the expanded lines are written into file 22. Therefore, file 22 will contain only the text that will be seen by the BDL processor.

##nowrite

DEFAULT; stop writing expanded text into file 22.

##symboltable

Prints current macro names table. All of the macro names that are defined will be printed.

##clear

Clear all macro definitions. All the macro names defined up to this point will be deleted.

##reserve TEXT *k* NAMES *l* STACK *m*

Allocates memory.
Reserves *k* words of space in AA array for macro definition storage.
Reserves *l* positions in macro definition names table.
Reserves *m* words of stack space.

This command should be used only if one or more of the following error messages is received:

"Need more memory for storing macro definitions.
Use "**##reserve** TEXT *nnnnnn*" command to get more memory. Current value of *nnnnnn* is: _ _ _"

"macro table capacity exceeded.
Use "**##reserve** NAMES *nnnnnn*" command to get more memory. Current value of *nnnnnn* is: _ _ _"

"macro stack overflow".
Use "**##reserve** STACK *nnnnnn*" command to get more memory. Current value of *nnnnnn* is: _ _ _" If used, this command must precede other macro commands in the BDL input.

Listing format
The format of listing in DOE2.1D has been changed to give information about the status of the input macros.

```
1.1.1 * 123 * ...... DOE-2 input line
- - - ------- ---------------------------------
↑ ↑ ↑    ↑     ↑
| | |    |     |
| | |    |    echo of DOE-2 input line
| | |    |
| | |   line number ( if the current line is being skipped
| | |                 by "##if..." etc, this is
| | |                 indicated by printing "- 123 -" instead
| | |                 of "* 123 *" in the line number field )
| | |
| |macro expansion nesting level
| |
|"##if" nesting level
|
"##include" nesting level
```

Example:
This example shows the use of the **##set**, **##include**, **##eval** and **##if** commands. Let an external file called cities.lib contain the following text:

```
##if    #[city[ ] EQS CHICAGO]

   BUILDING-LOCATION   LAT=41.88
                       LON=87.63
                       ALT=600
                       T-Z=6    $Chicago$
                       ..

##elseif    #[city[ ] EQS WASHINGTON]

   BUILDING-LOCATION   LAT=38.9
                       LON=77
                       ALT=50
                       T-Z=5    $Washington$
                       ..
##else
   ERROR--City Undefined

##endif
```

Then the BDL input

```
INPUT  LOADS ..
##set1        city CHICAGO
##include     cities.lib
     .
     .
     .
```

will be converted, after macro processing, to:

```
INPUT  LOADS ..
BUILDING-LOCATION    LAT=41.88
                     LON=87.63
                     ALT=600
                     T-Z=6    $Chicago$
                     ..
     .
     .
     .
```

DOE-2.1D INPUT MACROS/LIBRARY EXAMPLE

Following is a listing of individual files. File office.inp is the DOE-2 input file; the library files that are needed by office.inp are the following: location.inp, lds_sch.inp, const.inp and sys_plt.inp.

```
$************************* file : office.inp *************************

$ ##write will write macro-processed lines in file for022.dat
##write

##set1  f_area    100000
##set1  b_vint    stock
##set1  e_vint    old
##set1  b_oper    high
##set1  city      washington

$ DOE-2.1D BDL Input for Large Office Building

INPUT LOADS ..
TITLE LINE-1= #[ "large office  " // city[] ]
      LINE-2= #[ f_area[] /// #[ b_vint[] /// #[ e_vint[] /// b_oper[] ]]]  ..

ABORT ERRORS  ..  LIST WARNINGS  ..
RUN-PERIOD        JAN 1  1982 THRU DEC 31 1982  ..

##include      location.inp

##include      lds_sch.inp

##include      const.inp

B-WALL= CONS  LA=WA1  ..    ROF=  CONS  LA=RF1  ..    PART=  CONS  LA=P1   ..
FLOOR=  CONS  LA=FL   ..    CEIL= CONS  LA=C1   ..    PANEL= CONS  LA=PA1  ..

                    $ SPACE DESCRIPTIONS $

$ sum of space areas = 599560
##set1   a_ratio    #[f_area[] / 597544]

TYP-NW-L=  SPACE  A= #[448 * a_ratio[]]
                  V= #[4480 * a_ratio[]]
                  L-W= #[1.05 + #[1.05 * a_ratio[]]]
                  E-W= #[.375 + #[.375 * a_ratio[]]]
                  N-O-P= #[4 * a_ratio[]]
                  X=38  Y=90  Z=70  AZ=135  F-W=0
                  P-SCH=OCCUP   P-H-G=450
                  L-SCH=LIGHTS  L-T-R=.3  L-T=REC-FLUOR-RV  L-T-S=.7
                  E-SCH=LIGHTS
                  I-M=AIR-CHANGE  A-C=.3  I-SCH=INFIL  ..
             E-W  CONS=B-WALL  AZ=180  H=14  W=28   ..
              WI  X=2  Y=1  H=7  W=23  G-T=GLASS1   ..
            ROOF  H=40  W=30  CONS=B-WALL  AZ=180  ..
        IN1= I-W  A=448  CONS=FLOOR  TILT=180  NEXT-TO=TYP-NW-S  S-F=(.5,.1) ..

TYP-NW-S=  SPACE  LIKE=TYP-NW-L  A= #[336 * a_ratio[]]
                  V= #[336 * #[a_ratio[] * 9]]
                  N-O-P= #[3 * a_ratio[]]
                  X=16  Y=9090  AZ=135  ..
             E-W  CONS=B-WALL  AZ=180  H=14  W=21   ..
              WI  X=2  Y=1  H=7  W=16  G-T=GLASS1   ..
             U-F  A=448  CONS=FLOOR   ..

BUILDING-RESOURCE  VERT-TRANS-KW=236  VERT-TRANS-SCH=ELEV  ..

LOADS-REPORT  S=(LS-A,LS-C)  ..
END  ..
COMPUTE LOADS  ..
##include    sys_plt.inp
STOP  ..
```

```
$************************ file : location.inp ************************

##if #[city[] eqs washington]
  BUILDING-LOCATION  LAT=38.9  LON=77   ALT=50  T-Z=5
      ATM-MOISTURE= (.90,.90,.94,1.12,1.31,1.48,1.57,1.60,1.64,1.31,1.07,.96)
      ATM-TURBIDITY=(.07,.12,.16,.16,.36,.35,.36,.53,.45,.23,.19,.21)  ..
##elseif #[city[] eqs chicago]
  BUILDING-LOCATION  LAT=41.88  LON=87.63  ALT=600  T-Z=6
      ATM-MOISTURE= (.36,.32,.40,.53,.76,1.11,1.21,1.12,.88,.66,.43,.35)
      ATM-TURBIDITY=(.15,.18,.21,.18,.18,.19,.22,.16,.16,.14,.13,.15)  ..
##else
  Abort -- City Undefined
##endif

$************************ file : lds_sch.inp ************************

$ Large Office Loads Schedules
##if   #[b_oper[] eqs low]

    insert schedules for low operation here

##elseif    #[b_oper[] eqs high]
                    $ SCHEDULES TAKEN FROM STD EVAL TECH $
OC1= D-SCH (1,7) (0) (8,24) (.1,.2,.95,.95,.95,.45,.95,.95,.95,.95,.50,
                            .3,.1,.1,.1,0,0)  ..
OC2= D-SCH (1,7) (0) (8,18) (.1,.1,.1,.1,.1,.1,.1,.1,.1,.1,.05) (19,24) (0)  ..
OC3= D-SCH (1,24) (0)  ..
OCCUP= SCH THRU DEC 31 (WD) OC1 (SAT) OC2 (SUN,HOL) OC3  .. $ PROFILE '1

LG1= D-SCH (1,6) (.05) (7,24) (.1,.3,.9,.9,.9,.9,.8,.9,.9,.9,.9,.5,.3,.3,
                              .2,.2,.05,.05)  ..
LG2= D-SCH (1,6) (.05) (7,12) (.1,.1,.1,.1,.1,.1) (13,17) (.15) (18,24) (.05)..
LIGHTS= SCH THRU DEC 31 (WD) LG1 (SAT) LG2 (SUN,HOL) OC3  ..  $ PROFILE '43

INFIL= SCH THRU DEC 31 (WD) (1,6) (1) (7,18) (0) (19,24) (1)
                       (WEH) (1,24) (1)  ..            $ MIRROR OF PROFILE '192

EL1= D-SCH (1,6) (0) (7,20) (.05,.35,.7,.45,.35,.45,.5,.5,.35,.35,.45,.6,.2,.1)
                     (21,24) (0)  ..
EL2= D-SCH (1,6) (0) (7,17) (.05,.15,.15,.2,.2,.25,.2,.15,.1,.05,.05)
                     (18,24) (0)  ..
ELEV=  SCH THRU DEC 31 (WD) EL1  (SAT) EL2  (SUN,HOL) OC3  .. $ PROFILE '128

##else
Abort -- Building Operation Undefined

##endif

$************************* file : const.inp *************************

$ large office constructions

##if    #[city[] eqs chicago]
    ##if    #[b_vint[] eqs stock]
$ chicago stock
WA1 LAYERS  MAT (CC24,AL21,GP02)  ..
RF1 LAYERS  MAT (BR01,CC24,IN35,CC16,AL32,AC03) I-F-R .61  ..
PA1 LAYERS  MAT (AS01,IN35,AL22,AC03) I-F-R .65  ..
P1  LAYERS  MAT (GP02,AL12,GP02)  ..
FL  LAYERS  MAT (CC03,CP01)  ..
C1  LAYERS  MAT (AC02)  ..
FOUND CONS  U 1.0  ..
DR1 CONS  U .19  ..
GLASS1 G-T  G-T-C 8 PANES 2 VIS-TRANS .32  .. $ 1/4 SOLARGREY 2 PANE
    ##elseif    #[b_vint[] eqs current]
$ chicago current
WA1 LAYERS  MAT (CC24,AL21,GP02)  ..
RF1 LAYERS  MAT (BR01,CC24,IN35,CC16,AL32,AC03) I-F-R .61  ..
PA1 LAYERS  MAT (AS01,IN35,AL22,AC03) I-F-R .65  ..
P1  LAYERS  MAT (GP02,AL12,GP02)  ..
FL  LAYERS  MAT (CC03,CP01)  ..
C1  LAYERS  MAT (AC02)  ..
FOUND CONS  U 1.0  ..
DR1 CONS  U .19  ..
GLASS1 G-T  G-T-C 8 PANES 2 VIS-TRANS .32  .. $ 1/4 SOLARGREY 2 PANE
    ##else
Abort -- building vintage undefined
    ##endif
```

```
##elseif    #[city[] eqs washington]
    ##if    #[b_vint[] eqs stock]
$ washington stock
$ chicago stock
WA1 LAYERS  MAT (CC24,AL21,GP02)  ..
RF1 LAYERS  MAT (BR01,CC24,IN35,CC16,AL32,AC03) I-F-R .61  ..
PA1 LAYERS  MAT (AS01,IN35,AL22,AC03) I-F-R .65  ..
P1  LAYERS  MAT (GP02,AL12,GP02)  ..
FL  LAYERS  MAT (CC03,CP01)  ..
C1  LAYERS  MAT (AC02)  ..
FOUND CONS  U 1.0  ..
DR1 CONS  U .19  ..
GLASS1 G-T  G-T-C 8 PANES 2 VIS-TRANS .32  .. $ 1/4 SOLARGREY 2 PANE

    ##elseif    #[b_vint[] eqs current]
$ washington current

    ##else
Abort -- building vintage undefined
    ##endif

##elseif    #[city[] eqs atlanta]
    ##if    #[b_vint[] eqs stock]
$ atlanta stock

    ##elseif    #[b_vint[] eqs current]
$ atlanta current
    ##else
Abort -- building vintage undefined
    ##endif

##endif

$************************** file : sys_plt.inp **************************

$large office systems and plant input

##if    #[e_vint[] eqs old]
INPUT SYSTEMS  ..
SYSTEMS-REPORT  V=(ALL-VERIFICATION)  S=(SS-D,SS-A,SS-I,SS-O)  ..

##include    sys_sch.inp

                                                   $ PROFILE '192
C-SETPT= SCH THRU DEC 31 (ALL) (1,24) (76)  ..
H-SETPT= SCH THRU DEC 31 (WD)  (1,5)  (60) (6,18) (72) (19,24) (60)
                         (WEH) (1,24) (60)  ..

ENV  ZONE-CONTROL  D-H-T=72  D-C-T=74  H-T-SCH=H-SETPT  C-T-SCH=C-SETPT
                   B-C=THERMOSTATIC  ..

TYP-NW-L=  Z  Z-C=ENV  O-CFM/P=15  CFM/SQFT=.7  M-C-R=.3  M=93  ..
TYP-NW-S=  Z  LIKE TYP-NW-L  M=62   ..

SYS1=  SYSTEM  S-TYPE=VAVS  MAX-S-T=105  MIN-S-T=55  OA-CONTROL=TEMP  E-L-T=68
               R-A-P=DUCT   F-C=INLET    MIN-F-R=.3  S-S=4.5  S-E=.55  R-S=1.5
               R-E=.47      N-C-C=CYCLE-ON-ANY       R-D-T=50  HEAT-SET-T=105
               Z-N=(TYP-NW-L,TYP-NW-S)  F-SCH=FANSON  ..
END  ..
COMPUTE SYSTEMS  ..
INPUT PLANT  ..
PLANT-REPORT   S=(PS-A,PS-B,PS-G,BEPS)  ..

HWG=  P-E  TYPE=HW-BOILER       I-N=2  SIZE=-999  ..
CHL=  P-E  TYPE=HERM-CENT-CHLR  I-N=2  SIZE=-999  ..
CTW=  P-E  TYPE=COOLING-TWR            SIZE=-999  ..

PLANT-PARAMETERS  BOILER-FUEL=NATURAL-GAS  HW-BOILER-HIR=1.33  ..
PART-LOAD-RATIO   TYPE=HERM-CENT-CHLR  E-I-R=.2  ..

END  ..
COMPUTE PLANT  ..
##elseif    #[e_vint[] eqs new]

    insert new equip description here

##else
    Abort -- Equipment Vintage Undefined
##endif
```

```
$************************* file : sys_sch.inp *************************

$ large office system schedules
##if    #[b_oper[] eqs low]

    insert system schedules for low building operation here


##elseif    #[b_oper[] eqs high]
FANSON=  SCHEDULE
   THRU APR 15 (WD) (1,6) (0) (7,18) (1) (19,24) (0) (WEH) (1,24) (0)
   THRU OCT 15 (WD) (1,6) (-1) (7,18) (1) (19,24) (-1) (WEH) (1,24) (-1)
   THRU DEC 31 (WD) (1,6) (0) (7,18) (1) (19,24) (0) (WEH) (1,24) (0) ..
##else
   Abort -- Building Operation Undefined
##endif
```

Following is the BDL listing of processing the office.inp file.

```
               ****     ***    *****           ***       *     ****
               *   *   *   *   *              *   *     **     *   *
               *   *   *   *   *****   ***       *       *     *   *
               *   *   *   *   *               **        *     *   *
               ****     ***    *****          *****  *  ***    ****

   B U I L D I N G     E N E R G Y     A N A L Y S I S     P R O G R A M
```

DEVELOPED BY

LAWRENCE BERKELEY LABORATORY/UNIVERSITY OF CALIFORNIA

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ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY
OFFICE OF BUILDINGS AND COMMUNITY SYSTEMS
BUILDING SYSTEMS DIVISION

```
                              LBL RELEASE FEB 1989
      *    1 * $************************** file : office.inp *************************
      *    2 *
      *    3 * $ ##write will write macro-processed lines in file for022.dat
      *    4 * ##write
      *    5 *
      *    6 * ##set1  f_area    100000
      *    7 * ##set1  b_vint    stock
      *    8 * ##set1  e_vint    old
      *    9 * ##set1  b_oper    high
      *   10 * ##set1  city      washington
      *   11 *
      *   12 * $ DOE-2.1D BDL Input for Large Office Building
      *   13 *
      *   14 * INPUT LOADS  ..
             L D L   P R O C E S S O R   I N P U T   D A T A
                        4/12/1989    13:45:52  LDL RUN  1



      *   15 * TITLE LINE-1= #[ "large office  " // city[] ]
      *   16 *       LINE-2= #[ f_area[] /// #[ b_vint[] /// #[ e_vint[] /// b_oper[] ]]]  ..
      *   17 *
      *   18 * ABORT ERRORS  ..  LIST WARNINGS  ..
      *   19 * RUN-PERIOD        JAN 1  1982 THRU DEC 31 1982  ..
      *   20 *
      *   21 * ##include     location.inp
1     *    1 * $************************* file : location.inp ************************
1     *    2 *
1     *    3 * ##if #[city[] eqs washington]
1.1   *    4 *   BUILDING-LOCATION  LAT=38.9  LON=77   ALT=50  T-Z=5
1.1   *    5 *       ATM-MOISTURE= (.90,.90,.94,1.12,1.31,1.48,1.57,1.60,1.64,1.31,1.07,.96)
1.1   *    6 *       ATM-TURBIDITY=(.07,.12,.16,.16,.36,.35,.36,.53,.45,.23,.19,.21)  ..
1     *    7 * ##elseif #[city[] eqs chicago]
1.1   -    8 -   BUILDING-LOCATION  LAT=41.88  LON=87.63  ALT=600  T-Z=6
1.1   -    9 -       ATM-MOISTURE= (.36,.32,.40,.53,.76,1.11,1.21,1.12,.88,.66,.43,.35)
1.1   -   10 -       ATM-TURBIDITY=(.15,.18,.21,.18,.18,.19,.22,.16,.16,.14,.13,.15)  ..
1     *   11 * ##else
1.1   -   12 -   Abort -- City Undefined
1     *   13 * ##endif
file : input2.tmp
      *   22 *
      *   23 * ##include     lds_sch.inp
1     *    1 * $************************* file : lds_sch.inp *************************
1     *    2 *
1     *    3 * $ Large Office Loads Schedules
1     *    4 * ##if   #[b_oper[] eqs low]
1.1   -    5 -
1.1   -    6 -     insert schedules for low operation here
1.1   -    7 -
1     *    8 * ##elseif    #[b_oper[] eqs high]
1.1   *    9 *                         $ SCHEDULES TAKEN FROM STD EVAL TECH $
1.1   *   10 * OC1= D-SCH (1,7) (0) (8,24) (.1,.2,.95,.95,.95,.45,.95,.95,.95,.95,.50,
1.1   *   11 *                               .3,.1,.1,.1,0,0)  ..
1.1   *   12 * OC2= D-SCH (1,7) (0) (8,18) (.1,.1,.1,.1,.1,.1,.1,.1,.1,.1,.05) (19,24) (0)  ..
1.1   *   13 * OC3= D-SCH (1,24) (0)  ..
1.1   *   14 * OCCUP= SCH THRU DEC 31 (WD) OC1 (SAT) OC2 (SUN,HOL) OC3  .. $ PROFILE '1
1.1   *   15 *
1.1   *   16 * LG1= D-SCH (1,6) (.05) (7,24) (.1,.3,.9,.9,.9,.9,.8,.9,.9,.9,.9,.5,.3,.3,
1.1   *   17 *                                 .2,.2,.05,.05)  ..
```

```
1.1   *  18 * LG2= D-SCH (1,6) (.05) (7,12) (.1,.1,.1,.1,.1,.1) (13,17) (.15) (18,24) (.05)..
1.1   *  19 * LIGHTS= SCH THRU DEC 31 (WD) LG1 (SAT) LG2 (SUN,HOL) OC3  ..  $ PROFILE '43
1.1   *  20 *
1.1   *  21 * INFIL= SCH THRU DEC 31 (WD) (1,6) (1) (7,18) (0) (19,24) (1)
1.1   *  22 *                        (WEH) (1,24) (1)  ..             $ MIRROR OF PROFILE '192
1.1   *  23 *
1.1   *  24 * EL1= D-SCH (1,6) (0) (7,20) (.05,.35,.7,.45,.35,.45,.5,.5,.35,.35,.45,.6,.2,.1)
1.1   *  25 *                     (21,24) (0)  ..
1.1   *  26 * EL2= D-SCH (1,6) (0) (7,17) (.05,.15,.15,.2,.2,.25,.2,.15,.1,.05,.05)
1.1   *  27 *                     (18,24) (0)  ..
1.1   *  28 * ELEV=  SCH THRU DEC 31 (WD) EL1  (SAT) EL2  (SUN,HOL) OC3  .. $ PROFILE '128
1.1   *  29 *
1     *  30 * ##else
1.1   -  31 - Abort -- Building Operation Undefined
1.1   -  32 -
1     *  33 * ##endif
file : input2.tmp
      *  24 *
      *  25 * ##include    const.inp

1     *   1 * $************************** file : const.inp ***************************
1     *   2 *
1     *   3 * $ large office constructions
1     *   4 *
1     *   5 * ##if    #[city[] eqs chicago]
1.1   -   6 -     ##if    #[b_vint[] eqs stock]
1.1   -   7 - $ chicago stock
1.1   -   8 - WA1 LAYERS  MAT (CC24,AL21,GP02)  ..
1.1   -   9 - RF1 LAYERS  MAT (BR01,CC24,IN35,CC16,AL32,AC03) I-F-R .61  ..
1.1   -  10 - PA1 LAYERS  MAT (AS01,IN35,AL22,AC03) I-F-R .65  ..
1.1   -  11 - P1  LAYERS  MAT (GP02,AL12,GP02)  ..
1.1   -  12 - FL  LAYERS  MAT (CC03,CP01)  ..
1.1   -  13 - C1  LAYERS  MAT (AC02)  ..
1.1   -  14 - FOUND CONS  U 1.0  ..
1.1   -  15 - DR1 CONS  U .19  ..
1.1   -  16 - GLASS1 G-T  G-T-C 8 PANES 2 VIS-TRANS .32  .. $ 1/4 SOLARGREY 2 PANE
1.1   -  17 -     ##elseif    #[b_vint[] eqs current]
1.1   -  18 - $ chicago current
1.1   -  19 - WA1 LAYERS  MAT (CC24,AL21,GP02)  ..
1.1   -  20 - RF1 LAYERS  MAT (BR01,CC24,IN35,CC16,AL32,AC03) I-F-R .61  ..
1.1   -  21 - PA1 LAYERS  MAT (AS01,IN35,AL22,AC03) I-F-R .65  ..
1.1   -  22 - P1  LAYERS  MAT (GP02,AL12,GP02)  ..
1.1   -  23 - FL  LAYERS  MAT (CC03,CP01)  ..
1.1   -  24 - C1  LAYERS  MAT (AC02)  ..
1.1   -  25 - FOUND CONS  U 1.0  ..
1.1   -  26 - DR1 CONS  U .19  ..
1.1   -  27 - GLASS1 G-T  G-T-C 8 PANES 2 VIS-TRANS .32  .. $ 1/4 SOLARGREY 2 PANE
1.1   -  28 -     ##else
1.1   -  29 - Abort -- building vintage undefined
1.1   -  30 -     ##endif
1.1   -  31 -
1     *  32 * ##elseif    #[city[] eqs washington]
1.1   *  33 *     ##if    #[b_vint[] eqs stock]
1.2   *  34 * $ washington stock
1.2   *  35 * $ chicago stock
1.2   *  36 * WA1 LAYERS  MAT (CC24,AL21,GP02)  ..
1.2   *  37 * RF1 LAYERS  MAT (BR01,CC24,IN35,CC16,AL32,AC03) I-F-R .61  ..
1.2   *  38 * PA1 LAYERS  MAT (AS01,IN35,AL22,AC03) I-F-R .65  ..
1.2   *  39 * P1  LAYERS  MAT (GP02,AL12,GP02)  ..
1.2   *  40 * FL  LAYERS  MAT (CC03,CP01)  ..
1.2   *  41 * C1  LAYERS  MAT (AC02)  ..
1.2   *  42 * FOUND CONS  U 1.0  ..
1.2   *  43 * DR1 CONS  U .19  ..
1.2   *  44 * GLASS1 G-T  G-T-C 8 PANES 2 VIS-TRANS .32  .. $ 1/4 SOLARGREY 2 PANE
1.2   *  45 *
1.1   *  46 *     ##elseif    #[b_vint[] eqs current]
1.2   -  47 - $ washington current
1.2   -  48 -
1.1   *  49 *     ##else
1.2   -  50 - Abort -- building vintage undefined
1.1   *  51 *     ##endif
1.1   *  52 *
1     *  53 * ##elseif    #[city[] eqs atlanta]
1.1   -  54 -     ##if    #[b_vint[] eqs stock]
1.1   -  55 - $ atlanta stock
1.1   -  56 -
1.1   -  57 -     ##elseif    #[b_vint[] eqs current]
1.1   -  58 - $ atlanta current
1.1   -  59 -
```

```
1.1  -  60 -     ##else
1.1  -  61 - Abort -- building vintage undefined
1.1  -  62 -     ##endif
1.1  -  63 -
1    *  64 * ##endif
file : input2.tmp
     *  26 *
     *  27 * B-WALL= CONS   LA=WA1   ..    ROF=  CONS   LA=RF1   ..    PART=  CONS   LA=P1   ..
     *  28 * FLOOR=  CONS   LA=FL    ..    CEIL= CONS   LA=C1    ..    PANEL= CONS   LA=PA1  ..
     *  29 *
     *  30 *                    $ SPACE DESCRIPTIONS $
     *  31 *
     *  32 * $ sum of space areas = 599560
     *  33 * ##set1   a_ratio   #[f_area[] / 597544]
     *  34 *
     *  35 * TYP-NW-L=  SPACE   A= #[448 * a_ratio[]]
     *  36 *                    V= #[4480 * a_ratio[]]
     *  37 *                    L-W= #[1.05 + #[1.05 * a_ratio[]]]
     *  38 *                    E-W= #[.375 + #[.375 * a_ratio[]]]
     *  39 *                    N-O-P= #[4 * a_ratio[]]
     *  40 *                    X=38  Y=90  Z=70  AZ=135  F-W=0
     *  41 *                    P-SCH=OCCUP   P-H-G=450
     *  42 *                    L-SCH=LIGHTS  L-T-R=.3  L-T=REC-FLUOR-RV  L-T-S=.7
     *  43 *                    E-SCH=LIGHTS
     *  44 *                    I-M=AIR-CHANGE  A-C=.3  I-SCH=INFIL  ..
     *  45 *               E-W  CONS=B-WALL  AZ=180  H=14  W=28    ..
     *  46 *                WI  X=2  Y=1  H=7  W=23  G-T=GLASS1    ..
     *  47 *              ROOF  H=40  W=30  CONS=B-WALL  AZ=180  ..
     *  48 *          IN1= I-W  A=448  CONS=FLOOR  TILT=180  NEXT-TO=TYP-NW-S  S-F=(.5,.1) ..
     *  49 *
     *  50 * TYP-NW-S=  SPACE   LIKE=TYP-NW-L  A= #[336 * a_ratio[]]
     *  51 *                    V= #[336 * #[a_ratio[] * 9]]
     *  52 *                    N-O-P= #[3 * a_ratio[]]
     *  53 *                    X=16  Y=9090  AZ=135  ..
     *  54 *               E-W  CONS=B-WALL  AZ=180  H=14  W=21    ..
     *  55 *                WI  X=2  Y=1  H=7  W=16  G-T=GLASS1    ..
     *  56 *               U-F  A=448  CONS=FLOOR   ..
     *  57 *
     *  58 * BUILDING-RESOURCE  VERT-TRANS-KW=236  VERT-TRANS-SCH=ELEV  ..
     *  59 *
     *  60 * LOADS-REPORT  S=(LS-A,LS-C)  ..
      *  61 * END  ..
      *  62 * COMPUTE LOADS  ..
      *  63 * ##include    sys_plt.inp

1     *   1 * $************************* file : sys_plt.inp *************************
1     *   2 *
1     *   3 * $large office systems and plant input
1     *   4 *
1     *   5 * ##if    #[e_vint[] eqs old]
1.1   *   6 * INPUT SYSTEMS  ..
                S D L   P R O C E S S O R   I N P U T   D A T A

                        4/12/1989    13:45:52  SDL RUN  1


1.1   *   7 * SYSTEMS-REPORT  V=(ALL-VERIFICATION)  S=(SS-D,SS-A,SS-I,SS-O)  ..
1.1   *   8 *
1.1   *   9 * ##include    sys_sch.inp

2.1   *   1 * $************************* file : sys_sch.inp *************************
2.1   *   2 *
2.1   *   3 * $ large office system schedules
2.1   *   4 * ##if    #[b_oper[] eqs low]
2.2   -   5 -
2.2   -   6 -     insert system schedules for low building operation here
2.2   -   7 -
2.1   *   8 * ##elseif    #[b_oper[] eqs high]
2.2   *   9 * FANSON=  SCHEDULE
2.2   *  10 *    THRU APR 15 (WD) (1,6) (0) (7,18) (1) (19,24) (0) (WEH) (1,24) (0)
2.2   *  11 *    THRU OCT 15 (WD) (1,6) (-1) (7,18) (1) (19,24) (-1) (WEH) (1,24) (-1)
2.2   *  12 *    THRU DEC 31 (WD) (1,6) (0) (7,18) (1) (19,24) (0) (WEH) (1,24) (0) ..
2.1   *  13 * ##else
2.2   -  14 -     Abort -- Building Operation Undefined
2.1   *  15 * ##endif
```

```
file : sys_plt.inp
1.1   *   10 *
1.1   *   11 *                                                      $ PROFILE '192
1.1   *   12 * C-SETPT= SCH THRU DEC 31 (ALL) (1,24) (76)  ..
1.1   *   13 * H-SETPT= SCH THRU DEC 31 (WD)   (1,5)   (60) (6,18) (72) (19,24) (60)
1.1   *   14 *                            (WEH) (1,24) (60)  ..
1.1   *   15 *
1.1   *   16 * ENV  ZONE-CONTROL  D-H-T=72  D-C-T=74  H-T-SCH=H-SETPT  C-T-SCH=C-SETPT
1.1   *   17 *                    B-C=THERMOSTATIC  ..
1.1   *   18 *
1.1   *   19 * TYP-NW-L=  Z  Z-C=ENV  O-CFM/P=15  CFM/SQFT=.7  M-C-R=.3  M=93  ..
1.1   *   20 * TYP-NW-S=  Z  LIKE TYP-NW-L  M=62   ..
1.1   *   21 *
1.1   *   22 * SYS1=  SYSTEM  S-TYPE=VAVS  MAX-S-T=105  MIN-S-T=55  OA-CONTROL=TEMP  E-L-T=68
1.1   *   23 *                R-A-P=DUCT   F-C=INLET    MIN-F-R=.3  S-S=4.5  S-E=.55  R-S=1.5
1.1   *   24 *                R-E=.47      N-C-C=CYCLE-ON-ANY       R-D-T=50  HEAT-SET-T=105
1.1   *   25 *                Z-N=(TYP-NW-L,TYP-NW-S)  F-SCH=FANSON  ..
1.1   *   26 * END  ..
1.1   *   27 * COMPUTE SYSTEMS  ..
1.1   *   28 * INPUT PLANT  ..
```

```
                    P D L   P R O C E S S O R   I N P U T   D A T A

                             4/12/1989    13:45:52  PDL RUN  1

1.1   *   29 * PLANT-REPORT   S=(PS-A,PS-B,PS-G,BEPS)  ..
1.1   *   30 *
1.1   *   31 * HWG=  P-E  TYPE=HW-BOILER        I-N=2  SIZE=-999  ..
1.1   *   32 * CHL=  P-E  TYPE=HERM-CENT-CHLR   I-N=2  SIZE=-999  ..
1.1   *   33 * CTW=  P-E  TYPE=COOLING-TWR             SIZE=-999  ..
1.1   *   34 *
1.1   *   35 * PLANT-PARAMETERS  BOILER-FUEL=NATURAL-GAS  HW-BOILER-HIR=1.33  ..
1.1   *   36 * PART-LOAD-RATIO   TYPE=HERM-CENT-CHLR  E-I-R=.2  ..
1.1   *   37 *
1.1   *   38 * END  ..
1.1   *   39 * COMPUTE PLANT  ..
1     *   40 * ##elseif    #[e_vint[] eqs new]
1.1   -   41 -
1.1   -   42 -     insert new equip description here
1.1   -   43 -
1     *   44 * ##else
1.1   -   45 -     Abort -- Equipment Vintage Undefined
1     *   46 * ##endif
file : input2.tmp
      *   64 * STOP  ..
```

Following is the listing of the file FOR022.dat. This file is requested by the ##write command in file OFFICE.inp. Note that this file shows the end result of macro processing; i.e., all the macro commands are taken out and all macro expansions are done.

```
<   5 >
<  11 >
<  12 > $ DOE-2.1D BDL Input for Large Office Building
<  13 >
<  14 > INPUT LOADS  ..
<  15 > TITLE LINE-1=  "large office  washington"
<  16 >       LINE-2=    "100000 stock old high"  ..
<  17 >
<  18 > ABORT ERRORS  ..  LIST WARNINGS  ..
<  19 > RUN-PERIOD        JAN 1  1982 THRU DEC 31 1982  ..
<  20 >

<   1 > $************************* file : location.inp ************************
<   2 >
<   4 >   BUILDING-LOCATION  LAT=38.9  LON=77   ALT=50  T-Z=5
<   5 >       ATM-MOISTURE= (.90,.90,.94,1.12,1.31,1.48,1.57,1.60,1.64,1.31,1.07,.96)
<   6 >       ATM-TURBIDITY=(.07,.12,.16,.16,.36,.35,.36,.53,.45,.23,.19,.21)  ..
<  22 >
```

```
$************************* file : lds_sch.inp *************************

$ Large Office Loads Schedules
                    $ SCHEDULES TAKEN FROM STD EVAL TECH $
OC1= D-SCH (1,7) (0) (8,24) (.1,.2,.95,.95,.95,.45,.95,.95,.95,.95,.50,
                          .3,.1,.1,.1,0,0)  ..
OC2= D-SCH (1,7) (0) (8,18) (.1,.1,.1,.1,.1,.1,.1,.1,.1,.1,.05) (19,24) (0)  ..
OC3= D-SCH (1,24) (0)  ..
OCCUP= SCH THRU DEC 31 (WD) OC1 (SAT) OC2 (SUN,HOL) OC3  .. $ PROFILE '1

LG1= D-SCH (1,6) (.05) (7,24) (.1,.3,.9,.9,.9,.9,.8,.9,.9,.9,.9,.5,.3,.3,
                            .2,.2,.05,.05)  ..
LG2= D-SCH (1,6) (.05) (7,12) (.1,.1,.1,.1,.1,.1) (13,17) (.15) (18,24) (.05)..
LIGHTS= SCH THRU DEC 31 (WD) LG1 (SAT) LG2 (SUN,HOL) OC3  ..  $ PROFILE '43

INFIL= SCH THRU DEC 31 (WD) (1,6) (1) (7,18) (0) (19,24) (1)
                       (WEH) (1,24) (1)  ..           $ MIRROR OF PROFILE '192

EL1= D-SCH (1,6) (0) (7,20) (.05,.35,.7,.45,.35,.45,.5,.5,.35,.35,.45,.6,.2,.1)
                     (21,24) (0)  ..
EL2= D-SCH (1,6) (0) (7,17) (.05,.15,.15,.2,.2,.25,.2,.15,.1,.05,.05)
                     (18,24) (0)  ..
ELEV=  SCH THRU DEC 31 (WD) EL1  (SAT) EL2  (SUN,HOL) OC3  .. $ PROFILE '128


$************************* file : const.inp *************************

$ large office constructions

$ washington stock
$ chicago stock
WA1 LAYERS  MAT (CC24,AL21,GP02)  ..
RF1 LAYERS  MAT (BR01,CC24,IN35,CC16,AL32,AC03) I-F-R .61  ..
PA1 LAYERS  MAT (AS01,IN35,AL22,AC03) I-F-R .65  ..
P1  LAYERS  MAT (GP02,AL12,GP02)  ..
FL  LAYERS  MAT (CC03,CP01)  ..
C1  LAYERS  MAT (AC02)  ..
FOUND CONS  U 1.0  ..
DR1 CONS  U .19  ..
GLASS1 G-T  G-T-C 8 PANES 2 VIS-TRANS .32  .. $ 1/4 SOLARGREY 2 PANE



B-WALL= CONS  LA=WA1  ..    ROF=  CONS  LA=RF1  ..    PART=  CONS  LA=P1   ..
FLOOR=  CONS  LA=FL   ..    CEIL= CONS  LA=C1   ..    PANEL= CONS  LA=PA1  ..

                    $ SPACE DESCRIPTIONS $

$ sum of space areas = 599560

TYP-NW-L=  SPACE  A=  74.973556519
                  V=  749.735595703
                  L-W=   1.225719213
                  E-W=   0.437756926
                  N-O-P=  0.669406772
                  X=38  Y=90  Z=70  AZ=135  F-W=0
                  P-SCH=OCCUP   P-H-G=450
                  L-SCH=LIGHTS  L-T-R=.3  L-T=REC-FLUOR-RV  L-T-S=.7
                  E-SCH=LIGHTS
                  I-M=AIR-CHANGE  A-C=.3  I-SCH=INFIL  ..
             E-W  CONS=B-WALL  AZ=180  H=14  W=28   ..
              WI  X=2  Y=1  H=7  W=23  G-T=GLASS1   ..
            ROOF  H=40  W=30  CONS=B-WALL  AZ=180  ..
        IN1= I-W  A=448  CONS=FLOOR  TILT=180  NEXT-TO=TYP-NW-S  S-F=(.5,.1) ..

TYP-NW-S=  SPACE  LIKE=TYP-NW-L  A=  56.230167389
                  V=  506.071563721
                  N-O-P=  0.502055109
                  X=16  Y=9090  AZ=135  ..
```

```
               E-W  CONS=B-WALL  AZ=180  H=14  W=21   ..
                WI  X=2  Y=1  H=7  W=16  G-T=GLASS1   ..
               U-F  A=448  CONS=FLOOR   ..

BUILDING-RESOURCE  VERT-TRANS-KW=236  VERT-TRANS-SCH=ELEV  ..

LOADS-REPORT  S=(LS-A,LS-C)  ..
END  ..
COMPUTE LOADS  ..

$************************* file : sys_plt.inp *************************

$large office systems and plant input

INPUT SYSTEMS  ..
SYSTEMS-REPORT  V=(ALL-VERIFICATION)  S=(SS-D,SS-A,SS-I,SS-O)  ..


$************************* file : sys_sch.inp *************************

$ large office system schedules
FANSON=  SCHEDULE
   THRU APR 15 (WD) (1,6) (0) (7,18) (1) (19,24) (0) (WEH) (1,24) (0)
   THRU OCT 15 (WD) (1,6) (-1) (7,18) (1) (19,24) (-1) (WEH) (1,24) (-1)
   THRU DEC 31 (WD) (1,6) (0) (7,18) (1) (19,24) (0) (WEH) (1,24) (0) ..

                                                  $ PROFILE '192
C-SETPT= SCH THRU DEC 31 (ALL) (1,24) (76)  ..
H-SETPT= SCH THRU DEC 31 (WD)  (1,5)  (60) (6,18) (72) (19,24) (60)
                         (WEH) (1,24) (60)  ..

ENV  ZONE-CONTROL  D-H-T=72  D-C-T=74  H-T-SCH=H-SETPT  C-T-SCH=C-SETPT
                   B-C=THERMOSTATIC  ..

TYP-NW-L=  Z  Z-C=ENV  O-CFM/P=15  CFM/SQFT=.7  M-C-R=.3  M=93  ..
TYP-NW-S=  Z  LIKE TYP-NW-L  M=62  ..

SYS1=  SYSTEM  S-TYPE=VAVS  MAX-S-T=105  MIN-S-T=55  OA-CONTROL=TEMP  E-L-T=68
               R-A-P=DUCT   F-C=INLET    MIN-F-R=.3  S-S=4.5  S-E=.55  R-S=1.5
               R-E=.47      N-C-C=CYCLE-ON-ANY       R-D-T=50  HEAT-SET-T=105
               Z-N=(TYP-NW-L,TYP-NW-S)  F-SCH=FANSON  ..
END  ..
COMPUTE SYSTEMS  ..
INPUT PLANT  ..
PLANT-REPORT   S=(PS-A,PS-B,PS-G,BEPS)  ..

HWG=  P-E  TYPE=HW-BOILER         I-N=2  SIZE=-999  ..
CHL=  P-E  TYPE=HERM-CENT-CHLR    I-N=2  SIZE=-999  ..
CTW=  P-E  TYPE=COOLING-TWR              SIZE=-999  ..

PLANT-PARAMETERS  BOILER-FUEL=NATURAL-GAS  HW-BOILER-HIR=1.33  ..
PART-LOAD-RATIO   TYPE=HERM-CENT-CHLR  E-I-R=.2  ..

END  ..
COMPUTE PLANT  ..
```

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Overview

Algorithms have been added to DOE-2.1C to allow the program to model the different forms of heat transfer that can occur between a sunspace (or atrium) and adjacent spaces; see Fig. 2.1.

XBL 843-10167

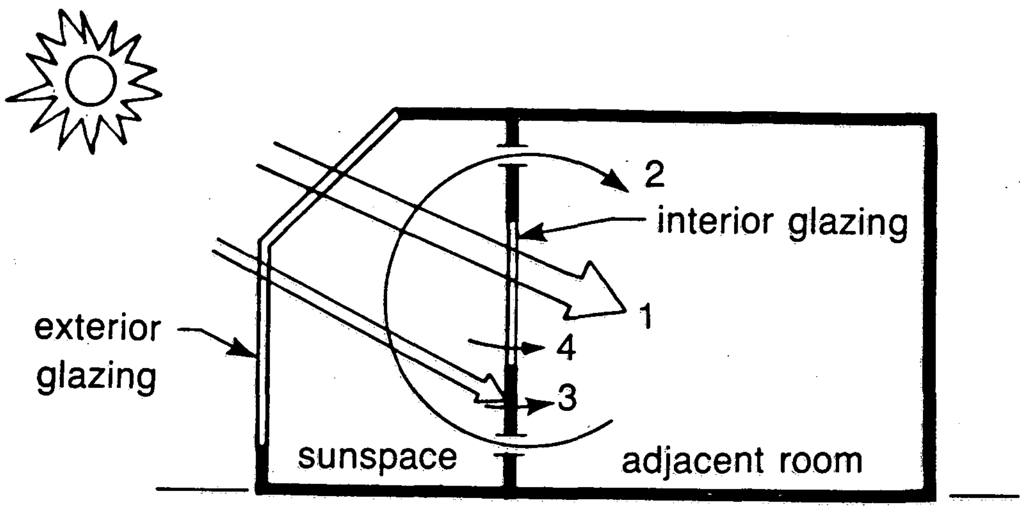


Figure 2.1: Forms of heat transfer calculated by the sunspace model: (1) direct and diffuse solar gain through interior glazing; (2) forced or natural convection through vents or an open doorway; (3) quick or delayed conduction through an interior wall, taking into account solar radiation absorbed on the sunspace side of the wall; and (4) conduction through interior glazing.

The model also simulates venting of the sunspace with outside air to prevent overheating and, for residential application, the use of a sunspace to preheat outside ventilation air.

The user can control the airflow from the sunspace with a schedule or on the basis of a threshold temperature difference between the sunspace and the adjacent space.

Capabilities already existing in DOE-2.1B allow the user to simulate additional features which are important for solar-driven spaces, including sun-control with movable window shades, movable insulation on exterior windows, shading by fins and overhangs, sloped glazing, and the effects of thermal mass.

The model is intended primarily for residential and small commercial building applications. Because DOE-2 calculates only a single, average air temperature in a space, **this simulation cannot be expected to give accurate results for multi-story atriums unless there is sufficient air mixing to eliminate temperature stratification.**

Table 2.1 gives a comparison of modeling capabilities for sunspaces in DOE-2.1C vs. DOE-2.1B.

TABLE 2.1

Comparison of Modelling Capabilities for Sunspaces in DOE-2.1C vs. DOE-2.1B

Version 2.1B	Version 2.1C
Solar radiation absorbed by interior surfaces (annual average) is used only in Custom Weighting Factor calculation.	Solar radiation absorbed by sunspace INTERIOR–WALLs is determined hourly and used in conduction calculation.
INTERIOR–WALL position is unused (except for TILT in daylighting calculation).	Sunspace INTERIOR–WALLs can be positioned with X, Y, Z, AZIMUTH, and TILT.
Conduction across INTERIOR–WALLs can be quick only.	Conduction across sunspace INTERIOR–WALLs can be quick or delayed.
INTERIOR–WALLs cannot have WINDOWs.	Sunspace INTERIOR–WALLs can have WINDOWs. Solar gain through these WINDOWs from sunspace to adjacent spaces is calculated. Conduction across interior WINDOWs is calculated. Interior WINDOWs can have movable insulation and shading. They can be shaded by BUILDING–SHADEs inside or outside the sunspace.
Convection across an INTERIOR–WALL can be approximated by assigning an effective U-value to the wall. Non-linear ΔT dependence of natural convection cannot be modeled. Convection cannot be controlled.	Sunspace INTERIOR–WALLs can have openings through which fan-forced or natural convective heat transfer between sunspaces and adjacent spaces can occur. For natural convection, non-linear ΔT dependence is accounted for. Convection can be controlled thermostatically or via schedule.
Only the RESYS system has venting. The venting is controlled by the temperature of the control zone.	A sunspace can be vented with outside air to prevent overheating. Venting is independent of temperature of other zones. It works with any SYSTEM–TYPE except PIU.
Moisture gain for ZONE–TYPE = PLENUM is not considered.	Moisture gain in a sunspace (or non-sunspace) is accounted for both ZONE–TYPE = CONDITIONED and ZONE–TYPE = PLENUM.
Zone-level exhaust via EXHAUST–CFM works only for ZONE–TYPE = CONDITIONED.	EXHAUST–CFM works for ZONE–TYPE = CONDITIONED and PLENUM.

Sunspace-Related Keywords

LOADS

SPACE–CONDITIONS

SUNSPACE takes codeword values YES or NO (the default). If YES, the space can be directly vented with outside air to prevent overheating (see keywords SS–VENT–SCH, SS–VENT–T–SCH, etc., below), and, if the space has INTERIOR–WALLs, the heat transfer across these walls into adjacent spaces by convection, delayed conduction, and solar transmission will be calculated.

Note 1. A building can have more than one sunspace (i.e., SPACE with SUNSPACE = YES). There can be more than one sunspace on a system.

Note 2. A sunspace can have several INTERIOR–WALLs, i.e., a sunspace can have more than one adjoining space.

Note 3. A sunspace or a non-sunspace can have at most one INTERIOR–WALL with convective heat exchange (AIR–FLOW–TYPE = FORCED–RECIRC, FREE–RECIRC, OPEN–DOORWAY, or FORCED–OA–PREHT in the WALL–PARAMETERS command).

Note 4. A sunspace and an adjacent non-sunspace can share several INTERIOR–WALLs (only one of which can have convective heat transfer). The conductive heat exchange is calculated separately for each INTERIOR–WALL.

Note 5. Two sunspaces can be adjacent, but any windows in the common INTERIOR–WALL will be ignored, convective exchange across the wall will not be calculated, and the effect on the conduction through the wall due to absorbed solar radiation will not be considered.

Note 6. A daylighting simulation can be done for a sunspace (by entering DAYLIGHTING = YES and setting daylighting related keywords), but the program cannot directly calculate daylight passing through interior windows from the sunspace to adjacent spaces.

INTERIOR–WALL

X, Y, Z give the coordinates (in the coordinate system of the space in which the wall is defined) of the lower left-hand corner of the wall as viewed from the NEXT–TO space (see Fig. 2.2).

AZIMUTH is the azimuth of the wall in the coordinate system of the space in which the wall is defined (see Fig. 2.2). The outward normal used to determine the azimuth points into the NEXT–TO space.

Note: HEIGHT, WIDTH, X, Y, Z, AZIMUTH, and TILT are required for an INTERIOR–WALL in a sunspace so that the amount of solar radiation falling on the wall from exterior windows in the sunspace can be calculated. If the sunspace has no exterior windows, which is an exceptional case, these geometrical quantities do not have to be specified. These keywords take the same defaults, meanings, and abbreviations as those under EXTERIOR—WALL.

XBL 843-10168

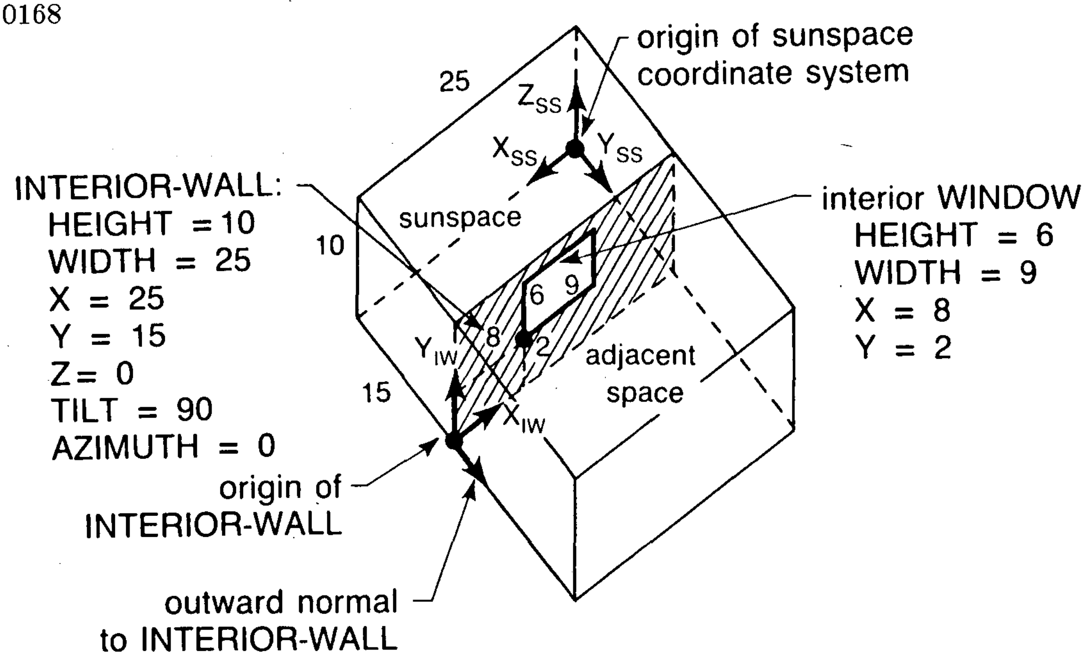


Figure 2.2: A sunspace and an adjacent space showing the geometrical positioning of the INTERIOR—WALL separating them. The INTERIOR—WALL has been defined in the sunspace. The lower left-hand corner of the wall (as viewed from the adjacent space) is located at X = 25, Y = 15, Z = 0 in the sunspace coordinate system. The azimuth of the INTERIOR—WALL is 0°, which is the angle between the sunspace Y-axis, Y_{SS} and the outward normal to the INTERIOR—WALL. The wall contains a 6 ft x 9 ft WINDOW with lower left-hand corner at X=8, Y=2 with respect to the wall origin.

WINDOW

SOL—TRANS—SCH is the u-name of a schedule which gives the solar transmittance of a window shading device when it covers the window. This keyword is used only for exterior windows in a sunspace. The program multiplies the schedule value by the direct and diffuse solar radiation striking the shade to determine the hourly amount of solar radiation (assumed diffuse) which is transmitted by the shade. The SHADING—SCHEDULE value will be used if this keyword is not specified.

Note: This keyword should be defined in addition to, not in place of, SHADING—SCHEDULE. Also, the value of SOL—TRANS—SCH in a given hour must not exceed the corresponding SHADING—SCHEDULE value. If it does, the program will reset it equal to the SHADING—SCHEDULE value.

Note: WIN–SHADE–TYPE = FIXED–EXTERIOR or MOVABLE–EXTERIOR should be entered if a sunspace exterior window has a shading device on the outside of the window. Otherwise, the program will assume the shade is on the inside.

Interior Windows

Interior windows can be specified by following an INTERIOR–WALL command by one or more WINDOW commands. The keywords for such windows are the same as those for windows in an EXTERIOR–WALL with some exceptions:

(1) The following keywords are unused:

GLARE–CTRL–PROB	RIGHT–FIN–A, etc.
GND–FORM–FACTOR	SETBACK
INF–COEF	SHADING–DIVISION
LEFT–FIN–A, etc.	VIS–TRANS–SCH
OVERHANG–A, etc.	WIN–SHADE–TYPE

(2) SKY–FORM–FACTOR multiplies the total diffuse radiation incident on an interior window. If the interior window has a setback (relative to the sunspace) or there are obstructions inside the sunspace which shade the interior window, a value of SKY–FORM–FACTOR less than 1.0 should be specified (the default value is 1.0).

Shading devices on interior windows, like Venetian blinds, drapes, or pull-down shades, can be simulated via the keywords SHADING–SCHEDULE and MAX–SOLAR–SCH. Movable insulation on interior windows can be modeled using keywords CONDUCT–SCHEDULE and CONDUCT–TMIN–SCH.

For an accurate calculation of the solar radiation transmitted by a sunspace interior window, it is important to specify the X and Y coordinates of the window. These coordinates are measured with respect to the lower-left hand corner of the INTERIOR–WALL as viewed in the NEXT–TO space (see Fig. 2.2). The position of exterior windows should also be carefully specified. The program will only recognize interior windows in an INTERIOR–WALL between a sunspace and a non-sunspace.

Sliding glass doors can be modeled as interior WINDOWs. If the INTERIOR–WALL containing the glass door has AIR–FLOW–TYPE = FREE–DOORWAY (see WALL–PARAMETERS, below), the door will be assumed to be open, and convection through the opening will be calculated, if T(sunspace) - T(adjacent space) > AIR–FLOW–CTRL–DT.

Additional control of the opening and closing of the door can be obtained by using SS–FLOW–SCH (see description of new ZONE–AIR keywords, below).

An unglazed opening in a sunspace INTERIOR–WALL can be input as a WINDOW with GLASS–TYPE–CODE = 0 and GLASS–CONDUCTANCE = 0. The program will calculate the solar radiation passing through the opening by using a transmittance of 1.0 for all angles of incidence. WALL–PARAMETERS data, described below, would be entered for the INTERIOR–WALL to specify the convective air flow through the opening.

Interior Doors
The DOOR command cannot be used with INTERIOR–WALL. However, an opaque interior door with a conductance significantly different from the sunspace interior wall containing it can be input as a separate INTERIOR–WALL. Alternatively, the door can simply be ignored if the conduction across it is small compared to the overall conduction across the wall. The program will calculate convection through a fully or partially open door if AIR–FLOW–TYPE = FREE–DOORWAY and appropriate values of DOORWAY–H and DOORWAY–W are specified (see WALL–PARAMETERS, below).

GLASS–TYPE
It is strongly recommended that exterior WINDOWs in a sunspace be described with GLASS–TYPE–CODE rather than SHADING–COEF. This allows the program to accurately calculate the hourly direct and diffuse radiation transmitted by the glazing. This is not possible with SHADING–COEF except for standard 1/8" clear glass.

WALL–PARAMETERS
This command is used to specify data which are used by the program to calculate air flow across a sunspace INTERIOR–WALL. The u-name of this command is referenced by the CONSTRUCTION command for the INTERIOR–WALL. The sequence is as follows:

```
WP-1      =   WALL-PARAMETERS FOR INTERIOR-WALL
              .
              . ..
IWCON-1   =   CONSTRUCTION
              WALL-PARAMETERS = WP-1
              .
              . ..
IW-1      =   INTERIOR-WALL
              CONSTRUCTION = IWCON-1
              .
              . ..
```

The keywords for WALL–PARAMETERS are:

FOR — now accepts the value INTERIOR–WALL (in addition to the Trombe wall codewords).

AIR–FLOW–TYPE — is the type of air flow across the INTERIOR–WALL. The default is NO–AIR–FLOW, and the other allowed values, which are illustrated in Fig. 2.3, are:

FORCED–RECIRC — A fan blows air through a vent from the sunspace to the adjacent space at a rate equal to AIR–FLOW–RATE. Air is recirculated back to the sunspace through another vent. All of the fan heat is assumed to be picked up by the airstream flowing into the adjacent space.

FORCED–OA–PREHT

A fan draws outside air into the sunspace where it is preheated, then transferred across the INTERIOR–WALL into the adjacent space. The fan is assumed to be located in the building exhaust airstream so that no fan heat is delivered to the building. The flowrate of outside air drawn into the sunspace is the same as the flowrate from the sunspace across the INTERIOR–WALL.

FREE–RECIRC

Air circulates through upper and lower vents in the INTERIOR–WALL by natural convection. The heat transfer from sunspace to adjacent space is calculated by the program as

$$Q = 31267\, C_p\, P \left[\frac{h \left| T_S - T_R \right|}{T_S\, T_R \left(\frac{T_S}{A_U^2} + \frac{T_R}{A_L^2} \right)} \right]^{\frac{1}{2}} \left(T_S - T_R \right)$$

where

Q is in Btuh,
C_p = heat capacity of air [Btu/lb-°F],
P = atmospheric pressure [in. Hg],
h = vertical separation between vents [ft],
T_S = sunspace air temperature [°R],
T_R = air temperature of adjacent space [°R],
A_U = upper vent area [ft^2],
A_L = lower vent area [ft^2].

FREE–DOORWAY

Air circulates by natural convection through a doorway in the INTERIOR–WALL. The heat transfer from sunspace to adjacent space when the doorway is fully open is given by

$$Q = 4.6\, W H^{\frac{3}{2}} \left| T_S - T_R \right|^{\frac{1}{2}} \left(T_S - T_R \right),$$

where

Q is in Btuh,
W = width of opening [ft],
H = height of opening [ft],
T_S = sunspace air temperature [°F],
T_R = air temperature of adjacent space [°F].

Note: this option should only be used for vertical openings.

XBL 843-10165

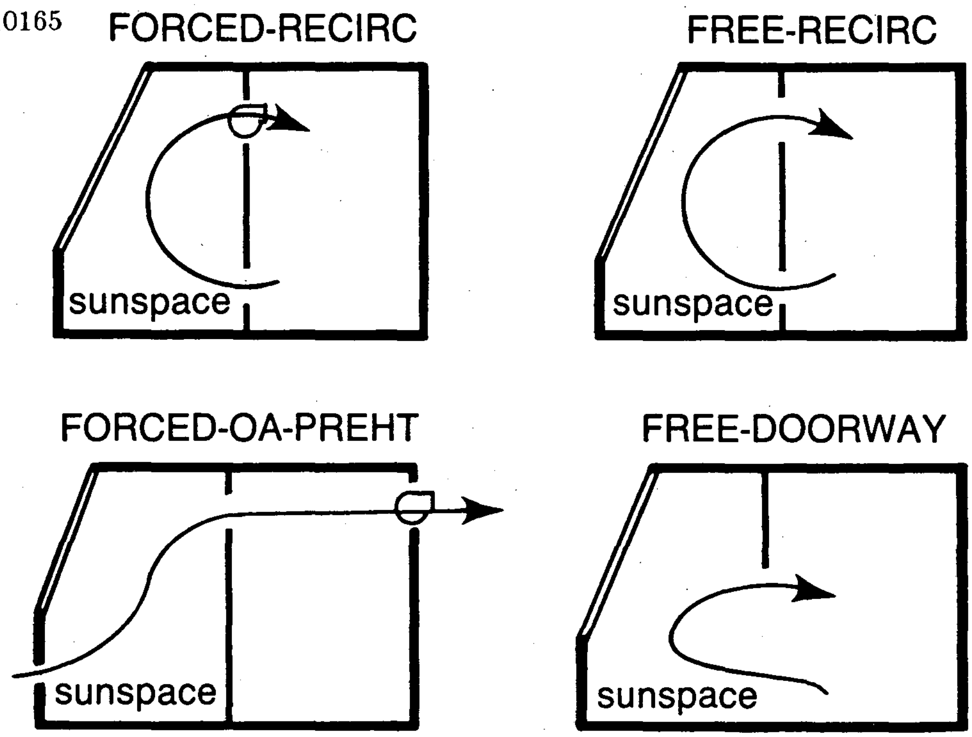


Figure 2.3: Air-flow configurations for different values of AIR–FLOW–TYPE.

The applicability of the following keywords depends on AIR–FLOW–TYPE, as illustrated in Table 2.2.

LOWER–VENT–AREA and **UPPER–VENT–AREA** are the cross-sectional areas (ft^2) of the lower and upper vents, respectively, for AIR–FLOW–TYPE = FREE–RECIRC.

VERT–VENT–SEP is the center-to-center vertical separation (ft) between the upper and lower vents for AIR–FLOW–TYPE = FREE–RECIRC.

AIR–FLOW–RATE is the air flow rate (cfm) across a sunspace INTERIOR–WALL for AIR–FLOW–TYPE = FORCED–RECIRC or FORCED–OA–PREHT. The range is from 0.0 to 999999.0 ft^3/min, and there is no default.

AIR–FLOW–CTRL–DT is the threshold temperature difference (°F) for control of air flow across a sunspace INTERIOR–WALL. Air flow will occur only if:

[T(sunspace)-T(adjacent space) > AIR–FLOW–CTRL–DT].

The default value is 3.0°F for all AIR–FLOW–TYPEs except FORCED–OA–PREHT, in which case it is -100.0°F (therefore the keyword has no effect if not specified for FORCED–OA–PREHT).

FAN–KW is the electrical power per unit air flow (kW/cfm) of the fan for AIR–FLOW–TYPE = FORCED–RECIRC or FORCED–OA–PREHT. The default is 0.00003 and range is from 0.0 to 0.1.

DOORWAY–H and **DOORWAY–W** are, respectively, the height and width in feet of the opening through which air flow occurs for AIR–FLOW–TYPE = FREE–DOORWAY. The range is from 0.0 to 8.0 ft, and 0.0 to 99.0 ft, respectively; there are no defaults.

Note 1. To get solar radiation transmitted across an unglazed opening, a WINDOW with
GLASS–TYPE–CODE = 0,
GLASS–CONDUCTANCE = 0,
HEIGHT = same value as DOORWAY–H, and
WIDTH = same value as DOORWAY–W,
should be entered in the sunspace INTERIOR–WALL.

Note 2. A non-rectangular doorway opening should be approximated by rectangular opening of the same area.

Note 3. Multiple openings of height H_i and width W_i in the same wall can be represented by a single opening with

$DOORWAY\text{–}H = \langle H \rangle$ and $DOORWAY\text{–}W = \sum_i W_i H_i^{1.5} / \langle H \rangle^{1.5}$,
where $\langle H \rangle$ is the average of the H_i.

Note: The rate of air flow, natural or forced, determined by the program from the above WALL–PARAMETERS data and the temperature difference across the INTERIOR–WALL, is multiplied each hour by the value of SS–FLOW–SCH (default 1.0) which is specified in the SYSTEMS ZONE–AIR input for the sunspace.

Example:
A 500 CFM fan circulates air between sunspace and adjacent room if the sunspace is 5° warmer than the room. The fan power is 25W. The WALL–PARAMETERS input would be:

```
WP-1 = WALL-PARAMETERS   FOR INTERIOR-WALL
                         AIR-FLOW-TYPE = FORCED-RECIRC
                         AIR-FLOW-RATE = 500
                         AIR-FLOW-CTRL-DT = 5
                         FAN-KW = .00005 ..
```

TABLE 2.2

WALL–PARAMETERS keyword applicability for INTERIOR–WALL.
The X's show keywords which are used for each AIR–FLOW–TYPE.

	AIR–FLOW–TYPE			
	FORCED–RECIRC	FORCED–OA–PREHT	FREE–RECIRC	FREE–DOORWAY
LOWER–VENT–AREA			X	
UPPER–VENT–AREA			X	
VERT–VENT–SEP			X	
AIR–FLOW–RATE	X	X		
AIR–FLOW–CTRL–DT	X	X	X	X
FAN–KW	X	X		
DOORWAY–H				X
DOORWAY–W				X

EXTERIOR–WALL, ROOF, UNDERGROUND–WALL, UNDERGROUND–FLOOR, INTERIOR–WALL

INSIDE–SOL–ABS is the inside surface solar absorptance. For INTERIOR–WALL, a list of two values is required, where the first value is the absorptance on the side of the interior wall that is in the space the wall is defined in, and the second value is the absorptance of the other side of the wall.

The default value of INSIDE–SOL–ABS is 0.8 if the surface is a floor (TILT $> 170°$), 0.5 if a wall ($10° \leq$ TILT $\leq 170°$), and 0.3 if a ceiling (TILT $< 10°$).

If Custom Weighting Factors have been requested for a sunspace by inputting FLOOR–WEIGHT = 0,
a SOLAR–FRACTION value should be specified for each inside wall/floor/ceiling surface in addition to INSIDE–SOL–ABS (see Reference Manual, pp.III.103, 114, and 119). These keyword values are related but not, in general, equal.
SOLAR–FRACTION is the fraction of the solar radiation (that enters and remains in a space) that is ultimately absorbed by a particular surface after inter-reflection in the space; it is used (once) to calculate solar weighting factors. INSIDE–SOL–ABS is the fraction of solar radiation striking an opaque surface that is absorbed (the rest being reflected); it is used hourly to determine the interior solar radiation distribution in a sunspace.

Sunspace-Related Keywords (cont.)

SYSTEMS

ZONE–AIR (or ZONE)

Venting of a sunspace with outside air to prevent overheating can be specified with the following keywords:

SS–VENT–SCH is the u-name of a schedule which determines when a sunspace can be vented. The allowed schedule values are 0 if venting is not allowed and 1 if venting is allowed (subject to the temperature conditions described under SS–VENT–T–SCH, below). The default is no venting if this schedule is not input.

SS–VENT–T–SCH is the u-name of a schedule of sunspace air temperatures (in °F) above which venting will occur if the outside air temperature is low enough. Letting T(vent) be the value of SS–VENT–T–SCH, venting will take place if,

T(sunspace) > T(vent), and
T(outside air) < SS–VENT–LIMIT–T, and
T(outside air) < T(sunspace), and
SS–VENT–SCH value = 1.

The venting temperature is input as a schedule in order to allow seasonal variation. For example, the venting temperature might be set higher in the winter to increase the amount of heat convected or conducted from the sunspace to adjacent rooms.

SS–VENT–CST and **SS–VENT–WND** and **SS–VENT–TEMP** are coefficients in the following expression which give the number of outside-air changes per hour when venting by *natural convection*, which is assumed to occur if SS–VENT–KW = 0:

Venting ach = (SS–VENT–CST)
+ (SS–VENT–WND) * (windspeed in knots)
+ (SS–VENT–TEMP) * | T(sunspace) - T(outside air) |

If SS–VENT–KW > 0, the venting is assumed to be *fan-forced* at a constant air change rate given by SS–VENT–CST. In this case, SS–VENT–WND and SS–VENT–TEMP are ignored. The ranges and the defaults are:

SS–V–CST — range of 0.0 to 20.0; default of 5.0
SS–V–WND — range of 0.0 to 5.0 $knot^{-1}$; default of 0.0 and
SS–V–TEMP — range of 0.0 to 1.0 $1/°F^{-1}$; default of 0.0.

SS–VENT–LIMIT–T is the outside drybulb temperature below which venting can occur (see description of SS–VENT–T–SCH, above); the default value is 120°F.

SS–VENT–KW is the electrical power per unit air flow (kW/cfm) of the venting fan. The default value is 0.0. If this keyword is not specified, or is set equal to 0.0, venting is assumed to be by natural convection.

Note 1. For the RESYS system, sunspace venting is done independently of the natural ventilation of other zones (which is determined by the SYSTEM–AIR keywords NATURAL–VENT–AC, NATURAL–VENT–SCH, and VENT–TEMP–SCH).

Note 2. If a sunspace is vented, the program will bypass mechanical cooling that hour even if venting cannot bring the sunspace temperature down to the cooling setpoint.

Note 3. If venting can reduce the sunspace temperature below T(vent), the program will automatically reduce the fraction of the hour that venting takes place to give a final temperature exactly equal to T(vent). The average venting CFM during the hour and the venting fan electrical consumption are adjusted accordingly.

The following two keywords are defined for a sunspace. They modify the flow of air across an INTERIOR–WALL between the sunspace and adjoining zone, as determined by the AIR–FLOW–RATE, AIR–FLOW–CTRL–DT, AIR–FLOW–TYPE, etc. parameters for the wall (see description of the WALL–PARAMETERS command for INTERIOR–WALL).

SS–FLOW–SCH is the u-name of a schedule, with values between 0 and 1, which multiply the air flow across an INTERIOR–WALL between a sunspace and an adjoining zone. This schedule could be used, for example, to turn off flow at night or during the summer months. If SS–FLOW–SCH is not specified for a sunspace, the flow multiplier defaults to 1.0, and so has no effect.

SS–FLOW–T–SCH is specified to prevent warm air from a sunspace from overheating the adjacent zone. The air flow, forced or natural, from the sunspace is turned off if T(zone adjacent to sunspace) > SS–FLOW–T–SCH value. The default is 74°F.

Note: If SS–FLOW–SCH or SS–FLOW–T–SCH is defined for a non-sunspace, it will be ignored.

Warning: The PIU (powered induction unit) system should not be used to serve a sunspace or a zone adjacent to a sunspace if the two zones are convectively coupled, or if the sunspace is vented.

Example:
A sunspace is mechanically vented at 10 ach from 8:00 AM to 7:00 PM during the summer months if the inside temperature exceeds 80°F and the outside temperature is below 75°F. The venting fan uses .05 Watts/cfm.

```
INPUT SYSTEMS      ..
      .
      .
      .
V-SCH-1   = SCHEDULE   THRU MAR 31 (ALL) (1,24) (0)
                       THRU OCT 31 (ALL) (1,8)  (0)
                                         (9,19) (1)
                                         (20,24) (0)
                       THRU DEC 31 (ALL) (1,24) (0)    ..
TV-SCH-1  = SCHEDULE   THRU DEC 31 (ALL) (1,24) (80)    ..
      .
      .
      .
ZA-1      = ZONE-AIR   SS-VENT-SCH = V-SCH-1
                       SS-VENT-T-SCH = TV-SCH-1
                       SS-VENT-CST = 10
                       SS-VENT-LIMIT-T = 75
                       SS-VENT-KW = 0.00005
                            .
                            .
                            .   ..
SUNSP     = ZONE    ZONE-AIR = ZA-1
                       .
                       .
                       .   ..
```

SUNSPACE MODELING GUIDELINES

In the following,

sunspace is a SPACE with SUNSPACE = YES;

room is a SPACE with SUNSPACE = NO (the default) which is adjacent to a sunspace.

Control of Air Flow

It is usually necessary to control the airflow between a sunspace and adjacent rooms. This is done for one or more of the following reasons: (1) to avoid overheating the room with warmer air from the sunspace; (2) to prevent circulating cold air from the sunspace during the heating season; (3) to run the sunspace fan only when the sunspace-room air temperature differential is large enough to give effective heat transfer at design airflow. In the DOE-2.1C sunspace simulation, the following control mechanisms are available; they can be used singly or in combination.

Differential Control Using AIR–FLOW–CTRL–DT in WALL–PARAMETERS gives differential temperature control for flow across a sunspace INTERIOR–WALL. Air flow across the wall occurs only if

T(sunspace) - T(room) > AIR–FLOW–CTRL–DT.

AIR–FLOW–CTRL–DT is generally chosen to be a few °F.

For AIR–FLOW–TYPE = FREE–RECIRC, this assumes that the vents have back-flow dampers which prevent reverse circulation.

For AIR–FLOW–TYPE = FREE–DOORWAY, this assumes occupants open and close the intervening doorway as relative temperature conditions change.

For AIR–FLOW–TYPE = FORCED–RECIRC, it assumes that the fan is controlled by a differential thermostat.

Time-Clock Control For seasonal or day-night control, SS–FLOW–SCH can be specified under the systems ZONE or ZONE–AIR command for the sunspace. The airflow from a sunspace is multiplied by the hourly SS–FLOW–SCH value. If the value is 0, the flow is cut off completely as in the following example where there is no flow at night or from June to September.

```
FLOWSCH–1   =   SCHEDULE   THRU MAY 31   (ALL) (1,8) (0) (9,17) (1)
                                         (18,24) (0)
                           THRU SEP 30   (ALL) (1,24) (0)
                           THRU DEC 31   (ALL) (1,8) (0) (9,7) (1) (18,24) (0) ..
                    .
                    .
                    .
SUNSP–1     =   ZONE       SS–FLOW–SCH = FLOWSCH–1   $ SUNSPACE $
                    .
                    .
                    . ..
```

Room Thermostat Flow Control SS–FLOW–T–SCH allows control of airflow from a sunspace to an adjacent room based on room air temperature. If T(room) is *higher* than the SS–FLOW–T–SCH value, airflow from the sunspace is turned off. If T(room) is *lower* than the SS–FLOW–T–SCH value (and the SS–FLOW–SCH value is non-zero) airflow occurs if

$$T(sunspace) - T(room) > AIR\text{–}FLOW\text{–}CTRL\text{–}DT$$

Generally, SS–FLOW–T–SCH values should be between the room heating and cooling setpoints. If SS–FLOW–T–SCH is not specified, the program will use a default value of 74°F for all hours.

Sun Control Methods

Sun control is generally needed to reduce solar heat gain in a sunspace during the summer. This can be accomplished with external projections such as overhangs, by making some or all of the sunspace glazing reflective or heat absorbing, or by using window coverings. The window coverings may be fixed or movable as determined by SHADING–SCHEDULE. They can also be deployed whenever transmitted solar gain exceeds a threshold value as specified by MAX–SOLAR–SCH.

The degree of shading that a sunspace requires depends, of course, on the extent to which it is used as a living space.

Example:

Window coverings with a shading coefficient multiplier of 0.3 and 20% solar transmittance are used from June through October whenever transmitted solar radiation exceeds 50 Btu/ft^2-hr:.

```
SOLTRANS-1    =  SCHEDULE  THRU DEC 31   (ALL) (1,24) (0.2) ..
SHMULT-1      =  SCHEDULE  THRU DEC 31   (ALL) (1,24) (0.3) ..
SOL-THRESH-1  =  SCHEDULE  THRU MAY 31   (ALL) (1,24) (1000)
                           THRU OCT 30   (ALL) (1,24) (50)
                           THRU DEC 31   (ALL) (1,24) (1000) ..
                 .
                 .
                 .
SUNSPWIN      =  WINDOW    SOL-TRANS-SCH = SOLTRANS-1
                           SHADING-SCHEDULE = SHMULT-1
                           MAX-SOLAR-SCH = SOL-THRESH-1
                                .
                                .
                                . ..
```

Sun control may also be desirable for interior windows in a sunspace to prevent excessive direct solar gain into the adjoining room. SHADING–SCHEDULE and MAX–SOLAR–SCH can be used for interior windows in the same way as they are used for exterior windows Another way of shading interior windows is to locate one or more BUILDING–SHADEs inside the sunspace.

Reducing Conductive Heat Loss From Sunspace Exterior Glazing

Sunspaces typically have large glazed areas. The high U-value of bare, single glazing (about 1.0 Btu/ft^2-hr-F) leads to significant conductive heat loss to the outside in the winter except in very mild climates. Some ways of ameliorating this heat loss are:

(1) Use double or even triple glazing (PANES = 2 or 3, respectively).

(2) Use movable insulation by inputting a CONDUCT–SCHEDULE which decreases the overall window conductance at night, or specify CONDUCT–TMIN–SCH which moves insulation into place when the outside temperature is low.

(3) Use translucent insulating panels in place of some or all of the clear glazing by inputting values for SHADING–COEF and GLASS–CONDUCTANCE obtained from manufacturer's data.

(4) Use glass with a low emissivity coating. The coating reduces the air film conductance, thereby lowering the overall U-value. (See description of the INSIDE–EMISS keyword in the WINDOW command.)

Example:

R-5 insulating panels cover a single-glazed sunspace exterior window November through April whenever the outside air temperature falls below 40°F. The shading coefficient multiplier of the insulation is 0.1. The solar transmittance is 2%.

```
CONDMULT–1   =  SCHEDULE   THRU  DEC 31  (ALL) (1,24) (.12) ..
SHMULT–1     =  SCHEDULE   THRU  DEC 31  (ALL) (1,24) (.1)  ..
TMIN–1       =  SCHEDULE   THRU  APR 30  (ALL) (1,24) (40)
                           THRU  OCT 31  (ALL) (1,24) (0)
                           THRU  DEC 31  (ALL) (1,24) (40)
SOLTRANS–1   =  SCHEDULE   THRU  DEC 31  (ALL) (1,24) (.02) ..
                                 .
                                 .
                                 .
SUNSPWIN     =  WINDOW     CONDUCT–SCHEDULE = CONDMULT–1
                           SHADING–SCHEDULE = SHMULT–1
                           CONDUCT–TMIN–SCH = TMIN–1
                           SOL–TRAN–SCH = SOLTRANS–1
                                 .
                                 .
                                 . ..
```

In this example, the value for the conductance multiplier is the ratio of the window conductance (excluding outside air film) with and without insulation:

$$\frac{(5+.68)^{-1}}{(.68)^{-1}} = \frac{.176}{1.47} = .12$$

The above measures can also be modeled for interior glazing. In this case, the program expects outside air temperatures for CONDUCT–TMIN–SCH (as for exterior windows), not sunspace air temperatures.

Positioning of Sunspace Surfaces

For an accurate calculation of solar radiation falling on the INTERIOR–WALLs of a sunspace, the bounding surfaces of the sunspace need to be geometrically positioned. This applies to the EXTERIOR–WALLs and ROOFs and their associated windows, and the INTERIOR–WALLs and their associated windows. INTERIOR–WALL keywords X,Y,Z and AZIMUTH, formerly unused, are now operational (along with TILT) for geometrical positioning. It is recommended that INTERIOR–WALLs between a sunspace and adjacent room be defined in the sunspace. Otherwise, the adjacent room must be properly located with respect to the sunspace. If this is not done, the interior walls and windows will be mis-positioned relative to the sunspace exterior windows, and the projection of solar radiation from the windows onto the interior walls will be incorrect. This will result in a wrong calculation of the solar radiation transferred from sunspace to room. Even in this case, there will be no fictitious overall gain or loss of solar gain since the solar which stays in the sunspace plus that transferred to adjacent rooms is constrained by the program to equal that entering the sunspace. There will, however, be an error message if the transferred solar exceeds the entering solar, which would give a net negative solar gain in the sunspace. This may occur if interior walls or windows on them overlap, if MULTIPLIER is used on an interior window, or if MULTIPLIER is used on rooms adjacent to a sunspace.

Massive Interior Walls

Sunspace interior walls are often fairly massive, leading to a significant time delay in the heat transfer across them by conduction. Such walls should be described by response factors, i.e. with a delayed-type construction. This was a new feature in 2.1C. Previously, INTERIOR–WALL response factors were used only in the Custom Weighting Factor calculation; hourly conduction through all INTERIOR–WALLs was calculated as quick.

The order of defining layers in a delayed INTERIOR–WALL is from "outside" to "inside", where "outside" is the side of the wall in the NEXT–TO space, and "inside" is the side in the space in which the wall was defined.

Delayed conduction through INTERIOR–WALLs is calculated only for INTERIOR–WALLs between a sunspace and a non-sunspace. For other INTERIOR–WALLs the hourly conduction is quick.

Delayed conduction through an INTERIOR–WALL between two non-sunspaces can be obtained simply by assigning SUNSPACE = YES to one of the spaces, even though the space is not actually a sunspace. If the solar flux on the "sunspace" side of the wall is small, it is recommended that INSIDE–SOL–ABS = (0,0) be input for the wall in order to zero out absorption of solar radiation. Otherwise, all interior and exterior walls and windows in the "sunspace" should be geometrically positioned as described above in **Positioning of Sunspace Surfaces**.

Solar Radiation Absorbed by Interior Walls

The program calculates conduction through a sunspace INTERIOR—WALL by doing a heat balance on both surfaces. The hourly solar radiation absorbed by the sunspace side of the wall is included in the heat balance. Part of this solar radiation is conducted into the adjacent room.

The amount of solar radiation absorbed depends on the incident flux and the absorptance of the wall. The following section, **Interior Solar Radiation**, describes how the incident flux is determined. The absorptance is input via the keyword INSIDE—SOL—ABS for INTERIOR—WALL. Typical solar absorptance values are listed in a table under the CONSTRUCTION command in the DOE-2 Reference Manual. If not specified, absorptance defaults to 0.5 for walls, 0.8 for floors, and 0.3 for ceilings.

For the purposes of the conduction calculation, the direct and diffuse solar radiation absorbed by an interior wall is uniformly distributed over its surface. If part of the wall gets significantly more radiation, the user can improve the conduction calculation by dividing the wall into two or more sections. The sections would then be input as separate INTERIOR—WALLs of the same AZIMUTH and TILT, but with X,Y,Z,HEIGHT, and WIDTH chosen to give correct geometrical positioning.

Interior Solar Radiation

In DOE-2.1B, the solar radiation entering a space is counted as a heat gain only for that particular space. In 2.1C, however, part of the solar radiation entering a sunspace can be transferred directly to adjacent rooms through interior glazing, or indirectly via solar radiation absorbed by the opaque part of INTERIOR—WALLs.

Beam Radiation	To find the *beam radiation* falling on an inside surface, the program projects the image of each sunspace exterior window onto the surface. This is done using the DOE-2 shadow routines. Summing the contribution from all the exterior windows then gives the net beam radiation incident on the surface. If the surface is an interior window, the transmission and absorption properties of the glazing are used to find the solar gain through the window into the adjacent space. If the surface is opaque, part of the absorbed radiation is conducted to the neighboring space.

Diffuse Solar Radiation	The *diffuse solar radiation* striking sunspace interior walls is also calculated. This radiation has three sources: diffuse radiation from exterior windows; diffuse radiation coming from beam radiation reflected from interior surfaces; and diffuse radiation coming from diffuse radiation from exterior windows which reflects from interior surfaces. The diffuse irradiance inside a sunspace is assumed to be uniform.

If a shading device is present on a sunspace exterior window in a given hour, it is assumed that the radiation transmitted by the shade is totally diffuse; i.e., there is no transmitted beam component. The transmittance of the shade is assumed to be the same for direct and diffuse incident radiation and given by SOL—TRANS—SCH. Solar transmittances for various window treatments can be obtained from Table 2.3 or from manufacturer's data.

The solar energy absorbed by sunspace INTERIOR—WALLs is deducted from the sunspace load. The solar energy transmitted through sunspace interior glazing is also deducted from the sunspace load and credited to the load on adjacent rooms.

Up to 20-25% of the solar radiation entering the sunspace can be reflected back out the exterior windows. The exact percentage depends on inside surface reflectances, glazing fraction, and glass shading coefficient, as described in Section 2.3.4.2 of the DOE-2 Engineers Manual. This loss is included in the Custom Weighting Factors for solar gain; therefore, it is accounted for in the weighted solar load for the space (but not in the instantaneous solar gain). The loss is *not* accounted for in the ASHRAE weighting factors, so that Custom Weighting Factors, obtained by specifying FLOOR—WEIGHT = 0, should be used for sunspaces.

The program does not account for the loss of radiation entering one exterior window and leaving another exterior window without an intermediate reflection. This radiation is included in the solar gain.

TABLE 2.3

Description of Window Treatment and Performance*

Window Treatment (1,2,3, or 4) and Fabrication/Finish/Color	Solar Characteristics** Trans-mittance %	Reflec-tance %	Absorp-tance %
Lined Drapery			
1 Satin/NFF†/Goldenrod--Lining: Plain/Opaque/White	15	66	19
2 Satin/NFF/Dk. Brown--Lining: Plain/Opaque/White	02	57	41
3 Satin/NFF/White--Lining: Plain/Opaque/White	18	68	14
4 Mali/NFF/Beige with brown accent--Lining: Plain/Translucent/Beige	34	47	19
Unlined Satin Drapery			
1 Brocade/Acrylic Foam back/Beige	08	70	21
2 Brocade/Acrylic Foam back/Beige	10	67	24
3 Modified Satin/Acrylic Foam back/Beige	17	73	10
4 Modified Satin/Acrylic Foam back/Green	09	75	16
5 Modified Satin/NFF/Variegated Brown	30	51	19
Unlined Casement Drapery			
1 Mali/NFF/Beige	54	41	05
2 Mali/NFF/Variegated Brown	29	54	16
3 Mali/NFF/Beige	56	37	07
4 Mali/NFF/Beige	36	42	23
Shirred Curtains			
1 Plain (Ninon)/NFF/Beige	65	27	08
2 Plain (Ninon)/NFF/White	66	29	05
3 Leno (Marquisette)/NFF/White	86	14	00
Pleated Curtains			
1 Plain (Ninon)/NFF/Beige	27	37	37
Venetian Blinds (slats closed)			
1 2" steel slats/NFF/White	04	55	41
2 1" aluminum slats/NFF/White	02	57	41
Vertical Blinds (slats closed)			
1 3.5" film PVC/NFF/White	01	70	28
2 3.5" Plain weave/NFF/White	31	58	11
Translucent Roller Shade			
1 Open plain weave/vinyl-coated Fiberlgas/White	48	43	09
2 Plain weave/vinyl-coated cotton/White	19	65	16
Opaque Roller Shade			
1 Plain weave/vinyl-coated cotton embossed/White	00	66	34
2 Plain weave/vinyl-coated layer/White	00	74	26

3 Plain weave/laminated embossed/White	00	75	26
4 Film/vinyl-coated embossed/White	15	67	18
Roll-up Shade			
1 Modified plain weave/vinyl tube yarn/NFF/Beige	33	53	14
Drapery Liner			
1 Plain weave/Acrylic coated/White	18	66	16
2 Plain weave/Acrylic coated/White	17	70	13
Wooden Shutter (louvers closed)			
1 Wood/NFF/Beige	00	63	37
Wooden Shutter Frame with Shirred Fabric			
1 Wood/NFF/Beige--Fabric: Ninon/NFF/White Width: three times the frame opening	62	35	04
2 Wood/NFF/Beige--Fabric: Ninon/NFF/White Width: six times the frame opening	32	51	17

† NFF — No Functional Finish relevant to Heat Flux

* From "Solar Optical Properties of Accepted Interior Window Treatments", Eleanor Woodson, Samina Kahn, Patricia Horridge, and Richard W. Tock, **ASHRAE Journal**, p.40, August 1983.

** Due to roundoff, sum of transmittance, reflectance, and absorptance may not be 100%.

Use of Multipliers

To obtain an accurate interior solar radiation calculation, it is recommended that MULTIPLIER *not* be used for sunspace exterior WINDOWS, interior WINDOWS, or EXTERIOR—WALLs (if they have windows). In addition, it is recommended that MULTIPLIER not be used on a SPACE adjacent to a sunspace.

The dangers of using MULTIPLIERs are illustrated in Figs. 2.4 and 2.5. If the two identical exterior WINDOWs in Fig. 2.4 are entered as a single WINDOW W—1 with MULTIPLIER = 2, no direct radiation will be calculated to fall on interior wall IW—2, whereas the radiation on IW—3 will be over-estimated by a factor of 2. The two windows should be input separately. In Fig. 2.5 beam radiation strikes the interior window between sunspace and B, but not the one between sunspace and A. If the "identical" SPACE's A and B are input as A with MULTIPLIER = 2, there will be zero beam radiation transmitted to these SPACEs from the sunspace.

If the radiation inside the sunspace is predominately *diffuse*, which would be the case if beam radiation were blocked by overhangs or window shades, the various MULTIPLIERs discussed *can* be used with little loss of accuracy.

XBL 849-8739

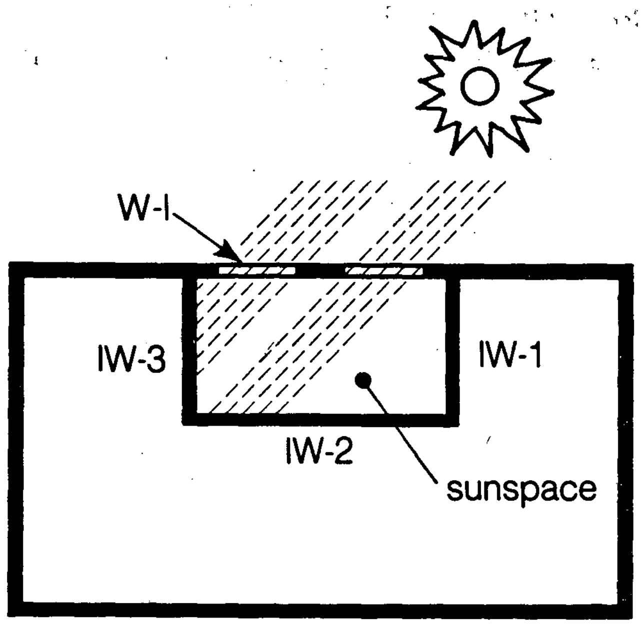


Figure 2.4: If the two exterior WINDOWs are input as a single window W—1 with MULTIPLIER = 2, the program will get zero beam radiation striking interior wall IW—2 and twice the actual amount striking IW—3.

XBL 849-8738

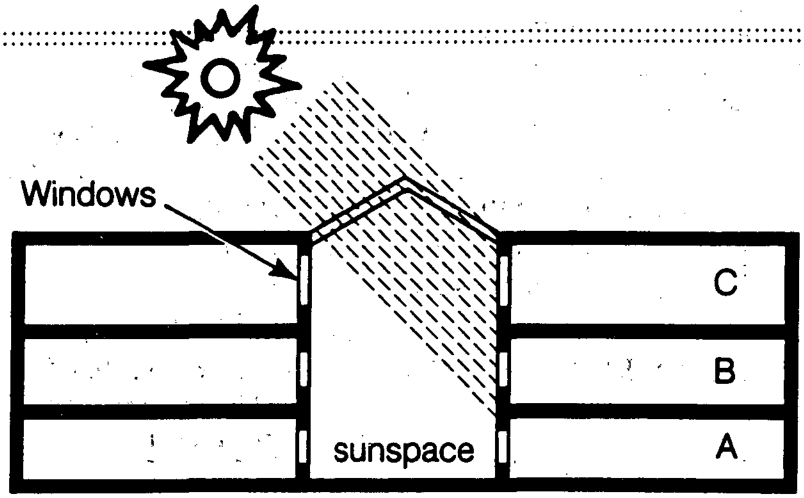


Figure 2.5: If SPACEs A and B are input as a single space A with MULTIPLIER = 2, the beam radiation transmitted through the interior windows in these spaces will be calculated to be zero.

Translucent Glazing

Translucent exterior glazing in a sunspace should be modeled with GLASS–TYPE–CODE = 1 and with SHADING–SCHEDULE values equal to the shading coefficient of the glazing. (A SHADING–SCHEDULE is used here to give a window which is diffusely transmitting.) A SOL–TRANS–SCH should also be specified, with a constant value equal to $T/0.878$, where T is the solar transmittance of the glazing at normal incidence. (0.878 is the transmittance at normal incidence for the clear reference glass used in DOE-2.)

Example:

A sunspace has single-pane translucent exterior glazing with a shading coefficient of 0.71 and solar transmittance of 0.82:

```
GT-1         = GLASS-TYPE  GLASS-TYPE-CODE = 1  ..
                    .
                    .
                    .
SHSCH-1      = SCHEDULE  THRU DEC 31 (ALL) (1,24) (.71)  ..
SOLTRSCH-1   = SCHEDULE  THRU DEC 31 (ALL) (1,24) (.93)  ..
                                     $ .93 = .82/.878 $
                    .
                    .
                    .
SUNSPWIN-1 = WINDOW  GLASS-TYPE = GT-1
                     SHADING-SCHEDULE = SHSCH-1
                     SOL-TRANS-SCH = SOLTRSCH-1
                            .
                            .
                            .
```

Moisture from Plants and Trees

Atriums often have plants and trees. Moisture transpiring from leaves and evaporating from soil can produce a significant latent load. To model this load, plants can be described using the "SOURCE" keywords in SPACE or SPACE–CONDITIONS as follows:

SOURCE–TYPE	=	PROCESS
SOURCE–LATENT	=	1.0
SOURCE–SENSIBLE	=	0.0
SOURCE–BTU/HR	=	latent load from plants and soil
SOURCE–SCHEDULE	=	u-name of schedule (which could vary seasonally or with time of day, if desired)

Baffles and Louvers

Baffles and louvers on sunspace exterior windows, which block and/or diffuse incoming beam radiation, can be modeled as shading devices by specifying SOL–TRANS–SCH and SHADING–SCHEDULE. This method is very approximate, however, since the transmittance of devices of this kind is usually very incidence-angle dependent. Furthermore, very little measured data is currently available that would be useful in choosing average transmittance values.

Atrium as Return Air Plenum

In some commercial building designs, some or all of the return air from conditioned zones is passed to a central sunspace/atrium, from which it is passed back to the central air handling system or exhausted. The atrium thus behaves like a return air plenum. This arrangement can be modeled by assigning ZONE–TYPE = PLENUM to the atrium zone and including the atrium u-name in the PLENUM–NAMES list for the system.

If only part of the system return air goes to the atrium, two PLENUM zones can be defined, one of them being the atrium and the other being a real or dummy plenum. In a system with two plenums, the return air is split by DOE-2 between the plenums, in proportion to their floor areas, as given by the AREA keyword in the SPACE commands. Thus, if a fraction f of return air goes to the atrium, the atrium AREA divided by the AREA of the second plenum should be $f/(1-f)$.

If some of the return air is exhausted directly from the atrium, EXHAUST–CFM can be specified for the atrium zone. Previously, this keyword worked only for ZONE–TYPE = CONDITIONED. (EXHAUST–CFM will also work for PLENUMs which are not sunspaces, i.e., have SUNSPACE = NO.)

The program accounts for the various forms of sensible and latent heat gain or loss, such as solar gain, infiltration, and moisture from people, for ZONE–TYPE = PLENUM just as it does for ZONE–TYPE = CONDITIONED. There are two important restrictions, however. The atrium as PLENUM cannot be mechanically cooled (although it can be vented) and it can be heated only with baseboards (see p. 3.21, **Baseboard Heating in Plenums**, of this Supplement).

Example:
Two-thirds of the return air from five identical conditioned zones goes to a 10,000 sq.ft. atrium; the remaining one-third goes directly back to the air handling system.

```
INPUT LOADS    ..
        .
        .
        .
CONDZONES = SPACE  MULTIPLIER = 5
                   ZONE-TYPE = CONDITIONED
                        .
                        .
                        .    ..
ATRIUM    = SPACE  AREA = 10000
                   SUNSPACE = YES
                   ZONE-TYPE = PLENUM
                        .
                        .
                        .    ..
DUMPLEN   = SPACE  AREA = 5000
                   ZONE-TYPE = PLENUM
                        .
                        .
                        .    ..
INPUT SYSTEMS    ..
        .
        .
        .
CONDZONES = ZONE
            .
            .
            .    ..
ATRIUM    = ZONE
            .
            .
            .    ..
DUMPLENS  = ZONE
            .
            .
            .    ..
SYS-1     = SYSTEM  ZONE-NAMES   = (CONDZONES, ATRIUM, DUMPLEN)
                    PLENUM-NAMES = (ATRIUM, DUMPLEN)
                        .
                        .
                        .    ..
```

Heating, Cooling, and Venting of Residential Sunspaces
For SYSTEM–TYPE = RESYS, sunspaces are not heated by the central system; a sunspace can be heated only with thermostatic baseboards (BASEBOARD–CTRL = THERMOSTATIC). Unlike baseboard heating of the other zones in this system, baseboard heating of a sunspace is independent of the heating requirements of the control zone (the first zone in the ZONE–NAMES list).

Sunspaces in SYSTEM–TYPE = RESYS are not cooled by the central system. They can, however, be vented with outside air, as explained in the keyword descriptions for SS–VENT–SCH, SS–VENT–T–SCH, etc., in the ZONE–AIR command. The venting of a sunspace in this system is independent of the natural ventilation of the other zones as determined by NATURAL–VENT–SCH, etc., in SYSTEM–AIR.

Use of Custom Weighting Factors for Sunspaces
It is recommended that Custom Weighting Factors (CWF) be used for sunspaces for several reasons:

(1) For high conductance spaces, the precalculated (ASHRAE) weighting factors in DOE-2 overestimate heating and cooling loads. The overestimate can be as high as 25-30% for heavily glazed spaces.

(2) The CWF account for loss of solar gain due to reflection of sunlight back out of exterior windows.

(3) The CWF give a more accurate calculation of the generally large temperature swings in a solar-driven space.

CWF's will automatically be calculated for any space with FLOOR–WEIGHT = 0. Otherwise, the program will use ASHRAE weighting factors. See the DOE-2 Reference Manual, Chap. III, Sec. C, for CWF input guidelines.

Hourly Report Variables for Sunspace Analysis
In 2.1C, nine new hourly report variables (56 through 64) were added in SYSTEMS to VARIABLE–TYPE = u-name of ZONE for sunspace analysis. Also, the LOADS VARIABLE–TYPE = u-name of WINDOW variable descriptions were updated to reflect the addition of sunspace-related interior windows. See the Appendix at the end of this volume for a full listing of the program hourly variables.

Sunspace–related Error, Caution, and Warning Messages

In the following, "sunspace" means a SPACE with SUNSPACE = YES; "non-sunspace" means a SPACE with SUNSPACE = NO (the default).

Error Message (1)

INTERIOR–WALL <u-name>, WHICH IS BETWEEN A SUNSPACE AND A NON-SUNSPACE, HAS AREA SPECIFIED RATHER THAN HEIGHT AND WIDTH. HEIGHT AND WIDTH ARE REQUIRED FOR CALCULATION OF SOLAR RADIATION ABSORBED ON THE SUNSPACE SIDE OF THIS WALL.

Meaning: Self-explanatory.

User-Action: Specify HEIGHT and WIDTH for this wall.

Error Message (2)

EXTERIOR–WALL <u-name>, IN SUNSPACE <u-name>, HAS A MULTIPLIER OF <value>. THE MULTIPLIER ON AN EXTERIOR–WALL (WITH WINDOWS) IN A SUNSPACE SHOULD BE 1.0.

Meaning: A sunspace has an EXTERIOR–WALL with a MULTIPLIER different from 1.0. Since this wall has one or more WINDOWs, the use of a MULTIPLIER will give an inaccurate calculation of the interior solar radiation distribution from these windows.

User-Action: Do not use a MULTIPLIER on sunspace EXTERIOR–WALLs.

Error Message (3)

SPACE <u-name> HAS <value> SUNSPACE COMMON WALLS WITH CONVECTIVE HEAT TRANSFER (AIR–FLOW–TYPE = FORCED–RECIRC, FORCED–OA–PREHT, FREE–RECIRC, OR FREE–DOORWAY. AT MOST, ONE COMMON WALL WITH CONVECTIVE TRANSFER IS ALLOWED IN A SPACE.

Meaning: A space cannot have more than one interior wall across which convective flow is specified using the AIR–FLOW–TYPE keyword in the WALL–PARAMETERS command.

User-Action: Reduce number of interior walls with convection to one.

Warning Message (1)

WINDOW <u-name> ON INTERIOR WALL <u-name> HAS X=0, Y=0 AND THEREFORE HAS PROBABLY NOT BEEN CORRECTLY POSITIONED. THIS MAY CAUSE AN INACCURATE SOLAR RADIATION TRANSMISSION

CALCULATION.

Meaning: The user has probably forgotten to geometrically position the interior WINDOW.

User-Action: Specify X, Y, HEIGHT and WIDTH for the WINDOW; see Fig. 2.2 and subsection **Positioning of Sunspace Surfaces** (p. 2.17).

Warning Message (2)

<u-name> IS AN INTERIOR—WALL BETWEEN SUNSPACE <u-name> AND SPACE <u-name>. SINCE THE INTERIOR—WALL WAS DEFINED IN <u-name> IT IS IMPORTANT THAT THIS SPACE BE CORRECTLY POSITIONED WITH RESPECT TO THE SUNSPACE TO OBTAIN AN ACCURATE CALCULATION OF SOLAR RADIATION INCIDENT ON THE WALL FROM EXTERIOR WINDOWS IN THE SUNSPACE.

Meaning: A sunspace INTERIOR—WALL was defined in the adjacent space rather than in the sunspace.

User-Action: Be sure that the SPACE in which the INTERIOR—WALL was defined is geometrically positioned with respect to the sunspace. Alternatively, define the INTERIOR—WALL in the sunspace.

Warning Message (3)

SPACE <u-name>, WHICH IS NEXT TO SUNSPACE <u-name> HAS MULTIPLIER <value>. A MULTIPLIER DIFFERENT FROM 1.0 MAY CAUSE AN INACCURATE

CALCULATION OF HEAT TRANSFER FROM THE SUNSPACE.

Meaning: The use of a MULTIPLIER on a SPACE adjacent to a sunspace multiplies the common INTERIOR—WALL. This may give an incorrect calculation of the total solar radiation absorbed by the wall and transmitted by windows in the wall.

User-Action: See subsection **Use of Multipliers** (p. 2.22).

Warning Message (4)

WINDOW <u-name> IN INTERIOR—WALL <u-name> HAS MULTIPLIER <value>. A MULTIPLIER DIFFERENT FROM 1.0 MAY CAUSE AN INACCURATE SOLAR RADIATION TRANSMISSION CALCULATION.

Meaning: The location of sunspace interior glazing is important in the calculation of the amount of solar radiation striking the glazing.

User-Action: Do not use a MULTIPLIER. Input WINDOWs separately.

Caution Message (1) SUNSPACE INTERIOR WALL <u-name> HAS X=0, Y=0 AND THEREFORE MAY NOT BE CORRECTLY POSITIONED. THIS MAY CAUSE AN INACCURATE CALCULATION OF SOLAR RADIATION ABSORBED BY THE WALL.

Meaning: The user has probably forgotten to geometrically position a sunspace INTERIOR–WALL.

User-Action: Specify X, Y, Z, AZIMUTH, TILT, HEIGHT, and WIDTH. See Fig. 2.2 and subsection **Positioning of Sunspace Surfaces** (p. 2.17).

Caution Message (2) WINDOW <u-name> IN SUNSPACE EXTERIOR–WALL <u-name> HAS MULTIPLIER <value>. A MULTIPLIER DIFFERENT FROM 1.0 MAY CAUSE AN INACCURATE CALCULATION OF THE AMOUNT OF SOLAR RADIATION FROM THIS WINDOW WHICH STRIKES THE INTERIOR WALLS OF THE SUNSPACE.

Meaning: The geometrical position of a sunspace exterior WINDOW is important in the interior solar radiation calculation.

User-Action: Do not use MULTIPLER; input windows separately.

Caution Message (3) WINDOW <u-name> IS IN INTERIOR WALL <u-name> WITH TYPE=[AIR, ADIABATIC, or INTERNAL]. THIS WINDOW WILL BE IGNORED.

Meaning: The program calculates heat transfer through interior windows only if they are in an INTERIOR–WALL with INT–WALL–TYPE = STANDARD (the default) and this INTERIOR–WALL is between a sunspace and a non-sunspace. In all other cases, INTERIOR–WALLs are considered as being without WINDOWS.

User-Action: Remove WINDOW from wall, or change INT–WALL–TYPE to STANDARD if heat transfer calculation across the wall is desired.

Caution Message (4) WINDOW <u-name> IS IN INTERIOR–WALL <u-name> BETWEEN TWO SUNSPACES. THIS WINDOW WILL BE IGNORED.

Meaning: The program calculates heat transfer through interior windows only if they are in an INTERIOR–WALL with

INT–WALL–TYPE = STANDARD (the default) and this INTERIOR–WALL is between a sunspace and a non-sunspace. In all other cases, INTERIOR–WALLs are considered as being without WINDOWS.

User-Action: Check whether the spaces on either side of this wall should both be sunspaces. If not, assign SUNSPACE = NO to one of them. Otherwise, remove WINDOW from wall.

Caution Message (5) WINDOW <u-name> IS IN INTERIOR–WALL <u-name> BETWEEN TWO NON–SUNSPACES. THIS WINDOW WILL BE IGNORED. (HEAT TRANSFER WILL BE CALCULATED ONLY FOR WINDOWS IN A STANDARD–TYPE INTERIOR WALL BETWEEN A SUNSPACE AND A NON–SUNSPACE.)

Meaning: The program calculates heat transfer through interior windows only if they are in an INTERIOR–WALL with INT–WALL–TYPE = STANDARD (the default) and this INTERIOR–WALL is between a sunspace and a non-sunspace. In all other cases, INTERIOR–WALLs are considered as being without WINDOWS.

User-Action: Check whether the spaces separated by this wall should both be non-sunspaces. If not, assign SUNSPACE = YES to one of them. Otherwise, remove WINDOW from wall.

WINDOW MANAGEMENT AND SOLAR RADIATION

Window Management

There are several ways of controlling the operation of window shading devices in DOE-2. In DOE-2.1A, the shading-coefficient and conductance of a window could be modified each hour to account for the presence of a shading device by specifying a SHADING–SCHEDULE and CONDUCT–SCHEDULE for the window. We call these "schedule controls". This option was retained in 2.1B; in addition, options to control shading devices when solar gain, outside temperature, or daylight glare exceed user-specified threshold values were added in 2.1B. We call these "threshold controls".

The 2.1B options made use of the following keywords:

MAX–SOLAR–SCH
SUN–CTRL–PROB
CONDUCT–TMIN–SCH
WIN–SHADE–TYPE

Please refer to the **DAYLIGHTING** section, p. 2.33, of this Supplement for a discussion on the use of these keywords (whether or not daylighting is to be employed).

The various control options for window management and their input requirements are summarized in Table 2.4 (p. 2.43) under **Window Management** in the **DAYLIGHTING** section. Note in Table 2.4 the additional input requirements for windows in spaces for which a daylighting calculation has been requested by specifying DAYLIGHTING=YES in SPACE or SPACE–CONDITIONS.

Conditional Shading-Device Control

A new keyword was introduced in 2.1C, in the WINDOW command, to be used in conjunction with window management:

<u>WINDOW</u>

OPEN–SHADE–SCH is the u-name of a schedule whose value in any given hour is the probability that the shading device will be opened if both the solar gain and the glare (with shade open) would be below the limits set by MAX–SOLAR–SCH in the WINDOW command and MAX–GLARE in the SPACE–CONDITIONS command. If OPEN–SHADE–SCH is not specified, the shading devices will be reopened as soon as both the heat gain and glare fall below the specified limits. The shading devices are reopened at midnight in any case. The abbreviation is O–S–SCH.

Example:
Drapes on a window are closed from April to October whenever the transmitted direct solar gain (with the drapes open) exceeds a threshold value of 15 Btu/ft^2-hr. From November to March, the drapes are closed when the solar gain exceeds 50 Btu/ft^2-hr. The shading coefficient multiplier for the drapes when they are closed is 0.3. The drapes have a negligible effect on the window conductance. There is a 10% probability each hour that the occupants will reopen the drapes if the transmitted solar gain falls below the above threshold values.

```
DRAPEMULTSCH-1  = SCHEDULE  THRU DEC 31 (ALL) (1,24) (0.3)  ..
MAXSOLSCH-1     = SCHEDULE  THRU MAR 31 (ALL) (1,24) (50)
                            THRU OCT 31 (ALL) (1,24) (15)
                            THRU DEC 31 (ALL) (1,24) (50)   ..
REOPEN-PROB-1   = SCHEDULE  THRU DEC 31 (ALL) (1,24) (0.1)  ..
                     .
                     .
                     .
WIN-1           = WINDOW  SHADING-SCHEDULE = DRAPEMULTSCH-1
                          MAX-SOLAR-SCH = MAXSOLSCH-1
                          OPEN-SHADE-SCH = REOPEN-PROB-1
                                  .
                                  .
                                  .  ..
```

D A Y L I G H T I N G

Overview

The DOE-2 daylighting calculation allows users to determine what effect the use of daylighting to dim electric lighting has on energy use, peak loads, and energy cost. The calculation is done in the LOADS program; it has three main stages:

(1) A preprocessor calculates in detail a set of "daylight factors" (interior illuminance divided by exterior horizontal illuminance) for later use in the hourly loads calculation. The user specifies the coordinates of one or two reference points in a space. DOE-2 then integrates over the area of each window to obtain the contribution of direct light from the window to the illuminance at the reference points, and the contribution of light from sky and ground which enters the window and reflects from the walls, floor, and ceiling before reaching the reference points. Taken into account are such factors as window size and orientation, glass transmittance, inside surface reflectance of the space, sun-control devices such as blinds and overhangs, and the luminance distribution of the sky. Since this distribution depends on the position of the sun and cloudiness of the sky, the calculation is carried out for standard clear and overcast sky conditions for a series of 20 different solar altitude and azimuth values covering the annual range of sun positions. Analogous factors for discomfort glare are also calculated and stored.

(2) An hourly daylight illuminance and glare calculation is performed. The illuminance contribution from each window is found by interpolating the stored daylight factors using the current-hour sun-position and cloud cover, then multiplying by the current-hour exterior horizontal illuminance obtained from measured horizontal solar radiation, if present on the weather file, or from a calculation. If the glare-control option has been specified, the program will automatically close window blinds or drapes in order to decrease glare below a pre-defined comfort level. (A similar option is available to use window shading devices to automatically control solar gain.) Adding the illuminance contributions from all the windows then gives the total number of footcandles at each reference point.

(3) Stepped and continuously dimming control systems are simulated to determine the electrical lighting energy needed to make up the difference, if any, between the daylighting level and the required illuminance. Finally, the zone lighting electrical requirements are passed to the DOE-2 thermal loads calculation.

Acknowledgement: The Daylighting Program was developed in collaboration with the Windows and Daylighting Group at Lawrence Berkeley Laboratory.

Guidelines for daylighting modeling in DOE-2

Following are some guidelines for preparing DOE-2 input to model the effects of daylighting. Before studying these guidelines, however, the user should read the description of each daylighting keyword* in the **DOE-2 Daylighting Keywords** section, p. 2.44, of this Supplement and review the sample daylighting run in the DOE-2 Sample Run Book.

* The daylighting keywords are:		
in BUILDING–LOCATION	**ATM–MOISTURE** **ATM–TURBIDITY**	
in GLASS–TYPE	**VIS–TRANS**	
in BUILDING–SHADE and FIXED–SHADE	**SHADE–VIS–REFL** **SHADE–GND–REFL**	
in SPACE–CONDITIONS	**DAYLIGHTING** **DAYLIGHT–REP–SCH** **LIGHT–CTRL–PROB** **LIGHT–CTRL–STEPS** **LIGHT–CTRL–TYPE1** **LIGHT–CTRL–TYPE2** **LIGHT–REF–POINT1** **LIGHT–REF–POINT2**	**LIGHT–SET–POINT1** **LIGHT–SET–POINT2** **MAX–GLARE** **MIN–POWER–FRAC** **MIN–LIGHT–FRAC** **VIEW–AZIMUTH** **ZONE–FRACTION1** **ZONE–FRACTION2**
in WINDOW	**CONDUCT–TMIN–SCH**** **GLARE–CTRL–PROB** **MAX–SOLAR–SCH**** **OPEN–SHADE–SCH****	**SUN–CTRL–PROB**** **VIS–TRANS–SCH** **WIN–SHADE–TYPE**
in WINDOW, DOOR, ROOF, EXTERIOR–WALL UNDERGROUND–WALL UNDERGROUND–FLOOR and INTERIOR–WALL	**INSIDE–VIS–REFL**	
** can also be used without daylighting		

As is the case when custom weighting factors are being used, all of the bounding surfaces of a space should be input, even INTERIOR–WALLs across which negligible heat transfer takes place.

Thermal Zoning

To correctly calculate both direct and inter-reflected illuminance, one should try to model thermal zones consisting of several rooms separated by interior walls as a representative room with a multiplier. An example of this is shown in Fig. 2.6. ROOM–1 is the representative room, with MULTIPLIER = 4. INTERIOR–WALLs IW–1 and IW–2 should have INT–WALL–TYPE = ADIABATIC. INTERIOR–WALL IW–3 could be INT–WALL–TYPE = STANDARD or ADIABATIC. (See Section **FLOOR MULTIPLIERS AND INTERIOR WALL TYPES**, p. 2.81, in this Supplement for a description of INT–WALL–TYPE.) The floor and ceiling of ROOM–1 would probably be input as interior walls with INT–WALL–TYPE = ADIABATIC.

XBL 8211-7338

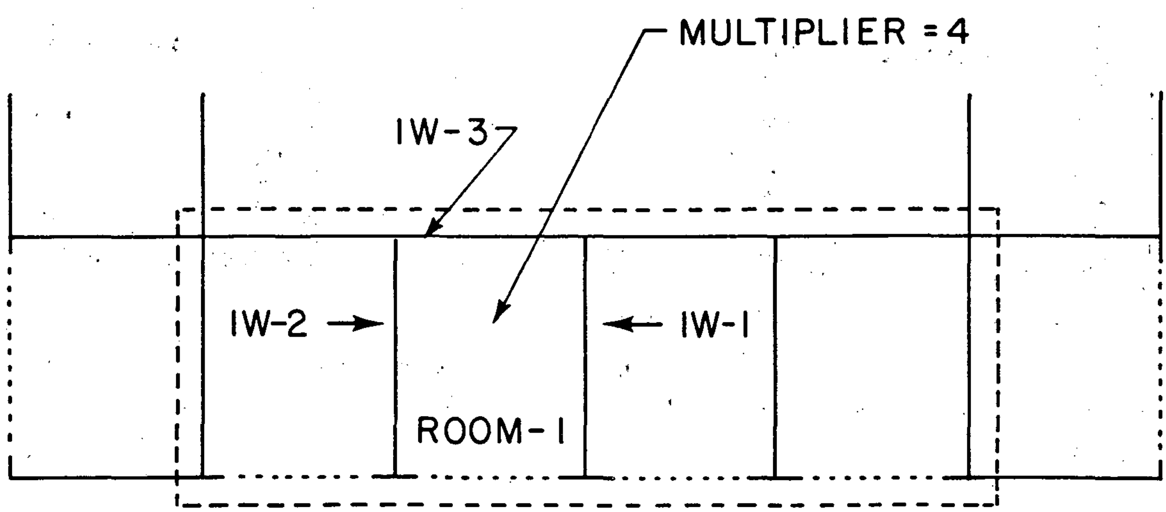


Figure 2.6: For daylighting purposes the thermal zone indicated by the dashed boundary line should be modelled as a typical room with a MULTIPLIER of 4.

Sometimes a representative room cannot be found. Figure 2.7 shows a section of a building with four rooms having different daylight characteristics because of floor area, orientation, and window size. In this case, the analyst must choose between two alternatives: (1) simplify input by lumping the rooms into a single thermal zone, neglect partitions, and thereby get a possibly questionable daylighting result; or (2) describe each room as a separate thermal zone, input the partitions, and obtain an accurate daylighting calculation.

XBL 8211-7337

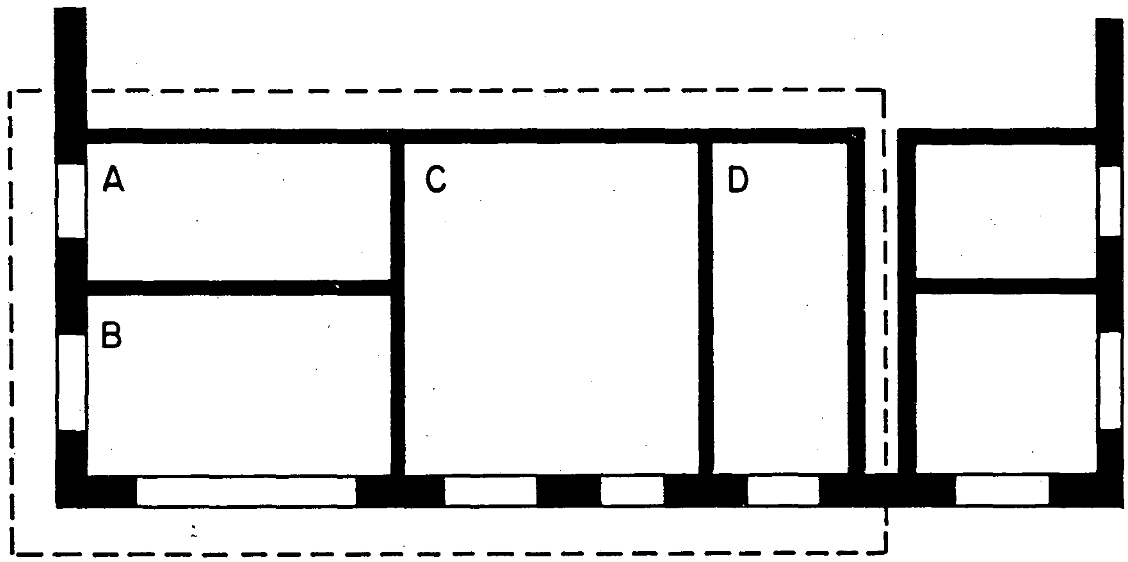


Figure 2.7: Rooms A, B, C, and D have different daylighting characteristics. If lumped into a single zone, input is simplified, but daylighting calculation will be inaccurate.

Surface Orientation

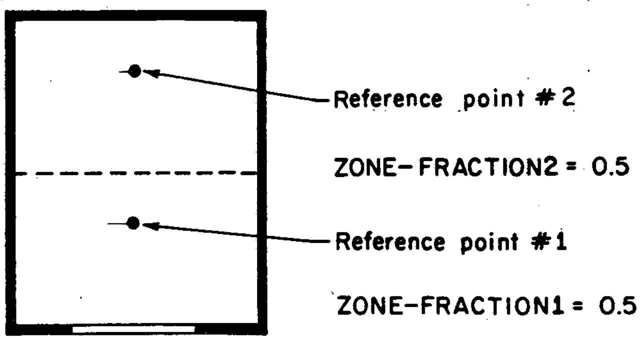
In the calculation of inter-reflected illuminance, the daylighting program uses surface tilt to distinguish between floors, walls, and ceilings. It is therefore important that the TILT values of all the bounding surfaces of a space be correctly specified. This applies not only to EXTERIOR–WALLs, but also to INTERIOR–WALLs, and UNDERGROUND–FLOORs and UNDERGROUND–WALLs.

Multiple Lighting Zones

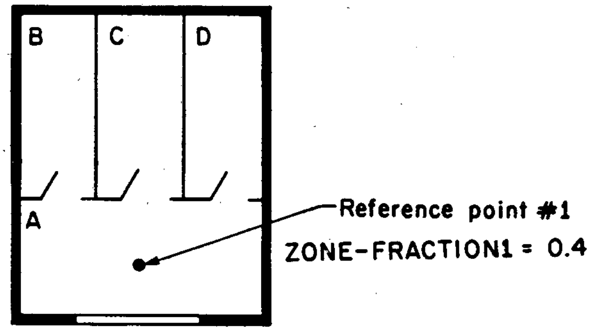
The daylighting program allows a thermal zone to be divided into two independently-controlled lighting zones. An example is shown in Fig. 2.8(a), where a relatively deep thermal zone has two lighting zones of equal area.

It is also possible to daylight only part of a thermal zone. Fig. 2.8(b) shows an example in which room A, with 40% of the zone's floor area, is daylit, whereas B, C, and D, having no windows, are not daylit. Note that a reference point and zone fraction are specified only for the daylit room.

XBL 8211-7335



(a) two independently controlled lighting zones, each with 50% of the area of the thermal zone;



(b) a thermal zone with four rooms. Only room (a), with 40% of the floor area, is daylit.

Figure 2.8: Examples of multiple lighting zones in a single thermal zone

Translucent Glazing

Skylights with diffusing glass, translucent fabric roofs, etc., can be modeled as clear glazing with a diffusing shade. For example, the input for a skylight with specularly-reflective, diffusely-transmitting glass, having a visible transmittance at normal incidence of 0.14 and a shading coefficient of 0.20, might be as follows:

```
GT-1        =  GLASS-TYPE  VIS-TRANS = 1.0
                           SHADING-COEF = 1.0  ..
VT-MULT-1   =  SCHEDULE  THRU DEC 31 (ALL) (1,24) (.14)  ..
SC-MULT-1   =  SCHEDULE  THRU DEC 31 (ALL) (1,24) (.20)  ..
                  .
                  .
                  .
               WINDOW  GLASS-TYPE = GT-1
                       VIS-TRANS-SCH = VT-MULT-1
                       SHADING-SCHEDULE = SC-MULT-1
                       WIN-SHADE-TYPE = FIXED-INTERIOR
                                        .
                                        .
                                        .  ..
```

If the outside surface of the glazing material reflects diffusely, rather than specularly, WIN–SHADE–TYPE = FIXED–EXTERIOR is recommended.

Fins, Overhangs, and Other Shading Surfaces

The daylighting program accounts for the presence of overhangs and other shading surfaces which affect the amount of solar radiation and visible light that strikes the windows (see p. 2.63, **FIXED SHADES, FINS, AND OVERHANGS**, of this Supplement). There are five categories of shading surfaces in DOE-2:

1) Shades defined by BUILDING–SHADE 2) Shades defined by FIXED–SHADE 3) Shades defined by EXTERIOR–WALLs with SHADING–SURFACE = YES ("self shades")	global shades
4) Shades associated with window SETBACK 5) Overhangs and fins generated by the WINDOW keywords OVERHANG–A, LEFT–FIN–A, RIGHT–FIN–A, etc. ("overhangs" and "fins")	local shades

For daylighting, the program assumes local shades are opaque and black, i.e., they neither transmit nor reflect incident light. A horizontal "overhang", for example, is modeled as blocking part of the diffuse light from the sky and the direct light from the sun, and reflecting none of the light from the ground.

XBL 8211-7333

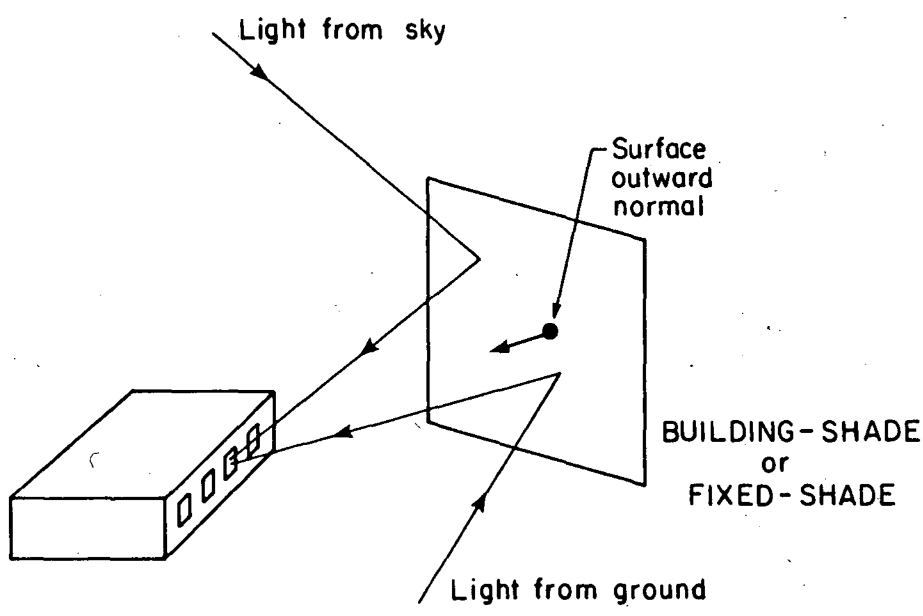


Figure 2.9: Shading surface oriented so that building sees luminous side of shade (the other side of the shade is assumed to be non-reflective).

Global shades are also assumed to be opaque, but, unlike local shades, they are assumed to have luminance due to the light from the sky and ground which they reflect. (However, the building itself is assumed to have no effect on this luminance.

For this reason, light shelves cannot be accurately modelled.) Only one side of the shade is taken to be luminous. For BUILDING–SHADE and FIXED–SHADE, this is the side from which the surface outward normal points. For "self shades", it is the outside of the wall. To receive reflected light from BUILDING–SHADEs and FIXED–SHADEs (which may represent neighboring buildings, trees, etc.,) the shade azimuth should be chosen so that the surface outward normal points toward the building, as shown in Fig. 2.9. The visible reflectance of BUILDING–SHADEs and FIXED–SHADEs is given by the SHADE–VIS–REFL keyword and the ground reflectance by the SHADE–GND–REFL keyword. The visible reflectance of "self shades" is calculated from the absorbtance of the exterior wall which generates the "self shade".

In general, it is recommended that building projections be described as "fins" and "overhangs", category (5).

Skylight with Light Well

Skylights often have a rectangular light well (Fig. 2.10) which is deep enough to cause substantial attenuation of the light which is transmitted into the room below. This attenuation can be approximately accounted for by multiplying T_{vis}, the visible transmittance of the skylight glazing material, by W_e, the light well efficiency factor[†] given in Fig. 2.11. W_e is determined by the well wall reflectance and by the well index, which is related to the dimensions of the well.

XBL 8211-7332

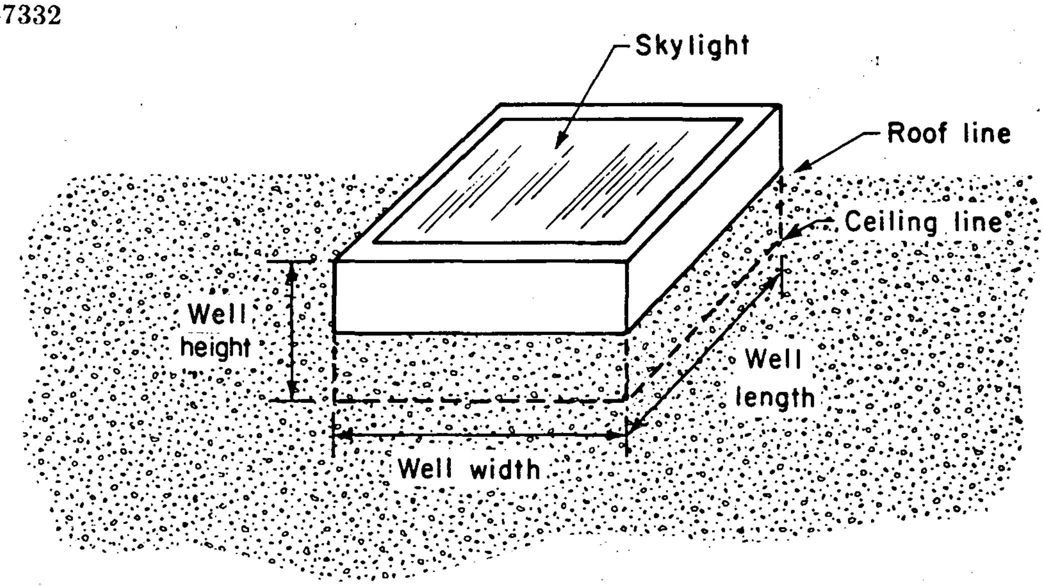


Figure 2.10: Skylight with light well.

[†]: IES Lighting Handbook, 1981 Reference Volume, Illuminating Engineering Society of North America, p. 9-84 ff.

For example, if well height = 3 ft,
well width = 4 ft,
and well length = 6 ft,
then...

$$well\ index = \frac{(well\ \ height)\ x\ (well\ width + well\ length)}{2\ x\ (well\ \ length)\ x\ (well\ \ width)}$$

$$= \frac{3\ x\ (\ 4 + 6\ )}{2\ x\ 4\ x\ 6} = 0.63$$

If the well wall reflectance is 80%, Fig. 2.11 gives $W_e = 0.74$. If T_{vis} is 90%, then the effective skylight transmittance that would be input to DOE-2 is

$$VIS\text{—}TRANS = T_{vis}\ x\ W_e = 0.90\ x\ 0.74 = 0.67.$$

Domed Skylights

The visible transmittance of the acrylic material commonly used in domed skylights is generally given for the flat-sheet material before it is formed. The forming process produces a dome with a thickness that decreases towards the center. To account for the effect of this thickness variation and for the shape of the dome, the following equation can be used[†] to determine an effective transmittance:

$$T_{eff} = 1.25\ T_{vis}\ (1.18 - 0.416\ T_{vis})$$

where T_{vis}, the acrylic sheet's unformed visible transmittance at normal incidence, can be obtained from skylight manufacturer's data. (If the skylight has a light well, the above value of T_{eff} should also be multiplied by the well efficiency factor, W_e, as described in the previous section.)

Example:

A skylight consists of a double dome. The outer dome is transparent with an unformed visible transmittance of 90%. The inner dome is translucent with an unformed transmittance of 40%. The effective transmittance of the outer dome is

$$1.25\ x\ 0.9\ (1.18 - 0.416\ x\ 0.9) = 0.91$$

The effective transmittance of the inner dome is

$$1.25\ x\ 0.4\ (1.18 - 0.416\ x\ 0.4) = 0.51$$

The effective transmittance of both layers (neglecting inter-reflection between the domes) is then 0.91 x 0.51 = 0.46. If the well efficiency factor is 0.67, as in the example in the previous section, the value entered into DOE-2 for the net effective transmittance would be

$$VIS\text{—}TRANS = 0.46\ x\ 0.67 = 0.31$$

Note that, since the inner dome in this example is translucent, a diffusing shade should be assigned with a visible transmittance of 1.0 (see p. 2.23, **Translucent Glazing**).

[†]: IES Lighting Handbook, 1981 Reference Volume, Illuminating Engineering Society of North America, p. 9-84 ff.

XBL 8211-7331

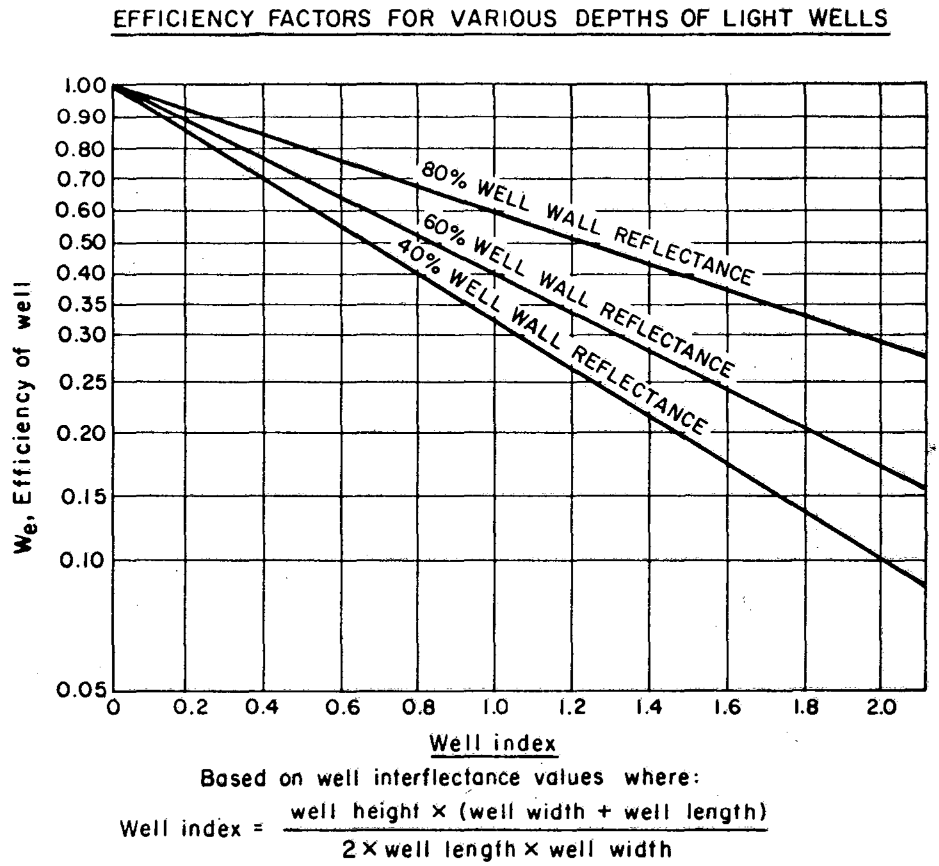


Figure 2.11: Reprinted with permission from the *IES Lighting Handbook*, 1981 Reference Volume, fig. 9-75.

Window Management

There are several ways of controlling the operation of window shading devices in DOE-2. The shading-coefficient and conductance of a window can be modified each hour to account for the presence of a shading device by specifying a SHADING–SCHEDULE and CONDUCT–SCHEDULE for the window. We call this "preset schedule control". In addition, there are options to control shading devices when solar gain, outside temperature, or daylight glare exceed user-specified threshold values. These are called "threshold controls".

The various control options and their input requirements are summarized in Table 2.4(A). Note in Table 2.4(B) the additional input requirements for windows in spaces for which a daylighting calculation has been requested by specifying DAYLIGHTING = YES in SPACE or SPACE–CONDITIONS.

Notes:

(1) For threshold controls, the preset schedule values given by SHADING–SCHEDULE, CONDUCT–SCHEDULE, or VIS–TRANS–SCH are still used, *but only when the shading device is closed,* i.e., only when a threshold condition is exceeded. When the shading device is open, the schedule values are automatically replaced with a value of 1.0.

(2) If two or more threshold controls are specified for the same window (e.g., if MAX–SOLAR–SCH and MAX–GLARE are both input), the shading device will be deployed if either threshold condition is met.

(3) The program cannot model windows with more than one operable shading device. However, windows with one fixed and one operable shading device can be handled by describing the operable shade with SHADING–SCHEDULE, VIS–TRANS–SCH, etc., and describing the properties of the window-plus-fixed-shade combination in the GLASS–TYPE keywords SHADING–COEF, GLASS–CONDUCTANCE, and VIS–TRANS.

(4) CONDUCT–SCHEDULE will have no effect on a window unless a corresponding SHADING–SCHEDULE is also given.

(5) WIN–SHADE–TYPE is required only for windows in daylit spaces.

☞ Limitations of the Daylighting Calculation ☜

The current daylighting model cannot reliably simulate the following:

(1) light shelves

(2) roof monitors

(3) window shading devices with highly directional transmittance (e.g., Venetian blinds).

TABLE 2.4
Window Shading Device Control Options

A. Windows in Non–Daylit Spaces (DAYLIGHTING = NO)

Control Type	Input Required	Effect
Preset schedule	SHADING–SCHEDULE*	Shading coefficient of glazing is multiplied hourly by SHADING–SCHEDULE value.
Solar gain control	MAX–SOLAR–SCH SHADING–SCHEDULE* (SUN–CTRL–PROB and OPEN–SHADE–SCH optional)	Shade is fully closed if transmitted direct solar gain exceeds MAX–SOLAR–SCH value.
Heat loss control with movable insulation	CONDUCT–TMIN–SCH CONDUCT–SCHEDULE SHADING–SCHEDULE (OPEN–SHADE–SCH optional)	Insulation is moved into place if outside drybulb temperature falls below CONDUCT–TMIN–SCH value.

B. Windows in Daylit Spaces (DAYLIGHTING = YES)

Control Type	Input Required	Effect
Preset schedule	VIS–TRANS–SCH SHADING–SCHEDULE*	Glass visible transmittance and shading coefficient are multiplied hourly by VIS–TRANS–SCH and SHADING–SCHEDULE, respectively.
Solar gain control	MAX–SOLAR–SCH VIS–TRANS–SCH SHADING–SCHEDULE* WIN–SHADE–TYPE† (SUN–CTRL–PROB and OPEN–SHADE–SCH optional)	Shade is fully closed if transmitted direct solar gain exceeds MAX–SOLAR–SCH value
Heat loss control with movable insulation	CONDUCT–TMIN–SCH CONDUCT–SCHEDULE VIS–TRANS–SCH** SHADING–SCHEDULE WIN–SHADE–TYPE† (OPEN–SHADE–SCH optional)	Insulation is moved into place if outside drybulb temperature falls below CONDUCT–TMIN–SCH value
Glare control	MAX–GLARE (in SPACE command) VIS–TRANS–SCH SHADING–SCHEDULE* WIN–SHADE–TYPE† (OPEN–SHADE–SCH optional)	Shade is fully closed if daylight glare at either lighting reference point exceeds MAX–GLARE value

* CONDUCT–SCHEDULE should also be input if shading device significantly affects window conductance.

** Since VIS–TRANS-SCH can be assigned, the insulation need not be opaque.

† Must be either MOVABLE–INTERIOR (the default) or MOVABLE–EXTERIOR.

DOE-2 Daylighting Keywords

BUILDING–LOCATION

ATM–MOISTURE is a list of twelve monthly values, given in inches, of the amount of precipitable moisture in the atmosphere. The values should be chosen from Table 2.4, p. 2.56. If the location being analyzed is not in Table 2.4, choose values for a location with a similar climate.

If a similar climate cannot be found, a set of twelve constant monthly values can be assigned according to the following climate types:

Climate Type	Atmospheric Moisture (in.)
Desert (dry air)	0.4
Temperate	0.7 (default)
Tropical (humid air)	1.3

ATM–TURBIDITY is a list of twelve monthly values of atmospheric turbidity (a measure of the amount of aerosols, i.e., particulate pollutants in the atmosphere). The values should be chosen from Table 2.6, p. 2.58. If the location being analyzed is not in this Table, choose values for a location with a similar level of atmospheric pollution.

If a similar climate cannot be found, a set of twelve constant monthly values can be assigned according to the following categories:

Category	Atmospheric Turbidity
Rural Area	0.07
Urban Area	0.12 (default)
Industrial Area	0.16

Note: ATM–MOISTURE and ATM–TURBIDITY are used by the program to calculate the luminance of clear skies.

BUILDING–SHADE and FIXED–SHADE

SHADE–VIS–REFL is the visible reflectance of that side of a BUILDING–SHADE or FIXED–SHADE from which the outward normal points (see text). The other side of the shading surface is assumed to be black, i.e., to have zero reflectance.

SHADE–GND–REFL is the visible reflectance of the ground in the vicinity of the BUILDING–SHADE or FIXED–SHADE.

GLASS–TYPE

VIS–TRANS

is the visible (daylight) transmittance of glazing at normal incidence. Values, which can be found in glass manufacturer's product data sheets, vary from about 0.91 for clear, 1/8" sheet glass, to about 0.07 for some kinds of reflective, heat-absorbing multi-pane glazing.

Note: *visible* transmittance, which determines how much daylight is transmitted by the glass, should not be confused with *total solar* transmittance, which determines how much solar radiation (ultraviolet, visible, and infrared) is transmitted. For most commercially available glass, visible transmittance is higher than total solar transmittance; in some cases it is significantly higher. For example, blue-green single glazing is available which has a visible transmittance of 0.74 vs a total solar transmittance of 0.48.

SPACE–CONDITIONS

DAYLIGHTING

takes codeword values YES or NO (the default). If YES, a daylighting calculation will be done for the space.

LIGHT–REF–POINT1
LIGHT–REF–POINT2

give the x, y, z coordinates (in the space coordinate system) of the reference points at which daylight illuminance levels are to be calculated.
If DAYLIGHTING = YES, LIGHT–REF–POINT1
must be specified. If the user wishes to divide a thermal zone into two independently-controlled lighting zones, then LIGHT–REF–POINT2 should also be specified.

It is assumed that the photocells which control the electric lighting system respond to the light levels at the specified reference points.

Example: The lighting reference point is located at x = 20, y = 10, and z = 2.5ft (desk height).
Then, LIGHT–REF–POINT1 = (20,10,2.5).

Since the location of the reference point(s) is used to determine if the design illuminance condition is met, specification of these points must be done with some care if the daylighting results are to be meaningful.

Zones are generally laid out parallel to the plane of the glazing and a typical depth is 15 ft. Thus, a row of perimeter offices may be treated as a single SPACE with a MULTIPLIER, with results from a single sensor being used to determine daylighting savings for the entire row. If the reference point is placed too near the window, the levels will be high relative to the rest of the space and will overpredict savings. A point at the back of the room will underpredict total savings. Since the drop-off in illuminance is a function with an exponentially declining shape, a point just beyond the mid-point is normally selected as a reasonable location. Until more definitive data is available, the reference point(s) should be placed two-thirds of the zone depth back from the window wall.

These guidelines assume the use of a ceiling-mounted sensor. Although these sensors may be located at a specific point in the room, they generally "view" the reflected light from a larger area in the room. Thus, the sensor itself tends to see an average light level.

ZONE–FRACTION1
ZONE–FRACTION2

give the fraction of the floor-area of the thermal zone (SPACE) which is controlled by LIGHT–REF–POINT1 and LIGHT–REF–POINT2, respectively. If only one reference point (i.e. LIGHT–REF–POINT1) is specified, then ZONE–FRACTION1 should not exceed 1.0. If ZONE–FRACTION1 is less than 1.0, then a fraction of the thermal zone equal to 1.0–ZONE–FRACTION1 is assumed to be non-daylit. If two reference points are specified (i.e. LIGHT–REF–POINT1 and LIGHT–REF–POINT2), then the sum of ZONE–FRACTION1 and ZONE–FRACTION2 should not exceed 1.0. If ZONE–FRACTION1 + ZONE–FRACTION2 is less than 1.0, then a fraction of the thermal zone equal to 1.0–(ZONE–FRACTION1 + ZONE–FRACTION2) is assumed to be non-daylit.

LIGHT–SET–POINT1
LIGHT–SET–POINT2

give the desired lighting level, in footcandles, at LIGHT–REF–POINT1 and LIGHT–REF–POINT2, respectively. Recommended values, which depend on type of activity, occupant age, and other factors, may be found on p. 2.5ff of the IES Lighting Handbook, 1981 Application Volume. It is assumed that this lighting level will be produced by the electric lights at full input power as specified by keywords LIGHTING–KW or LIGHTING–W/SQFT.

LIGHT–CTRL–TYPE1
LIGHT–CTRL–TYPE2

take codewords which specify the type of electric lighting control system at LIGHT–REF–POINT1 and LIGHT–REF–POINT2, respectively. Allowed values are CONTINUOUS and STEPPED.

Codeword CONTINUOUS gives the dimmable control system shown in Fig. 2.12 in which light output varies linearly and continuously with input power. (Non-linear dimming control can be modeled using the functional input capability. See p.1.1, **FUNCTIONAL VALUES**, in this Supplement and the Daylighting Sample in the DOE-2 Sample Run Book.) Specifically, the fractional light output (light output at partial power divided by light output at full power) decreases from 1.0 at full power to a value MIN–LIGHT–FRAC at minimum power fraction MIN–POWER–FRAC (see keyword definitions below).

Codeword STEPPED gives the control system shown in Fig. 2.13, in which power input and light output vary in discrete, equally spaced steps. The number of steps (excluding zero) is given by keyword LIGHT–CTRL–STEPS.

XBL 8211 7343(a)

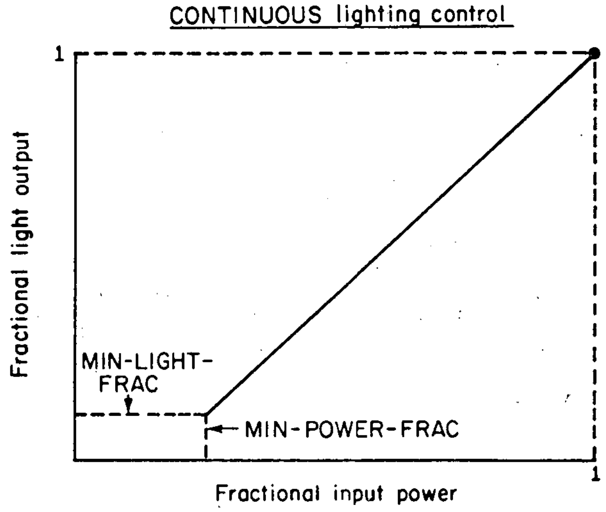


Figure 2.12: Relationship between light output and electrical input for a continuous dimming system.

MIN–POWER–FRAC specifies the lowest input power fraction for a continuously dimmable lighting control system (see Fig. 2.12). See manufacturer's data for appropriate value.

MIN–LIGHT–FRAC specifies the fractional light output that a continuously dimmable lighting control system produces at the minimum fractional input power given by MIN–POWER–FRAC (see Fig. 2.12). See manufacturer's data for appropriate value.

LIGHT–CTRL–STEPS gives the number of steps, excluding zero, in a stepped lighting control system. The steps are assumed to be equally spaced, as shown in Fig. 2.13.

XBL 8211-7343(b)

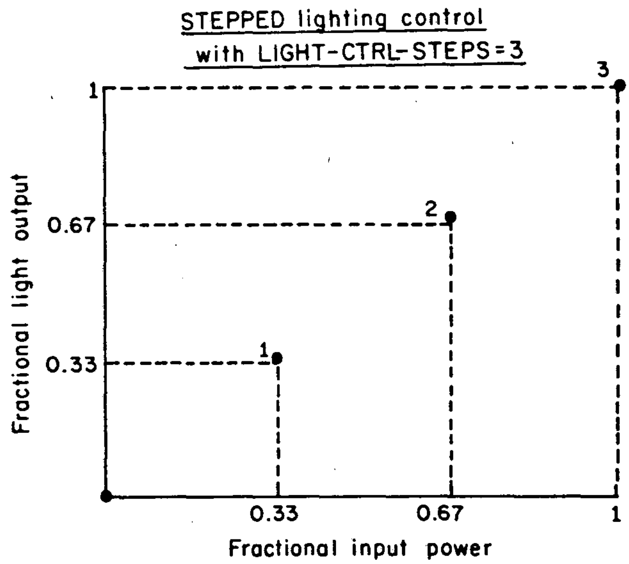


Figure 2.13: STEPPED lighting control with **LIGHT–CTRL–STEPS=3**

LIGHT–CTRL–PROB may be specified if a stepped lighting control system is manually operated, such as in a simple one-step, on-off system. This keyword gives the probability the occupants of a daylit space will set the electric lights to the correct level to obtain the required illuminance. The rest of the time the lights are assumed to be set one step too high. For example, consider an on-off system with

LIGHT–SET–POINT1 = 60,
LIGHT–CTRL–TYPE1 = STEPPED,
LIGHT–CTRL–STEPS = 1, and
LIGHT–CTRL–PROB = 0.7
Then, when daylighting exceeds 60 fc, the electric lights will be off 70% of the time and on 30% of the time.

DAYLIGHT–REP–SCH is the name of a schedule which specifies the time periods over which various entries in daylighting reports LS–G and LS–J are to be accumulated. See description of these reports for more details.

Example:
For space SP–1, accumulate report entries, such as percent lighting energy reduction by daylighting in report LS–G, only from 7am to 6pm on weekdays, i.e., only for the hours that the space is occupied.

```
OCC–HOURS–1    =   SCHEDULE   THRU DEC 31
                              (MON,FRI) (1,7) (0) (8,18) (1)
                              (19,24) (0)
                              (SAT) (1,24) (0)
                              (SUN,HOL) (1,24) (0) ..
                   .
                   .
SP–1           =   SPACE  DAYLIGHTING = YES
                   DAYLIGHT–REP–SCH = OCC–HOURS–1
                   .
                   .
                   . ..
```

MAX–GLARE

The program will automatically deploy window shading devices (if WIN–SHADE–TYPE = MOVABLE–INTERIOR or MOVABLE–EXTERIOR) to reduce daylight glare whenever glare with bare windows exceeds the MAX–GLARE value. Table 2.7 gives recommended MAX–GLARE values for different situations. For example, MAX–GLARE = 22 would be specified for general office work.

If a space has two or more windows, the shading devices will be deployed one by one in the order in which the windows are input, until the glare level at each lighting reference point falls below MAX–GLARE. If MAX–GLARE is not specified, no glare control will occur.

VIEW–AZIMUTH

is the direction of occupant view (in the horizontal plane), measured as a clockwise angle from the space y-axis (see Fig. 2.14). It is used by the program to calculate daylight glare. If not specified, VIEW–AZIMUTH will be calculated by the program for a view direction parallel to the first window in the space (obtained by rotating clockwise by 90° the horizontal projection of the window outward normal). In general, the daylight glare contribution from a particular window is highest when the occupant faces the window.

XBL 8211-7342

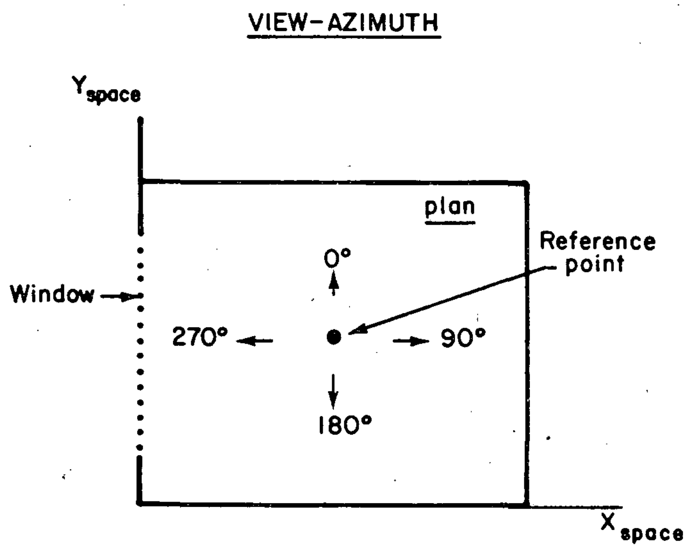


Figure 2.14: VIEW—AZIMUTH for four different occupant view directions. Daylight glare from the window will be greatest when occupant faces window, which corresponds to VIEW—AZIMUTH=270° in this example.

Daylighting input examples for SPACE—CONDITIONS

Example (1)

A space has a single lighting zone with 2.4 watts/ft^2 of installed electric lighting power. The photocell of a 5-step lighting control responds to the lighting level at x = 10, y = 20, z = 2.5ft. The illuminance set point is 60 footcandles.

The SPACE-CONDITIONS (or SPACE) daylighting input would then be

```
    $ --- ONE LIGHTING ZONE WITH STEPPED SYSTEM --- $

SCON—1    =    SPACE—CONDITIONS
               DAYLIGHTING          =    YES
               LIGHTING—W/SQFT      =    2.4
               LIGHT—REF—POINT1     =    (10,20,2.5)
               ZONE—FRACTION1       =    1.0 (the default)
               LIGHT—SET—POINT1     =    60
               LIGHT—CTRL—TYPE1     =    STEPPED
               LIGHT—CTRL—STEPS     =    5
                 .
                 .
                 . ..
```

Example (2)
An office space with 2 watts/ft^2 of installed electric lighting power has three lighting zones. The first lighting zone, with 40% of the floor area, has a continuously dimmable control system with a setpoint of 60 footcandles and a minimum light output of 10 footcandles at 30% input power. The lighting reference point is at x = 10, y = 10, z = 2.5ft. The second lighting zone, with 50% of the floor area, has a 4-step control system with a setpoint of 60 footcandles. The lighting reference point is at x = 10, y = 25, z = 2.5ft. A third lighting zone with 10% of the floor area is not daylit.

The SPACE–CONDITIONS (or SPACE) daylighting input would then be:

```
                $ --- THREE LIGHTING ZONES --- $

SCON-2    =    SPACE-CONDITIONS
               DAYLIGHTING           =   YES
               LIGHT-CTRL-STEPS      =   4
               LIGHT-CTRL-TYPE1      =   CONTINUOUS
               LIGHT-CTRL-TYPE2      =   STEPPED
               LIGHT-REF-POINT1      =   (10,10,2.5)
               LIGHT-REF-POINT2      =   (10,25,2.5)
               LIGHT-SET-POINT1      =   60
               LIGHT-SET-POINT2      =   60
               LIGHTING-W/SQFT       =   2
               MIN-LIGHT-FRAC        =   0.167
               MIN-POWER-FRAC        =   0.3
               ZONE-FRACTION1        =   0.4
               ZONE-FRACTION2        =   0.5
                  .
                  .
                  ..
```

Note that no entry is required for the third, non-daylit lighting zone.

Example (3)
A space has a task-ambient lighting system. Task lighting is provided by electric lights with an installed power of 0.5 watts/ft^2. Ambient lighting with a setpoint of 10 footcandles is provided by daylight plus installed electric lighting at 0.4 watts/ft^2 controlled by a 3-step control system. The ambient lighting reference point is at x = 15, y = 20, z = 2.5ft.

The SPACE CONDITIONS (or SPACE) daylighting input would then be:

```
               $ --- TASK-AMBIENT  SYSTEM --- $

SCON-3    =    SPACE-CONDITIONS
               DAYLIGHTING            =   YES
               LIGHT-CTRL-TYPE1       =   STEPPED
               LIGHT-REF-POINT1       =   (15,20,2.5)
               LIGHT-SET-POINT1       =   10
               LIGHTING-W/SQFT        =   0.4
               TASK-LT-W/SQFT         =   0.5
               ZONE-FRACTION1         =   1.0 (the default)
                 .
                 .
                 .
```

WINDOW

WIN–SHADE–TYPE specifies a codeword giving the type of shading device when a shading device is present on the window for sun and/or glare control. The choices are:

- MOVABLE–INTERIOR — (the default) interior shade which can be retracted, such as drapes or Venetian blinds.
- MOVABLE–EXTERIOR — exterior shade which can be retracted.
- FIXED–INTERIOR — interior shade which cannot be retracted.
- FIXED–EXTERIOR — exterior shade which cannot be retracted.

Note: If SHADING–SCHEDULE is not assigned to a window, the window will be considered to have no shading device and WIN–SHADE–TYPE will be ignored. (The 2.1B codeword, NO–SHADE, is no longer being used.)

VIS–TRANS–SCH is the u-name of a schedule which gives the daylight transmittance of the window shading device when it covers the window. (If WIN–SHADE–TYPE = MOVABLE–INTERIOR or MOVABLE–EXTERIOR, the program will use a transmittance multiplier value of 1.0 when the shade is retracted.) Typical visible transmittance values for translucent drapes and shades are given in Table 2.8. A transmittance schedule is used, rather than a single fixed value, to allow seasonal change in the transmittance of the shading device.

Note: this schedule is used only for windows in a space with DAYLIGHTING = YES.

Note: for windows with a shading device in a daylit space, be sure to specify not only VIS–TRANS–SCH, but also SHADING–SCHEDULE (and CONDUCT–SCHEDULE if the change in window conductance with the shade in place is significant).

Note: In the daylighting calculation, shading surfaces are modeled as perfect diffusers with a daylight transmittance which is independent of angle of incidence. For this reason, slat-type devices, such as Venetian blinds, whose transmittance is a strong function of the angles at which light enters and leaves the device, can only be modeled very approximately.

MAX–SOLAR–SCH is the u-name of a schedule of direct solar gain values in Btu/ft^2-hr. The program will automatically deploy a shading device if the heat gain per ft^2 of window from direct (beam) solar radiation transmitted through the window exceeds the specified value. If MAX–SOLAR–SCH is specified, a corresponding SHADING–SCHEDULE (and CONDUCT–SCHEDULE, if desired) should be assigned to the window. In addition, if the space is daylit, a VIS–TRANS–SCH should be assigned and WIN–SHADE–TYPE should be set equal to MOVABLE–INTERIOR or MOVABLE–EXTERIOR.

SUN–CTRL–PROB may be specified if the sun control device on a window is manually operated. This keyword gives the probability that the occupants of a space will deploy the shading device if the transmitted direct solar gain exceeds the MAX–SOLAR–SCH value.

GLARE–CTRL–PROB may be specified if manual operation of a window shading device for glare control is desired. This keyword gives the probability that the occupants of a space will deploy a shading device when the MAX–GLARE value (see SPACE–CONDITIONS) is exceeded.

CONDUCT–TMIN–SCH is a schedule of values of outside drybulb temperature below which movable insulation will be deployed on a window. If this keyword is specified, a corresponding SHADING–SCHEDULE and CONDUCT–SCHEDULE should be assigned to the window. In addition, if the space is daylit, a VIS–TRANS–SCH should be assigned and WIN–SHADE–TYPE should be set equal to MOVABLE–INTERIOR or MOVABLE–EXTERIOR.

Note that the CONDUCT–SCHEDULE, in the WINDOW command, will have no effect on a window unless a corresponding SHADING–SCHEDULE is also given.

Example of window shading device assignment

Window glazing has a visible transmittance of 0.83. Operable drapes have a visible transmittance multiplier of 0.35, a shading coefficient multiplier of 0.25, and a conductance multiplier of 0.85. The drapes will be closed when transmitted direct solar gain exceeds 30 Btu/ft^2-hr.

The input might be

```
SC–MULT–1       =   SCHEDULE THRU DEC 31 (ALL)(1,24)(0.25) ..
TVIS–SC         =   SCHEDULE THRU DEC 31 (ALL)(1,24)(0.35) ..
COND–MULT–1     =   SCHEDULE THRU DEC 31 (ALL)(1,24)(0.85) ..
SOL–SCH–1       =   SCHEDULE THRU DEC 31 (ALL)(1,24)(30) ..
                                  .
                                  .
GT–1            =   GLASS–TYPE
                    VIS–TRANS = 0.83
                                  .
                                  . ..
SP–1            =   SPACE
                    DAYLIGHTING = YES
                                  .
                                  . ..
WIN–1           =   WINDOW
                    GLASS–TYPE = GT–1
                    WIN–SHADE–TYPE = MOVABLE–INTERIOR
                    VIS–TRANS–SCH = TVIS–SCH–1
                    MAX–SOLAR–SCH = SOL–SCH–1
                    SHADING–SCH = SC–MULT–1
                    CONDUCT–SCH = COND–MULT–1
                                  .
                                  .
                                  . ..
```

WINDOW, DOOR, EXTERIOR–WALL, ROOF, UNDERGROUND–WALL, UNDERGROUND–FLOOR, INTERIOR–WALL

INSIDE–VIS–REFL

is the inside surface visible reflectance (hemispherical average). For INTERIOR–WALL a list of two values is required, where the first value is the reflectance on the side of the interior wall that is in the space the wall is defined, and the second value is the reflectance on the other side of the wall.

For EXTERIOR–WALL, ROOF, UNDERGROUND–WALL, UNDERGROUND–FLOOR, and INTERIOR–WALL, the default value of INSIDE–VIS–REFL is
0.2 if surface is a floor (TILT $> 170^\circ$),
0.5 if a wall ($10^\circ \leq$ TILT $\leq 170^\circ$), and
0.7 if a ceiling (TILT $< 10^\circ$).

Daylighting Verification and Summary Reports

The following verification and summary reports may be printed to help the user understand the effects of daylighting. These reports are described in Appendix C of this Supplement and are illustrated in the daylighting sample in the DOE-2 Sample Run Book.

Report LV-L	Daylight Factor Summary
Report LS-G	Space Daylighting Summary
Report LS-H	Percent Lighting Energy Reduction by Daylighting vs Hour of Day (for each daylit space)
Report LS-I	Percent Lighting Energy Reduction by Daylighting vs Hour of Day (for whole building)
Report LS-J	Daylight Illuminance Frequency of Occurrence

Table 2.5

Monthly Average Atmospheric Moisture (inches of water) for U.S. Cities

City	J	F	M	A	M	J	J	A	S	O	N	D
Montgomery, AL	.65	.56	.65	.85	1.00	1.31	1.58	1.60	1.39	.95	.67	.69
Ft. Smith, AR	.48	.47	.56	.78	1.08	1.39	1.66	1.56	1.16	1.03	.53	.48
Little Rock, AR	.51	.46	.55	.81	.94	1.26	1.47	1.42	1.29	.86	.63	.59
Ft. Huachuca, AZ	.27	.27	.24	.26	.36	.59	1.01	1.01	.73	.48	.31	.27
Phoeniz, AZ	.42	.38	.38	.45	.51	.67	1.29	1.31	.92	.63	.43	.40
China Lake, CA	.28	.25	.28	.34	.38	.40	.66	.68	.47	.33	.29	.32
Oakland, CA	.52	.49	.48	.45	.53	.63	.64	.67	.64	.59	.61	.50
Point Mugu, CA	.46	.45	.48	.51	.65	.79	1.04	.97	.89	.69	.54	.49
San Diego, CA	.46	.46	.47	.50	.60	.71	.98	1.04	.83	.62	.60	.48
San Nicolas Is., CA	.47	.42	.43	.42	.52	.65	.85	.80	.73	.61	.53	.46
Santa Maria, CA	.48	.48	.48	.52	.61	.68	.82	.80	.74	.63	.55	.49
Santa Monica, CA	.48	.51	.49	.56	.65	.75	.93	.95	.85	.72	.54	.50
Denver, CO	.20	.19	.21	.27	.41	.57	.75	.71	.51	.35	.25	.20
Grand Junction, CO	.25	.24	.24	.28	.39	.51	.73	.72	.52	.41	.31	.26
Cocoa Beach, FL	.86	.85	.95	1.03	1.26	1.60	1.73	1.79	1.76	1.37	1.02	.90
Key West, FL	1.04	1.03	1.06	1.13	1.34	1.65	1.64	1.71	1.78	1.53	1.20	1.05
Miami, FL	.96	.95	1.00	1.10	1.31	1.64	1.69	1.74	1.77	1.50	1.16	1.10
Atlanta, GA	.54	.52	.56	.72	.95	1.26	1.48	1.45	1.20	.83	.59	.54
Boise, ID	.35	.32	.30	.34	.44	.59	.60	.60	.52	.42	.40	.32
Joliet, IL	.36	.32	.40	.53	.76	1.11	1.21	1.12	.88	.66	.43	.35
Peoria, IL	.30	.31	.37	.55	.76	1.02	1.17	1.13	.96	.65	.46	.36
Salem, IL	.31	.35	.41	.57	.72	1.09	1.19	1.19	1.12	.74	.46	.42
Dodge City, KS	.28	.27	.30	.42	.61	.86	1.09	1.04	.81	.53	.37	.30
Boothville, LA	.82	.72	.78	1.00	1.13	1.41	1.69	1.72	1.60	1.17	.87	.94
Lake Charles, LA	.74	.72	.77	.95	1.17	1.45	1.70	1.67	1.50	1.05	.83	.78
Nantucket, MA	.38	.36	.40	.53	.73	.97	1.15	1.26	.95	.71	.56	.42
Caribou, ME	.23	.22	.26	.36	.55	.79	.95	.90	.74	.55	.40	.27
Portland, ME	.30	.29	.33	.46	.66	.93	1.08	1.05	.87	.63	.49	.34
Flint, MI	.27	.26	.31	.46	.64	.89	.99	.97	.86	.61	.43	.33
Sault Ste. Marie, MI	.23	.22	.27	.39	.57	.83	.92	.93	.78	.58	.39	.28
Int'l Falls, MN	.19	.19	.23	.35	.52	.77	.90	.87	.68	.49	.30	.22
St. Cloud, MN	.22	.23	.27	.42	.63	.86	1.00	.99	.77	.56	.34	.26
Columbia, MO	.36	.32	.42	.62	.78	1.10	1.23	1.21	.98	.70	.52	.42
Jackson, MS	.59	.60	.65	.87	1.05	1.36	1.59	1.56	1.36	.92	.71	.65
Glasgow, MT	.23	.24	.25	.34	.49	.68	.77	.73	.57	.42	.31	.25
Great Falls, MT	.23	.22	.23	.27	.39	.54	.58	.58	.46	.34	.28	.23
North Platte, NB	.26	.28	.30	.41	.62	.85	1.02	.99	.72	.49	.33	.28
Omaha, NB	.28	.29	.35	.50	.74	1.03	1.18	1.13	.87	.62	.40	.31
Cape Hatteras, NC	.59	.52	.56	.70	.96	1.20	1.57	1.57	1.25	.97	.67	.63
Greensboro, NC	.47	.45	.50	.65	.90	1.18	1.39	1.37	1.11	.77	.55	.47
Bismarck, ND	.22	.24	.26	.38	.56	.81	.93	.88	.65	.47	.31	.25
Rapid City, ND	.26	.26	.28	.37	.53	.75	.87	.81	.59	.42	.30	.26
Ely, NV	.21	.20	.20	.22	.31	.42	.54	.57	.38	.29	.26	.21

Albuquerque, NM	.21	.20	.21	.24	.33	.47	.80	.79	.58	.38	.27	.22
Albany, NY	.30	.28	.35	.48	.70	.98	1.11	1.10	.93	.65	.49	.36
Buffalo, NY	.30	.29	.34	.47	.66	.91	1.04	1.02	.87	.63	.46	.35
New York City, NY	.34	.33	.40	.54	.76	1.02	1.18	1.16	1.01	.69	.55	.42
Dayton, OH	.33	.33	.39	.56	.74	1.00	1.13	1.08	.93	.65	.47	.38
Medford, OR	.46	.42	.40	.41	.51	.65	.67	.67	.59	.52	.53	.43
Salem, OR	.52	.48	.45	.47	.56	.71	.73	.76	.70	.62	.60	.51
Pittsburgh, PA	.34	.32	.38	.52	.72	.97	1.09	1.06	.90	.63	.47	.37
Charleston, SC	.65	.63	.68	.83	1.11	1.42	1.67	1.66	1.43	1.02	.75	.66
Nashville, TN	.45	.41	.49	.70	.85	1.13	1.33	1.31	1.19	.77	.55	.53
Amarillo, TX	.28	.26	.30	.39	.55	.80	1.03	1.00	.80	.52	.37	.30
Brownsville, TX	.90	.90	.94	1.12	1.31	1.48	1.57	1.60	1.64	1.31	1.07	.96
Midland, TX	.34	.33	.37	.48	.65	.89	1.06	1.10	.97	.64	.44	.36
El Paso, TX	.29	.28	.30	.33	.44	.67	.98	1.00	.83	.52	.37	.32
Ft. Worth, TX	.48	.51	.58	.80	1.06	1.32	1.48	1.46	1.28	.90	.65	.54
Salt Lake City, UT	.29	.26	.25	.30	.40	.54	.66	.66	.50	.38	.34	.27
Quillayute - Tatoosh Is., WA	.46	.47	.44	.48	.57	.71	.77	.82	.75	.67	.55	.50
Green Bay, WI	.23	.23	.28	.44	.63	.89	1.02	.99	.82	.60	.39	.28
Huntington, WV	.39	.37	.47	.62	.82	1.08	1.25	1.19	1.04	.72	.53	.45
Lander, WY	.18	.17	.18	.24	.33	.47	.54	.53	.40	.29	.23	.18

Source: George A. Lott, "Precipitable Water Over the United States, Volume 1: Monthly Means", National Oceanic and Atmospheric Administration Technical Report NWS 20, November 1976.

Table 2.6

Monthly Average Atmospheric Turbidity for U. S. Cities

City	Source	J	F	M	A	M	J	J	A	S	O	N	D
Eielson AFB, AL	2	.03	.03	.11	.11	.20	.07	.09	.12	.07	.04	.04	.04
Little Rock, AR	2	.11	.16	.17	.22	.22	.20	.22	.20	.19	.13	.10	.09
Tucson, AZ	1	.05	.05	.06	.07	.07	.07	.07	.07	.07	.06	.06	.07
Edwards AFB, CA	2	.02	.02	.06	.09	.09	.08	.08	.08	.07	.06	.04	.04
Los Angeles, CA	1	.11	.14	.15	.16	.18	.21	.20	.21	.19	.17	.11	.11
Alamosa, CO	2	.09	.11	.12	.15	.13	.10	.10	.06	.07	.07	.07	.07
Boulder, CO	1	.04	.05	.07	.09	.08	.07	.07	.07	.07	.05	.05	.04
Washington, DC	1	.11	.12	.15	.17	.19	.21	.24	.20	.17	.13	.13	.13
Miami, FL	2	.19	.29	.30	.31	.36	.54	.51	.55	.40	.33	.31	.24
Tallahassee, FL	2	.12	.18	.19	.20	.28	.34	.35	.25	.25	.19	.18	.12
Idaho Falls, ID	1	.03	.04	.06	.07	.07	.07	.06	.06	.06	.05	.04	.03
Chicago, IL	1	.15	.18	.21	.18	.18	.19	.22	.16	.16	.14	.13	.15
Salem, IL	2	.09	.10	.16	.17	.21	.22	.23	.21	.17	.16	.10	.09
Topeka, KS	1	.05	.07	.07	.07	.09	.12	.09	.07	.07	.06	.04	.04
Blue Hill, MA	1	.07	.07	.09	.11	.13	.16	.17	.13	.08	.07	.07	.06
Baltimore, MD	1	.12	.18	.18	.19	.22	.27	.31	.32	.31	.12	.17	.18
College Park, MD	2	.07	.08	.13	.17	.23	.21	.13	.23	.17	.13	.08	.07
St. Cloude, MN	2	.08	.06	.08	.13	.11	.09	.11	.10	.08	.06	.05	.05
St. Louis, MO	1	.12	.12	.16	.17	.21	.20	.22	.19	.19	.12	.12	.11
Meridian, MS	1	.07	.07	.07	.09	.12	.15	.15	.13	.11	.07	.07	.07
Missoula, MT	1	.06	.07	.07	.08	.09	.07	.07	.06	.09	.08	.07	.07
Greensboro, NC	1	.07	.08	.09	.11	.14	.24	.22	.21	.14	.08	.07	.07
Raleigh, NC	2	.06	.10	.10	.10	.12	.14	.24	.15	.13	.06	.06	.04
Bismarck, ND	2	.04	.02	.04	.08	.08	.07	.05	.06	.07	.08	.08	.05
Albany, NY	1	.10	.09	.11	.12	.14	.14	.15	.15	.14	.11	.10	.09
Brookhaven, NY	1	.07	.07	.10	.11	.12	.14	.15	.11	.12	.07	.07	.07
New York City, NY	1	.11	.11	.12	.15	.17	.22	.21	.24	.20	.15	.11	.11
Cincinnati, OH	1	.07	.09	.12	.13	.14	.20	.20	.19	.17	.12	.10	.08
Toledo, OH	2	.09	.08	.12	.11	.15	.13	.15	.11	.09	.05	.06	.06
Youngstown, OH	2	.14	.14	.16	.19	.25	.29	.22	.28	.22	.17	.15	.13
Pendleton, OR	2	.10	.12	.16	.20	.19	.19	.16	.15	.11	.09	.09	.09
Philadelphia, PA	1	.12	.15	.18	.20	.22	.25	.27	.23	.17	.15	.14	.14
Huron, SD	1	.04	.05	.07	.07	.08	.09	.08	.07	.07	.06	.05	.04
Memphis, TN	1	.08	.08	.10	.16	.15	.18	.19	.16	.16	.09	.10	.08
Oak Ridge, TN	2	.10	.14	.13	.17	.33	.26	.37	.31	.25	.13	.09	.09
College Stn., TX	1	.10	.10	.11	.12	.13	.08	.15	.12	.11	.09	.08	.07
Grand Prarie, TX	2	.07	.12	.16	.16	.36	.35	.36	.53	.45	.23	.19	.21
Victoria, TX	2	.03	.03	.05	.02	.08	.08	.06	.05	.04	.04	.03	.02
Green Bay, WI	2	.09	.09	.15	.16	.19	.17	.16	.10	.09	.10	.05	.06
Elkins, WV	1	.07	.07	.09	.14	.15	.21	.21	.19	.14	.07	.07	.07

Source:

1. E. C. Flowers, R. A. McCormick, and K. R. Kurfis, "Atmospheric Turbidity over the United States, 1961-66", Journal of Applied Meteorology, Vol. 8, No. 6, 1969, pp. 955-962.

2. "Global Monitoring of the Environment for Selected Atmospheric Constituents, 1977", Environmental Data and Information Service, National Climatic Center, Asheville, NC, June 1980.

Note: This table contains values for the Angstrom turbidity coefficient (β).

Table 2.7

Recommended MAX–GLARE Values

Location or Building Type	Maximum Daylight Glare Index	Location or Building Type	Maximum Daylight Glare Index
Art Galleries	16	Laboratories	22
Factories		Museums	20
Rough Work	28		
Engine Assembly	26	Offices	
Fine Assembly	24	General	22
Instrument Assembly	22	Drafting	20
Hospital Wards	18	School Classrooms	20

Note: The values in this table were obtained from the relationship

$$\text{MAX–GLARE} = 2/3\ (14 + I_{max}),$$

where I_{max} is the limiting IES (London) glare index for artificial lighting given in R.G. Hopkinson, P. Petherbridge and J. Longmore, "Daylighting", Heinemann, London, 1966, p. 309.

Table 2.8

Daylight Transmittance of Different Window Shading Devices

Shading Device	Daylight Transmittance **(VIS–TRANS–SCH Value)**
Translucent Drapes[1]	
Light (white)	.35
Medium (grey)	.23
Dark (tan)	.14
Translucent Shades[2]	
Glossy white	.18
Flat white	.23

Data Sources:

1. Pennington, C. W., et. al., "Experimental Analysis of Solar Heat Gain Through Insulating Glass with Indoor shading", ASHRAE Journal, February 1964.
2. Jordan, R. C., and Threlkeld, J. L., "Determination of the Effectiveness of Window Shading Materials on the Reduction of Solar Radiation Heat Gain", ASHRAE Transactions, Volume 65, 1959.

Note: Refer to manufacturer's data for specific products.

TROMBE WALLS

DOE-2 has models for both vented and unvented Trombe walls. The following describes the input needed to use the Trombe wall simulation. The simulation requires the following sets of information:

(A) The size, location, and orientation of the Trombe wall.

(B) The size and type of glazing of the window that covers the Trombe wall. The amount and scheduling of window insulation.

(C) The material description of the wall.

(D) The channel width of the air gap and the emissivity of the wall.

(E) The cross-sectional area of the upper and lower vents and the vertical distance separating the vents (vented Trombe walls only).

(F) The venting schedule (vented Trombe walls only).

Most of the information is handled in a way familiar to DOE-2 users. The command is TROMBE–WALL–V (T–W–V) or TROMBE–WALL–NV (T–W–NV).

TROMBE–WALL–V
TROMBE–WALL–NV

Trombe walls are synonymous with EXTERIOR–WALLs. Thus, all information (see A above) is entered exactly like the information for an EXTERIOR–WALL command. Specifying TROMBE–WALL–V or TROMBE–WALL–NV tells the program to model a vented or unvented Trombe wall in the given space.

The TROMBE–WALL–V or TROMBE–WALL–NV command is immediately followed by a WINDOW command, which contains the information in (B). Note that the use of the keywords SHADING–SCHEDULE and CONDUCT–SCHEDULE allows the user to simulate movable insulation being placed over the glass.

The material description of the wall (C) is entered in the same way as a regular wall; i.e. through the MATERIAL, LAYERS, and CONSTRUCTION commands.

The remaining physical descriptions of the Trombe wall (D and E) is entered by means of the following command:

WALL–PARAMETERS

which is referenced by the CONSTRUCTION command. The keywords for WALL–PARAMETERS (abbreviated as W–P) are:

WALL–PARAMETERS

Keyword	Abbrev.	Input Desc.	Default	Min.	Max.
FOR	—	Code-word	Note 1		
EMISSIVITY	EM	fraction	0.93	0.0	1.0
CHANNEL–WIDTH	C–W	ft	required	0.0	1.0
LOWER–VENT–AREA	L–V–A	ft^2	Note 2	0.0	100.0
UPPER–VENT–AREA	U–V–A	ft^2	Note 2	0.0	100.0
VERT–VENT–SEP	V–V–S	ft	Note 2	0.0	20.0

Note 1: Required; legal values are TROMBE–WALL–V and TROMBE–WALL–NV.
Note 2: Required for TROMBE–WALL–V; unused by TROMBE–WALL–NV.
Rule: The keyword FOR must be the first keyword entered.
It operates just as it does in SET–DEFAULT.

One additional keyword is used (in SDL) to specify a venting schedule, for the vented Trombe wall only. The keyword is in the ZONE command and is TROM–VENT–SCH (T–V–SCH).

TROM–VENT–SCH

This keyword allows the user to define which hours the Trombe wall is allowed to vent to the occupied space. A schedule value of 1 means venting is allowed. A value of 0 means venting is not allowed. The venting is done by natural convection and *not* by mechanical means, i.e., fans.

General Rules:

1. Only *one* TROMBE–WALL–V or TROMBE–WALL–NV is allowed per SPACE.
2. The wall is denoted a Trombe wall by use of the commands TROMBE–WALL–V or TROMBE–WALL–NV.
3. Each TROMBE–WALL–V or TROMBE–WALL–NV command must be followed by one, and only one, WINDOW command.
4. The window area must equal the Trombe wall area.
5. The CONSTRUCTION command referenced by the TROMBE–WALL–V or TROMBE–WALL–NV command must, in turn, reference a WALL–PARAMETERS command.

Warning:
There are certain restrictions on the use of Trombe walls in combination with other DOE-2 features.

Use of the **vented** Trombe wall should be avoided in combination with systems which use the COOL–CONTROL = WARMEST or HEAT–CONTROL = COLDEST option. In the warmest/coldest calculations, the thermal gains from the vented Trombe wall are not included. This could cause the hot or cold duct supply temperatures to be incorrectly set, resulting in excess energy consumption, or underheated or undercooled zones. The system types involved are MZS, DDS, SZCI, HVSYS, TPIU, FPIU, VAVS, RHFS, CBVAV, PMZS, and PVAVS. This problem will not occur in these systems if other control methods are used. For similar reasons, the use of Trombe walls in combination with optimum start (see p. 3.17, **OPTIMUM FAN START OPTION**, in this Supplement) should be avoided.

::

Example:
We add a Trombe wall (vented) to the Simple Structure, Run 3A, in the Sample Run Book.

```
TWLAY=          LAYERS
TWCONS=         CONSTRUCTION     LAYERS = TWLAY
                                 WALL-PARAMETERS = TWPARS ..
TWPARS=         WALL-PARAMETERS FOR TROMBE-WALL-V
                CHANNEL-WIDTH = .3333 LOWER-VENT-AREA = 15
                UPPER-VENT-AREA = 15 VERT-VENT-SEP = 7 ..
TROMWGLASS=     GLASS-TYPE GLASS-TYPE-CODE = 1 PANES = 2 ..
   .
   .
   .
SPACE1-1=       SPACE SPACE-CONDITIONS = OFFICE etc. ..
FRONT-1=        TROMBE-WALL-V HEIGHT = 8 WIDTH = 100
                X = 0   Y = 0
                Z = 0   AZ = 180
                CONSTRUCTION = TWCONS ..
WF-1=           WINDOW HEIGHT = 8 WIDTH = 100
                GLASS-TYPE = TROMWGLASS ..
   .
   .
   .
INPUT SYSTEMS ..
VENT-1=         DAY-SCHEDULE (1,7) (0) (8,18) (1) (19,24) (0) ..
VENT-2=         DAY-SCHEDULE (1,24) (0) ..
VENT-WEEK=      WEEK-SCHEDULE    (MON,FRI) VENT-1
                                 (WEH) VENT-2 ..
VENT-SCH=       SCHEDULE THRU DEC 31 VENT-WEEK ..
   .
   .
   .
SPACE1-1=       ZONE             ZONE-TYPE = CONDITIONED
                                 ZONE-CONTROL = CONTROL
                                 TROM-VENT-SCH = VENT-SCH ..
```

Reporting

No new hourly report variables have been added, but some of the existing ones for wall and window can be informative. Variables of interest are Q (E—W(5)), the heat conducted into the space through the wall, and T (E—W(6)), the outside surface temperature of the wall. In the window variables, QTRANS, (WI(13)), the amount of solar passing through the window (and hence the energy available to the Trombe wall), and QCON, (WI(15)), the heat lost back out the window by conduction, are very useful. These variables are of interest only for the unvented Trombe wall. For the vented Trombe wall, all calculations are done in SYSTEMS and no useful hourly report variables are available.

FIXED SHADES, FINS, AND OVERHANGS

The shading routines were upgraded in DOE-2.1B to (1) model fixed shades (e.g., neighboring buildings) that do not move when the position or orientation of the building being analyzed is changed; (2) model fins and overhangs on windows; (3) permit the transmittance of a shading surface to be scheduled, allowing, for example, deciduous trees to be modeled; and (4) simplify the input for exterior walls that shade other exterior walls and windows ("self shading").

Fixed Shades

When the location or orientation of a building is changed, then shading surfaces defined with BUILDING–SHADE (or with the new fin and overhang keywords described below) will move with the building. In order to describe shading surfaces that *do not move* with the building, the FIXED–SHADE command was introduced:

FIXED–SHADE	This command specifies the position of stationary shading surfaces that remain fixed with respect to the surface of the earth when the building is translated or rotated. The keywords for FIXED–SHADE are the same as those for BUILDING–SHADE except for X, Y and Z, which for FIXED–SHADE are replaced by X–REF and Y–REF.
X–REF **Y–REF**	are the coordinates of the lower left-hand corner of a fixed shade in the *reference coordinate system,* as shown in Fig. 2.15. The reference coordinate system is a coordinate system that is fixed with respect to the surface of the earth. Its y-axis points North and its x-axis points East. The FIXED–SHADE keyword, AZIMUTH, gives the angle between the y-axis of the reference coordinate system and the outward normal of the fixed shade. The reference coordinate system is used only when fixed shades are present. Then it is also necessary to position the building in the reference coordinate system in order to obtain the proper geometrical relationship between the fixed shade(s) and the building. This is done by assigning values to the X–REF and Y–REF keywords of the BUILDING–LOCATION command.

XBL 8211-7334

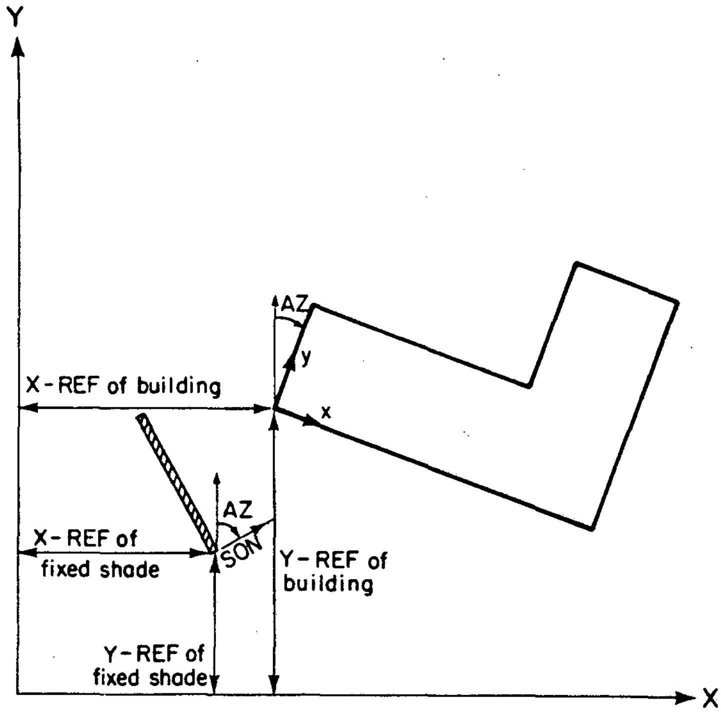


Figure 2.15: Reference Coordinate System. X–REF and Y–REF are the coordinates of the lower left-hand corner of a fixed shade.

BUILDING–LOCATION

X–REF
Y–REF

are the coordinates of the origin of the building coordinate system in the reference coordinate system. As before, the BUILDING–LOCATION keyword AZIMUTH is the angle between North and the y-axis of the building coordinate system. Since the y-axis of the reference coordinate system points North, AZIMUTH is also the angle between the y-axis of the reference coordinate system and y-axis of the building coordinate system.

Figure 2.16 shows an example in which a fixed shade and an L-shaped building have been positioned in the reference coordinate system using X–REF, Y–REF, and AZIMUTH for the fixed shade and X–REF, Y–REF, and AZIMUTH for the building. This figure also shows the building being translated and rotated (dashed lines) in the reference coordinate system by changing the building's X–REF, Y–REF, and AZIMUTH values. This moves the building but not the fixed shade.

XBL 8211-7334(a)

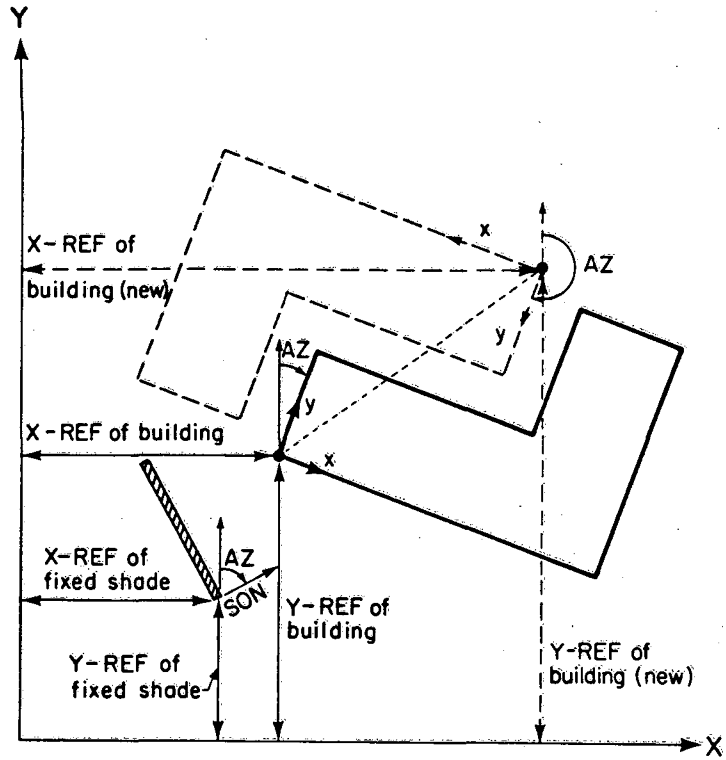


Figure 2.16: Reference coordinate system showing fixed shade and building. When the building is moved (dashed line), the fixed shade remains stationary.

Overhangs and Fins

Note that even though overhangs and/or fins are specified under the WINDOW or DOOR command, these shading surfaces are attached to the wall where the window or door is located. These attached shades are used in shading calculations for this wall and for all of the windows and doors on this wall. Also, if this WINDOW or DOOR is referred to in another WINDOW or DOOR command with the LIKE keyword, the attached shades are also copied.

WINDOW or DOOR

OVERHANG–A	Units are feet, 0.0 is the default; there are no limits. See Fig. 2.17.
OVERHANG–B	Units are feet, 0.0 is the default; there are no limits. See Fig. 2.17.
OVERHANG–W	Units are feet, 0.0 is the default; the range is 0.0 to no limits. See Fig. 2.17.
OVERHANG–D	Units are feet, 0.0 is the default; the range is 0.0 to no limits. See Fig. 2.17.

OVERHANG–ANGLE is the angle between the overhang and the window. When set at 90°, the overhang is perpendicular to the window (the default); if < 90° it is tilted down; if > 90° it is tilted up. The range is 0 to 180°.

Note: For overhang shading calculations to be performed, both OVERHANG–W and OVERHANG–D **must** be specified. If one of them is specified but not both, a WARNING message is printed and overhang shading is not performed.

LEFT–FIN–A Units are feet; 0.0 is the default; there are no limits. See Fig. 2.17.

LEFT–FIN–B Units are feet; 0.0 is the default; there are no limits. See Fig. 2.17.

XBL 8210-4858

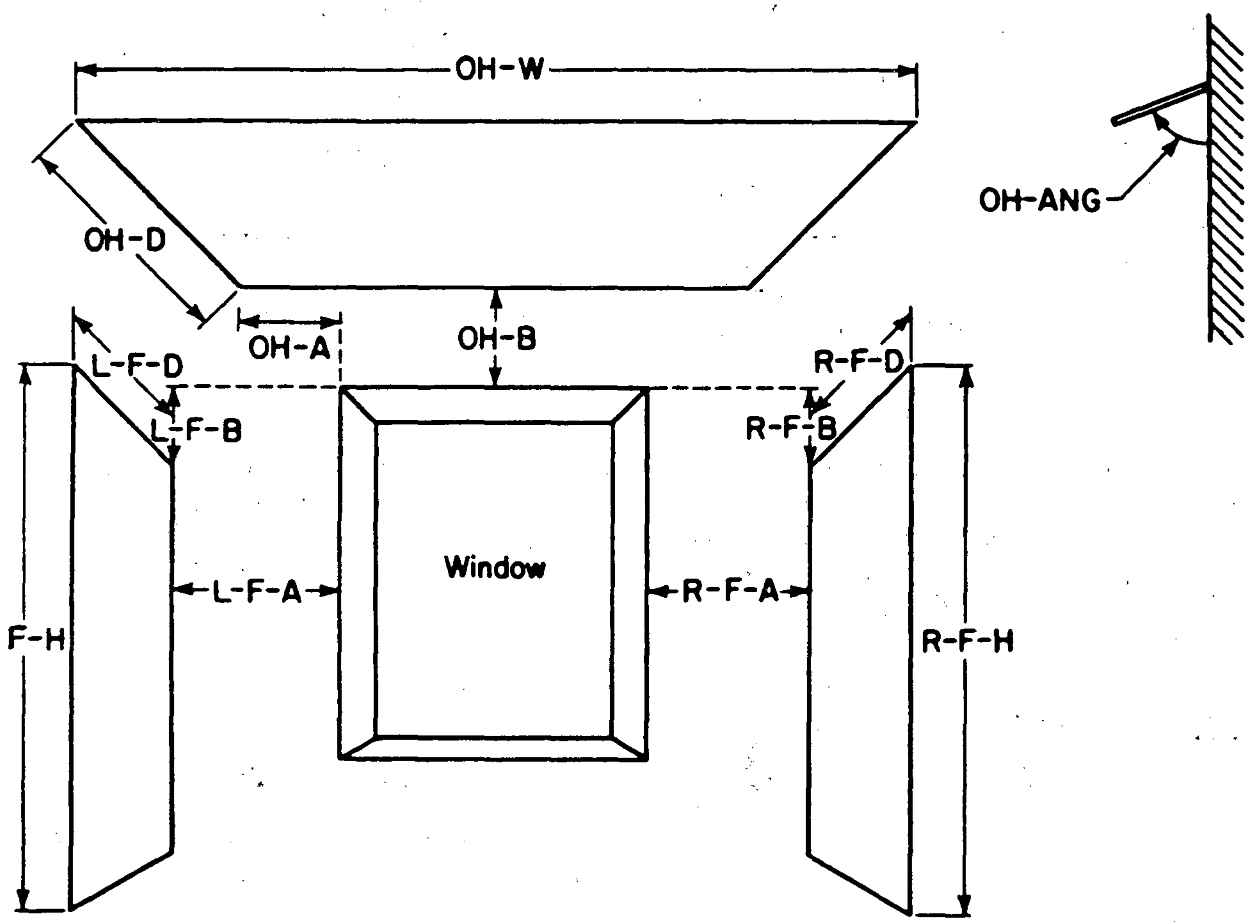


Figure 2.17: Positioning of overhang and fins with respect to a window. The values in this figure are all positive. If the value for L–F–B is input as negative, then the left fin will originate at a point above the top edge of the window, and similarly for R–F–B.

LEFT–FIN–H Units are feet; 0.0 is the default; the range is 0.0 to no limits. See Fig. 2.17.

LEFT–FIN–D Units are feet; 0.0 is the default; the range is 0.0 to no limits. See Fig. 2.17.

RIGHT–FIN–A Units are feet; 0.0 is the default; there are no limits. See Fig. 2.17.

RIGHT–FIN–B Units are feet; 0.0 is the default; there are no limits. See Fig. 2.17.

RIGHT–FIN–H Units are feet; 0.0 is the default; the range is 0.0 to no limits. See Fig. 2.17.

RIGHT–FIN–D Units are feet; 0.0 is the default; the range is 0.0 to no limits. See Fig. 2.17

Note: For fin shading calculations to be performed, both of the pair (–FIN–H and –FIN–D) **must** be specified. If only one of the pair is specified, a WARNING message is printed and fin shading is not performed.

Note: Overhangs and fins are assumed by the program to be opaque. Non-opaque shades can be specified with the BUILDING–SHADE and FIXED–SHADE commands.

Shade Schedule
A keyword was added in DOE-2.1B to the FIXED–SHADE and the BUILDING–SHADE commands:

SHADE–SCHEDULE is the u-name of a schedule which gives the time-dependent transmittance value of the shading device for solar radiation. This keyword can be used to simulate movable exterior devices or deciduous trees. The values in the schedule override the TRANSMITTANCE keyword value. The range of the schedule values is 0.0 to 1.0. A value of 0.0 represents an opaque device and any greater value represents a device that passes some solar radiation, such as a tree or lattice.

Self Shading
A keyword was added in DOE-2.1B to the EXTERIOR–WALL command:

SHADING–SURFACE takes a codeword value of YES or NO (NO is the default). YES causes this EXTERIOR–WALL surface to be considered also as a BUILDING–SHADE surface with TRANSMITTANCE=0. Whenever an exterior wall is capable of shading another exterior surface (for example, in an L-shaped building), setting SHADING–SURFACE=YES greatly simplifies shading surface input.

AUTOMATIC CALCULATION OF THE SHADING OF DIFFUSE SOLAR RADIATION

DOE-2 has always automatically calculated shading of *direct* solar radiation by overhangs and other obstructions. On the other hand, shading of *diffuse* solar radiation by the same obstructions was not automatically calculated; instead, the user was required to estimate the effects of diffuse shading by entering values for SKY–FORM–FACTOR and GND–FORM–FACTOR for each exterior wall, window, and door that was shaded. Because these form factors are difficult to estimate, users rarely specified them, resulting in no diffuse shading even though building shades had been input. However, diffuse radiation can be a large contributor to overall solar gain. For example, the annual solar gain for an unshaded rectangular building in Chicago with the same amount of vertical glazing on north, south, east, and west facades is roughly 50% direct and 50% diffuse. To relieve the user of having to guess form factors, routines have been added to DOE-2.1D that automatically calculate the shading of diffuse radiation by obstructions defined by BUILDING–SHADE, FIXED–SHADE, SETBACK, SHADING–SURFACE, etc.

Notes:

(1) Overhangs and fins (input using OVERHANG–A, LEFT–FIN–A, etc. in the WINDOW and DOOR commands) are assumed by DOE-2 to be opaque. For non-opaque (partially transmitting) shades, use BUILDING–SHADE or FIXED–SHADE and specify TRANSMITTANCE (default = 0).

(2) The obstructions are assumed to have zero reflectance for both direct and diffuse radiation; the effects of solar radiation bouncing off obstructions onto a window or wall are not considered.

(3) The user has the option of overriding the automatic diffuse shading calculation for a particular exterior wall, window, or door by specifying SKY–FORM–FACTOR and GND–FORM–FACTOR for that surface, as in previous versions of DOE-2 (see the descriptions of these keywords on p. III.100 of the Reference Manual).

DISTRIBUTION OF HEAT FROM LIGHTS

The heat from the lights in a space can be considered to be deposited in three places:

in the space itself,

in an adjoining unconditioned space on the other side of the fixture,

in the return air stream.

This distribution of light heat is determined by the keywords LIGHT–TO–SPACE, LIGHT–TO–OTHER, and LIGHT–TO–RETURN under the SPACE–CONDITIONS command. The heat transfer to the space and/or to the adjoining space is considered to be partially radiative and partially convective. This split is determined by the keyword LIGHT–RAD–FRAC and is only applicable if Automatic Custom Weighting Factors have been specified (FLOOR–WEIGHT = 0). The convective portion is treated as an instantaneous load, whereas the radiative portion is assumed to be absorbed by the mass in the space and released in time according to the lighting weighting factors.

SPACE–CONDITIONS

LIGHT–TO–SPACE is the fraction of the light heat in a given hour that is to be treated as heat gain in the space.

LIGHT–TO–OTHER is the fraction of light heat in a given hour that is deposited in an adjacent space. Unless the light fixture is in contact with an adjacent space or unless the "interior wall" between this space and the adjacent space is translucent or transparent, LIGHT–TO–OTHER should be zero.

LIGHT–TO–RETURN is the fraction of light heat in a given hour that goes directly into the return air stream. Unless the return air passes through the light fixtures, LIGHT–TO–RETURN should be zero.

The sum of LIGHT–TO–SPACE + LIGHT–TO–OTHER + LIGHT–TO–RETURN must be 1.0 and the program will increase LIGHT–TO–RETURN to ensure this total, if the sum is less than 1.0. If the sum is greater than 1.0, an ERROR message will be issued. When it is appropriate to have a non-zero value for LIGHT–TO–OTHER, its value should be chosen in the following way: assume that the return air path is through a duct and estimate the values of LIGHT–TO–SPACE and LIGHT–TO–RETURN under conditions of maximum air flow; now set LIGHT–TO–OTHER = 1.0 - (LIGHT–TO–SPACE) - (LIGHT–TO–RETURN).
This procedure is valid even if the user intends to simulate return air plenums in SYSTEMS.

LIGHT–HEAT–TO takes the u-name of an unconditioned or plenum space as a value and indicates the space that is the recipient of the fraction of light heat specified as LIGHT–TO–OTHER. This is a required keyword if LIGHT–TO–OTHER > 0. Only unconditioned or plenum spaces may be the recipients of such heat from lights.

LIGHT–RAD–FRAC takes a list of two fractions: the first is the fraction of the light heat to a space that is radiative, the second is the fraction of light heat to an adjacent space that is radiative. The second fraction, although required if this keyword is used, is not used if LIGHT–TO–OTHER = 0. This keyword only applies if Automatic Custom Weighting Factors are requested by specifying FLOOR–WEIGHT = 0.

The LIGHTING–TYPE keyword has the effect of determining defaults for the keywords LIGHT–TO–SPACE, LIGHT–TO–RETURN, and LIGHT–RAD–FRAC, described above. If these keywords are defined explicitly by the user, LIGHTING–TYPE may be allowed to default. In particular, if there is a mixture of types of lighting within a space, the user should select appropriate values for LIGHT–TO–SPACE, LIGHT–TO–OTHER, LIGHT–TO–RETURN, and LIGHT–RAD–FRAC corresponding to a weighted average for the lighting types present.

Default Values For Lighting Types

	SUS–FLUOR	REC–FLUOR–RV	REC-FLUOR–RSV	INCAND	REC–FLUOR–NV
LIGHT–TO–SPACE	1.0	0.8	0.8	1.0	1.0
LIGHT–TO–OTHER	0.0	0.0	0.0	0.0	0.0
LIGHT–TO–RETURN	*	*	*	*	*
LIGHT–RAD–FRAC:					
in this space	0.67	0.59	0.19	0.71	0.67
in other space	1.0	0.09	0.09	1.0	0.09

* Defaults to 1.0 minus LIGHT–TO–SPACE minus LIGHT–TO–OTHER.

Depending upon the type of system being modeled in SYSTEMS, or upon the choice for RETURN–AIR–PATH in the SYSTEM command, the light heat that has been assigned by the user to the return air path through the use of the keyword LIGHT–TO–RETURN (referred to here as QRETURN) will be treated as follows. If the HVAC system is zonal (that is, if SYSTEM–TYPE in the SYSTEM command is UHT, UVT, HP, TPFC, FPFC, TPIU, FPIU, or PTAC) or RETURN–AIR–PATH = DIRECT, QRETURN will be added to the zone load in SYSTEMS. If plenum zones are defined in SYSTEMS, then the return air path, along with QRETURN, is assumed to pass through the plenum zones. If there is a variable volume fan, then the light heat to the return air is proportional to the airflow rate to the zone, with the residue of QRETURN being added to the zone load.

As an example of these lighting keywords, consider the situation shown in Fig. 2.18. A 2500 ft^2 conditioned zone SPACE–1 is illuminated to an intensity of 2 watts/ft^2 with recessed fluorescent light fixtures, designed so that the return air passes through the fixture into a return air duct. It is estimated that at design air flow, 30% of the heat given off from the fixture goes directly into the return air stream and 45% remains in the space. The remaining 25% is dissipated from the back of the fixture into the unconditioned space PLEN–1. Measurements indicate that 75% of the heat that goes into SPACE–1 is radiative (the other 25% is convective), while only 5% of the heat into PLEN–1 is radiative.

XBL 8210-4857

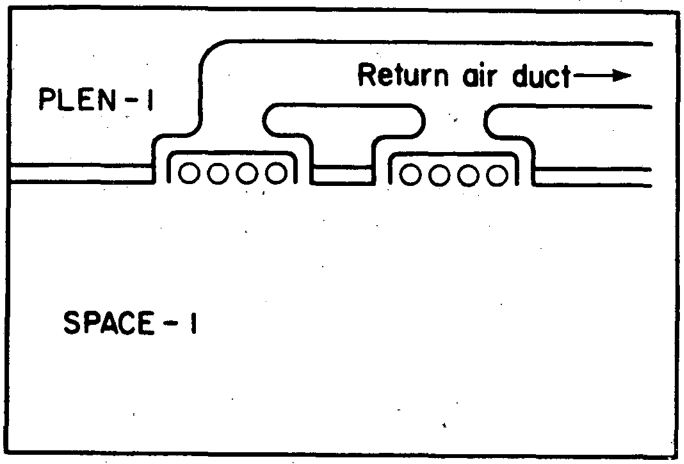


Fig. 2.18: A 2500 ft^2 conditioned zone SPACE—1 is illuminated to an intensity of 2 watts/ft^2 with recessed fluorescent light fixtures, designed so that the return air passes through the fixture into a return air duct.

The DOE-2 input for this situation is:

```
SPACE-1 = SPACE
           AREA = 2500
           LIGHTING-W/SQFT = 2.0
           LIGHT-TO-SPACE = .45
           LIGHT-TO-OTHER = .25
           LIGHT-HEAT-TO  = PLEN-1
           LIGHT-RAD-FRAC = (.75,.05)
                  .
                  .
                  .
```

Note that no value for LIGHT—TO—RETURN has been entered. It could have been entered as .30, but the program will adjust its default value of 0.2 to ensure that the sum of the three fractions is 1.0.

In SYSTEMS the keyword RETURN—AIR—PATH will be given the value DUCT. Suppose that the system being simulated is a constant volume system. In that case, the heat added to the return air will be a constant 1.5 kW (30% of 2500 ft^2 times 2 watts/ft^2). If the system were a variable air volume system with a minimum cfm ratio of 0.4, then at the minimum air flow the light heat going into the return air would be 0.6 kW (0.4 times 1.5 kW). The 0.9 kW difference between 1.5 kW and 0.6 kW would be added to the zone load.

The meanings of the codewords applicable to RETURN–AIR–PATH have been revised as follows:

Code-Word	**RETURN–AIR–PATH**
DIRECT	This codeword is used when the return air flows back to the air-handler or relief point (central exhaust) via the zones, hallways or stairwells. Any heat from lights that was specified in LOADS to go to the return air through the LIGHT–TO–RETURN keyword will be added to the zone load.
DUCT	Use of this codeword causes a fraction of the heat from lights, specified through the LIGHT–TO–RETURN keyword in LOADS, to be added to the return air stream. If there is a variable air volume system, the fraction is the ratio of the cfm to the zone that hour to the maximum design cfm to the zone. This codeword should be used in two main cases: (1) when return air duct work actually exists in the building and (2) when the return air passes through a plenum and the plenum is essentially at the same temperature as the zone it serves. The second case allows a great simplification of input for high-rise office buildings where there are plenum zones in the intermediate floors. The user specifies the conditioned spaces large enough to include the plenum areas and does not input a plenum at all. The heat from lights that goes to the plenum is specified through the LIGHT–TO–RETURN keyword (*not* the LIGHT–TO–OTHER keyword). In the first case, if the return air ducts are located in an unconditioned zone, that zone should be identified in SYSTEMS as ZONE–TYPE = UNCONDITIONED.
PLENUM–ZONES	This codeword is used when the return air path is through plenums and the heat exchange between the return air and the plenum wall mass is important. Heat from lights can be added in two ways: directly through the LIGHT–TO–OTHER keyword in LOADS and through the LIGHT–TO–RETURN. The former assignment will allow some of the light heat to be stored in the plenum wall mass, while the latter will show up as an instantaneous cooling load in the return air. This keyword must be chosen if there are zones in this system, defined as ZONE–TYPE = PLENUM and listed under the SYSTEM command in the PLENUM–NAMES keyword.

Because of these improvements in the calculation of the distribution of heat from lights, it is necessary that the user be more specific in the definition of ZONE–TYPEs in the SPACE–CONDITIONS command. Also, be sure that the ZONE–TYPEs in the SYSTEMS ZONE command are in *perfect* agreement with those specified in LOADS. There are two major reasons for this.

1) First, the program sorts the spaces by ZONE–TYPE to assure that the heat of lights is first calculated for CONDITIONED spaces prior to calculating PLENUMs and UNCONDITIONED spaces and any light heat going into the latter types of spaces.

2) The second reason is to insure that the spaces specified in the SYSTEMS input as UNCONDITIONED are not included in the building coincident peak loads calculation. An inconsistancy between LDL and SDL can result in a calculated SULPLY–CFM greater than the sum of the zone CFMs.

Associated with this treatment of heat from lights are changes in certain hourly report variables. In LOADS, for VARIABLE–TYPE = u-name of SPACE, VARIABLE–LIST numbers 15 and 34 have the following meanings:

15	QPLENUM	Light heat gain to return air
34	ZLTOTH	Light heat gain to other space

In SYSTEMS, for VARIABLE–TYPE = u-name of ZONE, the meaning of VARIABLE–LIST number 4, <QP>, is "Light heat to return air — from LOADS (Btu/hr)".

For VARIABLE–TYPE = u-name of SYSTEM, the description of VARIABLE–LIST number 16, QPSUM, has been changed to "Total system light heat to return (Btu/hr)".

See Appendix A, **Hourly Report Variable List**.

THE SHERMAN–GRIMSRUD INFILTRATION METHOD

An additional method of computing residential air infiltration was added to DOE-2.1B using a model developed by Sherman and Grimsrud[1]. It is applicable only to single zone residential simulation (system type RESYS). This method is specified by setting INF–METHOD = S–G in the SPACE–CONDITIONS command.

Also under the SPACE–CONDITIONS command, there are three keywords:

HOR–LEAK–FRAC To compute the stack effect term in the S–G infiltration method, the leakage area and the leakage distribution are needed. HOR–LEAK–FRAC is the fraction of the leakage that is in the floor and ceiling. A value of 0.3 is appropriate if there are few ceiling penetrations. Otherwise, the default of 0.4 may be used.

NEUTRAL–LEVEL is the dimensionless height of the neutral level for the S–G infiltration method. That is, it is the fraction of the height of the space at which the indoor-outdoor pressure is zero. In general, this keyword can be allowed to default (to 0.5).

FRAC–LEAK–AREA is the total leakage area expressed as a fraction of the floor area used in the S–G infiltration method. This number can be obtained from a pressurization measurement. Otherwise, values may be selected from Table 2.9. The default is 0.0005.

Table 2.9

Type of construction	FRAC–LEAK–AREA
Tight	0.0003
Average	0.0005
Loose	0.0010

Under the BUILDING–LOCATION command, there are the following keywords:

SHIELDING–COEF is the shielding coefficient in the Sherman-Grimsrud infiltration method. This coefficient modifies the wind speed term in the model to account for changes in the wind pressure caused by local obstructions. A value should be selected from Table 2.10.

1 M.H. Sherman and D.T. Grimsrud, "Measurement of Infiltration Using Fan Pressurization and Weather Data," October 1980, LBL-10852

Table 2.10

Shielding Coefficient Values

SHIELDING–COEF	Description
0.32	No obstructions or local shielding whatsoever, e.g., desert.
0.29	Light local shielding with few obstructions, perhaps a few trees or a small shed.
0.24	Moderate local shielding, some obstructions within two house heights, a thick hedge or a solid fence, or one neighboring house.
0.19	Heavy shielding, obstructions around most of perimeter, buildings or trees within 30 feet in most directions, typical suburban shielding.
0.10	Very heavy shielding, large obstructions surrounding perimeter within two house heights, typical downtown shielding.

TERRAIN–PAR1 is a constant used to modify the free stream wind speed to account for ground roughness and height above ground level at the building site. Select a value from Table 2.11.

TERRAIN–PAR2 is a constant used to modify the free stream wind speed to account for ground roughness and height above ground level at the building site. Select a value from Table 2.11.

WS–TERRAIN–PAR1 is a constant corresponding to TERRAIN–PAR1, but for the location of the wind speed measurement; i.e., the weather station. Select a value from Table 2.11.

WS–TERRAIN–PAR2 is a constant corresponding to TERRAIN–PAR2, but for the location of the wind speed measurement; i.e., the weather station. Select a value from Table 2.11.

WS–HEIGHT is the height (in feet) above ground level at which the wind speed measurement was made.

For most weather stations, this information can be obtained from *Local Climatological Data — Annual Summaries for 1981*, published by:

The National Climatic Data Center
Federal Building
Asheville, NC 28801

Table 2.11

TERRAIN–PAR1 WS–TERRAIN–PAR1	TERRAIN–PAR2 WS–TERRAIN–PAR2	Description
1.30	0.10	Ocean or other body of water with at least 5 km of unrestricted expanse.
1.00	0.15	Flat terrain with some isolated obstacles, e.g., buildings or trees well separated from each other.
0.85	0.20	Rural area with low buildings, trees, etc.
0.67	0.25	Urban, industrial, or forest area.
0.47	0.35	Center of big city, e.g., Manhattan

Associated with the infiltration method are three variables appearing in the LV–C report. Under INFILTRATION, (if INF–METHOD=S–G) these are:

1. FRAC.OF LEAKAGE AREA
2. S–G NEUTRAL LEVEL
3. HOR–LEAK AREA/FLOOR AREA

ADDITIONS TO GLAZING

Low-emissivity Coating
A keyword was added in DOE-2.1B to the GLASS–TYPE command for single glazing with a low-emissivity coating:

GLASS–TYPE

INSIDE–EMISS	is the inside surface infrared emissivity for single glazing. This keyword should only be specified if PANES = 1 and the glass has a low-emissivity (low-e) coating on the inside surface which lowers the surface emissivity from that of ordinary glass (0.84). The effect of such a coating is to increase the inside air film resistance by decreasing long-wave radiation from the glass. (INSIDE–EMISS should not be used with GLASS–TYPE–CODE 9, 10, or 11, since the transmission and absorption coefficients in this case were calculated for a reflective coating with an emissivity of 0.84).

New Defaults for Glass Conductance
If GLASS–CONDUCTANCE is not specified, a default value is assigned that depends on the number of panes and GLASS–TYPE–CODE. These default values were changed in DOE-2.1B; they are given in Table 2.12, which is a revision of Table III.1 in the Reference Manual.

For single glazing only (PANES = 1), the default GLASS–CONDUCTANCE for single glazing only varies *hourly* depending on the inside-outside air temperature difference and the inside surface emissivity of the glass (see INSIDE–EMISS keyword). This temperature and emissivity dependence will be ignored if the user specifies a value for GLASS–CONDUCTANCE for single glazing.

SHADING–COEF vs. GLASS–TYPE–CODE
The choice between using SHADING–COEF and GLASS–TYPE–CODE depends on whether the glass is covered by a shading device (blinds, drapes, louvers, etc.) or is unshaded (shading here does not refer to that from fins, overhangs, etc.).

unshaded glass	Use GLASS–TYPE–CODE (see Example 1, p. 2.79). This approach guarantees that the program will use the proper dependence of the transmission and absorption coefficients on the angle of incidence of solar radiation.
shaded glass	Specify SHADING–COEF (see Examples 3 and 4, p. 2.80). The value to use can be obtained from manufacturer's data. The user should be aware that this approach uses the angular dependence of the transmission and absorption coefficients for a single pane of 1/8-inch-thick clear glass; it does *not* account for the angular dependence of the shading device.

Sometimes parametric runs are made changing from no shade to varying degrees of shading on the glass. In this case, for consistency, SHADING–COEF should be used for each step, even the unshaded case. (Manufacturers also give shading coefficients for unshaded glass.)

Table 2.12

TRANSMITTANCE, REFLECTANCE, DEFAULT CONDUCTANCE, AND U–VALUES FOR DIFFERENT GLASS–TYPE–CODES AND NUMBER OF PANES

	GLASS-TYPE-CODE	Trans-mittance(1) (percent)	Reflec-tance(2) (percent)	Default Conductance (*excludes* outside air film) (Btu/hr-ft^2-°F)	U-Value † (*includes* outside air film) (Btu/hr-ft^2-°F)
SINGLE PANE					
	1	88	7	1.42(3)	1.00
	2	83	7		
	3	79	7	1.24(3)	0.90
un-	4	75	7		
coated	5	61	6		
	6	50	6		
	7	41	6		
	8	34	5		
with	9	50	30	1.42(4)	1.00
reflective	10	20	45		
coating(5)	11	10	50	1.24(4)	0.90
DOUBLE-PANE					
	1	75	16		
	2	71	16		
	3	68	14		
un-	4	64	14		
coated	5	53	11	0.574	0.49
	6	43	9		
	7	35	8		
	8	29	7		
with	9	45	31		
reflective	10	19	45	0.311	0.285
coating(5)	11	9	51		
TRIPLE-PANE					
	1	68	18		
	2	64	16		
	3	61	15		
un-	4	58	14		
coated	5	47	10	0.305	0.279
	6	39	7		
	7	32	6		
	8	26	5		
with	9	40	33		
reflective	10	17	45	0.232	0.217
coating(5)	11	8	51		

† U-Value corresponding to the Default Conductance (includes outside air film at 7.5 mph windspeed (Btu/hr-ft^2-°F).

(1) Transmittance at normal incidence for overall solar spectrum (not just visible portion).

(2) Reflectance at normal incidence for overall solar spectrum.

(3) Varies with emissivity (ϵ) of inside glass surface and with inside-outside temperature difference. First value given here is for $\epsilon = 0.84$ and winter temperature condition of 32°F outside air temperature, 70°F room temperature; second value is for $\epsilon = 0.84$ and summer temperature condition of 90°F outside air temperature, 75°F room temperature.

(4) Varies with with inside-outside temperature difference. First value given here is for winter temperature condition of 32°F outside air temperature, 70°F room temperature; second value is for summer temperature condition of 90°F outside air temperature, 75°F room temperature.

(5) Coating is on inside of outer pane; all panes are clear glass.

Examples

DOUBLE THERMOPANE INSULATING GLASS										
GLASS	THICKNESS		TRANSMITTANCE		U-VALUE		SHADING-COEFFICIENTS			
			Avg	Total	Summer	Winter	No shade	Draperies		
	in	mm	Daylight %	Solar %	(7.5 mph windspeed)	(15 mph windspeed)		Light	Med	Dark
BRONZE	1/4	6	44	36	.57	.49	.54	.37	.42	.43

Shown above is an excerpt from a glass manufacturer's product data sheet; it gives data for double-pane insulating glass with a heat-absorbing outer pane. Following are some examples of DOE-2 input for this glass.

1. Using GLASS–TYPE–CODE with no shading device

```
INSUL–GLASS–1 = GLASS–TYPE    PANES=2
                              GLASS–TYPE–CODE=7
                              GLASS–CONDUCTANCE=0.54 ..
```

GLASS–TYPE–CODE = 7 was chosen since this gives, from Table 2.12, a total solar transmittance of 35%, which is close to the 36% transmittance of the glass in question. The GLASS–CONDUCTANCE value of 0.54 was determined using

$$GLASS\text{–}CONDUCTANCE = \left(\frac{1}{U} - R_{film} \right)^{-1} ,$$

with U=0.49, the manufacturer's winter U-value for 15 mph windspeed, and $R_{film} = [-0.001661 * v^2 + 0.302 * v + 1.45]^{-1} = .20$ hr-ft^2-°F/Btu with v = 15 mph / 1.15 = 13.04 knots.

2. Using SHADING–COEF, no shading device

```
INSUL–GLASS–2 = GLASS–TYPE    PANES=2
                              SHADING–COEF=0.54
                              GLASS–CONDUCTANCE=0.54 ..
```

The shading coefficient in this case is just the "No shade" value from the data sheet. GLASS–CONDUCTANCE is calculated as in Example 1.

3. Using SHADING–COEF with light-colored drapes always in place

```
INSUL–GLASS–3 = GLASS–TYPE    PANES=2
                              SHADING–COEF=0.37
                              GLASS–CONDUCTANCE=0.54 ..
```

The shading coefficient here is for the window-plus-drape combination and is taken from the "Draperies-Light" entry on the data sheet. GLASS–CONDUCTANCE is calculated as in Example 1, assuming that the drapes have a negligible effect on the conductance.

4. Using SHADING–COEF with light-colored drapes that are in place only in the afternoon

```
SHADE–SCH–4    =  SCHEDULE     THRU DEC 31 (ALL) (1,12) (1.0) (13,24) (.69) ..
                                  .
                                  .
                                  .
INSUL–GLASS–4  =  GLASS–TYPE   PANES=2
                               SHADING–COEF=0.54
                               GLASS–CONDUCTANCE=0.54 ..
                                  .
                                  .
                                  .
WIN–4          =  WINDOW       GLASS–TYPE=INSUL–GLASS–4
                               SHADING–SCHEDULE=SHADE–SCH–4
                                .
                                .
                                .  ..
```

The SHADING–COEF here is the "No shade" value from the data sheet, as in Example 2. The shading schedule gives a window-plus-drapes shading coefficient of 1.0 * 0.54 = 0.54 before 12 noon, and 0.69 * 0.54 = 0.37 after 12 noon.

FLOOR MULTIPLIERS AND INTERIOR WALL TYPES

With the addition of Automatic Custom Weighting Factors and Daylighting, the requirement to input all of the interior surfaces of a space becomes mandatory. Thus a long-standing problem with space multipliers (see DOE-2.1A Reference Manual, Section III.B.14 for discussion) has been addressed by the addition of keywords to the SPACE command as discussed below.

SPACE

MULTIPLIER may be used to specify the total number of *identical* spaces. Use of this keyword reduces the amount of required data entry, but does not actually create other spaces. The program will calculate the loads for the space defined and multiply these loads by MULTIPLIER. If a STANDARD or AIR type INTERIOR–WALL (see discussion immediately following) is defined within the space, the heat transfer to the NEXT–TO space is multiplied by MULTIPLIER. In effect, the area of the INTERIOR–WALL, as seen from the NEXT–TO space, is larger than that entered by a factor of MULTIPLIER. The user must enter a wall AREA for INTERIOR–WALLs corresponding to that in the space being multiplied.

Because it creates an ambiguity with regard to the area of the interior wall between them, it is always an ERROR for MULTIPLIER to be different from 1.0 in both of two adjacent spaces connected by STANDARD or AIR type INTERIOR–WALLs.

FLOOR–MULTIPLIER may also be used, like MULTIPLIER, to multiply the loads from one of a number of essentially identical spaces. Unlike MULTIPLIER, there is no multiplication of heat transfer through INTERIOR–WALLs. The major function of FLOOR–MULTIPLIER (abbreviated as F–M) is to simplify the input for a multi-storied building where a number of the floors are thermodynamically identical and where there is negligible heat transfer from floor-to-floor. The default is 1.0 and the range is from 1.0 to 200.0.

The MULTIPLIER or FLOOR–MULTIPLIER keywords in the SPACE command should be used only when the several spaces being modeled in this fashion are equivalent with respect to thermodynamics and/or daylighting. Exterior shading, for example, must be the same for each of the spaces included. When there are adjacent spaces that are presumably identical, there should not be heat transfer between the spaces and it might be supposed that the wall could be ignored. When precalculated weighting factors are used and daylighting is not important, this solution is satisfactory. However, if Custom Weighting Factors are to be calculated or daylighting is being invoked, the wall must be described. The common wall must be described as INT–WALL–TYPE = ADIABATIC.

In the INTERIOR–WALL command, the MULTIPLIER keyword has been removed and the following keyword added:

INTERIOR–WALL

INT–WALL–TYPE indicates the type of interior wall. It can take the following codeword values:

STANDARD designates a physical interior wall that separates two spaces and is capable of transmitting heat between the spaces. STANDARD is the default. Such a wall typically has non-zero values for both INSIDE–VIS–REFL and SOLAR–FRACTION. It may be defined with LAYERS-type CONSTRUCTION or with U-VALUE-type CONSTRUCTION. In either case its overall U-value must be less than UCRIT = 0.709 Btu/ft^2-°F-hr, since that is the value for a wall of R-value .05 ft^2-°F-hr/Btu with an inside film resistance on both sides. If the user inputs a U-value for a STANDARD wall that is greater than UCRIT, the INT–WALL–TYPE is changed to AIR. The NEXT–TO keyword is required for this wall type. If the NEXT–TO space is the same as the space under which the interior wall is defined, the value of INT–WALL–TYPE will be changed to ADIABATIC. A STANDARD wall will contribute to the overall conductance of the zone.

AIR specifies an artifice intended to approximate the convective coupling between two spaces that are separated by an imaginary wall. It must be defined with a U–VALUE–type CONSTRUCTION. If the U-value is less than UCRIT, a CAUTION message is printed stating that the U-value is low for air. The NEXT–TO keyword is required for AIR type walls. If the NEXT–TO space is the same as the space under which the interior wall is defined, the value of INT–WALL–TYPE will be changed to ADIABATIC. An AIR wall contributes to the overall conductance of a zone, but not to the Custom Weighting Factors. The U-value should not exceed U=2.7, as discussed under CONSTRUCTION.

If the AIR wall is part of a daylit space, its INSIDE–VIS–REFL values need to be specified (even though it is not a physical wall) since daylight can be reflected back across the AIR wall from the adjacent space. If an AIR wall of area A (defined in space 1) separates spaces 1 and 2 with inside surface area, S_i (excluding the AIR wall) and average reflectance, ρ_i (excluding the AIR wall), then

INSIDE–VIS–REFL $= (R_2, R_1)$,

where R_i is the cavity reflectance of space i, given by

$$R_i = \frac{A\ \rho_i}{S_i - (S_i - A)\ \rho_i} .$$

For example, if A=200 ft^2, S_1=1500 ft^2, S_2=2000 ft^2, and $\rho_1 = \rho_2 = 0.5$,

$R_1 = 0.12$ and $R_2 = 0.09$

This gives
INSIDE–VIS–REFL = (.09,.12).

If the AIR wall was defined in space 2,
INSIDE–VIS–REFL = (.12,.09)

ADIABATIC

ADIABATIC interior walls have been introduced to allow the user to model daylighting and/or to calculate Custom Weighting Factors for similar spaces using the MULTIPLIER keyword in the SPACE command. Such walls may have reflective and absorptive properties, as well as the ability to store heat. They will not, however, allow heat to be transferred between spaces (and thus the name). The NEXT–TO keyword is not used for this type wall. Since such walls will not contribute to Custom Weighting Factors unless they have mass, a WARNING message will be issued if a U–VALUE–type CONSTRUCTION is used.

Generally, ADIABATIC interior walls should be used to separate two spaces that are considered to be identical and are defined via the MULTIPLIER or
FLOOR–MULTIPLIER keywords in a SPACE command (see discussion below). Examples are (1) identical spaces that are side-by-side on one floor of a building and (2) identical spaces that are above one another in a high rise building. The wall or ceiling/floor that separates these spaces should be designated as ADIABATIC. In this way, the representative space will have appropriate boundaries even though there is no named space to be NEXT–TO. Another type of use arises when one is modeling only part of a building, e.g., a store abutting two adjacent buildings. The wall that separates that portion of the building that is being modeled from the rest of the structure should be ADIABATIC. The assumption here is that there is no appreciable heat flow through these boundaries. ADIABATIC walls will not contribute to the conductance of the space.

INTERNAL

The last type of interior wall has been introduced to permit the treatment of another kind of thermal mass interior to a space. Like furniture, the INTERNAL wall will contribute only to the calculation of Custom Weighting Factors and therefore must be of LAYERS–type CONSTRUCTION. This type of wall is ignored by the daylighting calculation, and therefore daylighting-related keywords do not apply. On the other hand, SOLAR–FRACTION is applicable. The NEXT–TO keyword is not used with this type of interior wall. One possible use for walls of this type is to model water walls.

Example

Assume one wants to simulate a multi-story office building with an elevation as in Fig. 2.19 and a typical floor plan as in Fig. 2.20.

XBL 8210-8740

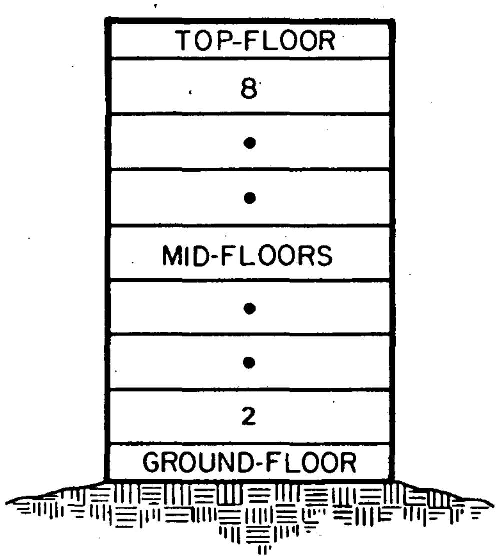


Figure 2.19: Multi-Story Office Building Elevation

XBL 8210-4844

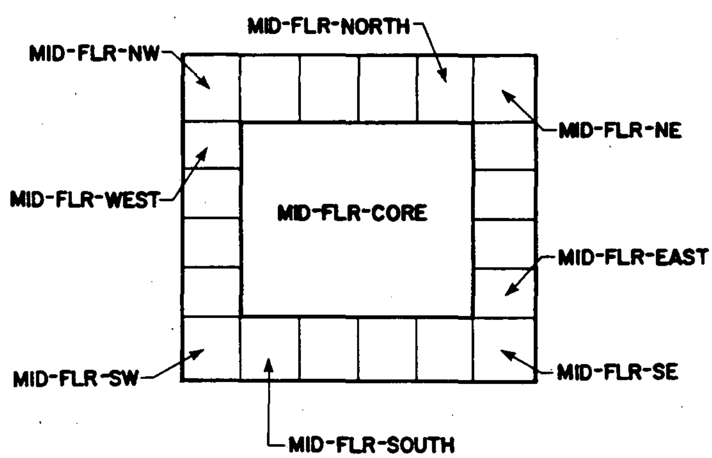


Figure 2.20: Typical Floor Plan

The floors named TOP–FLOOR and GROUND–FLOOR are both unique. Floors 2 through 8, typified by the floor labeled MID–FLOORS, are identical enough to permit the use of the FLOOR–MULTIPLIER keyword. Similarly, the non-corner spaces on each exposure are sufficiently alike to permit the use of the MULTIPLIER keyword. Using MULTIPLIER rather than FLOOR–MULTIPLIER for these spaces will permit the treatment of heat transfer between the peripheral spaces and the core space. Omitting keywords and commands not pertinent to this discussion and illustrating only the East exposure, the input for the building in Figs. 2.19 and 2.20 is:

```
TOP-FLOOR        =   SPACE
                      .
                      .
                      . ..
   FLOOR         =   INTERIOR-WALL     INT-WALL-TYPE = ADIABATIC ..
MID-FLR-CORE     =   SPACE
                      FLOOR-MULTIPLIER = 7  $-- FLOORS 2 THRU 8 --$
                                  .
                                  .
                                  . ..
   CORE-FLOR     =   INTERIOR-WALL     INT-WALL-TYPE = ADIABATIC ..
   CORE-CEIL     =   INTERIOR-WALL     INT-WALL-TYPE = ADIABATIC ..
MID-FLR-EAST     =   SPACE
                      FLOOR-MULTIPLIER = 7  $-- FLOORS 2 THRU 8 --$
                                  .
                                  .
                                  . ..
   EAST-FLOR     =   INTERIOR-WALL     INT-WALL-TYPE = ADIABATIC ..
   EAST-CEIL     =   INTERIOR-WALL     INT-WALL-TYPE = ADIABATIC ..
   EAST-CORE     =   INTERIOR-WALL     INT-WALL-TYPE = STANDARD
                                       NEXT-TO MID-FLR-CORE ..
                      .
                      .  $-- OTHER MID-FLOOR SPACES --$
                      . ..
GROUND-FLOOR     =   SPACE
                      .
                      .
                      . ..
CLNG             =   INTERIOR-WALL     INT-WALL-TYPE = ADIABATIC ..
                      .
                      .
                      . ..
```

Of the walls entered above only those between the peripheral spaces and the core space will permit the transfer of heat between the spaces. On the other hand, thermal mass and daylighting effects will be accounted for correctly.

In the UNDERGROUND–WALL (or UNDERGROUND–FLOOR) command, the keyword MULTIPLIER is used to specify the total number of identical underground wall or floor panels. Its effect is to multiply the AREA by MULTIPLIER.

In SYSTEMS, the MULTIPLIER keyword in the ZONE command refers to the number of identical zones in the building served by the same system and in thermal contact with an adjoining zone, e.g., a plenum or core zone. This keyword is analogous to the MULTIPLIER keyword in the SPACE command in LOADS and will default to the value of that keyword, if not entered in the ZONE command.

In SYSTEMS, the FLOOR–MULTIPLIER keyword in the ZONE command is analogous to the FLOOR–MULTIPLIER in the SPACE command in LOADS and will default to the value given that keyword in the space with the same u-name as the current zone.

Associated with the interior wall types are two ERROR messages in the Custom Weighting Factors Generation Program.

Error Message (4)	CUSTOM WEIGHTING FACTOR CALCULATION FAILED FOR SPACE <U-name>. USE ASHRAE WEIGHTING FACTORS FOR THIS SPACE.
Meaning:	The weighting factor calculation does not converge.
User Action:	Check for odd constructions such as upside-down floors with carpets on underside (as a result of incorrectly entering material layers), or walls that are too massive or too light. If nothing out of the ordinary can be found, the user is advised to abandon the Custom Weighting Factor approach and to use pre-calculated weighting factors (either custom weighting factors calculated earlier and stored in a library or ASHRAE weighting factors using the FLOOR-WEIGHT keyword with a non-zero value).
Error Message (5)	INTERNAL TYPE INTERIOR WALLS MUST HAVE DELAYED CONSTRUCTION.
Meaning:	U–VALUE–type CONSTRUCTION has been used to describe an INTERNAL type INTERIOR–WALL. Since the only purpose for INTERNAL type walls is to provide another thermal mass in the space, the user must use a massive (LAYERS) type CONSTRUCTION for this type of wall.
User Action:	Use a LAYERS–type CONSTRUCTION for INTERNAL–type INTERIOR–WALLS.

IMPROVED EXTERIOR INFRARED RADIATION LOSS CALCULATION

In DOE-2.1D an important improvement has been made in the calculation of the infrared (IR) radiation heat loss from windows and walls to the sky and ground. The result is to increase heat loss from windows and walls relative to 2.1C values, giving 10-15% higher heating loads and 10-15% lower cooling loads. Most of the improvement comes from calculating sky IR emissivity hourly rather than assuming, as in 2.1C, a constant emissivity of 1.0 (blackbody) in determining the radiative part of the outside air film resistance. In the new calculation the sky emissivity depends on atmospheric moisture (as determined by dewpoint temperature), cloud amount, and cloud type. The sky emissivity can vary from about 0.59 for very dry, cloudless conditions to about 0.97 for moist, heavily overcast conditions.

DOE-2.1D also automatically accounts for the effect of building shades on IR loss. An overhang, for example, can significantly reduce IR loss from a window to the sky.

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POWERED INDUCTION UNIT (PIU)

Overview

The PIU system is basically just a VAV terminal box with a small fan that pulls some amount of air from a ceiling plenum. PIU's have two functions:

1) to move warm air from a core area through the plenum to exterior zones requiring heat; this conserves heating energy; and

2) to provide increased air movement in zones normally served by VAV terminals; such zones often suffer from stagnant air when the primary air damper is in its minimum position.

Two types of PIU are modeled — series and parallel. These are sometimes also called constant and intermittent fan powered units. In the series unit (Fig. 3.1), the fan draws air from both the secondary and primary air streams. The proportion of secondary to primary air is controlled by the primary air dampers. The amount of secondary plus primary air is constant, and the blower runs all the time (when the central fans are on) at constant speed. The booster (reheat) coil can be located in the secondary air inlet to save energy when cooling is near a maximum. The fan can run when the central system is off for ventilation or heating. Generally, the blower is sized by the zone recirculation air requirements (AIR–CHANGES/HR, CFM/SQFT). It must be sized equal to or greater than the primary air cfm.

XBL 843-10166

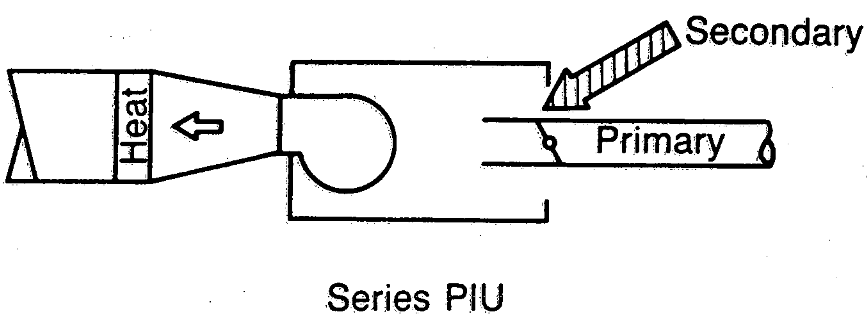

Figure 3.1: Series PIU

The series unit is controlled like a normal VAV unit. At maximum cooling, the primary air damper is open and only a small amount ($\leq 5\%$) of secondary air is induced (Fig. 3.2). As the space temperature falls, the primary air damper gradually closes. However, unlike VAV units, the PIU can throttle primary air down to essentially zero. Once the primary air damper is closed, booster heating (reheat in VAV) can be supplied to meet any heating demand not met by the secondary air from the warm ceiling plenum. The fan can be used at night to limit the lowest building temperature. The fan will normally be off when the central fans are off, but when the zone temperature falls below the night set point, the fan turns on and the booster coil is activated.

XBL 843-10169

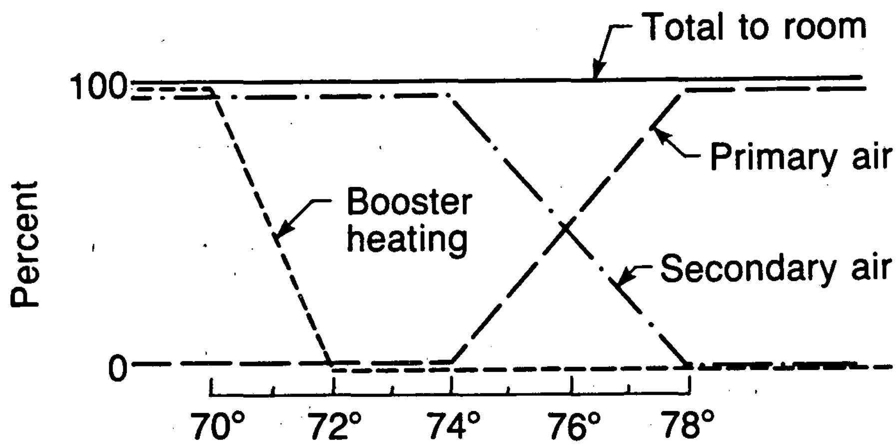

Figure 3.2: Series PIU

The parallel fan unit is slightly more complicated. As illustrated in the schematic, the parallel unit draws air from the secondary air stream only. In addition, the operation of the parallel blower is intermittent. A thermostat set point regulates turning the fan on and off. When cooling is required, the fan is generally off. Thus, we have normal variable volume - constant temperature cooling with the primary air. When the primary air damper is closed and the fan is on, we have constant volume ventilating/heating. Thus total air to the zone is not a constant, as in the series cases.

XBL 843-10164

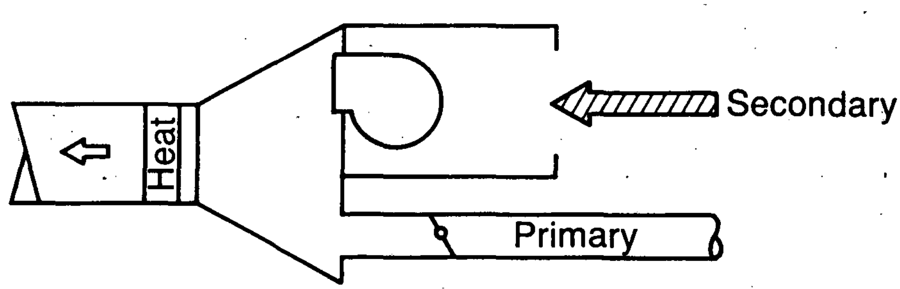

Figure 3.3: Parallel PIU

For parallel PIU's, the blower may be any size. It is commonly *less* than the primary cold air cfm.

At maximum cooling, the blower is off and the primary air damper is open (Fig. 3.4). As the space temperature drops, the damper closes. At a temperature selected by the designer, the blower turns on, and secondary air is mixed with the primary air. As the temperature continues to fall, the primary air damper closes to its minimum position, and the booster heater eventually turns on. The heating coil can (and probably should) be located in the secondary air stream.

XBL 843-10170

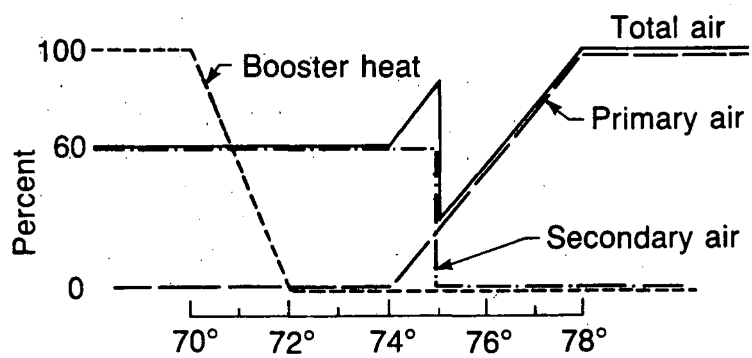

Figure 3.4: Parallel PIU

The blowers operate at a very low static pressure — 0.2 or 0.3 inches are common. A 1400 cfm blower against 0.2 inch static pressure will use about 400 watts.

Input for PIU

The PIU system is selected by using the codeword PIU in the SYSTEM command:

SYSTEM–TYPE = PIU

There are three ZONE keywords associated with PIU:

ZONE

TERMINAL–TYPE — This keyword specifies the type of terminal serving the zone. The same type of terminal box does not have to be used for the entire system. Typically, a PIU system will contain a mixture of fan powered terminal boxes and regular VAV or constant volume reheat units. The available codewords are:

SVAV — (the default) stands for Standard Variable Air Volume; i.e., regular VAV or constant volume.

SERIES–PIU — means that the fan draws air from both the secondary and primary air streams, and that the blower runs all the time.

PARALLEL–PIU — means that the fan draws air from the secondary air stream only, and that the blower runs intermittently.

INDUCED–AIR–ZONE — This keyword takes as a value the u-name of another zone. It is assumed that the PIU zone is taking its secondary air from the return air of the zone named as the INDUCED–AIR–ZONE. Normally, the core zone, served by a non-PIU terminal, will be designated the INDUCED–AIR–ZONE. Zones with PIU boxes will normally be exterior zones that need the heat reclaimed from the core zone. An exception would be a zone (such as a classroom) in which the primary concern is air movement, not energy conservation. In such a case, the corridors can be specified as the INDUCED–AIR–ZONE even though there is no heat to reclaim from them. The program treats this situation in the same way as it does when a core plenum is at a temperature lower than the exterior zone. For zones in which TERMINAL–TYPE = SERIES–PIU or PARALLEL–PIU, this keyword is **required**.

REHEAT–DELTA–T — should be specified, at the ZONE level, if reheat or booster heat is desired. This keyword used to be on the SYSTEM level only. Now, for the PIU system only, it is a keyword in both the SYSTEM and ZONE commands, and the ZONE level use takes precedence over the SYSTEM level. Its meaning remains the same as before.

MIN–CFM–RATIO should be specified in ZONE, just as it is for VAV systems. The usual input for PIU terminals should be to specify a ratio that just satisfies the minimum ventilation air requirements of the zone.

ZONE–FANS, a zone-level command associated with PIU, has been added. It is a subcommand of the ZONE command.

ZONE–FANS

ZONE–FAN–CFM — If TERMINAL–TYPE = SERIES–PIU or PARALLEL–PIU, the user can size the fan with this keyword. If ZONE–FAN–CFM is not specified, the program will size the fan. For series PIU fans, this is a straightforward process. The blower is sized to the zone cfm; i.e., the maximum of the cfm input via ASSIGNED–CFM, AIR–CHANGES/HR, or CFM/SQFT; or the cfm derived from the heating and cooling peaks from LOADS. For parallel PIU's, if ZONE–FAN–CFM is not input, the blower is sized from the heating peak. The ZONE level cfm keywords are assumed to refer to the primary air from the central system. It is recommended that the user explicitly size the fans, since the use of the heating peak to size the parallel PIU might result in a ridiculously small fan. The range is from 0.0 to 99999999.0 ft^3/min.

ZONE–FAN–RATIO For TERMINAL–TYPE = SERIES–PIU or PARALLEL–PIU, the user may enter a value which sets the ZONE–FAN–CFM as a ratio of the primary air. If both ZONE–FAN–CFM and ZONE–FAN–RATIO are specified, ZONE–FAN–CFM takes precedence.

ZONE–FAN–KW For TERMINAL–TYPE = SERIES–PIU or PARALLEL–PIU, this keyword specifies the power consumption of the fan. The default is .00033 kW/cfm. The range is from 0.0 to 0.01.

ZONE–FAN–T–SCH is the u-name of a schedule which gives, for zones with parallel PIU's, the space temperature at which the terminal blower turns on. This temperature must be above the heating range. This keyword is required for zones with TERMINAL–TYPE = PARALLEL–PIU.

In addition, there is a codeword associated with PIU for NIGHT–CYCLE–CTRL in the SYSTEM–FANS command.

SYSTEM–FANS

NIGHT–CYCLE–CTRL

ZONE–FANS–ONLY If input, the main or central system fan will remain off. However, the individual zone terminal fans will cycle on separately to satisfy the heating setback temperature for each zone.

HEAT RECOVERY FROM REFRIGERATED CASE WORK

Keywords were added to the PSZ (Packaged Single Zone) system to allow simulation of refrigerated case work, such as that found in supermarkets, with or without heat recovery. The routines can also be used to simulate ice rinks with or without heat recovery. The user can specify refrigerated case work up to three different temperature levels and specify a corresponding load for each level. The temperature levels reflect the evaporator temperatures of different types of display cases for various products such as frozen foods, meats, dairy products, and produce. However, these routines are only applicable to the situation of one main zone, served by a single PSZ unit, and all case work contained within that zone. This does not preclude splitting a supermarket into two or more zones, each with separate PSZ units. Subzones are allowed, such as office mezzanines, but the refrigerated cases, space temperature control, and heat recovery only apply to the *first–named* main zone in the ZONE–NAMES list. Therefore, subzone reheat can not be simulated as recovered heat.

ZONE

The ZONE keyword additions are as follows:

REFG–ZONE–LOAD is the total cooling effect (sensible + latent) to the zone due to air spilling from the open cases and by heat radiating from other surfaces to the cold surfaces of the cases. A list of up to three entries is allowed, all at zone design drybulb and relative humidity defined under keywords REFG–ZONE–DES–T and REFG–ZONE–DES–RH; see below. The list entries must be made in order, starting with the coldest and progressing to the warmest evaporator temperature. This keyword is required for the simulation, and can range from –99999999.0 to 0.0 Btu/hr.

Manufacturers of supermarket cases usually do not list the total cooling effect of their cases directly. Instead, they list the compressor capacity at a standard suction temperature required per lineal foot of case work. The sensible cooling effect is typically 65% of this number, and the latent cooling effect is about 10%. The total cooling effect is then about 75% of the listed compressor capacity per lineal foot, multiplied by the lineal feet of case work.

REFG–ZONE–SHR is the ratio of sensible to total heat. List of three entries (order corresponds to REFG–ZONE–LOAD entries) at all zone design drybulb and relative humidity defined under keywords REFG–ZONE–DES–T and REFG–ZONE–DES–RH, see below. The default is 0.8.

REFG–ZONE–DES–T is the zone drybulb temperature at which the case is rated (usually 75°F) as referenced by REFG–ZONE–LOAD. List of three entries (order corresponds to REFG–ZONE–LOAD entries). The range is from 30.0 to 100.0°F and the default is 75°F. Values must be greater than the corresponding REFG–EVAP–T values.

REFG–ZONE–DES–RH is the zone relative humidity at which the case is rated (usually 55% RH) as referenced by REF–ZONE–LOAD. List of three entries (order corresponds to REFG–ZONE–LOAD entries). The range is from 20.0 to 100.0°F and the default is 55°F.

REFG–DISCHARGE–T is the temperature of the air inside the cases. List of three entries (order corresponds to REFG–ZONE–LOAD entries). This keyword is required, and can range from –40.0 to 60.0°F.

Note: A simulation ERROR will occur if the zone temperature is ever allowed to float below the warmest temperature in this list.

REFG–EVAP–T is the apparatus dew point temperature. List of three entries (order corresponds to REFG–ZONE–LOAD entries). Values default to the corresponding REFG–DISCHARGE–T – 10.0°F, and the range is from –40.0 to 60.0°F.

REFG–SENS–SCH accepts schedules to simulate covers on case work at night and holidays to inhibit loss of cooling effect to the zone. List of three u-names (order corresponds to REFG–ZONE–LOAD entries).

REFG–LAT–SCH accepts schedules to simulate covering case work and the effect on moisture condensing inside the cases. List of three u-names (order corresponds to REFG–ZONE–LOAD entries).

REFG–AUX–KW is the rated capacity of lights, fans, anti–sweat heaters, or other electrical equipment within the case. List of three entries (order corresponds to REFG–ZONE–LOAD entries).
Values default to 0.4 * the corresponding
REFG–ZONE–LOAD / 12000, and ranges from 0.0 to 100.0.

REFG–AUX–HEAT allows for the entry of non-electrical loads, such as hot water resurfacing of an ice rink. List of three entries (order corresponds to REFG–ZONE–LOAD entries). The default is 0.0 Btu/hr, and can range from 0.0 to 99999999.0.

REFG–AUX–SCH accepts schedules for turning off lights, anti–sweat heaters, etc, and applies to both REFG–AUX–KW and
REFG–AUX–LOAD. List of three u-names (order corresponds to REFG–ZONE–LOAD entries).

REFG–DEF–MECH accepts codewords for type of defrost (RESISTANCE, FREON, TIME–OFF, NO–DEFROST) for the cases. List of three codewords (order corresponds to REFG–ZONE–LOAD entries).

RESISTANCE is electric resistance defrost (the default).

FREON is hot gas defrost.

TIME–OFF is timer controlled off cycle for frost melt.

NO–DEFROST is for use with units that never need defrosting, or for ice rinks.

REFG–DEF–EFF is the efficiency of the defrost mechanism. Based on the humidity ratio in the zone, the program calculates the moisture that condenses on each evaporator. It assumes that all condensation freezes and the energy required to defrost is equal to:

$$POUNDS\ FROST * PHASE\ CHANGE \div DEF{-}EFF.$$

List of three entries (order corresponds to REFG–ZONE–LOAD entries). Values default to 0.9, unless REFG–DEF–MECH = TIME–OFF, in which case the corresponding value defaults to 1.0.

REFG–DEF–CTRL is the type of defrost control. Code words are either TIMER (for a timed defrost cycle) or THERMOSTATIC (for a timed start with thermostat controlled off cycle). List of three entries (order corresponds to REFG–ZONE–LOAD entries). The default is THERMOSTATIC.

SYSTEM

The SYSTEM keyword additions are as follows:

REFG–SIZING–RAT is a single input to adjust the capacity of all compressors in the system. It is the ratio of compressor size to the total evaporator load (which includes the case work plus lights, anti–sweat heaters, etc.). It defaults to 1.2, and ranges from 0.8 to 2.0.

REFG–COMP–CAP allows the user to enter the installed compressor capacity at each temperature level. List of three entries (order corresponds to REFG–ZONE–LOAD entries of the ZONE input). The range is from 0.0 to 99999999.0 Btu/hr. The default is the refrigeration equipment design load multiplied by REFG–SIZING–RAT.

Note: Manufacturers of supermarket cases nominally rate compressors at a standard suction temperature which is usually *not* the actual suction temperature of the case. The input for this keyword must be the compressor capacity at the actual suction temperature of the case.

REFG–COMP–EER allows the user to input the compressor unit efficiency at each temperature level. If not input, the program will calculate these values as a linear relationship between a range of 3.5 Btu/W at –30°F and 7.3 Btu/W at 25°F. The range is from 0.0 to 20.0 Btu/W. List of three entries (order corresponds to REFG–ZONE–LOAD entries of the ZONE input).

REFG–COMP–GROUP allows the user to specify whether the compressors are multiplexed or serve separate refrigeration circuits. The codewords are SEPARATE (the default) and COMMON. For example, if the first (lowest temperature level) is separate, and the remaining two levels multiplexed, then the input must be as follows: REFG–COMP–GROUP = (SEPARATE, COMMON, COMMON). A mistaken input, such as (SEPARATE, COMMON, SEPARATE), will be interpreted as (SEPARATE, SEPARATE, SEPARATE). When separate refrigeration circuits share a COMMON compressor, the compressor must operate at a suction temperature low enough to match the coldest evaporator temperature in the multiplexed circuits. The energy consumption of the compressor is determined as though the total load of the multiplexed circuits occurred at the coldest evaporator temperature.

Multiplexing circuits will affect the input of other keywords pertaining to the compressors. Consider the following input for three circuits:

```
REFG-COMP-GROUP = (COMMON,COMMON,SEPARATE)
REFG-COMP-EER = (3.5, 20.0, 5.7)
    .
    .
    .
```

Because the first two circuits are multiplexed, the program will use the value 3.5 Btu/W in calculating the energy consumption of the compressor serving these two circuits. The value of 20.0 input for the second circuit is ignored. It (or any other legal value) was input simply to mark the second position in the list, so that the value for the third circuit could be input in the third position.

REFG–FAN–KW is the total value in KW to be assigned to either the fans of air cooled condensers or the fans of cooling towers. The default is 0.105 kW per ton of compressor capacity. The range is from 0.0 to 100.0 kW.

REFG–PUMP–KW is the total value in KW to be assigned to the condenser water pumps for cooling towers. The default is 0.025 kW per ton of compressor capacity. The range is from 0.0 to 100.0 kW.

REFG–MIN–COND–T is the setpoint of a thermostat located in the outside air that modulates condensing capacity of either air cooled condensers or cooling towers to maintain an approximate 10°F higher (than setpoint) condensing temperature. In situations where the condensing temperature is not allowed to "float", this value should be set 10°F lower than the rated condensing temperature of the equipment. The range is from 50.0 to 110.0°F, and defaults to 60.0°F.

REFG–COND–TYPE allows the user to input a codeword for either WATER (the default) for cooling towers or AIR for air cooled condensers. It is assumed that all condensing is of one type.

REFG–MAX–HTREC is the input value of total BTUH of all recoverable heat. The range is from 0.0 to 99999999.0 Btu/hr, and the default is that all compressor heat is recoverable.

REFG–HTREC–UNITS is the codeword of either YES (the default) or NO, which allows the user to specify which compressors operating at different evaporator temperature levels are available for heat recovery. List of three entries (order corresponds to REFG–ZONE–LOAD entries of the ZONE input).

REFG–HTREC–GROUP accepts the entry of a single codeword of either SEPARATE or COMMON (the default). Using SEPARATE, DOE-2 simulates the compressors operating at the highest evaporator temperature level as the first units to switch to the heat recovery mode, and thus forced to operate at a higher condensing temperature, given by REFG–HTREC–T. Using COMMON, DOE–2 simulates all compressors specified as being available for heat recovery as being switched to the heat recovery mode and the higher condensing temperature whenever the space temperature requires heating.

REFG–HTREC–T is the input value of the condensing setpoint during the heat recovery mode. The default is 90°F, and can range from 80.0 to 120.0°F.

REFG–FAN–T is the low limit setpoint at which the cooling tower fans or air cooled condenser fans shut off. The default is 30°F, and can range from 0.0 to 100.0°F.

SYSTEM–EQUIPMENT

Four curves were added to the SYSTEM–EQUIPMENT command in DOE-2.1B.

REFG–KW–FTCOND accepts the u-names of the curves input by the user to replace default curves of KW as a function of condensing temperature. List of three entries (order corresponds to REFG–ZONE–LOAD entries of the ZONE input). The default coefficients are 0.713536, –0.004959, 0.0000980.

REFG–KW–FPLR accepts the u-names of the curves input by the user to replace default curves of KW as a function of part load ratio of the compressors. List of three entries (order corresponds to REFG–ZONE–LOAD entries of the ZONE input). The default coefficients are 0.03829, 1.077839, –0.116129.

TWR–RFACT–FRT accepts a u-name of a curve input by the user that replaces the default curve. (See description of this same keyword in PLANT in the Reference Manual.) The default coefficients are 1.484326, 0.129479, –0.004014, –0.054336, 0.0003120, –0.000147.

TWR–APP–FRFACT accepts a u-name of a curve input by the user that replaces the default curve. (See description of this same keyword in PLANT in the Reference Manual.) The default coefficients are 4.981467, -6.761789, 24.709033, 0.114499, –0.000612, –0.250651.

Example:
Consider a supermarket which has three sets of cases: 1) frozen foods, 2) meat, dairy, and deli, and 3) produce. There are two sets of compressors, one set for the frozen foods and one set for the rest. Only the compressor set serving the meat, dairy, deli, and produce cases is available for heat recovery. All of the cases are covered at night.

```
                 $ SUPERMARKET  CASE  SCHEDULES $

FOOD-SENS-SCH  =  SCHEDULE  THRU DEC 31 (ALL)
                    (1,9) (0.4)              $ COVER CUTS SENSIBLE BY 60%$
                    (10,21) (1.0)            $ UNCOVERED $
                    (22,24) (0.4)            $ COVERED AGAIN $ ..
FOOD-LAT-SCH   =  SCHEDULE  THRU DEC 31 (ALL)
                    (1,9) (0.7)              $ COVER CUTS LATENT BY 30% $
                    (10,21) (1.0)
                    (22,24) (0.7)  ..
FOOD-AUX-SCH   =  SCHEDULE  THRU DEC 31 (ALL)
                    (1,9) (0.2)              $ AT NIGHT ONLY CASE FANS AND
                    (10,21) (1.0)            $ SWEAT HEATERS RUN.  LIGHTS
                    (22,24) (0.2)            $ TURNED OFF.$  ..
                          .
                          .
                          .
MARKET         =  ZONE  ZONE-TYPE = CONDITIONED
                          .
                          .
                          .
                   REFG-ZONE-LOAD = (-70000., -100000., -40000.)
                       $ FROZEN FOOD, MEAT/DAIRY/DELI, AND
                       $ PRODUCE INPUT AS NEGATIVE BECAUSE
                       $ THIS IS THE EFFECT ON THE ZONE.
                   REFG-ZONE-SHR = (0.9, 0.8, 0.9)
                       $ THE MEAT/DAIRY/DELI CASE SET IS MULTI-SHELF
                       $ AND INCURS A LARGER LATENT LOAD.
                   REFG-DISCHARGE-T = (-10.0, 35.0, 45.0)
                       $ ORDER OF ALL LISTS IS COLDEST TO WARMEST.
                   REFG-EVAP-T = (-25.0, 25.0, 36.0)
                   REFG-SENS-SCH = (FOOD-SENS-SCH,
                       FOOD-SENS-SCH,
                       FOOD-SENS-SCH)
                       $ SCHEDULES COULD BE DIFFERENT.
                   REFG-LAT-SCH = (FOOD-LAT-SCH, FOOD-LAT-SCH,
                       FOOD-LAT-SCH)
                   REFG-AUX-KW = (2.0, 8.0, 1.0)
                   REFG-AUX-SCH = (FOOD-AUX-SCH, FOOD-AUX-SCH,
```

```
    FOOD-AUX-SCH)
  REFG-DEF-MECH = (RESISTANCE, FREON, NO-DEFROST)
    $ NOTE THAT THIS INPUT FOR PRODUCE CASE IS
    $ IRRELEVANT; SINCE EVAP-T IS ABOVE FREEZING,
    $ NO DEFROST WILL OCCUR REGARDLESS.
  REFG-DEF-EFF = (0.95, 0.85)
    $ THE HEAT THAT DOESNT MELT ICE WILL BECOME A
    $ COMPRESSOR LOAD. VALUE FOR PRODUCE NOT INPUT
    $ BECAUSE NOT NEEDED.
  REFG-DEF-CTRL (THERMOSTATIC, TIMER)   ..
    .
    .
    .
MARKET-SYS      = SYSTEM SYSTEM-TYPE = PSZ
    .
    .
    .
  REFG-SIZING-RAT = 1.3
    $ WANT EXTRA SAFETY FOR FROZEN FOOD CIRCUIT.
  REFG-COMP-GROUP = (SEPARATE, COMMON, COMMON)
    $ MEAT/DAIRY/DELI CIRCUIT SHARES
    $ COMPRESSORS WITH PRODUCE CIRCUIT
  REFG-MAX-HTREC = 90000.
    $ HEAT RECOVERY COIL SIZED TO 90000 BTU
  REFG-HTREC-UNITS = (NO, YES)
    $ NO HEAT RECOVERY FROM FROZEN FOOD CASE;
    $ ONLY TWO VALUES INPUT BECAUSE THIRD SET
    $ SHARES COMPRESSORS WITH THE SECOND.$  ..
```

Reporting
A SUMMARY report, REFG, was added in DOE-2.1C for refrigerated case work, and the SV–A report was expanded to print verification values for case work energies at design temperatures, compressor efficiencies, and condenser energies. The REFG report and the expanded SV–A will automatically be printed whenever REFG-type keywords have been specified in system type PSZ. In addition, seven hourly report variables (82 through 88) have been added to SYSTEMS, VARIABLE–TYPE = u-name of SYSTEM. See Appendix A, **Hourly Report Variable List**, for a description.

REPORT REFG — REFRIGERATION EQUIPMENT SUMMARY

This report gives monthly energy use for each system in which there is refrigerated case work.

1. ZONAL SENSIBLE ENERGY (MBTU) is the sensible heat gain to the zone from the refrigerated case work.

2. ZONAL LATENT ENERGY (MBTU) is the latent heat gain to the zone from the refrigerated case work.

3. CONDENSER RECOVERED ENERGY (MBTU) is the energy recovered from the condensers and used for space heating in the heat recovery mode.

4. CONDENSER REJECTED ENERGY (MBTU) is the energy rejected from the condensers.

5. ELECTRIC COMPRESSOR ENERGY (KWH) is the electrical energy consumed by the compressors.

6. ELECTRIC DEFROST ENERGY (KWH) is the electrical energy consumed by the defrosters.

7. ELECTRIC AUXILIARY ENERGY (KWH) is the electrical energy consumed by lights, fans, and anti-sweat heaters in the refrigerated cases.

8. ELECTRIC TOTAL ENERGY (KWH) is the total electric energy used by the refrigerated case work.

AIR SOURCE HEAT PUMP ENHANCEMENTS

Expanded Supplemental Heat Source Options
A keyword was added to the SYSTEM–EQUIPMENT (and SYSTEM) command to allow user specification of the type of heat used to supplement the heat pump.

SYSTEM–EQUIPMENT

HP–SUPP–SOURCE — Input for this keyword is a codeword which specifies the source for the heat pump supplemental heating. Legal values for this keyword are ELECTRIC, HOT–WATER, GAS–FURNACE, and OIL–FURNACE. If the codeword HEAT–PUMP is mistakenly entered, it will be changed to ELECTRIC before the simulation. The default value is ELECTRIC.

In addition, the names of two existing keywords in the SYSTEM–EQUIPMENT command have been changed. This change allows simulation of heat pumps with supplemental heat sources other than electric resistance.

HP–SUPP–HT–CAP — Replaces ELEC–HEAT–CAP as the keyword used to specify the capacity of the heat pump supplemental heating. The value, in negative Btu/hr, can range from 0.0 to –99999999.0.

MAX–HP–SUPP–T — Replaces MAX–ELEC–T as the keyword used to specify the temperature above which the supplemental heat will not operate (except when the unit is defrosting). The value can range from –30°F to 70°F.

The above changes allow for the simulation of air source heat pumps which use something other than electric resistance for the supplemental heating unit. For example, residential add-on heat pump units can be modeled by specifying HEAT–SOURCE = HEAT–PUMP, and HP–SUPP–SOURCE = GAS–FURNACE or OIL–FURNACE with system type RESYS.

Addition of Heat Pumps to Single Duct Packaged Systems
Heat pumps as a heat source are now available for use in the packaged single zone system, PSZ. All ten of the heat pump keywords,

DEFROST–DEGRADE	HEATING–EIR
DEFROST–T	HP–SUPP–HT–CAP
HEAT–CAP–FT	HP–SUPP–SOURCE
HEAT–EIR–FPLR	MAX–SUP–T
HEAT–EIR–FT	MIN–HP–T

are now applicable to the PSZ system type.

Report Changes for the New Heat Pump Simulation

One additional field has been added to the SV-A report when a heat pump has been specified as the heat source with system types RESYS, PSZ, and PTAC. The new field, labeled HEAT PUMP SUPP HEAT, displays the capacity in Btu/hr of the heat pump supplemental heating element. For PTAC systems this value will be used with each unit.

In the SYSTEMS hourly reports, variable 43 (QHR) is now the adjusted capacity of the heat pump this hour in Btu/hr for system types RESYS and PSZ. A new variable, 81 (QHSUP), has been added for system types RESYS, PSZ, and PTAC. This variable displays the total supplemental heat load for the system if HP–SUPP–SOURCE = HOT–WATER or HOT–WATER/SOLAR.

ZONE hourly report variable 48 (FCHPS(15)) has been changed for system type PTAC. It now displays the supplemental heat load for this zone's heat pump this hour in Btu/hr. The load displayed here is independent of the supplemental heat source.

New Heat Pump Sizing Policy

For the systems (PSZ, PVAV, PMZ, PTAC) that accept the code word HEAT–PUMP, DOE-2 adjusts the capacity of the heat pump to:

Heat Pump Cap = Cooling Cap * Htg COP / Clg COP

/ Cooling Cap = Heating Cap * Clg COP / Htg COP

OPTIMUM FAN START OPTION

SYSTEM–FANS

FAN–SCHEDULE

takes as a value, as in the previous versions of the program, the u-name of a schedule instruction that specifies fan operation for each hour. If the hourly value is (1), the fans are on. If the hourly value is (0), the fans are off but may be turned on by NIGHT–CYCLE–CTRL if ZONE temperatures warrant it. If the hourly value is (–1), the fans are not permitted to be on for any reason.

The program now accepts hourly values of (–999.0) to define an optimum start period of up to six hours duration. During this period the fan start time is delayed until the fan run time matches that which is needed to meet the desired ZONE temperatures. Notice that this decision is made on an hourly basis, whereas in the real world, it is made on much smaller increments of time (i.e., ten minutes or less). For the hourly calculation, the number of hours needed to bring each ZONE on the system up or down to its set point is estimated. If the number of such hours for the majority of the zones is equal to or greater than the number of hours remaining in the start period, the fans are turned on. The target zone temperatures used in the calculation are the heating and cooling set temperatures scheduled in HEAT–TEMP–SCH and COOL–TEMP–SCH that correspond to the first hour following the scheduled optimum start period.

Rules:

1. The optimum start period must be less than or equal to six hours.
2. The fan must be scheduled on using the value (1) for the first hour following the optimum start period.
3. An optimum start period must be defined within a contiguous set of hours. Therefore, the optimum start period cannot begin before 1:00 A.M. E.g., the following example is *not valid*:

F1 = D–SCH (1,4) (–999) (5,18) (1) (19,22) (0) (23,24) (–999) ..

Cautions:

1. Zones with Trombe walls should not be used with optimum start.

2. Optimum start will not work well on systems serving zones which are not evenly balanced with respect to their start up duration.

3. If the system is under-sized, or can not supply sufficient air at its minimum or maximum supply temperature, the start time will be delayed too long and there will be excessive hours reported with loads not met. A VAV system with a low MIN–CFM–RATIO and a thermostat type that is not REVERSE–ACTION fits this description.

4. The results for short RUN–PERIODs of just a few days will not produce results as good as those for longer RUN–PERIODs since the program attempts to learn (simulating feedback) to improve on its estimating abilities.

5. During hours of the optimum start period in which the fan has not been started, the system will behave as if the fan schedule that hour were (0). Thus, the fan can cycle on during this period if NIGHT–CYCLE–CTRL is used.

6. For Air/Air Heat Pumps, where the primary interest is one of minimizing the use of electric resistance heating during start-up, it is suggested that the set point temperature be ramped upward. This should start with the first hour during a normal fan start period.

Example input/output may be found in the DOE-2 Sample Run Book in the 31-Story Office Building, Runs 1 through 6.

NIGHT VENTILATION

Several keywords were been added to DOE-2.1B to allow the simulation of night-time ventilation cooling using outside air and an alternative set of fans which run when the FAN–SCHEDULE is off. The keyword NIGHT–VENT–CTRL in the SYSTEM or SYSTEM–FANS command has five legal codewords which define the operation of fans when the FAN–SCHEDULE is off (and the NIGHT–CYCLE–CTRL has not caused the fans to cycle on). The user should consult the new SS-K report for assistance in determining the potential for night ventilation (see Appendix C, **DOE-2 Reports: Examples and Description**). The NIGHT–VENT–CTRL codewords are as follows:

SYSTEM or SYSTEM–FANS

NIGHT–VENT–CTRL

NOT–AVAILABLE (the default) means that, when the FAN–SCHEDULE is off, no other fans can be on.

NIGHT–FAN means that, when the main fans are scheduled off, the night fans always run to pressurize, for instance, a fabric roof system. One can also think of this as the main fans running but at a reduced volume.

NIGHT–FAN+REVERT means that, when the main fans are scheduled off, the night fans run unless any zone falls below its heating throttling range or rises above its cooling throttling range, in which case the main fans are turned on that hour.

WHEN–SCHEDULED means that, when the main fans are scheduled off, the night ventilation fans will turn on if the NIGHT–VENT–SCH is on and the outside drybulb temperature is at least NIGHT–VENT–DT degrees below the temperature in the first zone specified in the ZONE–NAMES list.

SCHEDULED+DEMAND is the same as WHEN–SCHEDULED except that, in addition, at least one conditioned zone in the ZONE–NAMES list must be above the VENT–TEMP–SCH value.

The following keywords supply the additional information for simulating the night fans and night ventilation options:

NIGHT–VENT–SCH is a required entry in the SYSTEM or SYSTEM–FANS command, when NIGHT–VENT–CTRL is equal to WHEN–SCHEDULED or SCHEDULED+DEMAND. It is the u-name of a schedule that defines the hours when the night ventilation fans are allowed to run, if the main fans are scheduled off. A zero or non-zero value is used to specify that the night ventilation fans are either not allowed or allowed, respectively, to turn on.

NIGHT–VENT–DT in the SYSTEM or SYSTEM–FANS command, is the minimum number of degrees that the outside drybulb temperature must be below the inside temperature for the night ventilation fans to operate. This inside temperature is that of the first zone specified in the ZONE–NAMES list. The value is usually set equal to at least the temperature rise across the ventilation fans plus a couple of degrees to ensure that a reasonable cooling capacity is available before ventilation cooling is used. The default is 5°F.

NIGHT–VENT–RATIOS is a required entry in the SYSTEM or SYSTEM–FANS command when NIGHT–VENT–CTRL is not equal to NOT–AVAILABLE. It is a list of six values that are ratios of night fan parameters to the normal operating fan parameters. The first three values define the ratios of flowrate, kW per unit flowrate, and fan temperature rise of the night supply fans to the normal supply fans. The last three values define the same three ratios of the night return fans to the normal return fans.

Q_N, night fan flowrate =
SUPPLY–CFM * NIGHT–FAN–RATIOS(1)

P_N, night fan power/flowrate =
SUPPLY–KW * NIGHT–FAN–RATIOS(2)

DT_N, night fan temperature rise =
SUPPLY–DELTA–T * NIGHT–FAN–RATIOS(3)

where

$Q_N * P_N$ = night supply fan total energy use

Similar relationships are true for the return fans during night operation. If no return fans are used during the night operation, the last three values of NIGHT–FAN–RATIOS should be set equal to zero. Note that the ratios of power/flowrate and temperature rise are normally similar and larger than the flowrate ratio (this is especially true if the night and day fans are the same fans operated under different control or pressure conditions). If the night and normal fans are, in fact, the same set run in the identical manner, all six values should be set to 1.0.

VENT–TEMP–SCH in the SYSTEM or SYSTEM–AIR command, is the u-name of a schedule used to define the setpoint for forced or natural ventilation. *Natural* ventilation is appropriate to the RESYS system only. The hourly values specified in the referenced SCHEDULE are the indoor dry-bulb temperatures to which the zone is to be cooled by natural ventilation, in lieu of mechanical cooling. For forced ventilation, this value is used when NIGHT–VENT–CTRL is equal to SCHEDULED+DEMAND. The night ventilation fan, in this case, will operate only if any conditioned zone specified in the ZONE–NAMES list is above this value. If this keyword is not defined, the top of the zones' heating throttling range (defined by value of HEAT–TEMP–SCH plus 0.5 * THROTTLING–RANGE) is used.

Report Modification

Report SS–C now reports out the number of hours of night venting. This report has been enhanced in other ways as well; it now also reports the number of hours the terminal unit is operating in the dead-band (HOURS FLOATING), the number of hours of heating and cooling available, number of hours the fans are on, fans cycling on, and number of hours the terminal unit is operating in the dead-band when the fans are on (HOURS FLOATING WHEN FANS ON).

Note: NIGHT–CYCLE–CTRL now also cycles fans on when the temperature goes above the COOL–TEMP–SCH's throttling range.

USER–DEFINED CURVE–FIT BOUNDARIES

In 2.1B two keywords were added to the CURVE–FIT command in SYSTEMS and PLANT that allow the user to establish both the lower and upper boundaries beyond which the curve is not valid. The keywords are:

OUTPUT–MIN	defines the lower boundary of the dependent variable, and
OUTPUT–MAX	defines the upper boundary of the dependent variable.

BASEBOARD HEATING IN PLENUMS

Several zone level keywords were activated in DOE-2.1B for PLENUM type zones. The use of these keywords allows "baseboards" to be placed in plenums. This allows the simulation of outside or space temperature controlled heaters in the return air space. The allowed keywords are:

HEAT–TEMP–SCH	to define the thermostat setpoint for the plenum heater when it is THERMOSTATICally controlled.
BASEBOARD–RATING	to define the size of the heating unit.
BASEBOARD–CTRL	to define the control method as THERMOSTATIC using HEAT–TEMP–SCH as the setpoints, or OUTDOOR–RESET to allow BASEBOARD–SCH reset control.
THROTTLING–RANGE	to define the throttling range around HEAT–TEMP–SCH.

The plenum heater is activated based on outside air temperature and reset schedule when it is outside controlled. When it is space temperature controlled, and if the interaction with the return air does not result in a temperature above the scheduled value, the heater is turned on. In both cases, the source of energy input to the heater is defined by the specified or defaulted value for BASEBOARD–SOURCE.

MIN–CFM–SCH AND OTHER SCHEDULE USES

A schedule keyword was added in DOE-2.1B to allow an hourly variation of the MIN–CFM–RATIO.

MIN–CFM–SCH

in the ZONE command, is the u-name of a schedule which has values that are to be used in place of the MIN–CFM–RATIO keyword to allow an hourly variation of MIN–CFM–RATIO. This schedule will always override the value specified or calculated for MIN–CFM–RATIO, unless the scheduled value is equal to –999.0 for an hour. When the value is equal to –999.0, then the calculated or specified value of MIN–CFM–RATIO (found on report SV–A for each zone) is used for that hour. This schedule can be used with a value of 1.0 during warmup periods and –999.0 for other hours to simulate full open VAV boxes during a warmup cycle.

MIN–AIR–SCH

The MIN–AIR–SCH keyword used in the SYSTEM or SYSTEM–AIR command defines the hourly value of the minimum outside air damper position as a ratio of design flowrate. The two exceptions to this definition are when the schedule has a value of either zero or –999.0; in which case special meanings are assumed. When the value is zero, a no outside air situation with no moveable dampers (economizer inactive if specified) is simulated. This usage is common for nighttime heating or a warmup cycle. If this schedule has a value of –999.0, the calculated or specified value for MIN–OUTSIDE–AIR (found on report SV–A for the SYSTEM or for each zone for zonal systems) is used as the minimum damper position for the current hour. If this value is zero, the discussion above for that special value applies. During a warmup period, this schedule is normally set to zero and can then be set to –999.0 during other hours to allow the specified or calculated ventilation minimum damper position to be used.

HEATING–SCHEDULE
COOLING–SCHEDULE

The HEATING–SCHEDULE and COOLING–SCHEDULE in the SYSTEM or SYSTEM–CONTROL commands are equal to the schedules whose values define the availability of active heating and cooling, respectively. A zero value for one of these schedules means that heating or cooling is not available except through ventilation. A non-zero value indicates that mechanical heating or cooling is available. Additionally, if either of the schedules has a value greater than 1.0, a special meaning is inferred. If the HEATING–SCHEDULE is set to a value greater than 1.0, heating is available only if the outside drybulb temperature is less than or equal to the specified value. In a similar manner, if the COOLING–SCHEDULE is set to a value greater than 1.0, cooling is available only if the outside drybulb temperature is greater than or equal to the specified value.

VARIOUS CONTROL ENHANCEMENTS

A keyword was been added in 2.1B to define the source of heat used to provide humidification in those SYSTEM–TYPEs that allow MIN–HUMIDITY to be specified. Note that humidification has been added to the HVSYS system.

HUMIDIFIER–TYPE in the SYSTEM command, is given one of the standard heat source codeword values: HOT–WATER, ELECTRIC, GAS–FURNACE, or OIL–FURNACE. The gas and oil furnace sources should be used with caution since the same HIR and part load functions are used as for other furnaces specified in the same system. The defaults for HUMIDIFIER–TYPEs are the same as those for BASEBOARD–TYPE.

MAX–HUMIDITY in the SYSTEM or SYSTEM–CONTROL command causes the simulation to function differently for system types SZRH, PSZ, and PVAVS than previously described. For SZRH, if the MAX–HUMIDITY level is exceeded, the system reverts to a full reheat. The cooling coil leaving air temperature is driven lower and reheat is added at the fan unit to satisfy the first-named zone. Further, for PSZ and PVAVS systems, specification of MAX–COND–RCVRY will activate the use of condenser recovery to accomplish a similar result.

A keyword was added in 2.1B to the SYSTEM and SYSTEM–CONTROL commands that adds an additional control to the outside air economizer cycle.

ECONO–LOW–LIMIT defines the outdoor drybulb temperature *below* which the outside dampers are returned to their minimum position (see Fig. 3.5). This is analogous to the ECONO–LIMIT–T, except that it is a low limit rather than a high limit. The range is from 0.0 to°F, and the abbreviation is E–L–L.

Note that Fig. 3.5 assumes some relative values for outside drybulb and return air drybulb temperatures. The purpose of this keyword is to allow the user to simulate the loading of an evaporator on a double bundle chiller (DBUN–CHLR) to satisfy the heating load. The value input for ECONO–LOW–LIMIT is the outside air temperature at which the outside air economizer damper is forced to a minimum position. This, in effect, increases the load on the evaporator and the additional heat rejected is available to satisfy the heating load. The economizer is only active between the outside temperature specified for ECONO–LOW–LIMIT and ECONO–LIMIT–T as seen in Fig. 3.5.

XBL-*none*

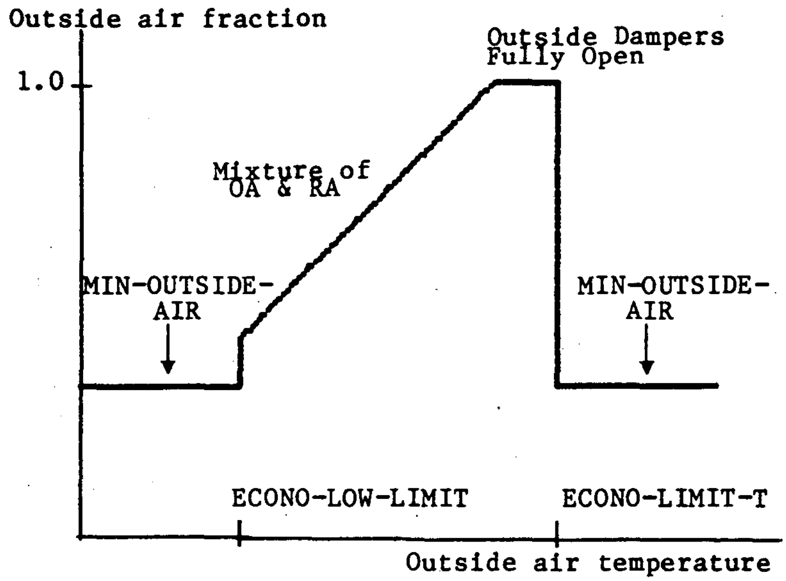

Figure 3.5: Outside Air Control Action

Another use of the ECONO–LOW–LIMIT keyword is to simulate the closing (to minimum position) of outside air dampers when humidification is required. There would be no direct tie to the humidifier controller as ECONO–LOW–LIMIT is only based on drybulb temperatures. However, the user could address the savings of humidifying minimum versus maximum outside air quantities.

Control of air flow rate to zones was upgraded in DOE-2.1B:

CFM/SQFT and **AIR–CHANGES/HR**

under the ZONE–AIR command took on new meanings in 2.1B.
In previous versions of the program, these two keywords always overrode the calculated zone CFM's and set them to satisfy these criteria. They now allow the user to set a minimum air flow rate to the zone, and only override the calculated value when the latter is less than the minimum criteria. The keyword ASSIGNED–CFM is now the only method the user has to set a value at the ZONE level.

SUPPLY–CFM

in the SYSTEM–AIR command has not been changed in meaning; however, the method of proportioning the specified total supply air into zone air quantities has been made more exact in the following manner.

Adjusted Zone Air CFM =

$$\left(\frac{<SUPPLY\text{–}CFM>}{\sum Calculated\ Zone\ Air\ CFMs} \right) * (\ Calculated\ Zone\ Air\ )$$

Note that user inputs of ZONE-level ASSIGNED–CFM and EXHAUST–CFM (but only when the latter exceeds calculated zone CFM) replace the other "Calculated Zone Air CFMs" in the summation.

When the user allows the program to calculate MIN–CFM–RATIO (rather than input it), the values for Minimum Flow Ratio (see SV–A Report) are corrected relative to the values of "Adjusted Zone Air CFM", taking into account the specified outside/exhaust air or the peak heating load. Likewise, user input of MIN–OUTSIDE–AIR would result in new quantities of Outside Air Flow (see SV–A report) as these values would be simply the ratio of the the zone flowrate and the SUPPLY–CFM value times the MIN–OUTSIDE–AIR value.

SYSTEM–EQUIPMENT DEFAULT CURVES

The default curves for most of the keywords in the SYSTEM–EQUIPMENT command were upgraded in DOE-2.1C in order to more closely resemble equipment now on the market. The table presented on the next two pages replaces Chap. IV, Table 39, of the DOE-2 Reference Manual. Also introduced are four new keywords and accompanying default curves for special use in the PSZ system (see p. 3.6, **HEAT RECOVERY FROM REFRIGERATED CASE WORK**, in this Supplement).

The new curves were developed from rated data using various representative equipment specifications found in manufacturers' catalogs:

RESYS	36,000 Btu/hr air-cooled condensing unit, rated 3 tons @ ARI, 1200 CFM, 3 row, 13-14 fins per inch (fpi), 4.5 ft/sec (indoor), 20 fpi, 3.5 ft/sec (outdoor).
PTAC	A combination of data from three units, from 6,900 Btu/hr to 11,800 Btu/hr in size.
HP	35,000 Btu/hr cooling, 39,000 Btu/hr heating, shr = 0.74, 26,000 Btu/hr sensible, 4.5 GPM 20° ΔT, 4 row, 12 fpi, 500 ft/min.
PSZ PMZS PVAVS	360,000 Btu/hr, 30 tons, 2 compressors unloading to 15%, 3 condensor fans, 3 row, 15 fpi, 7 ft/sec (outdoor condensor) 4 row, 15 fpi, 8 ft/sec (indoor evaporator).
Builtup ahu	Tube and fin coil, 6 row, 15 fpi, 600 ft/min, 86°DB/67°WB, 45° entering water, 10° ΔT, 4 ft/sec.
TPFC FPFC	4 row, 14 fpi, 600 ft/min, 44° entering water, 12°ΔT, 6 ft/sec.

Curve SDL-C18, COOL–EIR–FPLR for packaged units PSZ, PMZS, and PVAVS, comes from data in the ICES Report ANL/CES/TE 78-2. This curve corresponds to Curve 4 on p. 10 of that report. Coefficients for Curves 1 (Hot gas bypass), 2 (Back pressure valve), and 3 (Suction valve-lift unloading, single compressor) from this same report have been added to the program's predefined curves. However, they are not used as defaults for any of the equipment, but may be specified as alternatives to SDL-C18. The curve numbers are SDL-C117 (Hot gas bypass), SDL-C118 (Back pressure valve) and SDL-C119 (Suction valve). See table below for coefficients.

The hydronic heat pump curves have been normalized to a water temperature of 70°F. In earlier versions of the code, 60°F was used. This change reflects a change in the ARI reference conditions from ARI 240-75 to ARI 320-76, and to ASHRAE Std. 90A-1980, Table 6.10.

TABLE 3.1

SYSTEM–EQUIPMENT DEFAULT CURVES

Equations are assumed to take the form:

linear, or $z = a + bx$

bi-linear, or $z = a + bx + dy$

quadratic, or $z = a + bx + cx^2$

bi-quadratic, or $z = a + bx + cx^2 + dy + ey^2 + fxy$

cubic, or $z = a + bx + cx^2 + dx^3$

Default Curve U-name	Keyword	Independent Variable(s)*	Applicable SYSTEM-TYPE	Default Curve Coefficients a	b	c	d	e	f
SDL-C1	COOL-CAP-FT	WB/ODB	RESYS	0.60034040	0.00228726	-0.0000128	0.00138975	-0.0000806	0.00014125
SDL-C2	COOL-CAP-FT	WB/ODB	PTAC	1.1839345	-0.0081087	0.00021104	-0.0061425	0.00000162	-0.0000030
SDL-C3	COOL-CAP-FT	WB/ODB	PSZ,PMZS,PVAVS	0.87403018	-0.0011416	0.00017110	-0.0029570	0.00001018	-0.00005917
SDL-C5	COOL-CAP-FT	WB/WT	HP	-0.2780377	0.02483069	-0.00000954	-0.0032731	0.00000703	-0.0000272
SDL-C7	COOL-CAP-FT	WB/DB	Builtup ahu	2.5882585	-0.2305879	0.00383591	0.10258116	0.00059844	-0.0028721
SDL-C10	COOL-CAP-FT	WB/DB	TPFC,FPFC	0.50388665	-0.0869176	0.00168467	0.03363036	0.00024777	-0.00102968
SDL-C11	COOL-EIR-FT	WB/ODB	RESYS	-0.9617787	0.04817751	-0.0002311	0.00324392	0.00014876	-0.0002952
SDL-C12	COOL-EIR-FT	WB/ODB	PTAC	-0.6550461	0.03889096	-0.0001925	0.00130464	0.00013517	-0.0002247
SDL-C13	COOL-EIR-FT	WB/ODB	PSZ,PMZS,PVAVS	-1.063931	0.03065843	-0.0001269	0.01542130	0.00004973	-0.0002096
SDL-C15	COOL-EIR-FT	WB/WT	HP	2.0280385	-0.0423091	0.00030539	0.01496715	0.00002438	-0.00016396
SDL-C16	COOL-EIR-FPLR	PLR	RESYS	0.125	0.875	0.0	0.0	0.0	0.0
SDL-C17	COOL-EIR-FPLR	PLR	PTAC	0.125	0.875	0.0	0.0	0.0	0.0
SDL-C18	COOL-EIR-FPLR	PLR	PSZ,PMZS,PVAVS	0.20123007	-0.0312175	1.9504979	-1.1205104	0.0	0.0
SDL-C20	COOL-EIR-FPLR	PLR	HP	0.125	0.875	0.0	0.0	0.0	0.0
SDL-C21	COOL-SH-FT	WB/ODB	RESYS	6.5275698	-0.1261375	0.00056879	0.00907575	-0.0000483	-0.00000875
SDL-C22	COOL-SH-FT	WB/ODB	PTAC	6.3112709	-0.1129951	0.00043336	0.00377381	-0.0000499	0.00006375
SDL-C23	COOL-SH-FT	WB/ODB	PSZ,PMZS,PVAVS	4.8352962	-0.0575307	0.00006155	-0.0052683	0.00000317	0.00003375
SDL-C25	COOL-SH-FT	WB/WT	HP	1.0181313	0.04775910	-0.0006660	-0.0081062	0.00001950	0.00005371
SDL-C27	COOL-SH-FT	WB/DB	Builtup ahu	0.89827669	-0.1312367	0.00196883	0.08966396	0.00057034	-0.00200873
SDL-C30	COOL-SH-FT	WB/DB	TPFC,FPFC	-1.228054	-0.0320956	0.00043381	0.05749134	0.00013737	-0.0005685
SDL-C31	COIL-BF-FCFM	CFM-PLR	RESYS	-3.012800	6.5856000	-2.572800	0.0	0.0	0.0
SDL-C32	COIL-BF-FCFM	CFM-PLR	PTAC	-2.277000	5.2114000	-1.934400	0.0	0.0	0.0
SDL-C33	COIL-BF-FCFM	CFM-PLR	PSZ,PMZS,PVAVS	-0.2542341	1.2182557	0.03597841	0.0	0.0	0.0
SDL-C35	COIL-BF-FCFM	CFM-PLR	HP	-0.8281602	14.317915	-21.88944	9.3996894	0.0	0.0
SDL-C37	COIL-BF-FCFM	CFM-PLR	Builtup ahu	0.39660574	0.14964713	0.45374713	0.0	0.0	0.0
SDL-C40	COIL-BF-FCFM	CFM-PLR	TPFC,FPFC	-0.7177876	1.9070782	-0.1892906	0.0	0.0	0.0
SDL-C41	COIL-BF-FT	WB/DB	RESYS	-4.797791	0.14048147	-0.0001864	-0.0095173	0.00011125	-0.0004521
SDL-C42	COIL-BF-FT	WB/DB	PTAC	-1.571369	0.04696328	0.00031518	-0.0065347	0.00011055	-0.0003719
SDL-C43	COIL-BF-FT	WB/DB	PSZ,PMZS,PVAVS	1.0660054	-0.0005170	0.00005672	-0.0129181	-0.00000169	0.00015027
SDL-C45	COIL-BF-FT	WB/WT	HP	-29.93911	0.87534545	-0.0057055	0.16144500	0.00029073	-0.0031523
SDL-C50	COIL-BF-FT	WB/DB	TPFC,FPFC	1.2049495	-0.0034963	0.00011357	-0.0008867	0.00000759	-0.00008548
SDL-C51	HEAT-CAP-FT	ODB/DB	RESYS	0.29495686	0.01425344	-0.0000117	0.00000059	0.0	0.0
SDL-C52	HEAT-CAP-FT	ODB/DB	PTAC	0.25367141	0.01043512	0.00018606	-0.00000149	0.0	0.0
SDL-C55	HEAT-CAP-FT	DB/WT	HP	0.48865341	-0.0067774	0.0	0.01408231	0.0	0.0

SYSTEM–EQUIPMENT DEFAULT CURVES (continued)

SDL-C56	HEAT-EIR-FT	ODB/DB	RESYS	2.1855478	-0.0494718	0.00070417	-0.00000401	0.0	0.0
SDL-C57	HEAT-EIR-FT	ODB/DB	PTAC	2.4600299	-0.0622539	0.00088002	-0.0000046	0.0	0.0
SDL-C60	HEAT-EIR-FT	DB/WT	HP	1.3876102	0.00604794	0.0	-0.0115852	0.0	0.0
SDL-C61	HEAT-EIR-FPLR	PLR	RESYS	0.08565215	0.93881371	-0.1834361	0.15897022	0.0	0.0
SDL-C62	HEAT-EIR-FPLR	PLR	PTAC	0.08565215	0.93881371	-0.1834361	0.15897022	0.0	0.0
SDL-C65	HEAT-EIR-FPLR	PLR	HP	0.08565215	0.93881371	-0.1834361	0.15897022	0.0	0.0
SDL-C66	DEFROST-DEGRADE	OWB/ODB	RESYS,PTAC	0.03300000	0.0	0.0	0.0	0.0	0.0
SDL-C76	RATED-CCAP-FCFM	CFM-PLR	RESYS	0.80000000	0.20000000	0.0	0.0	0.0	0.0
SDL-C77	RATED-CCAP-FCFM	CFM-PLR	PTAC	0.80000000	0.20000000	0.0	0.0	0.0	0.0
SDL-C78	RATED-CCAP-FCFM	CFM-PLR	PSZ,PMZS,PVAVS	0.47278589	1.2433415	-1.0387055	0.32257813	0.0	0.0
SDL-C79	RATED-CCAP-FCFM	CFM-PLR	HP	0.93940260	-0.3005555	0.54955622	-0.1884034	0.0	0.0
SDL-C80	RATED-CCAP-FCFM	CFM-PLR	Builtup ahu	0.18883215	1.0928053	-0.2816374	0.0	0.0	0.0
SDL-C81	RATED-CCAP-FCFM	CFM-PLR	TPFC,FPFC	0.18273451	1.0990207	-0.2817552	0.0	0.0	0.0
SDL-C83	RATED-SH-FCFM	CFM-PLR	RESYS	0.60000000	0.40000000	0.0	0.0	0.0	0.0
SDL-C84	RATED-SH-FCFM	CFM-PLR	PTAC	0.60000000	0.40000000	0.0	0.0	0.0	0.0
SDL-C85	RATED-SH-FCFM	CFM-PLR	PSZ,PMZS,PVAVS	0.34465606	0.89289891	-0.3554498	0.11789480	0.0	0.0
SDL-C86	RATED-SH-FCFM	CFM-PLR	HP	-0.1300253	2.1583062	-1.601682	0.57340154	0.0	0.0
SDL-C87	RATED-SH-FCFM	CFM-PLR	Builtup ahu	0.20164516	0.85537158	-0.0570167	0.0	0.0	0.0
SDL-C88	RATED-SH-FCFM	CFM-PLR	TPFC,FPFC	0.15461794	1.0052259	-0.15984383	0.0	0.0	0.0
SDL-C91	RATED-CEIR-FCFM	CFM-PLR	RESYS	1.1560000	-0.1816000	0.02560000	0.0	0.0	0.0
SDL-C92	RATED-CEIR-FCFM	CFM-PLR	PTAC	1.1552000	-0.1808000	0.02560000	0.0	0.0	0.0
SDL-C93	RATED-CEIR-FCFM	CFM-PLR	PSZ,PMZS,PVAVS	1.0079484	0.34544129	-0.6922891	0.33889943	0.0	0.0
SDL-C94	RATED-CEIR-FCFM	CFM-PLR	HP	0.99987312	0.28009428	-0.4356050	0.15563756	0.0	0.0
SDL-C98	RATED-HCAP-FCFM	CFM-PLR	RESYS	0.84000000	0.16000000	0.0	0.0	0.0	0.0
SDL-C99	RATED-HCAP-FCFM	CFM-PLR	PTAC	0.84000000	0.16000000	0.0	0.0	0.0	0.0
SDL-C100	RATED-HCAP-FCFM	CFM-PLR	PSZ,PMZS,PVAVS	—					
SDL-C101	RATED-HCAP-FCFM	CFM-PLR	HP	0.48381838	0.81807753	-0.3018959	0.0	0.0	0.0
SDL-C102	RATED-HCAP-FCFM	CFM-PLR	TPFC,FPFC	—					
SDL-C105	RATED-HEIR-FCFM	CFM-PLR	RESYS	1.3824000	-0.4336000	0.05120000	0.0	0.0	0.0
SDL-C106	RATED-HEIR-FCFM	CFM-PLR	PTAC	1.3924000	-0.4468000	0.05440000	0.0	0.0	0.0
SDL-C108	RATED-HEIR-FCFM	CFM-PLR	HP	1.4606527	-0.7969647	0.33631204	0.0	0.0	0.0
SDL-C111	FURNACE-HIR-FPLR	PLR	All Types	0.01861	1.094209	-0.112819	0.0	0.0	0.0
SDL-C112	REFG-KW-FTCOND	TTWR	PSZ	0.7135360	-0.004959	0.0000980	0.0	0.0	0.0
SDL-C113	REFG-KW-FPLR	PLR	PSZ	0.0382900	1.0778390	-0.116129	0.0	0.0	0.0
SDL-C114	TWR-RFACT-FRT	RNG/OWB	PSZ	1.4843260	0.1294790	-0.004014	-0.054336	0.0003120	-0.000147
SDL-C115	TWR-APP-FRFACT	RF/OWB	PSZ	4.9814670	-6.761789	24.709033	0.1144990	-0.000612	-0.250651
SDL-C117	—	PLR	PSZ,PMZS,PVAVS	1.0758898	-0.6164059	0.93401744	-0.39350141	0.0	0.0
SDL-C118	—	PLR	PSZ,PMZS,PVAVS	0.21039364	2.2429549	-2.319486	0.86613714	0.0	0.0
SDL-C119	—	PLR	PSZ,PMZS,PVAVS	0.03125391	1.4895131	-0.7868148	0.26604779	0.0	0.0

* Independent Variables

WB	= entering wet-bulb temperature (°F)	DB	= entering dry-bulb temperature (°F)
ODB	= outside dry-bulb temperature (°F)	PLR	= part-load ratio (fraction)
WT	= entering water temperature (°F)	CFM-PLR	= change in full load capacity as a function of supply air flow rate
OWB	= outside wet-bulb temperature (°F)		
RNG	= range, temperature drop through tower	TTRW	= cooling tower temperature (°F)
RF	= rating factor		

PACKAGED TOTAL-GAS SOLID-DESICCANT SYSTEM

A new system has been added to the list of HVAC systems that can be modeled with the DOE-2 SYSTEMS subprogram. The system is a small (5 to 10 ton, 1800 - 3600 cfm) packaged unit that uses a desiccant wheel in conjunction with direct and indirect evaporative cooling, instead of the usual DX coils used in small packaged units. The unit uses a gas-fired hydronic heater to regenerate the desiccant and to provide heating. The result is a unit that primarily consumes gas to provide heating and cooling.

The unit consists of supply and return air fans, a lithium chloride impregnated desiccant wheel, an indirect evaporative cooler, a heating coil, a direct evaporative cooler, and a reactivation air heater coil (see Fig. 3.6). In the cooling mode, the supply fan blows 100% outside air onto the "dry" half of the desiccant wheel. Hot, dry air emerges from the other side of the wheel. This air is then cooled by an air-to-air heat exchanger, the other air stream being evaporatively cooled return air. Finally, the air is cooled even further by a direct evaporative cooler. The resulting supply air is then ducted to the zones. Return air is drawn through a direct evaporative cooler, and then heated by passing through the air-to-air heat exchanger (taking heat from the supply air emerging from the desiccant wheel). Further heat is added by the reactivation air heater coil. Then, the return air passes through the other half of the wheel, regenerating the desiccant by carrying off the moisture absorbed by the lithium chloride. Finally the return air is exhausted to the outside.

At rated conditions, outside air is at 95°F drybulb, 75°F wetbulb, and return air is 80°F drybulb, 67°F wetbulb. After going through the desiccant wheel and the air-to-air heat exchanger, the supply air is at 73°F drybulb, with a humidity ratio of .0055 (about 33% relative humidity). Upon emerging from the final direct evaporative cooling stage, the supply air is at 57°F drybulb, with a humidity ratio of .0092 (around 92% relative humidity).

The supply and return fans are assumed to be variable speed. The zone air temperature is controlled by varying the flow of the supply air; the system is a variable air volume system.

In the heating mode, the fans are assumed to be at minimum speed. The minimum amount of outside air is brought in, mixed with return air, and heated by the heating coil. The wheel motor, reactivation heater coil, and both humidifiers (direct evaporative coolers) and their pumps are, of course, turned off.

The unit can be operated in several intermediate modes. One such mode is to operate the unit as an evaporative cooler. Only the supply air humidifier and the indirect evaporative cooler (return air humidifier and air-to-air heat exchanger) are operated, no dehumidifying is done, and no gas is consumed. Another mode is to cool with outside air only, or with a mixture of outside and return air.

At present, the user has no control over which operating mode is selected for each hour time step. The simulation determines which modes are capable of meeting the load and, of these, which is most efficient. Thus, the unit is simulated to use the minimum possible energy.

The desiccant cooling system simulation in DOE-2.1D was developed with the support and collaboration of the Gas Research Institute and the GARD Division of the Chamberlain Manufacturing Corporation.

The unit is modeled with a set of six curves. These curves relate the supply air conditions at the exit of the air-to-air heat exchanger (point 8 in Fig. 3.6) to the outside wetbulb (point 6) and the return air wetbulb (point 1). The curves are:

Keyword	Coefficients (a)	(b)	(c)	(d)	(e)	(f)
T8–FWB1WB6	1.20347	0.902420	0.0	0.142597	0.0	0.0
T8PL–FWB1WB6	0.494371	0.971983	0.0	.0366191	0.0	0.0
HR8–FWB1WB6	−4.55708	.0514960	.00022655	.0953548	.00018254	−.00081736
HR8PL–WB1WB6	−3.66836	.0566377	.00015508	.0635270	.00038127	−.00075737
QREG–FWB1WB6	142.125	−.872537	.00527466	−1.40269	.00001349	.00585206
QREGPL–FWB1WB6	36.5727	−.231413	.00141848	−.372583	−.00007401	.00160681

The formula is:

$$f(wb1,wb6) = a + b*wb1 + c*wb1**2 + d*wb6 + e*wb6**2 + f*wb1*wb6$$

T8–FWB1WB6 gives the drybulb temperature at point 8 at full load. HR8–FWB1WB6 yields 10,000 times the log of the humidity ratio at full load. QREG–FWB1WB6 gives the full load regeneration energy in BTU. The other three curves give the same quantities at 25% part load. Interpolation is used to find the general part load results.

XBL 893-6159

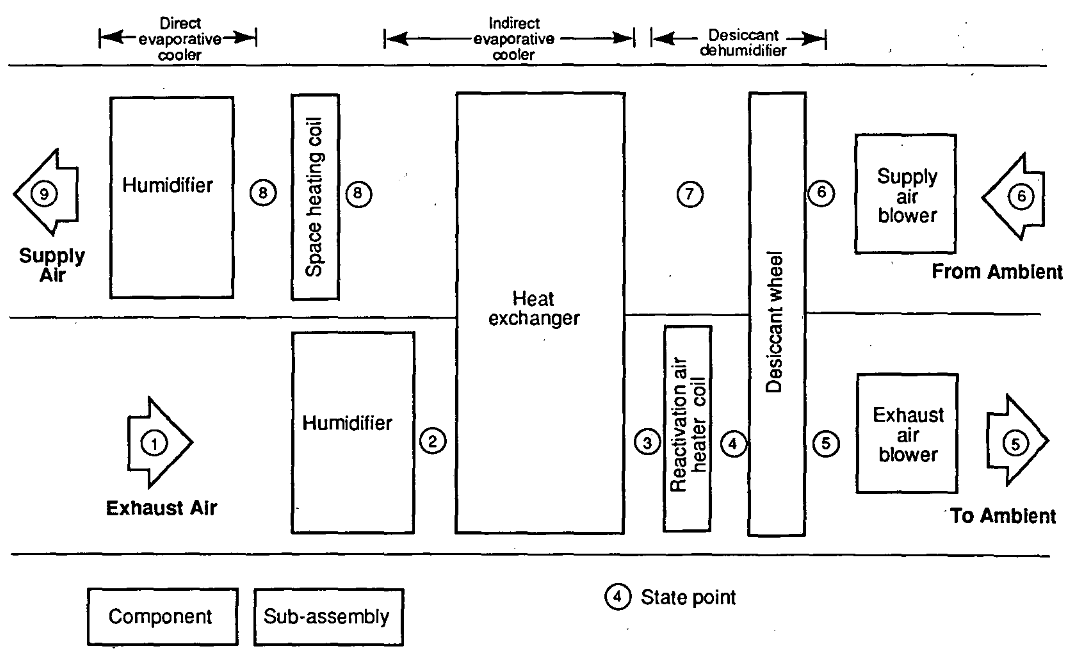

Figure 3.6: Schematic diagram for the Packaged Total Gas Solid Desiccant System

The PTGSD system must be sized by the user. The DOE-2 design routine will not estimate a size from the LOAD peaks as it does for other system types. The two keywords required are SUPPLY–CFM or SUPPLY–FLOW in the SYSTEM or SYSTEM–AIR command and HEATING–CAPACITY in the SYSTEM or SYSTEM–EQUIPMENT command. Keywords that are relevant to the PTGSD system are:

Keyword	Abbr	Sub–Command	Default
HEAT–SOURCE	HEAT–S		GAS–HYDRONIC
BASEBOARD–SOURCE	BASEB–S		GAS–HYDRONIC
RETURN–AIR–PATH	R–A–P		DIRECT
HEATING–SCHEDULE	H–SCH	SYSTEM–CONTROL	none
COOLING–SCHEDULE	C–SCH	SYSTEM–CONTROL	none
MAX–HUMIDITY	MAX–H	SYSTEM–CONTROL	100.
BASEBOARD–SCH	B–SCH	SYSTEM–CONTROL	none
SUPPLY–FLOW	S–F	SYSTEM–AIR	required
MIN–OUTSIDE–AIR	M–O–A	SYSTEM–AIR	0.1
MIN–AIR–SCH	M–A–SCH	SYSTEM–AIR	none
FAN–SCHEDULE	F–SCH	SYSTEM–FANS	none
FAN–CONTROL	F–C	SYSTEM–FANS	SPEED
SUPPLY–DELTA–T	SUP–D–T	SYSTEM–FANS	1.2
MAX–FAN–RATIO	MAX–F–R	SYSTEM–FANS	1.1
MIN–FAN–RATIO	MIN–F–R	SYSTEM–FANS	0.3
NIGHT–CYCLE–CTRL	N–C–C	SYSTEM–FANS	STAY–OFF
MIN–FLOW–RATIO	M–F–R	SYSTEM–TERMINAL	0.3
HEATING–CAPACITY	H–CAP	SYSTEM–EQUIPMENT	required
T8–FWB1WB6	T–FWB	SYSTEM–EQUIPMENT	SDL-C63
T8PL–FWB1WB6	TPL–FWB	SYSTEM–EQUIPMENT	SDL-64
HR8–FWB1WB6	HR–FWB	SYSTEM–EQUIPMENT	SDL-C67
HR8PL–FWB1WB6	HRPL–FWB	SYSTEM–EQUIPMENT	SDL-C68
QREG–FWB1WB6	QR–FWB	SYSTEM–EQUIPMENT	SDL-C69
QREGPL–FWB1WB6	QRPL–FWB	SYSTEM–EQUIPMENT	SDL-70
PLENUM–NAMES	P–N		none
ZONE–NAMES	Z–N		required

Electrical consumption is modeled by a fixed curve which cannot be altered by the user. At full load this consumption is .000976 kw/cfm. In the hourly and summary reports, columns labeled "Fan Energy" will include this full auxilliary electrical consumption -- both fans and pumps.

Outside air amounts can still be specified in the ZONE or ZONE–AIR commands. Supply air is apportioned to the zone according to the cooling load peaks, or by the cfm keywords in ZONE or ZONE–AIR. The ZONE keyword usage is basically the same as for any other system. Most of the above SYSTEM keywords should be allowed to default. The user should be concerned with sizing the system and deciding whether to have supplemental baseboard heaters.

A typical input would look like:

```
INPUT SYSTEMS ..

TITLE LINE-5 * PCKGD TOTAL GAS SOLID DESICCANT * ..

SYSTEMS–REPORT  S = (SS-A,SS-H,SS-I,SS-N,SS-O) ..

FANSON = SCH THRU DEC 31      (WD) (1,6) (0) (7,18) (1) (19,24) (0)
                              (WEH) (1,24) (0) ..
C–SETPT = SCH THRU DEC 31     (WD) (1,6) (90) (7,18) (76) (19,24) (90)
                              (WEH) (1,24) (90) ..
H–SETPT = SCH THRU DEC 31     (WD) (1,5) (62) (6,18) (72) (19,24) (62)
                              (WEH) (1,24) (62) ..

ENV Z–C        =    D–H–T=72
                    D–C–T=74
                    H–T–SCH=H–SETPT
                    C–T–SCH=C–SETPT
                    B–C THERMOSTATIC  ..
CENTER         =    Z Z–C=ENV  O–CFM/P=15  BASEBOARD–RATING=–10000  ..
EASTSIDE       =    Z LIKE CENTER  ..
SOUTHSIDE      =    Z LIKE CENTER BASEBOARD–RATING 0 ..
LOUNGE         =    Z LIKE CENTER  ..

SYS1    =    SYSTEM    S–TYPE=PTGSD
                       F–SCH=FANSON
                       SUPPLY–CFM=2500 MIN–CFM–RATIO=.4
                       HEATING–CAPACITY=–100000
                       Z–N=(SOUTHSIDE,CENTER,EASTSIDE,LOUNGE)
                       N–C–C=CYCLE–ON–FIRST  ..

END ..

COMPUTE SYSTEMS ..
```

ENHANCEMENTS TO THE RESIDENTIAL NATURAL VENTILATION ALGORITHM

In DOE-2.1D significant additions have been made to the capabilities of the natural ventilation model in the residential system (SYSTEM–TYPE = RESYS) simulation in SYSTEMS. The capabilities previous to 2.1D are described in the Reference Manual on pages IV.217 - IV.219. Basically, the user had considerable control over when venting occurred (i.e., when the windows were opened or closed) through the keywords NATURAL–VENT–SCH and VENT–TEMP–SCH in the SYSTEM–AIR command, but was forced to estimate (or guess) the air changes due to natural ventilation (keyword NATURAL–VENT–AC) when the windows were open. DOE-2.1D increases the user's ability to control when venting occurs; more importantly, it adds the capability to estimate the amount of venting taking place when the windows are opened.

The model used to calculate the amount of natural ventilation is identical to one of DOE-2's infiltration models — the Sherman–Grimsrud (S–G) model. The input needed for S–G infiltration is described on page 2.74 of this Supplement. The S–G natural ventilation model uses many of the same keywords; in particular the keywords NEUTRAL–LEVEL (in the SPACE or SPACE–CONDITIONS commands in LOADS) and SHIELDING–COEF, TERRAIN–PAR1, TERRAIN–PAR2, WS–TERRAIN–PAR1, WS–TERRAIN–PAR2, and WS–HEIGHT (in the BUILDING–LOCATION command in LOADS) are identical. That is, they are used by both the S–G infiltration model and by the S–G natural ventilation model. A description and discussion of these keywords should be obtained from the aforementioned section of this Supplement.

There are a number of new keywords in SYSTEMS relevant to the new natural ventilation capabilities. They are:

Keyword	Abbr	Type	Units	Default	Min.	Max.
VENT–METHOD	V–M	codeword		AIR–CHANGE		
MAX–VENT–RATE	M–V–R	numeric	air changes/hr	20.	0.0	100.
HOR–VENT–FRAC	H–V–F	numeric	fraction	0.0	0.0	1.0
FRAC–VENT–AREA	F–V–A	numeric	fraction	.05	0.0	1.0
OPEN–VENT–SCH	O–V–SCH	schedule		none		

All of the above keywords occur in the SYSTEM–AIR or SYSTEM command.

VENT–METHOD is used to select the ventilation model. VENT–METHOD=AIR–CHANGE selects the old natural ventilation model — the user must specify the ventilation air changes per hour by using the keyword NATURAL–VENT–AC. This sets a fixed air change rate which is used whenever the windows are open. VENT–METHOD=S–G selects the new natural ventilation model. In this case the new keywords MAX–VENT–RATE, HOR–VENT–FRAC, and FRAC–VENT–AREA are applicable. FRAC–VENT–AREA is analogous to FRAC–LEAK–AREA used in the S–G infiltration model. It should be set to 0.6 times the open window area divided by the floor area. The user might very well want to change the default of .05, depending on the situation being modeled. HOR–VENT–FRAC corresponds to HOR–LEAK–FRAC in the S–G infiltration model. It is the fraction of the venting area that is in the floor and ceiling; it is used to calculate the stack effect contribution to the ventilation. Unless there are openable skylights or clerestory windows or an open fireplace flue, this keyword can be allowed to default to zero. MAX–VENT–RATE sets a maximum on the ventilation air-changes. For high wind speeds, the S–G model can give unrealistically large ventilation rates. MAX–VENT–RATE eliminates this problem.

OPEN–VENT–SCH can be used for either VENT–METHOD=AIR–CHANGE or VENT–METHOD=S–G. It gives the user more control over when the windows are opened. OPEN–VENT–SCH references a schedule whose hourly values are probabilities that the windows will be opened that hour, given that the conditions set by NATURAL–VENT–SCH and VENT–TEMP–SCH are met, and given that the windows were not already open. Previously it was always assumed that the windows would be opened if the conditions set by NATURAL–VENT–SCH and VENT–TEMP–SCH were met. For example the user can now set a low probability that the windows will be opened when the occupants would normally be asleep, and a high probability that they will be opened when the occupants arise in the morning.

In summary, there are now two possible natural ventilation algorithms which can be used with SYSTEM–TYPE=RESYS. If VENT–METHOD=AIR–CHANGE is specified in the SYSTEM or SYSTEM–AIR command, the following keywords are applicable.

Keyword	Program	Command	New to DOE2.1D?
NATURAL–VENT–SCH	SYSTEMS	SYSTEM or SYSTEM–AIR	no
VENT–TEMP–SCH	SYSTEMS	SYSTEM or SYSTEM–AIR	no
NATURAL–VENT–AC	SYSTEMS	SYSTEN or SYSTEM–AIR	no
OPEN–VENT–SCH	SYSTEMS	SYSTEM or SYSTEM–AIR	yes
If VENT–METHOD=S–G is specified, the following keywords are applicable.			
NATURAL–VENT–SCH	SYSTEMS	SYSTEM or SYSTEM–AIR	no
VENT–TEMP–SCH	SYSTEMS	SYSTEM or SYSTEM–AIR	no
OPEN–VENT–SCH	SYSTEMS	SYSTEM or SYSTEM–AIR	yes
FRAC–VENT–AREA	SYSTEMS	SYSTEM or SYSTEM–AIR	yes
HOR–VENT–FRAC	SYSTEMS	SYSTEM or SYSTEM–AIR	yes
MAX–VENT–RATE	SYSTEMS	SYSTEM or SYSTEM–AIR	yes
NEUTRAL–LEVEL	LOADS	SPACE or SPACE–CONDITIONS	no
SHIELDING–COEF	LOADS	BUILDING–LOCATION	no
TERRAIN–PAR1	LOADS	BUILDING–LOCATION	no
TERRAIN–PAR2	LOADS	BUILDING–LOCATION	no
WS–TERRAIN–PAR1	LOADS	BUILDING–LOCATION	no
WS–TERRAIN–PAR2	LOADS	BUILDING–LOCATION	no
WS–HEIGHT	LOADS	BUILDING–LOCATION	no

PLANT EQUIPMENT OPERATING MODES

The 2.1C version of DOE-2 features an entirely reworked conception of the operation of chillers and, more importantly, electricity-generating prime movers. Earlier versions of the code simply assumed that, in the case of the electricity generators, only the electrical demands of a facility were important to decisions concerning the operation of a central plant. This reasoning stemmed from the fact that utility and regulatory attitudes toward the on-site generation of power often meant that generating power on-site was tantamount to leaving the electric grid entirely. The Public Utilities Regulatory Policy Act of 1978 mandated changes in those attitudes by requiring that utilities abandon discriminatory practices and offer fair rates and prices to cogenerators and small power producers. The outcome of this change is that the actual electrical loads of a facility need not be the only consideration in determining the output of primary energy conversion equipment in a central plant.

The concept embodied in DOE-2.1C treats the diesel engine and gas turbine as energy conversion devices with two useful outputs. Accordingly, the choice of which output to use in controlling the operation of these machines has been made an explicit option specifiable by the user. That is, the user can now specify that the machines generate enough heat to meet thermal loads irrespective of the amount of electricity produced and vice versa.

Two PLANT–PARAMETERS keywords, COGEN–TRACK–MODE, and COGEN–TRACK–SCH are used to specify the load (thermal or electrical) to be used in controlling the output of either the DIESEL–GEN or GTURB–GEN electrical generators. A third keyword, MIN–TRACK–LOAD, is used to specify the minimum thermal load that will be tracked. A fourth keyword specifies which thermal output(s) (jacket/lube-oil heat, exhaust heat, or both) are to be used for control of thermal-tracking for diesel engines (DIESEL–TRACK–MODE).

A fifth keyword (DBUN–MIN–HEAT) has been added to PLANT–PARAMETERS. It sets the minimum thermal load for heat recovery chillers when operating in tandem with standard chillers. When the DBUN–CHLR is operating alone, it responds to the evaporator load and not the thermal load.

The freedom to choose which loads the central plant equipment is to meet has resulted in a substantial reworking of the equipment allocation routines and the HEAT–RECOVERY links. For example, the default allocation routines now ensure that the thermal and electrical output of the generators, when coupled with absorption and compression chillers, will be balanced when meeting heating and cooling loads. The input formats to the LOAD–ASSIGNMENT and the HEAT–RECOVERY commands have not changed, although the commands have taken on more capabilities.

PLANT–PARAMETERS

The following keywords have been eliminated:

ELEC–GEN–MODE
MAX–DIESEL–EXH
MAX–GTURB–EXH
STURB–SPEED

COGEN–TRACK–MODE accepts a codeword that specifies the cogeneration scheme to be used in controlling the output of electrical generators equipped with heat recovery equipment. The allowable codewords are TRACK–ELEC (the default value),
TRACK–THERMAL, TRACK–LESSER (of the two previous options), its antithesis TRACK–GREATER, MAX–OUTPUT (full-out electrical generating), and DONT–RUN.

COGEN–TRACK–SCH accepts the u-name of a schedule of cogeneration schemes. A DAY–SCHEDULE command does not accept codewords, therefore the following values are used to indicate the desired cogeneration scheme:
DONT–RUN = 0
TRACK–ELEC = 1
TRACK–THERMAL = 2
TRACK–LESSER = 3
TRACK–GREATER = 4
MAX–OUTPUT = 5
An example of such a schedule appears in Example 3 below.

MIN–TRACK–LOAD specifies the minimum thermal load that the generators will attempt to track before shifting down. The default is 0.0 Btu/hr, and it can range from 0.0 to 1000.0.

DIESEL–TRACK–MODE accepts a codeword that specifies which diesel engine heat recovery source(s) will be used to control the output of the engine when tracking thermal loads. The allowable codewords are TRACK–EXH (exhaust heat only), TRACK–JAC/LUB (jacket and lube-oil), and TRACK–BOTH (the default).

DBUN–MIN–HEAT is the minimum thermal load at which the heat recovery chiller(s) are allowed to operate when in the heat recovery mode and when tracking thermal loads. This keyword will default to 0.0 MBtu. The range is from 0.0 to 1000000.0 MBtu.

LOAD–ASSIGNMENT

LOAD–ASSIGNMENTs for electrical generators are always defined in terms of electrical, not thermal, loads. If cogeneration equipment is to be controlled on the basis of thermal loads (COGEN–TRACK–MODE = TRACK–THERMAL) and a LOAD–ASSIGNMENT(s) is to be used to determine which pieces of cogeneration equipment are to run, the program will use the LOAD–ASSIGNMENT as follows: For every electrical LOAD–RANGE the user inputs under the cogeneration LOAD–ASSIGNMENT the program will calculate an equivalent thermal load range that is the sum of the nominal recoverable outputs of all equipment listed under that LOAD–RANGE. Thus, when the program is controlling cogeneration equipment on the basis of a thermal load, the program will compare the hourly thermal load to the thermal load ranges corresponding to the electrical LOAD–RANGE(s) input by the user. The LOAD–RANGE selected will be the one whose equivalent thermal load range matches the hourly thermal load.

To make this discussion more apparent, consider the comments contained in this example input for diesel generators.

```
LOAD–ASSIGNMENT
        .
        .
        .
LOAD–RANGE = 1.0  $THE DOE-2 EQUIVALENT THERMAL LOAD RANGE IS ~1.2 MBTUH$
PLANT–EQUIPMENT = 300KW–GEN  NUMBER = 1
LOAD–RANGE = 2.6  $THE DOE-2 EQUIVALENT THERMAL LOAD RANGE IS ~3.2 MBTUH$
PLANT–EQUIPMENT = 750KW–GEN  NUMBER = 1 ..
```

::

The thermal load ranges are calculated by the program and not input by the user. At peak capacity (100% part load ratio), the diesel generator is operating at 35% efficiency with a 20% exhaust heat efficiency and 23% jacket/lube-oil heat efficiency (the defaults). Therefore, the thermal load range at that full load condition is equal to the electric load range times (20 + 23) / 35 (or 1.22). This relationship changes as the generator loading drops, which lowers the efficiency of the diesel engine. This results in a consequent increase in the ratio of recoverable energy to electrical output. Notice that the thermal load range of a gas turbine at full load (using the default efficiencies) is 55 / 19 (or 2.89) times the electrical output.

Note on the Default Operation of Chillers
In the absence of user-defined operation of chillers via the LOAD–ASSIGNMENT and LOAD–MANAGEMENT commands, the default algorithms utilize information from the keyword SOURCE–SITE–EFF under the ENERGY–RESOURCE command (as well as the EIRs and HIRs of the equipment) to determine whether a heat-driven chiller is more efficient than an electrically-driven one, on the basis of source Btu consumption. A cogeneration plant, of course, produces electricity more efficiently than does a central plant, provided the waste heat is utilized. Therefore, SOURCE–SITE–EFF for RESOURCE = ELECTRICITY should be revised to, say, 0.5 (implying a net heat rate of about 6800 Btu/kWh). The disadvantage of this modification, however, is that the source Btu number in the BEPS report will be inconsistent with the generally agreed upon figures.

HEAT–RECOVERY

Associated with the above PLANT–PARAMETERS keywords are the following rules for the HEAT–RECOVERY command:

Rules:

1) If a diesel is to thermal track, the exhaust heat and jacket heat should not be entered at the same heat recovery supply level, unless the diesel is to track both the exhaust and jacket heat. If the diesel is to track on the basis of the exhaust at ~600°F or the jacket at ~240°F, the two supplies should be input at different levels.

2) If diesels and gas turbines are in the same plant and exhaust heat is to be recovered from both, the exhaust supplies should be entered at the same level.

3) If diesels and gas turbines are in the same plant, and the diesels are to thermal track, they should not be allowed to track on the basis of jacket heat; they should track either on exhaust heat, or both exhaust and jacket heat.

4) The program assumes that cogeneration equipment with heat recovery will not coexist in a plant with double bundle chillers. If this situation does exist, the user is directed to control the operation of equipment with LOAD–ASSIGNMENTs.

5) When both absorption and compression chillers are in the same plant with cogeneration equipment, and the program is to optimize the cooling operation, the user should exercise care in the assignment of the heat recovery linkages. Normally, space heating and other thermal demands should be input before absorption demands so that the absorption chillers will be given only enough of the cooling load needed to use up the excess waste heat. The compression chillers will then be used to satisfy the remainder of the cooling load. This sequence will prevent the boilers from operating unnecessarily. See Example 1, next page.

6) The default operation of the double-bundle chiller is one of tracking the thermal heating loads whenever standard chiller(s) are operated in tandem with double-bundle chillers. When the standard chiller(s) shut down for lack of a sufficient minimum part-load, the double-bundle chiller must track the cooling load. The user is directed to input a LOAD–ASSIGNMENT, if both standard and double-bundle chillers are to be loaded evenly with respect to their evaporators.

Examples

Example 1:
We begin the examples with a complete input for a plant with a two-stage absorption chiller, a compression chiller, a gas turbine, and a boiler. Subsequent examples will build upon and modify this input. In this example, the user wants the gas turbine to run full out at all times. By omitting any specification of a LOAD–ASSIGNMENT for the chillers the program will balance the distribution of the cooling load between the absorption and compression chiller to minimize wasting heat.

```
BOIL        =  PLANT-EQUIPMENT   TYPE   = STM-BOILER
                                 SIZE   =  5.0  MAX-NUMBER-AVAIL = 1   ..

ELEC-CHLR   =  PLANT-EQUIPMENT   TYPE   = OPEN-CENT-CHLR
                                 SIZE   =  2.0  MAX-NUMBER-AVAIL = 1   ..

STM-CHLR    =  PLANT-EQUIPMENT   TYPE   = ABSOR2-CHLR
                                 SIZE   =  3.0  MAX-NUMBER-AVAIL = 1   ..

TWR         =  PLANT-EQUIPMENT   TYPE   = COOLING-TWR
                                 SIZE   = -999   ..

ELEC-GENR   =  PLANT-EQUIPMENT   TYPE   = GTURB-GEN
                                 SIZE   = 3.0  MAX-NUMBER-AVAIL = 1    ..

        PLANT-PARAMETERS
          COGEN-TRACK-MODE    =    MAX-OUTPUT   ..

          HEAT-RECOVERY
            SUPPLY-1 =  (GTURB-GEN)        $ SPACE HEAT HAS PRIORITY
            DEMAND-1 = (SPACE-HEAT)        $ ON WASTE HEAT. ABSORPTION
            SUPPLY-2 =  (GTURB-GEN)        $ CHILLER ONLY GETS THE
            DEMAND-2 = (ABSOR2-CHLR)       $ EXCESS.  CENTRIFUGAL WILL
                                           $ PICK UP THE REST OF COOLING
                                           $ LOAD.   THIS MINIMIZES
                                           $ BOILER OPERATION.
                                           ..
```

Example 2:

In this example, diesel generators of 300kW and 750kW replace the gas turbine in Example 1. A LOAD–ASSIGNMENT is used to stage the generators. The 300kW diesel is to be run first, followed by the 750kW diesel, but never both (or else the facility will violate air quality standards). The user wants the diesels to be controlled by heating loads, and both the jacket and exhaust heat are recoverable for space heating but the recovered heat is not at a high enough temperature for a two-stage absorption chiller so it is changed to single-stage machine ABSOR1–CHLR. The thermal outputs at full load are 1.2 and 3.2MBtuh respectively. The revised input, replacing ELEC–GENR in the previous example, is:

```
300KW-GEN = PLANT-EQUIPMENT   TYPE = DIESEL-GEN  SIZE = 1.0
                              MAX-NUMBER-AVAIL = 1 ..

750KW-GEN = PLANT-EQUIPMENT   TYPE = DIESEL-GEN  SIZE = 2.6
                              MAX-NUMBER-AVAIL = 1 ..

            PLANT-PARAMETERS  COGEN-TRACK-MODE = TRACK-THERMAL
                              DIESEL-TRACK-MODE = TRACK-BOTH ..

            HEAT-RECOVERY     SUPPLY-1 = (DIESEL-GEN,DIESEL-JACKET)
                              DEMAND-1 = (SPACE-HEAT)
                              SUPPLY-2 = (DIESEL-GEN,DIESEL-JACKET)
                              DEMAND-2 = (ABSOR1-CHLR) ..

COGEN       = LOAD-ASSIGNMENT TYPE = ELECTRIC
                              LOAD-RANGE = 1.0
                              PLANT-EQUIPMENT = 300KW-GEN
                              NUMBER = 1
                              LOAD-RANGE = 3.0
                              PLANT-EQUIPMENT = 750KW-GEN
                              NUMBER = 1 ..

            LOAD-MANAGEMENT   PRED-LOAD-RANGE = 999
                              LOAD-ASSIGNMENT = (DEFAULT,DEFAULT,COGEN) ..
```

The SIZEs of the cogeneration equipment is in terms of electrical capacity, and so are the LOAD–RANGEs. When the cogeneration equipment is thermal tracking, the program will convert the LOAD–RANGEs to equivalent thermal load ranges, which are based on the full load thermal output of the equipment listed under the load range (see the discussion of how the operation of LOAD–ASSIGNMENTs is modified above).

Example 3:
This final example demonstrates the use of the keyword that allows cogeneration modes to be scheduled and would be an insert at the PLANT–PARAMETERS command in Example 2. A contractual agreement with the utility requires that the full capacity of the electrical plant be on-line during the on-peak hours of the utility. During the off-peak hours the machines revert to the thermal tracking mode to ensure that the fuel consumed by the generators will be utilized fully. This input corresponds to the ECONOMICS input in Example 7, (p. 5.16) in the section, **EXPANDED TREATMENT OF ENERGY COSTS**, in this Supplement.

```
                    PLANT-PARAMETERS DIESEL-TRACK-MODE = TRACK-BOTH
                                     COGEN-TRACK-SCH = UTL-CONTRCT ..

WINTER-WD    =DAY-SCHEDULE          (1,8) (2)   $ TRACK-THERMAL IS CODE 2
                                    (9,22) (5)  $ MAX-OUTPUT IS CODE 5
                                    (23,24)  (2) ..

WINTER-WEH  = DAY-SCHEDULE          (1,24) (0)   $ DONT-RUN IS CODE 0 $ ..

SUMMER-WD   = DAY-SCHEDULE          (1,8) (2) (9,20) (5) (21,24) (2)  ..

SUMMER-WED = DAY-SCHEDULE           (1,24)  (0)  ..

UTL-CONTRCT   =   SCHEDULE   THRU MAY 15    (WD) WINTER-WD
                                            (WEH) WINTER-WEH
                             THRU  SEP 15   (WD) SUMMER-WD
                                            (WEH) SUMMER-WEH
                             THRU  DEC 31   (WD) WINTER-WD
                                            (WEH) WINTER-WEH  ..
```

ELECTRICAL EQUIPMENT SIMULATIONS

The algorithms used to model the performance of electrical generators have been modified to permit easier translation of manufacturer's information to actual simulations. The modifications take the form of simpler transfer functions relating the inputs and outputs of the equipment being modeled. A PLANT–PARAMETERS command specifies the full load conversion efficiency of an input to an output. The EQUIPMENT–QUAD command is then used to relate the full load performance to operations at fractions of full load. The default values for the part load operation of the generators have also been changed. Finally, there are hourly report variables for the Diesel (11 through 17), Gas Turbine (10 through 13), and Steam Turbine (8 through 13). See Appendix A for full descriptions.

PLANT–PARAMETERS

Note that MAX–DIESEL–EXH, MAX–GTURB–EXH, and STURB–SPEED have been eliminated.

DIESEL–GEN–EFF specifies the diesel engine conversion efficiency of fuel to electricity at full load. The unloading curve is given by DIESEL–I/O–FPLR. The default is 0.35, and the range is from 0.+ to 1.0.

DIESEL–EXH–EFF specifies the diesel engine conversion efficiency of fuel to recovered energy from exhaust gasses at full load. The unloading curve is given by DIESEL–EXH–FPLR. The default is 0.23, and the range is from 0.+ to 1.0.

DIESEL–J/L–EFF specifies the diesel engine conversion efficiency of fuel to recovered energy from the jacket and lube-oil at full load. The unloading curve is given by DIESEL–JCLB–FPLR. The default is 0.20, and the range is from 0.+ to 1.0.

GTURB–GEN–EFF specifies the gas turbine conversion efficiency of fuel to electricity at full load. The unloading curve is given by GTURB–I/O–FPLR. The default is 0.19, and the range is from 0.+ to 1.0.

GTURB–EXH–EFF specifies the gas turbine conversion efficiency of fuel to recovered energy from exhaust gasses at full load. The unloading curve is given by GTURB–EXH–FPLR. The default is 0.55, and the range is from 0.+ to 1.0.

STURB–MECH–EFF specifies the mechanical efficiency of the steam turbine in converting theoretical work (defined as an isentropic enthalpy drop through the turbine; see discussion under EQUIPMENT–QUAD) to an electrical output at full load. The unloading curve is STURB–I/O–FPLR. The default is 0.60, and the range is from 0.+ to 1.0.

STEAM–SATURATION–T remains unchanged in its definition, but is no longer used by the diesel and gas turbine simulation routines to calculate the amount of heat recoverable from exhaust gas.

EQUIPMENT–QUAD

Note that the following curves have been eliminated:

DIESEL–JAC–FPLR
DIESEL–LUB–FPLR
DIESEL–STACK–FU
GTURB–EXH–FT
GTURB–I/O–FT
GTURB–STACK–FU
GTURB–TEX–FT

Also the functional form of ABSOR1–HIR–FPLR has been changed to a linear or quadratic equation from a cubic one. Table 4.2 contains a list of the default values for the curves described below, as well as changes in some existing ones. Table 4.1 contains a list of the default values for the minimum, maximum, and optimum PART–LOAD–RATIOs for the electrical generators.

Diesel

DIESEL–I/O–FPLR accepts the u-name of a CURVE–FIT instruction that defines a linear or quadratic equation. This equation correlates full load fuel consumption to the fraction of that consumption consumed at other loads (expressed as part load ratios). In conjunction with PLANT–PARAMETERS instruction DIESEL–GEN–EFF, the equation is used to calculate the amount of diesel fuel energy required to generate a given electrical load.

DIESEL–EXH–FPLR accepts the u-name of a CURVE–FIT instruction that defines a linear or quadratic equation. This equation correlates the full load exhaust heat recovery to the fraction of that recovery recovered at other loads (expressed as part load ratios). In conjunction with PLANT–PARAMETERS instruction DIESEL–EXH–EFF, the equation is used to calculate the amount of exhaust heat recovered at a given electrical load.

DIESEL–JCLB–FPLR accepts the u-name of a CURVE–FIT instruction that defines a linear or quadratic equation. This equation correlates the full load jacket and lube oil heat recovery to the fraction of that recovery recovered at other loads (expressed as part load ratios). In conjunction with PLANT–PARAMETERS instruction DIESEL–J/L–EFF, the equation is used to calculate the amount of jacket and lube oil heat recovered at a given electrical load.

DIESEL–TEX–FPLR

accepts the u-name of a CURVE–FIT instruction that defines a linear or quadratic equation. This equation correlates the temperature of the exhaust gasses to the load being met (expressed as a part load ratio).

Gas Turbine

GTURB–CAP–FT

accepts the u-name of a CURVE–FIT instruction that defines a linear or quadratic equation. This equation adjusts the nominal capacity rating of a gas turbine as a function of outdoor drybulb temperature. The adjustment takes the form of a value for RMAX corresponding to the ratio of highest generating capacity attainable, given the outdoor drybulb temperature, to the nominal rating.

GTURB–I/O–FPLR

accepts the u-name of a CURVE–FIT instruction that defines a linear or quadratic equation. This equation correlates full load fuel consumption to the fraction of that consumption consumed at other loads (expressed as part load ratios). In conjunction with PLANT–PARAMETERS instruction GTURB–GEN–EFF, the equation is used to calculate the gas turbine fuel energy required to generate a given electrical load.

GTURB–EXH–FPLR

accepts the u-name of a CURVE–FIT instruction that defines a linear or quadratic equation. This equation correlates full load exhaust heat recovery to the fraction of that recovery recovered at other loads (expressed as part load ratios). In conjunction with PLANT–PARAMETERS instruction GTURB–EXH–EFF, the equation is used to calculate exhaust heat recovered at a given electrical load.

GTURB–TEX–FPLR

accepts the u-name of a CURVE–FIT instruction that defines a linear or quadratic equation. This equation correlates the temperature of the exhaust gasses to the load being met (expressed as a part load ratio).

Steam Turbine

STURB–ENTH–FPIX accepts the u-name of a CURVE–FIT instruction that defines a bi-quadratic equation. This equation correlates inlet and exhaust pressures to an isentropic enthalpy drop, which is expressed as a theoretical steam rate (lbs/kWh).

Note: When performing curve-fits for STURB–ENTH–FPIX, the user is cautioned to ensure consistency between the enthalpy of the inlet pressure implied by the PLANT–PARAMETERS keywords STURB–T and STURB–PRES, and the isentropic enthalpy drop derived from tables of theoretical steam rates.

STURB–I/O–FPLR accepts the u-name of a CURVE–FIT instruction that defines a linear or quadratic equation. This equation expresses the electrical output of a steam turbine at part loads as a function of full load. In conjunction with STURB–MECH–EFF, this curve will determine the fraction of the theoretical steam rate (calculated with STURB–ENTH–FPIX) that is converted to electricity.

TABLE 4.1

Default Values for PART–LOAD–RATIO

Plant–Equipment	MIN	MAX	OPT
DIESEL–GEN	0.15	1.1	0.95
GTURB–GEN	0.30	1.1	1.0
STURB–GEN	0.10	1.1	1.0

TABLE 4.2

Default Performance Curves for EQUIPMENT–QUAD*

Equations are assumed to take the form: $F = a + bx + cx^2 + dy + ey^2 + fxy$ or $F = a + bx + cx^2 + dx^3$

Keyword	Independent Var(s)	Default Curve Coefficients a	b	c	d	e	f	Curve U-name
Diesel								
DIESEL–I/O–FPLR	PLR	0.107000	0.8930000	—	—	—	—	FUELD
DIESEL–EXH–FPLR	PLR	0.024516	0.3323871	0.6430968	—	—	—	THMHI
DIESEL–JCLB–FPLR	PLR	0.287936	1.0204516	-0.3083871	—	—	—	THMLO
DIESEL–TEX–FPLR	PLR	383.3300	466.67000	—	—	—	—	EXTEMP
Gas Turbine								
GTURB–CAP–FT	ODB	1.240000	-0.0041000	—	—	—	—	GTCAP
GTURB–I/O–FPLR	PLR	0.442979	0.3974000	0.1569621	—	—	—	FUELG
GTURB–EXH–FPLR	PLR	0.295626	0.4930194	0.2113548	—	—	—	THMXH
GTURB–TEX–FPLR	PLR	442.0910	255.73000	144.00000	—	—	—	EXTMP
Steam Turbine								
STURB–ENTH–FPIX	Pin,Pout	38.79236	-0.2113856	0.00052878	1.0200875	0.0009166	-0.00349944	KEENAN
STURB–I/O–FPLR	PLR	0.488308	0.994154	-0.482462	—	—	—	TURBD
Absorption-Chiller								
ABSOR1–HIR–FPLR	PLR	0.877733	0.7449211	0.1673056	—	—	—	HIRPLR1

* The following curves have been eliminated:

DIESEL–JAC–FPLR　GTURB–EXH–FT
DIESEL–LUB–FPLR　GTURB–I/O–FT
DIESEL–STACK–FU　GTURB–STACK–FU
GTURB–TEX–FT

REVISED CIRCULATION PUMP SIMULATIONS

Variable speed and methods of sizing circulation pumps can be specified in DOE-2 with the use of six PLANT–PARAMETERS keywords. In earlier versions of DOE-2, the simulation of hot and cold water circulation pumps was restricted to fixed speed pumps that were sized to meet the peak demands of the previous SYSTEM run. Now, options allow for the sizing of the pumps to be based on either the SYSTEM peak (as before) or the sum of the installed capacities of either the heating equipment or cooling equipment. Once sized, the pumps may be run in either a fixed speed or variable speed mode. For the latter mode, a minimum part-load ratio may be specified to place a floor on the electrical consumption of the pumps. The pipe distribution losses are considered a constant loss with either FIXED–SPEED or VARIABLE–SPEED pumps.

PLANT–PARAMETERS

CCIRC–SIZE–OPT accepts a codeword that indicates the load that the chilled water circulation pumps will be sized to meet. The allowable codewords are SYSTEM–PEAK (the default) and INST–PLANT–EQUIP. Specifying SYSTEM–PEAK will result in the pumps being sized to meet the peak load passed from SYSTEMS. Specifying INST–PLANT–EQUIP will result in the pumps being sized to meet the total installed capacity of PLANT–EQUIPMENT specified (regardless of whether this equipment was specified by default or input by the user).

HCIRC–SIZE–OPT accepts a codeword that indicates the load that the hot water circulation pumps will be sized to meet. The allowable codewords and definitions are identical to those available for CCIRC–SIZE–OPT.

CCIRC–PUMP–TYPE accepts a codeword that specifies whether the chilled water circulation pumps are fixed or variable speed pumps. The allowable codewords are FIXED–SPEED (the default) and VARIABLE–SPEED. If this keyword is set equal to VARIABLE–SPEED, then losses will be determined on the basis of the actual loads being served by the pumps.

HCIRC–PUMP–TYPE accepts a codeword that specifies whether the hot water circulation pumps are fixed or variable speed pumps. The allowable codewords and definitions are identical to those available for CCIRC–PUMP–TYPE.

CCIRC–MIN–PLR accepts a numeric value between 0. and 1. that places a floor on the electricity consumption of the chilled water circulation pumps It is expressed as as a fraction of the full load electricity consumption of the pumps. The default is 0.50, and the range is from 0.+ to 1.0.

HCIRC–MIN–PLR accepts a numeric value between 0. and 1. that places a floor on the electricity consumption of the hot water circulation pumps. It is expressed as fraction of the full load electricity consumption of the pumps. The default is 0.50, and the range is from 0.+ to 1.0.

REPLACEMENT OF THE ENERGY–COST COMMAND

In DOE-2.1C, the calculation of energy costs was moved from the PLANT simulation to ECONOMICS (see p. 5.1, **EXPANDED TREATMENT OF ENERGY COSTS**, in this Supplement). This change has not altered the choice of fuels or utilities available for use in the operation of central plants. The ENERGY–COST command in PLANT was replaced by an ENERGY–RESOURCE command, which may be entered for each fuel or utility. Two keywords, identical to RESOURCE and SOURCE–SITE–EFF in the old ENERGY–COST command, are used in conjunction with ENERGY–RESOURCE.

Several PLANT reports have been modified or eliminated to reflect the removal of energy cost calculations from PLANT. The eliminated reports are PV–D, Cost of Utilities; PV–H, Life-Cycle Parameters; and PS–J, Plant Life-Cycle Cost Summary. Summary report PS–B, Monthly Peak and Total Energy Use, has been modified so that the information pertaining to energy costs no longer appears.

ENERGY–RESOURCE

RESOURCE accepts a codeword, which informs the simulation that a fuel or utility will be used.

The acceptable codewords are
STEAM
CHILLED–WATER
ELECTRICITY
NATURAL–GAS
FUEL–OIL
DIESEL–OIL,
LPG
COAL
METHANOL
and
BIOMASS

Note that an ENERGY–RESOURCE command must be entered if a steam/hot-water (codeword STEAM) or a chilled water (codeword CHILLED–WATER) utility is to be used.

SOURCE–SITE–EFF accepts a numeric value which indicates the generating efficiency of the fuel or utility prior to its use in the building being simulated. Failure to specify an ENERGY–RESOURCE command for a fuel or utility will result in the use of the default values for SOURCE–SITE–EFF listed in Table 4.3.

TABLE 4.3

Default Values for ENERGY–RESOURCE

RESOURCE	SOURCE–SITE–EFF
CHILLED–WATER	1.5*
STEAM	0.60**
ELECTRICITY	0.333***
NATURAL–GAS	1.0
FUEL–OIL	1.0
COAL	1.0
DIESEL–OIL	1.0
METHANOL	1.0
LPG	1.0
BIOMASS	1.0

* Efficient electrically-driven chillers in a central chilled-water plant.
** Steam produced by heat-only boiler in a central steam generation plant.
*** California Energy Commission conversion factor for electricity: 10,239 Btu/kWh.

GAS FIRED ABSORPTION CHILLER

A model of a direct fired two-stage absorption chiller with optional heating capability has been added to the PLANT program. Units of this type have been available in the U.S. for the last ten years, and have achieved fairly wide usage. These units are now available in sizes ranging from 100 to 1500 tons. The units can burn either gas or oil.

To simulate a direct fired absorption chiller, the user must first specify it with the codeword ABSORG–CHLR in the PLANT–EQUIPMENT command. For instance:

DF–CHLR = PLANT–EQUIPMENT TYPE=ABSORG–CHLR SIZE=1.5 ..

Like the usual two-stage absorption chiller in DOE-2 (ABSOR2–CHLR), the unit is modeled with a full load, standard condition heat input ratio (HIR), modified by a set of curves, as well as an electric input ratio (EIR) for auxiliary power. The HIR can be specified with the keyword ABSORG–HIR in the PLANT–PARAMETERS command. The default is 1.0. Standard conditions are defined to be 85°F entering condenser temperature and 44°F leaving chilled water temperature. In the simulation the HIR is modified by the following curves:

Keyword	Independent Variables	Coefficients (a)	(b)	(c)	(d)	(e)	(f)
ABSORG–HIR–FT	leaving chilled water temp.	4.42871284	–.13298607	.00125331	0	0	0
ABSORG–HIR1–FTI	condenser temperature	.86173749	–.00708917	.00010251	0	0	0
ABSORG–HIR–FPLR	part load ratio	.13551150	.61798084	.24651277	0	0	0

The curves are all quadratic in the independent variable. The HIR at the operating point is the result of multiplying ABSORG–HIR by these curves.

The fuel used is the HIR times the capacity times the fraction of the hour the unit is on. The capacity is the size specified by the input (SIZE keyword in the PLANT–EQUIPMENT command) modified by following curve:

Keyword	Independent Variables	Coefficients (a)	(b)	(c)	(d)	(e)	(f)
ABSORG–CAP–FT	leaving chilled water temp. and condenser temperature	1.0	0.	0.	0.	0.	0.

The curve is bi-quadratic. For now, the curve does nothing, since no data on its shape is available.

The gas fired absorption chiller model in DOE-2.1D was developed with the support and collaboration of the Gas Research Institute and the GARD Division of the Chamberlain Manufacturing Corporation.

One final curve is used in the model. The chiller can optionally operate as a heater. The heating capacity is specified with the ABSORG–HCAPR keyword in the PLANT–PARAMETERS command. This keyword is the heat capacity ratio -- the heat capacity of the unit divided by the cooling capacity. The default is 1.0 -- the heating and cooling capacity are equal. When the unit is simultaneously cooling and heating, the available heating capacity is a function of the cooling load. This relationship is expressed by the following curve:

Keyword	Independent Variables	Coefficients (a)	(b)	(c)	(d)	(e)	(f)
ABSG–HCAP–FQC	cooling load	.863599	−1.30495346	.44135284	0.	0.	0.

This curve is quadratic. All the curves are keywords in the EQUIPMENT–QUAD command. They can be changed by using the keyword to reference the u-name of a CURVE–FIT command.

Several inputs to the model are accessed via the PART–LOAD–RATIO command. The most important is the EIR. This is input with the ELEC–INPUT–RATIO keyword. The default is .0071 in units of btuh/btuh, the numerator being the electric power input to the unit and the denominator the nominal cooling capacity of the unit. This ratio can vary significantly depending on the size of the unit. The default is for a 600 ton unit. For a 100 ton unit .014 would be appropriate and for 1400 tons .0053 could be used. Other keywords input through this command are MIN–RATIO and MAX–RATIO. The MIN–RATIO (default = 0.1) is the minimum operating ratio for the unit. Below this ratio, the unit cycles on and off. The MAX–RATIO (default = 1.15) is the maximum ratio at which the program allows the unit to operate.

Finally, there are two more relevant keywords in the PLANT–PARAMETERS command.

- The first is ABSORG–FUEL which specifies a codeword denoting the fuel type; the default is NATURAL–GAS. Other possible inputs would be FUEL–OIL, DIESEL–OIL, LPG, or METHANOL.
- The second new keyword is ABSORG–FUEL–XEFF, which is the efficiency of the hot water heat exchanger used in the heating mode; the default is 0.8.

The chiller always meets the cooling load first. The available heating capacity is then calculated and is used to meet the space heating and domestic hot water loads. The heat from the direct fired absorption chiller cannot be assigned via the HEAT–RECOVERY command. The chiller can be operated through the LOAD–MANAGEMENT and LOAD–ASSIGNMENT commands, and this is recommended if there are multiple chillers. The program cannot optimize the operation of the direct fired chiller in conjunction with compression or other types of absorption chillers. The only default mode of operation of the direct fired chiller is that it is used in preference to any other chiller or heat source.

In summary, the keywords relevant to the direct fired absorption chiller input are:

Command	Keyword	Abbr	Type	Unit	Def	Min	Max
PLANT–PARAMETERS	ABSORG–HIR	none	numeric	frac.	1.0	0.0	3.0
PLANT–PARAMETERS	ABSORG–HCAPR	none	numeric	frac.	1.0	0.	2.
PLANT–PARAMETERS	ABSORG–FUEL	none	codeword	NATURAL–GAS			
PLANT–PARAMETERS	ABSORG–HEAT–XEFF	none	numeric	frac.	0.8	0.1	1.0
EQUIPMENT–QUAD	ABSORG–HIR–FT	none	curve	HIRT3			
EQUIPMENT–QUAD	ABSORG–HIR1–FTI	none	curve	HIRTI1			
EQUIPMENT–QUAD	ABSORG–HIR–FPLR	none	curve	HIRPLR3			
EQUIPMENT–QUAD	ABSG–HCAP–FQC	none	curve	HCAPQC			
EQUIPMENT–QUAD	ABSORG–CAP–FT	none	curve	ACAPT3			
PART–LOAD–RATIO	ELEC–INPUT–RATIO	E–I–R	numeric	frac.	.0071	0.	10.
PART–LOAD–RATIO	MIN–RATIO	MIN–R	numeric	frac.	0.1	0.	1.
PART–LOAD–RATIO	MAX–RATIO	MAX–R	numeric	frac.	1.15	1.0	2.0

A simple example input might be:

```
DF–CHLR = PLANT–EQUIPMENT   TYPE=ABSORG–CHLR   SIZE=2.4 ..
          .
          .
          .
PLANT–PARAMETERS   ABSORG–HIR=1.023 ..
PART–LOAD–RATIO   E–I–R=.011 ..
```

ENGINE DRIVEN COMPRESSION CHILLER

The capability to simulate an engine-driven compression chiller has been added to the DOE-2 PLANT subprogram. To simulate the unit, the user must use the codeword ENG–CHLR in the PLANT–EQUIPMENT command in the PLANT input. For example:

ENGINE–CHILLER = PLANT–EQUIPMENT TYPE=ENG–CHLR SIZE=1.8 ..

The unit is modeled with a full load, standard condition coefficient of performance (COP) which is modified by several curves for part load and nonstandard conditions. Standard conditions are defined as 44°F leaving chilled water temperature and 85°F entering condenser temperature. The COP can be input by means of the ENG–CH–COP keyword in the PLANT–PARAMETERS command; the default is 1.4. The curves that modify the COP are:

Keyword	Independent Variables	Coefficients (a)	(b)	(c)	(d)	(e)	(f)
ENG–CH–COP–FT	chilled water temp., entering cond. temp.	1.23624	.0168923	0	–.0115235	0	0
ENG–CH–COP–FTS	chilled water temp., entering cond. temp.	1.08815	.0141064	0	–.00833923	0	0
ENG–CH–COP–FPLR1	part load ratio	1.14336	.0228899	0	0	0	0
ENG–CH–COP–FPLR2	part load ratio	1.38861	-.388614	0	0	0	0
ENG–CH–COP–FPLRS	part load ratio	.3802	2.3609	0	0	0	0

The function that modifies the COP as a function of the part load ratio is parameterized as three linear curves; i.e., the function is piecewise linear.

- ENG–CH–COP–FPLR2 is used above a part load of 0.6 (where 0.6 is the point with the highest COP -- the point defined by the keyword OPERATING–RATIO in the PART–LOAD–RATIO command, defaulted to 0.6 for this type of chiller).
- ENG–CH–COP–FPLR1 is used below 0.6 but above the engine's minimum speed.
- ENG–CH–COP–FPLRS is used when the engine is at minimum speed. The minimum speed is defined by the ENG–CH–IDLE–RAT keyword in the PLANT–PARAMETERS command; the default is .3125.

COP is modified as a function of chilled water temperature and entering condenser temperature by two bilinear curves. ENG–CH–COP–FT is used for part loads above the engine's minimum speed, ENG–CH–COP–FTS for those below it.

The capacity of the unit at standard conditions is set by the SIZE keyword in the user's input to the PLANT–EQUIPMENT command. For nonstandard conditions, the capacity is modified by the following bi-linear curve:

The engine driven compression chiller model in DOE-2.1D was developed with the support and collaboration of the Gas Research Institute and the GARD Division of the Chamberlain Manufacturing Corporation.

Keyword	Independent Variables	(a)	(b)	(c)	(d)	(e)	(f)
ENG–CH–CAP–FT	chilled water temperature -- entering condition temperature	.573597	.0186802	0	–.00465325	0	0

The engine also produces a large amount of recoverable heat. The efficiency of recoverable heat production at full load and standard conditions is set by the ENG–CH–REC–EFF keyword in the PLANT–PARAMETERS command. The default is .519; this number is modified by the following curves for nonstandard and part load conditions:

Keyword	Independent Variables	(a)	(b)	(c)	(d)	(e)	(f)
ENG–CH–HREJ–FT	entering cond. temp.	.705841	.00346070	0	0	0	0
ENG–CH–HREJ–FPLR	part load ratio	1.05270	–.0526991	0	0	0	0

Both curves are linear in the independent variable. All the curves described above are keywords in the EQUIPMENT–QUAD command. They can be changed by using the keywords to reference the u-name of a CURVE–FIT command.

Several important parameters in the model are set through the PART–LOAD–RATIO command. The most important is the electrical consumption of the unit. This is calculated using an electric input ratio (EIR) -- the ratio of the electrical usage in BTUH to the nominal capacity in the same units. The EIR is input by the ELEC–INPUT–RATIO keyword in the PART–LOAD–RATIO command; the default is .0053. The minimum operating part load ratio (keyword MIN–RATIO; default .06623) and the maximum operating part load ratio (keyword MAX–RATIO; default 1.25) can also be set in this command. Below the MIN–RATIO the unit is cycled on and off. The high value of the MAX–RATIO reflects the fact that the engine can be over revved for short periods.

There are two other keywords in the PLANT–PARAMETERS command that are relevant to the engine driven chiller.

- ENG–CH–COND–TYPE can be given the value TOWER or AIR to denote whether the condenser is cooled by tower water or air; the default is TOWER.
- ENG–CH–FUEL assigns the type of fuel burned by the engine; the default is NATURAL–GAS, and this should probably never be changed.

The engine driven chiller should be operated through the LOAD–MANAGEMENT and LOAD–ASSIGNMENT commands when there are other chillers available. There is no default optimizing of the operation of this chiller in conjunction with electrically driven compression chillers and/or steam or direct fired absorption chillers. The waste heat from the engine can be recovered by use of the HEAT–RECOVERY command. The codeword to be used with the SUPPLY keywords in HEAT–RECOVERY is just the equipment type codeword ENG–CHLR.

In summary, the keywords relevant to the engine driven chiller input are:

Command	Keyword	Abbr	Type	Unit	Def	Min	Max
PLANT–PARAMETERS	ENG–CH–COP	none	numeric	frac.	1.4	0.1	3.0
PLANT–PARAMETERS	ENG–CH–REC–EFF	none	numeric	frac.	.519	0.1	1.0
PLANT–PARAMETERS	ENG–CH–IDLE–RAT	none	numeric	frac.	.3125	0.0	1.0
PLANT–PARAMETERS	ENG–CH–COND–TYPE	none	codeword	TOWER			
PLANT–PARAMETERS	ENG–CH–FUEL	none	codeword	NATURAL–GAS			
EQUIPMENT–QUAD	ENG–CH–COP–F	none	curve	ECCOPT			
EQUIPMENT–QUAD	ENG–CH–COP–FTS	none	curve	ECCOPTS			
EQUIPMENT–QUAD	ENG–CH–COP–FPLR1	none	curve	ECCOPPLR1			
EQUIPMENT–QUAD	ENG–CH–COP–FPLR2	none	curve	ECCOPPLR2			
EQUIPMENT–QUAD	ENG–CH–COP–FPLRS	none	curve	ECCOPPLRS			
EQUIPMENT–QUAD	ENG–CH–CAP–FT	none	curve	ECCAPT			
EQUIPMENT–QUAD	ENG–CH–HREJ–FT	none	curve	ECHREJT			
EQUIPMENT–QUAD	ENG–CH–HREJ–FPLR	none	curve	ECHREJPLR			
PART–LOAD–RATIO	ELEC–INPUT–RATIO	E–I–R	numeric	frac.	.0053	0.	10.
PART–LOAD–RATIO	MIN–RATIO	MIN–R	numeric	frac.	.06623	0.	1.
PART–LOAD–RATIO	MAX–RATIO	MAX–R	numeric	frac.	1.25	1.0	2.0
PART–LOAD–RATIO	OPERATING–RATIO	O–R	numeric	frac.	0.6	0.	2.0

A simple input for the engine driven chiller might look like:

```
ENGINE–CHILLER = PLANT–EQUIPMENT  TYPE=ENG–CHLR  SIZE=1.8 ..
        .
        .
        .
HEAT–RECOVERY  SUPPLY–1=(ENG–CHLR)  DEMAND–1=(SPACE–HEAT,PROCESS–HEAT) ..
PLANT–PARAMETERS  ENG–CH–COP=1.1 ..
```

COMPONENT–BASED ICE STORAGE SIMULATION

DOE-2.1D incorporates the CBS/ICE program developed for ASHRAE by the University of Texas. CBS/ICE is part of the DOE-2 PLANT program. It simulates static (ice-on-coil) ice storage systems that provide thermal storage in HVAC systems applications. CBS/ICE is component-based; i.e., the user assembles a storage system description by linking together chilled-water loop components (ice tanks, agitator, exchanger, etc.), refrigeration loop components (evaporator, compressor, etc.), and control components. Detailed instructions on using the CBS/ICE portion of DOE-2.1D and a set of sample runs are contained in a separate publication, "CBS/ICE Program User's Guide", by Scott C. Silver, Jerold W. Jones, John L. Peterson, Andre Milbitz, and Bruce D. Hunn, June 1988, available from the Center for Energy Studies, the University of Texas at Austin, Balcones Research Center, 10100 Burnet Road, Austin, TX 78758.

The following overview of CBS/ICE is excerpted from the User's Guide.

KEY FEATURES OF THE CBS/ICE PROGRAM

Because CBS/ICE includes accurate heat transfer and thermodynamics algorithms in the component models, rather than generalized performance equations, simulations with CBS/ICE can be used to examine the effects of detailed equipment design parameter changes. The simulation philosophy of the refrigerant system portion of the program is such that primary refrigerant properties (temperature, pressure, and enthalpy) are tracked throughout the refrigerant flow streams. This arrangement allows detailed design analyses to be performed at the level of refrigerant equipment components.

The level of detail is not without its price, however. Due largely to the calculation of refrigerant properties from thermodynamic equations of state, execution times for CBS/ICE can be quite long. This fact will restrict most analyses to run periods that include only peak cooling days or representative load profiles for several days (perhaps one per month).

Several features of CBS/ICE are worth noting:

1. **Control Alternatives**

   - Chiller, ice, or constant priority to meet cooling loads
   - User-defined start/stop time for ice-building cycle
   - Compressor capacity control option: Full (100% capacity), fixed (partial capacity), or suction pressure setpoint (variable capacity).
   - Controllable or floating condensing temperature.
   - Constant or variable-speed chilled water pumps.
   - DX, gravity (flooded), or overfeed refrigeration system control.

2. **Multiple Equipment Options**
   - Multiple evaporator coil banks
   - Multiple ice storage tanks
   - Multiple refrigerant compressors

3. **Choice of Heat Rejection Devices**
   - Air-cooled condenser with or without direct evaporative precooling
   - Water-cooled condenser/cooling tower combination
   - Evaporatively cooled condenser

4. **Choice of Compressor Types**
   - Hermetic reciprocating
   - Open reciprocating
   - Hermetic screw
   - Open screw

LIMITATIONS AND RESTRICTIONS

Some features and capabilities not included in this version of CBS/ICE are as follows:

1. Dynamic (harvesting) and glycol (or brine) systems cannot be modeled; only static ice-on-coil ice builders are included.
2. Use of ice storage compressors to meet a building load directly with a DX coil cannot be modeled; i.e., the ice storage system compressor is dedicated to the ice builder evaporator coils.
3. Ice storage equipment is not self-sizing. This feature is a departure from the philosophy of the rest of the DOE-2 program where, by default, equipment is automatically sized to meet peak loads. In many cases ice storage equipment is sized for load leveling where its use may not be economical to meet the entire load. Therefore, it is assumed that the user will control the apportioning of the cooling load between standard plant equipment and ice storage through appropriate sizing and control of components.
4. No load prediction capability is included; the ice builders will make a prescribed quantity of ice (defined by the user) regardless of the current, previous, or next day's load profile.
5. Demand-limited control strategy is not included.
6. No optimized apportioning of cooling load between ice storage and auxiliary chillers beyond straight chiller priority, ice priority or constant proportional control is provided. The complete load assignment and load management features of the DOE-2 PLANT program may, however, be used to manage any load remaining each hour after simulation of the ice storage systems.
7. Only refrigerants R-12, R-22, R-500, R-502, and ammonia are included.

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EXPANDED TREATMENT OF ENERGY COSTS

In DOE-2.1C, the calculation of energy costs was moved from the PLANT sub-program to ECONOMICS. New commands and keywords were added to encompass a wider variety of tariff schedules for energy. Seasonal and time-of-day rates can now be accounted for and the existing block rate structure has been upgraded. Major modifications have been made to enhance the treatment of electricity, including more sophisticated demand ratchet mechanisms and the Congressionally-mandated options for the sale of electricity to a utility.

Three commands for all utilities (ENERGY–COST, CHARGE–ASSIGNMENT, DAY–CHARGE–SCH) and one special command for electricity (COST–PARAMETERS) are used in ECONOMICS for the calculation of energy costs. The interactions among them can be summarized as follows: The most basic features of a tariff — units, uniform cost rates, monthly charges, etc. — are all contained in an ENERGY–COST command, which is entered for each fuel or utility used in the previous PLANT run. The CHARGE–ASSIGNMENT is used primarily to specify block-rate structures but can also be used for simple uniform rate charges on demands as well as energy. CHARGE–ASSIGNMENTs can be referenced by the ENERGY–COST command in two ways, directly or through a SCHEDULE. Seasonal and time-of-day variations in tariffs require the use of a SCHEDULE (referenced in the ENERGY–COST command for that utility or fuel), which reference DAY–CHARGE–SCHs that, in turn, reference CHARGE–ASSIGNMENTs. The complex features of tariffs for electricity, which include provisions for demand ratchets and the sell-back of electricity to a utility, are specified through COST–PARAMETERS.

Certain Summary and Verification reports pertaining to energy use and costs have been modified, or completely eliminated, from PLANT. They have been replaced in, or supplemented by, ECONOMICS in the following reports: EV–B, Cost of Fuels and Utilities; ES–D, Summary of Fuel and Utility Use and Costs; ES–E, Summary of Electricity Charges; and ES–F, Summary of Electricity Sales. Samples of these reports appear in Appendix C, **DOE-2 Reports: Examples and Descriptions**.

The discussion of the new commands and associated keywords appear more complex than the actual sample inputs found at the end of this discussion, which display various rates, and can be studied in close conjunction with the following descriptions.

ENERGY–COST

For each utility or fuel used in PLANT, a separate ENERGY–COST command must be entered. The ENERGY–COST command has associated with it several keywords pertaining to the specified utility or fuel, which are similar to the old ENERGY–COST command found in PLANT. For a simple energy cost calculation in which all units consumed are valued at one rate, only the ENERGY–COST command and the associated keywords need be entered. Failure to specify an ENERGY–COST command for a utility or fuel used in PLANT will result in the use of the default values listed in Table 5.1. For more complex tariffs, involving either blocks or time-of-use/seasonal features, two additional new commands, CHARGE–ASSIGNMENT and DAY–CHARGE–SCH, are required.

RESOURCE is a required keyword that informs the program which fuel or utility is being valued. The codewords associated with this keyword are identical to those available in PLANT (STEAM, CHILLED–WATER, ELECTRICITY, NATURAL–GAS, LPG, FUEL–OIL, DIESEL–OIL, COAL, METHANOL, BIOMASS).

UNIT accepts a numeric input that specifies the number of Btu's in the unit to which the following tariff rates or schedules apply. This value can range from 0. + to 100000000.0 Btu/unit. Table 5.1 presents a list of the default values for this keyword by resource.

UNIFORM–COST accepts a numeric input that allows the user to bypass the more complex energy cost tariffs in favor of a uniform charge rate in dollars per unit. This value can range from 0.0 to 100000.0 $/unit. In the absence of references to a CHARGE–ASSIGNMENT, either directly or through a schedule, this keyword will default in accordance with Table 5.1.

ESCALATION accepts a numeric input in percent that specifies the annual rate of "real" escalation (relative to the general inflation rate) to be used in life-cycle cost calculations. This value can range from 0.0 to 100.0%. The default values are listed on Table 5.1.

TABLE 5.1

Default Values for ENERGY–COST

RESOURCE	UNIT	UNIFORM–COST ($/Unit)	ESCALATION (%/Year)
STEAM	1000000.00 Btu/unit	13.00	5.0
CHILLED–WATER	1000000.00 Btu/unit	13.4	5.0
ELECTRICITY	3412.97 Btu/kWh	0.0686	5.0
NATURAL–GAS	1031000.00 Btu/MCF	5.53	5.0
LPG	95500.00 Btu/gal.	1.50	5.0
FUEL–OIL	138700.00 Btu/gal.	1.186	5.0
DIESEL–OIL	138700.00 Btu/gal.	1.005	5.0
COAL	24580000.00 Btu/ton	30.00	5.0
METHANOL	63500.00 Btu/gal.	1.13	5.0
BIOMASS	1000000.00 Btu/unit	0.95	5.0

MIN–MONTHLY–CHG accepts a numeric input that places a floor on the cost of a fuel or utility for each month that costs are calculated. This value can range from 0.0 to 100000.0 $/month and defaults to 0.0.

FIXED–MONTH–CHG1 accepts a numeric value that adds a fixed charge to each month in the first SEASON, as designated in the CHARGE–ASSIGNMENTs for this utility or fuel. If no CHARGE–ASSIGNMENTs are used, SEASON is always assumed to be the first. If CHARGE–ASSIGNMENTs with different SEASONs overlap in one month, FIXED–MONTH–CHG1 is prorated by hours with FIXED–MONTH–CHG2. This value can range from 0.0 to 100000.0 $/month and defaults to 0.0.

FIXED–MONTH–CHG2 is identical to FIXED–MONTH–CHG1 except that it applies to the second SEASON specified in a CHARGE–ASSIGNMENT and, if allowed to default, will be set equal to FIXED–MONTH–CHG1.

RATE–LIMITATION accepts a numeric value in dollars per unit that places a ceiling on the effective rate that will be assessed on a utility or fuel for any month. This value can range from 0.0 to 100000.0 $/unit and defaults to 10000.0.

ASSIGN–CHARGE accepts, in parentheses, the u-names of up to two CHARGE–ASSIGNMENTs. There is no default for this keyword.

ASSIGN–SCHEDULE accepts, not in parentheses, the u-name of a SCHEDULE that references CHARGE–ASSIGNMENTs (through WEEK–SCHEDULEs and DAY–CHARGE–SCHs). There is no default for this keyword.

CHARGE–ASSIGNMENT

Because rate structures have become more complex, the allowed number of CHARGE–ASSIGN–SCH's has been increased from 6 to 10 in DOE-2.1D. As a suggestion, the user will find that setting Summer to SEASON=2 will usually make the input less complicated. Also, when there is more than one ASSIGN–CHARGE with DEMAND charges, the use of the keyword C–A–LINK is necessary to link demand ratchets so that they carry over into both the Summer and Winter seasons. This was not an explicit part of the instructions in DOE-2.1C for C–A–LINK (refer back to page 5-4 of the 2.1C Supplement). In 2.1D there is a new sample input attached to the Medical Building Run 1 of the Samp3.inp file. The new sample input uses 10 Charge-Assignments, 6 of which are used for time-of-day rates, 2 for summer/winter minimum demand charges, and 2 for summer/winter On-Peak demand charges that carries a 90% ratchet all year.

The CHARGE–ASSIGNMENT command is used to specify block-style tariffs and has been structured in a manner that is roughly analogous to the LOAD–ASSIGNMENT command in PLANT. That is, several keywords associated with this command may be entered more than once. Note that the repeatable keywords, beginning with TYPE (defined below) must be entered *after* the non-repeatable keywords (RESOURCE, C–A–LINK, and SEASON) or an error will result. CHARGE–ASSIGNMENTs for a utility or fuel are referenced through the ENERGY–COST command in a manner similar to the way in which the LOAD–MANAGEMENT command in PLANT references LOAD–ASSIGNMENTs, directly or through a schedule. In the latter case, the DAY–CHARGE–SCH command is used in conjunction with the existing SCHEDULE and WEEK–SCHEDULE commands to reflect seasonal and time-of-day tariff schedules. A total of six CHARGE–ASSIGNMENTs may be entered for each utility or fuel. Additional CHARGE–ASSIGNMENTs will generate a warning indicating that they will be ignored.

u-name — is a unique user-defined name that must be entered to identify this instruction.

RESOURCE — is a required keyword that identifies the fuel or utility that this CHARGE–ASSIGNMENT is to be applied against.

The codewords are:
STEAM
CHILLED–WATER
ELECTRICITY
LPG
NATURAL–GAS
DIESEL–OIL
FUEL–OIL
COAL
METHANOL
and
BIOMASS

C–A–LINK — accepts the u-name of a different CHARGE–ASSIGNMENT, which becomes linked to the present one. This keyword is *only* used when the RESOURCE is ELECTRICITY and charges are being assessed for demand (kW); it will not affect the calculation of charges, if specified for other fuels or utilities. This link will be used to allocate charges between CHARGE–ASSIGNMENTs in the event that, as a result of scheduling, more than one appears in the same month. For example, if summer on-peak demands switch to winter on peak-demands in mid-September, only the fraction the demand charge corresponding to the ratio of hours of winter on-peak to total on-peak hours (and vice-versa) will be assessed. This prevents the double counting of two "whole-month" demand charges in a single month.

A second use of C–A–LINK is to link two CHARGE–ASSIGNMENTs dedicated to TYPE=DEMAND (see below) that describe seasonal charges that differ from summer to winter. The link allows a ratchet to be carried from one season to the next when DEM–PERIOD–Tn=WHOLE–YEAR.

SEASON accepts an integer value of 1 or 2 (default = 1) that is used when there are seasonal changes in a set of scheduled CHARGE–ASSIGNMENTs. This keyword will be used to determine which FIXED–MONTH–CHG(1 or 2) or demand ratchet option (see COST–PARAMETERS) will be used. As with C–A–LINK, if there are overlaps in a month, FIXED–MONTH–CHG will be prorated on the basis of hours.

TYPE accepts a codeword which determines the type of units for energy upon which the charge assignment is to be applied. The codeword ENERGY means that this type of charge is for units per month, and the codeword DEMAND means that the type is for units per hour. With the exception of electricity (see discussion of demand ratchets in COST–PARAMETERS), DEMAND is always taken to be the highest use of energy (or "peak") per hour in the hours of the month to which the CHARGE–ASSIGNMENT applies. ENERGY is the default value. TYPE is the first repeatable keyword allowed in a CHARGE–ASSIGNMENT; a maximum of two TYPEs may appear in one CHARGE–ASSIGNMENT. Note that the keywords listed before TYPE (RESOURCE, C–A–LINK, SEASON), if they are to be entered, must be entered before TYPE.

UNIFORM–CHARGE accepts a numeric value that specifies a uniform charge rate in dollars per unit, where unit is determined by the previous TYPE. The use of this keyword implies that there is no block rate structure to follow, all units of energy are priced equally. Only one UNIFORM–CHARGE is allowed per TYPE. The range is from 0.0 to 1000.0 $/unit, and there is no default.

OVER–BLOCK–RANGE accepts a numeric value in units of TYPE that define ranges of applicability for the keywords that follow. It corresponds exactly to the LOAD–RANGE keyword in a LOAD–ASSIGNMENT. Up to three OVER–BLOCK–RANGEs can be specified for each TYPE so that the user can specify up to three ranges for which a different set of tariffs is to apply. In operation the code will check to see that the value for TYPE (ENERGY or DEMAND) is less than or equal to the value of OVER–BLOCK–RANGE in order for the following keywords to apply. If it exceeds this value, the code will skip to the next OVER–BLOCK–RANGE and repeat this check until the appropriate set of tariffs is found. If no OVER–BLOCK–RANGE can be found large enough, a warning is issued and no charges are assessed for this TYPE. If no OVER–BLOCK–RANGE is specified, it is assumed that there is only one OVER–BLOCK–RANGE of a very large size. The range is from 0.0 to 10^9 units.

BLOCK–UNIT

accepts a codeword that can be used to change the units of TYPE being assessed within the OVER–BLOCK–RANGE. The codewords are ENERGY, DEMAND, and KWH/KW. If not specified, BLOCK–UNIT will default to either the previous BLOCK–UNIT or TYPE specified in the OVER–BLOCK–RANGE. BLOCK–UNITs must be consistent with one another; BLOCK–UNITs of DEMAND and ENERGY can not appear in the same OVER–BLOCK–RANGE. Note that KWH/KW is used to specify blocks of energy whose size is a function of demand and therefore is a unit consistent with ENERGY.

BLOCK–RANGE

accepts a list enclosed by parentheses of up to ten values indicating the size of the blocks to be used in assessing block-charges. Blocks are increments; hence each successive block covers the next size increment. Rates written as "up to X" must be translated (see Example 2). The range is from 0.0 to 10^9, and there is no default.

BLOCK–CHARGE

accepts a list enclosed by parentheses of up to ten values corresponding to the charges to be assessed for each of the blocks previously specified in the BLOCK–RANGE. Up to two sets of BLOCK–RANGE/BLOCK–CHARGEs can be specified in each OVER–BLOCK–RANGE. The range is from -1000.0 to 1000.0 $/unit, and there is no default.

DAY–CHARGE–SCH

DAY–CHARGE–SCH

This command accepts, in parentheses, integer values referring to hours and for each of these groups of hours, also in parentheses, up to two u-names of CHARGE–ASSIGNMENTs. In a manner similar to the DAY–ASSIGN–SCH command used in PLANT to schedule LOAD–ASSIGNMENTs, DAY–CHARGE–SCH is referenced by u-name in a WEEK–SCHEDULE command, which, in turn, is referenced by a SCHEDULE command (see the discussion of scheduling concepts in the DOE-2 Reference Manual, p.II.12ff and in the DOE-2 User News, Fall 1988). The u-name for the SCHEDULE is referenced in the ENERGY–COST command by the keyword ASSIGN–SCHEDULE. DAY–CHARGE–SCH u-names can be nested in the SCHEDULE, thus bypassing WEEK–SCHEDULE.

u-name

A unique user-defined name must be entered to identify this instruction.

COST–PARAMETERS

COST–PARAMETERS

A final command, COST–PARAMETERS, is used to specify the special features of tariffs for electricity. These include the characteristics of demand ratchets, where the billing demand (kW) is taken to be the larger of the highest demand in the relevant period of the month and a "ratchet" based on previous recorded demands. In calculating demand ratchets, previous recorded demands can include months in the simulation that are "downstream" of the current one. That is, since DOE-2 run periods are for a single year, information from the entire year may be used in calculating the ratchet for a particular month. The COST–PARAMETERS command also accepts keywords that specify how electricity generated on-site (via diesel engines, gas and steam turbines; see the description of PLANT–EQUIPMENT in the **PLANT EQUIPMENT OPERATION MODES** section, starting on p. 4.1, of this Supplement) is to be accounted for with respect to interconnection with a utility.

DEM–RATCHET–T1

accepts a codeword that identifies how the demand is billed for SEASON = 1. The codewords are MEASURED, HIGHEST, and AVERAGE.

MEASURED (the default) implies no ratchet and the billing demand is the highest measured demand for any hour in every given month.

HIGHEST implies a ratchet based on the highest demand in the period(s) defined in the ASSIGN–SCHEDULE.

AVERAGE implies a ratchet based on an average of highest demand in the period(s) defined in the ASSIGN–SCHEDULE.

DEM–RATCHET–T2

is identical to DEM–RATCHET–T1, but applies to the SEASON = 2 as defined by the ASSIGN–SCHEDULE. The default value is that specified (or defaulted) for DEM–RATCHET–T1.

DEM–PERIOD–T1

accepts a codeword that limits the duration of a ratchet. The codewords are SEASON and WHOLE–YEAR (the default). SEASON limits the ratchet to a comparison against the highest demand in the months of SEASON = 1. WHOLE–YEAR allows the ratchet to carry for twelve months and, hence, into SEASON = 2 as well.

DEM–PERIOD–T2

is identical to DEM–PERIOD–T1, but applies to SEASON = 2. Note that if winter is season 1 and summer is season 2, setting DEM–PERIOD–T1 = SEASON and DEM–PERIOD–T2 = WHOLE–YEAR causes the winter months to be charged the higher of either winter or summer ratchet. For summer months, only the summer ratchet (i.e., highest demand during summer season) applies. The default is DEM–PERIOD–T1.

DEM–AVERAGE–MON1 accepts an integer value of 2 (the default) or 3. The program seeks the peak demand for SEASON = 1 as defined in the CHARGE–ASSIGNMENT commands, averages the highest demands for the month on each side of the peak, then compares and selects the higher peak average. The value of 2 limits this comparison to months on each side of the peak month. The value of 3 means that the selection is from the highest average from the combination of one month on either side of the peak, two consecutive months before, or two consecutive months after.

DEM–AVERAGE–MON2 is identical to DEM–AVERAGE–MON1, except that it applies to SEASON = 2.
The default value is DEM–AVERAGE–MON1.

DEM–RATCHET–FRC1 accepts a numeric value between 0.0 and 1.0 that is multiplied against either the highest or averaged value for months in the first season. The default value is 1.0.

DEM–RATCHET–FRC2 is identical to DEM–RATCHET–FRC1 except that it applies to ratchets calculated in the second season. The default is DEM–RATCHET–FRC1.

POWER–FACT–CORR accepts a numeric value between 0.0 and 1.0 that is divided into the kW demand or ratchet (whichever is greater) to arrive at the billing demand. Electricity demands are thus adjusted for power phase imbalances between the utility and the site. The default value is 1.0.

KWH/KW–DEM–TYPE accepts a codeword that indicates which demand is being used to partition blocks of energy charges in a CHARGE–ASSIGNMENT. The codewords are RECORDED (the default) and BILLING. The codeword RECORDED means that the highest measured demand will be used, when BLOCK–UNIT is KWH/KW. The codeword BILLING means that the billing demand, as determined by the above COST–PARAMETERS keywords will be used.

ELEC–SALES–OPT accepts a codeword that indicates the electricity sales option that will be used to value electricity that is generated on-site. The codewords are NET–SALE, SIM–BUY/SELL, and NONE (the default). The codeword NET–SALE indicates that only electricity generated beyond the needs of the facility in a given hour will be sold. Correspondingly, only electricity needed beyond that generated will be purchased in the form of kWh or kW. The codeword SIM–BUY/SELL means that all of the electricity generated on-site will be sold to the utility and all the electricity required on-site will be purchased from the utility. This option represents an accounting fiction that has been mandated to give on-site generators the ability to exploit arbitrage situations, which may arise when the prices paid for electricity sold are different from those paid when it is purchased. The keyword NONE indicates that there is no sales agreement to an outside buyer so that no excess electricity generated on-site can be sold, while any requirements not met on-site must be purchased from the utility. If either NET–SALE or SIM–BUY/SELL are specified, a ELEC–SALES–ASG or ELEC–SALES–SCH must also be specified.

ELEC–SALES–ASG

accepts, in parentheses, the u-name of a CHARGE–ASSIGNMENT with RESOURCE = ELECTRICITY that can be used to value electricity sales to a utility. The CHARGE–ASSIGNMENT is then treated as before except that the charges are treated as income and credited against expenditures for other fuels and utilities. Up to two ELEC–SALES–ASGs may be specified.

ELEC–SALES–SCH

accepts, not in parentheses, the u-name of a SCHEDULE that references WEEK–SCHEDULEs that reference DAY–CHARGE–SCHs containing u-names of CHARGE–ASSIGNMENTs for use in valuing electricity sales.

CAPACITY–PAYMENT

accepts a numeric value in dollars per year that represents a fixed annual payment for a contracted capacity sold to the utility. The value can range between -100000.0 and 1000000.0 $/yr and the default is 0.0.

ELEC–SALES–ESCL

accepts a numeric value between 0.0 and 100.0 that represents in percent per year the rate at which the value of electricity sold to the utility escalates relative to inflation (i.e., "real" escalation). The default value is the value given in the ESCALATION keyword used in the ENERGY–COST command for electricity.

Examples

To illustrate the use of the ECONOMICS commands and keywords, a series of examples are presented. The examples are for various electricity tariffs commonly found in the United States which, with the exception of COST–PARAMETERS keywords, can be extended to other fuels and utilities.

Example 1:

The most basic tariff is a uniform-charge levied on all units consumed in a month. For this example, all kilowatt-hours cost $.05 and there is a monthly customer charge of $15.00. The minimum bill is $17.00 and there are no demand charges.

```
ENERGY–COST
  RESOURCE=ELECTRICITY            $ THIS IS A REQUIRED KEYWORD $
  UNIT = 3413.                    $ THIS IS THE DEFAULT VALUE $
  UNIFORM–COST = .05
  MIN–MONTHLY–CHG = 17.
  MONTH–CHG1 = 15.    ..
```

::

Example 2:

Although block rates have been used for years, many of them now incorporate marginal-cost and equity-related concerns. A recent example of the latter, currently in wide usage among residential customers, are inverted block rates. The basic idea is that increased consumption is discouraged by increased per unit costs. A simple inverted block has three tiers. In this example, the first 500 kWh of consumption (sometimes referred to as a "baseline" or "lifeline" quantity) are charged at $.0535 per kWh. All kWh consumed in excess of 500 kWh, but less than 900 kWh, are charged at $.0725 per kWh. The third tier covers all consumption in excess of 900 kWh at a charge of $.1245 per kWh. There is no seasonal variation in this rate and we will ignore minimum and fixed monthly charges in this example.

```
ENERGY–COST
  RESOURCE = ELECTRICITY                   $ THIS KEYWORD IS REQUIRED $
  ASSIGN–CHARGE = (INVBLK)    ..

INVBLK = CHARGE–ASSIGNMENT
  RESOURCE = ELECTRICITY                   $ THIS KEYWORD IS REQUIRED $
  TYPE = ENERGY                            $ THIS IS THE DEFAULT VALUE $
  BLOCK–RANGE = (500,400,10000000)         $ THE SECOND ENTRY IS THE
                                           $ SIZE OF THE "NEXT" BLOCK
                                           $ AND THE THIRD IS JUST
                                           $ SOME LARGE NUMBER $

  BLOCK–CHARGE = (.0535,.0725,.1245)    ..
```

Example 3:
Most utilities are faced with demands for electricity that are not evenly distributed throughout the year. They reflect the fact that changing levels of demand result in differing costs of service by introducing seasonal variations in the rates for electricity. These variations may have different size blocks associated with them, as well. In this next example, there is a winter season that lasts from October to May and a summer season that lasts from June to September. This utility is winter-peaking, but recognizes the need for increased lifeline allowances at this time of year.

```
ENERGY-COST
  RESOURCE = ELECTRICITY
  ASSIGN-SCHEDULE = TWOSEASON    ..

WINTERBLK = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  BLOCK-RANGE = (1000,1000000)          $ SECOND ENTRY
                                        $ IS A BIG NUMBER $
  BLOCK-CHARGE = (.07,.10)   ..

SUMMERBLK = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  BLOCK-RANGE = (500,1000000)
  BLOCK-RANGE = (.06,.09)   ..

WINTERDY = DAY-CHARGE-SCH
  (1,24) (WINTERBLK)   ..

SUMMERDY = DAY-CHARGE-SCH
  (1,24) (SUMMERBLK)   ..

TWOSEASON = SCHEDULE
  THRU MAY 31  (ALL)  WINTERDY          $ NOTE NESTING
  THRU SEP 30  (ALL)  SUMMERDY          $ OF WEEK-SCHEDULE $
  THRU DEC 31  (ALL)  WINTERDY   ..
```

Example 4:
Some block rate structures partition energy use by blocks, whose size is determined by demands (kW). There may also be instances where it is not clear which such schedule of charges to apply because this decision is determined by, say, the kW demand, which is not yet known. In this example, the OVER–BLOCK–RANGE is used to decide which schedule to use and BLOCK–UNITs are used to set the actual charges. For this utility, a demand greater than 50 kW means using one schedule of charges, while a demand of less than or equal to 50 kW requires using another. The schedules are identical in the manner in which the blocks are sized, but the charges differ.

	≤ 50 kW	> 50kW	
first 1000 kWh	.050	.060	$/kWh
next 4000 kWh	.045	.055	
next 200 kWh per kW demand	.040	.050	
all remaining kWh	.035	.045	

```
ENERGY–COST
  RESOURCE = ELECTRICITY
  ASSIGN–CHARGE = (KWHKWBLOCK) ..
KWHKWBLOCK = CHARGE–ASSIGNMENT
  RESOURCE = ELECTRICITY   TYPE = DEMAND
    OVER–BLOCK–RANGE = 50                  $ THIS SAYS TO USE THE
                                           $ FOLLOWING CHARGES WHEN
                                           $ DEMAND IS LESS THAN 50 KW
      BLOCK–UNIT = ENERGY
      BLOCK–RANGE = (1000,4000)
      BLOCK–CHARGE = (.05,.045)
      BLOCK–UNIT = KWH/KW
      BLOCK–RANGE = (200,1000000)          $ THE SECOND ENTRY IS
                                           $ JUST SOME LARGE NUMBER
    BLOCK–CHARGE = (.040,.035)
    OVER–BLOCK–RANGE = 1000000             $ ANOTHER LARGE NUMBER
                                           $ INDICATING THAT DEMANDS
                                           $ WILL BE GREATER THAN THE
                                           $ PREVIOUS ONE FOR THIS SET
                                           $ OF CHARGES
      BLOCK–UNIT = ENERGY
      BLOCK–RANGE = (1000,4000)
      BLOCK–CHARGE = (.06,.055)
      BLOCK–UNIT = KWH/KW
      BLOCK–RANGE = (200,1000000)
      BLOCK–CHARGE = (.050,.045)    ..
```

Note in this example that, if the demand to be used in determining the size of the third block is the billing demand not the measured demand, the following command must be included:

```
COST–PARAMETERS
  KWH/KW–DEM–TYPE = BILLING    $ DEFAULT VALUE IS MEASURED $   ..
```

Example 5:
The most significant difference between residential and commercial electricity tariffs is the inclusion of demand charges. Typically, the highest measured demand (integrated over some fraction of an hour) is compared against a "ratchet" chosen or calculated from some set of previous highest demands and the larger of the two is taken to be the billing demand. These tariffs can also include rate limitation features to ensure that when the charges are all totaled the effective rate per kWh is less than or equal to a specified amount. We first present an example in which the ratchet is taken to be 90% of the highest demand recorded in the previous 12 months and the charge is $12.00 per kW. There is a flat charge on energy of $.05 per kWh but in no circumstance can the effective rate (i.e., including the demand charges) exceed $.07 per kWh.

```
ENERGY–COST
  RESOURCE = ELECTRICITY
  RATE–LIMITATION = .07
  ASSIGN–CHARGE = (HIDEMAND)   ..

HIDEMAND = CHARGE–ASSIGNMENT
  RESOURCE = ELECTRICITY
  TYPE = ENERGY
    UNIFORM–CHARGE = .05
  TYPE = DEMAND
    UNIFORM–CHARGE = 12.00   ..

COST–PARAMETERS
  DEM–RATCHET–T1 = HIGHEST
  DEM–PERIOD–T1  = WHOLE–YEAR
  DEM–RATCHET–FRC1 = .90   ..
```

We can alter this example by specifying the ratchet to be the average of the two highest demands in the previous twelve simply by substituting codewords in the COST–PARAMETERS command as follows:

```
COST–PARAMETERS
  DEM–RATCHET–T1 = AVERAGE
  DEM–PERIOD–T1  = WHOLE–YEAR
  DEM–AVERAGE–MON1 = 2  ..
```

Example 6:
The most recent innovation in rate design has been the introduction of time-of-use rates wherein the time of day, week, and year that energy is consumed get broken into different costing periods and have different charges assigned to them. The charges, moreover, can be for demand and energy and for each of these the definition of the periods can change. In this example, there is a winter and summer season, for each season an on-peak, and off-peak period for each weekday, and only off-peak on Saturday, Sunday and holidays. There is no demand ratchet but there are two demand charge periods corresponding to the the month in each season.

```
ENERGY-COST
  RESOURCE = ELECTRICITY
  ASSIGN-SCHEDULE = TIMEOFUSE   ..

WINDEM = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 1                          $ FOR THIS EXAMPLE
  C-A-LINK = SUMDEM                   $ WINTER=1 SUMMER=2 $
  TYPE = DEMAND
  UNIFORM-CHARGE = 5.00   ..

WINOFF = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 1                          $ C-A-LINK ONLY FOR DEMANDS $
  TYPE = ENERGY                       $ NOT NEEDED FOR THIS C-A $
  UNIFORM-CHARGE = .04   ..

WINON = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 1
  TYPE = ENERGY                       $ ENERGY IS THE DEFAULT VALUE
  UNIFORM-CHARGE = .06   ..

SUMDEM = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 2
  C-A-LINK = WINDEM
  TYPE = DEMAND
  UNIFORM-CHARGE = 15.00   ..

SUMOFF = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 2
  TYPE = ENERGY
  UNIFORM-CHARGE = .05   ..

SUMON = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 2
  TYPE = ENERGY
  UNIFORM-CHARGE = .07   ..
```

```
WINWEEKDY = DAY–CHARGE–SCH
  (1,8)      (WINOFF,WINDEM)
  (9,22)     (WINON,WINDEM)
  (23,24)    (WINOFF,WINDEM)    ..

WINWKND = DAY–CHARGE–SCH
  (1,24)     (WINOFF,WINDEM)    ..

SUMWEEKDY = DAY–CHARGE–SCH
  (1,8)      (SUMOFF,SUMDEM)
  (9,20)     (SUMON,SUMDEM)
  (21,24)    (SUMOFF,SUMDEM)    ..

SUMWKND = DAY–CHARGE–SCH
  (1,24)     (SUMOFF,SUMDEM)    ..

TIMEOFUSE = SCHEDULE
  THRU MAY 15     (WD)     WINWEEKDY
                  (WEH)    WINWKND
  THRU SEP 15     (WD)     SUMWEEKDY
                  (WEH)    SUMWKND
  THRU DEC 31     (WD)     WINWEEKDY
                  (WEH)    WINWKND    ..
```

We now modify the time-of-day example by substituting a DAY–CHARGE–SCH that has shoulder- or partial-peak periods in addition to on- and off-peak periods. For this sub-example, we ignore the specification of the corresponding CHARGE–ASSIGNMENTs beyond mention of the U-name in the DAY–CHARGE–SCH command.

```
WWKDY = DAY–CHARGE–SCH
  (1,8)      WOFF
  (9,16)     WPAR
  (17,20)    WON
  (21,22)    WPAR        $ WPAR IS WINTER PARTIAL PEAK  $
  (23,24)    WOFF  ..

WWKND = DAY–CHARGE–SCH
  (1,24)     WOFF  ..
SWKDY = DAY–CHARGE–SCH
  (1,8)      SOFF
  (9,12)     SPAR
  (13,17)    SON
  (18,21)    SPAR        $ SPAR IS SUMMER PARTIAL PEAK $
  (22,24)    SOFF  ..
SWKND = DAY–CHARGE–SCH
  (1,24) SOFF     ..

TIME–OF–DAY = SCHEDULE
  THRU MAY 15    (WD)    WWKDY    (WEH)    WWKND
  THRU SEP 15    (WD)    SWKDY    (WEH)    SWKND
  THRU DEC 31    (WD)    WWKDY    (WEH)    WWKND    ..
```

Example 7:
The Public Utilities Regulatory Policy Act (PURPA) guaranteed on-site generators of electricity fair and equitable access to the utility grid for the purpose of either selling or buying electricity. The Act also mandated that the revenues from the sale of power could be valued in two ways. The first option, called Net-Sale, has the utility purchase only power generated in excess of on-site requirements, while the facility is only billed for electricity required when the on-site requirements exceed the capacity of the on-site generators. The second option, called Simultaneous Buy/Sell, has the utility purchase the full output of the generators (as though this output were dumped directly into the grid), while the facility is billed for the entire amount of electricity consumed on-site (as though there were no generators on-site). Further, utilities were directed to offer payments reflecting the capacity value of the generators. In this example, the simultaneous buy/sell option has been chosen because the utility is currently paying more for electricity it purchases ($.08/kWh) than it charges for what it sells (we will use the time-of-day prices in the previous example). A contract has also been signed with the utility for $80./kW guaranteeing that the cogenerator's capacity of 1 MW will always be available to the utility during the on-peak hours (see Example 3 in the **PLANT EQUIPMENT OPERATION MODES** section, starting on p. 4.1, of this Supplement).

```
ENERGY-COST
  RESOURCE = ELECTRICITY
  ASSIGN-SCHEDULE = TIMEOFUSE         $ SEE EXAMPLE 6 $      ..

COST-PARAMETERS
  ELEC-SALES-OPT = SIM-BUY/SELL
  ELEC-SALES-ASG = SELLELEC
  CAPACITY-PAYMENT = 80000.           $ 1 MW * 80 = 80000. $  ..

SELLELEC = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  TYPE = ENERGY
  UNIFORM-CHARGE = .08   ..
```

ECONOMICS

Error, Warning, and Caution Messages

Error Message (1) — SCHEDULE FOR <u-name> HAS HOURS UNACCOUNTED FOR.

Meaning: If ASSIGN–SCHEDULE is to be used, all hours of the RUN–PERIOD must have a CHARGE–ASSIGNMENT associated with them via a DAY–CHARGE–SCH.

User-Action: Specify a CHARGE–ASSIGNMENT for the missing hours.

Error Message (2) — RESOURCE <codeword> IN CHARGE–ASSIGNMENT <u-name> DOES NOT MATCH FUEL TYPE.

Meaning: Either the RESOURCE is mis-specified or the CHARGE–ASSIGNMENT is for a different fuel or utility.

User-Action: Ensure that the RESOURCE matches the fuel or utility that the CHARGE–ASSIGNMENT is to be used for.

Error Message (3) — INCONSISTENT UNITS FOR BLOCKS IN OVER–BLOCK–RANGE <value> IN CHARGE–ASSIGNMENT <u-name>.

Meaning: When there are two sets of BLOCKS in an OVER–BLOCK–RANGE, the units must be consistent. KWH/KW and ENERGY are consistent, but DEMAND is consistent only with itself.

User-Action: Check BLOCK–UNITS in the OVER–BLOCK–RANGE for consistency.

Error Message (4) — MUST ENTER ELEC–SALES–ASG OR ELEC–SALES–SCH FOR ELECTRICITY SALES.

Meaning: If there is a possibility of electricity sales to the utility (ELEC–SALES–OPT = NET–SALE or SIM–BUY/SELL), then a CHARGE–ASSIGNMENT for sales must be entered and accessed through ELEC–SALES–ASG or ELEC–SALES–SCH.

User-Action: Enter a CHARGE–ASSIGNMENT for electricity sales and access it through ELEC–SALES–ASG or ELEC–SALES–SCH.

Warning Message (1) — PLANT UTILITY <codeword> NOT ENTERED - DEFAULTS ASSUMED.

Meaning: A fuel or utility used in the previous PLANT run was not entered with an ENERGY–COST command in this ECONOMICS run. The default values for UNIT, UNIFORM–COST, and ESCALATION will be used.

User-Action:	Enter an ENERGY—COST command for this resource, if values other than the defaults are to be used.
Warning Message (2)	TOO MANY CHARGE—ASSIGNMENTS FOR <codeword> <u-name> WILL BE IGNORED.
Meaning:	Up to six CHARGE—ASSIGNMENTs may be used with each fuel or utility, additional ones will be ignored.
User-Action:	Restrict number of CHARGE—ASSIGNMENTs to six.
Warning Message (3)	ASSIGN—CHARGE OR ASSIGN—SCHEDULE FOR <codeword> INCOMPATIBLE WITH UNIFORM—COST - WILL BE IGNORED.
Meaning:	Within the ENERGY—COST command a RESOURCE may have a UNIFORM—COST or CHARGE—ASSIGNMENT(s) via ASSIGN—CHARGE or ASSIGN—SCHEDULE, but not both. The UNIFORM-COST will be used.
User-Action:	Remove the UNIFORM—COST, if the ASSIGN—CHARGE or ASSIGN—SCHEDULE keyword is to be used.
Warning Message (4)	RAN OUT OF OVER—BLOCK—RANGES IN CHARGE-ASSIGNMENT <u-name> - NO CHARGE WILL BE ASSESSED.
Meaning:	The value being used to determine which OVER—BLOCK—RANGE is to be used for assessing charges exceeds the value of the largest OVER—BLOCK—RANGE. No charges are assessed.
User-Action:	Increase the value of the largest OVER—BLOCK—RANGE.
Warning Message (5)	NOT ENOUGH BLOCKS IN OVER-BLOCK-RANGE <value> IN CHARGE—ASSIGNMENT <u-name> - ADDITIONAL USAGE WILL NOT BE INCLUDED IN CHARGES.
Meaning:	For this OVER—BLOCK—RANGE, the quantity being charged extends beyond the range of the BLOCKS. The additional usage will have no charge associated with it.
User-Action:	Increase the value of the last block.
Caution Message (1)	UTILITY <codeword> NOT USED IN PLANT - WILL BE IGNORED.
Meaning:	An ENERGY—COST command is entered for a RESOURCE that was not used by the previous PLANT run.
User-Action:	Either remove the ENERGY—COST command or enter the RESOURCE in the PLANT run with an ENERGY—RESOURCE command.

APPENDIX A

HOURLY–REPORT VARIABLE LIST

Appendix A

LOADS

VARIABLE–TYPE = GLOBAL

Variable-List Number	Variable in FORTRAN Code	Description
1	CLRNES	Clearness number
2	TGNDR	Ground temperature (Rankine)
3	WBT	Outside wet-bulb temperature (°F)
4	DBT	Outside dry-bulb temperature (°F)
5	PATM	Atmospheric pressure (in. Hg)
6	CLDAMT	Cloud amount, 0 to 10
7	ISNOW	Snow flag (1 = snowfall); not used in simulation
8	IRAIN	Rain flag (1 = rainfall); not used in simulation
9	IWNDDR	Wind direction (0-15) (see table, RM Chap. III, Sec. B.3)
10	HUMRAT	Humidity ratio (lb H_2O/lb air)
11	DENSTY	Air density (lb/ft^3)
12	ENTHAL	Specific enthalpy of air (Btu/lb)
13	DIFSOL	Diffuse horizontal solar radiation from the weather file; zero when no solar on weather file (Btu/hr-ft^2). [Used only in France]
14	DIRSOL	Direct normal solar radiation from the weather file; zero when no solar on weather file (Btu/hr-ft^2)
15	SOLRAD	Total horizontal solar radiation from the weather file (Btu/hr-ft^2)
16	ICLDTY	Cloud type (0, 1, or 2) (see table, RM, Chap. III, Sec. B.3)
17	WNDSPD	Wind speed (knots) (°F)
18	DPT	Dew-point temperature (°F) only for design days, otherwise, zero
19	WNDDRR	Wind direction in radians (clockwise from North)
20	CLDCOV	Cloud cover multiplier (fraction of sky covered by cloud; 0 to 1)
21	RDNCC	Clear day direct normal solar radiation times CLDCOV; if solar tape, then set equal to DIRSOL (Btu/hr-ft^2)
22	BSCC	Clear day diffuse solar radiation on a horizontal surface times CLDCOV (Btu/hr-ft^2)
23	*UNUSED*	*Formerly: "Heat lost by horizontal exterior wall to sky"*
24	DBTR	Drybulb temperature (Rankine)
25	ISUNUP	Sun up flag (= 1 if sun is up; = 0 if down)
26	GUNDOG	Hour angle of sunrise for the day (radians)
27	HORANG	Current hour angle (radians)
28	TDECLN	Tangent of solar declination angle
29	EQTIME	Value of the solar equation of time (hr)
30	SOLCON	Direct normal extraterrestrial solar radiation (Btu/hr-ft^2)

LOADS

VARIABLE–TYPE = GLOBAL (continued)

Variable-List Number	Variable in FORTRAN Code	Description
31	ATMEXT	Atmospheric extinction coefficient
32	SKYDFF	Sky diffusivity factor
33	RAYCOS(1)	Solar direction cosine (x)
34	RAYCOS(2)	Solar direction cosine (y)
35	RAYCOS(3)	Solar direction cosine (z)
36	RDN	Direct normal solar radiation intensity on a clear day [calculated] (Btu/hr-ft^2)
37	BSUN	Diffuse solar intensity on a horizontal surface on a clear day [calculated] (Btu/hr-ft^2)
38	IYR	Year
39	IMON	Month
40	IDAY	Day
41	IHR	Hour (local time; with Daylight Saving Time if appropriate)
42	IDOY	Day of year (1-365)
43	IDOW	Day of week (1-7)
44	ISCHR	Schedule hour (DST corrected, IHR + IDSTF)
45	ISCDAY	Schedule day (Day of week; 1 = Sunday, 2 = Monday, ..., 8 = Holiday)
46	IDSTF	Daylight saving time flag (1 if daylight saving in effect, 0 if not)
47	PTWV	Pressure caused by wind velocity (inches of water)
48	ATMTUR(IMO)	Atmospheric turbidity factor according to Angstrom
49	ATMMOI(IMO)	Atmospheric moisture (inches of precipitable water)
50	PHSUND	Solar altitude (degrees above horizon)
51	THSUND	Solar azimuth (degrees) measured clockwise from North
52	ETACLD	Cloudiness factor; ranges from 0 for overcast sky to 1.0 for clear sky
53	CHISKF	Exterior horizontal illuminance from clear part of sky (footcandles)

LOADS

VARIABLE–TYPE = GLOBAL (continued)

Variable-List Number	Variable in FORTRAN Code	Description
54	OHISKF	Exterior horizontal illuminance from overcast part of sky (footcandles)
55	HISUNF	Exterior horizontal illuminance from direct sun (footcandles).
56	ALFAD	Ratio of exterior horizontal illuminance calculated from measured insolation to exterior horizontal illuminance calculated from theoretical CIE sky luminance distributions
57	CDIRLW	Luminance efficacy of direct solar radiation (lumens/watt)
58	CDIFLW	Luminance efficacy of diffuse solar radiation from clear part of sky (lumens/watt)
59	ODIFLW	Luminance efficacy of diffuse solar radiation from overcast part of sky (lumens/watt)

LOADS

VARIABLE–TYPE = BUILDING

For each hour, entries are summed for all spaces with a heating load that hour and appear in BLDDTH (1-18), VARIABLE–LIST numbers 1-18; similarly, entries are summed for all zones with a cooling load and appear in BLDDTC (1-18), VARIABLE–LIST numbers 19-36. For example, if a building has three spaces, S1, S2, and S3, and for a given hour, S1 and S2 each have a net heating load, and S3 has a net cooling load, then: (1) the sensible heating load for S1 and S2 appears in VARIABLE–LIST number 1, the latent heating load appears in VARIABLE–LIST number 2, etc.; (2) the sensible cooling load for S3 appears in VARIABLE–LIST number 19, the latent cooling load for S3 appears in VARIABLE–LIST number 20, etc. All loads are in Btu/hr, including electric. "Sensible load" is heat extraction from space air required to maintain constant air temperature; "sensible loads" are obtained from corresponding instantaneous heat gains by application of weighting factors that account for heat storage and release by building mass. "Walls" below are exterior surfaces with tilt $\geq 45^\circ$; "roofs" are exterior surfaces with tilt $< 45^\circ$. (All gains and loads reported here are calculated at **constant space air temperatures**. Corrections for variable space temperature are made in the SYSTEMS calculation.)

LOADS

VARIABLE–TYPE = BUILDING

Variable-List Number	Variable in FORTRAN Code	Description
1	BLDDTH(1)	Building heating load (sensible)
2	BLDDTH(2)	Building heating load (latent)
3	BLDDTH(3)	Building heating load from wall conduction
4	BLDDTH(4)	Building heating load from roof conduction
5	BLDDTH(5)	Building heating load from window conduction
6	BLDDTH(6)	Building heating load from solar radiation through windows
7	BLDDTH(7)	Building sensible heating load from infiltration
8	BLDDTH(8)	Building heating load from interior wall conduction
9	BLDDTH(9)	Building heating load from conduction through underground walls and floors
10	BLDDTH(10)	Building lighting heating load
11	BLDDTH(11)	Building heating load from doors
12	BLDDTH(12)	Building equipment (electrical) heating load (sensible)
13	BLDDTH(13)	Building source heating load (sensible)
14	BLDDTH(14)	Building people heating load (sensible)
15	BLDDTH(15)	Building people heating load (latent)

LOADS

VARIABLE–TYPE = BUILDING (continued)

Variable-List Number	Variable in FORTRAN Code	Description
16	BLDDTH(16)	Building equipment (electrical) heating load (latent)
17	BLDDTH(17)	Building source heating load (latent)
18	BLDDTH(18)	Building infiltration heating load (latent)
19	BLDDTC(1)	Building cooling load (sensible)
20	BLDDTC(2)	Building cooling load (latent)
21	BLDDTC(3)	Building cooling load from wall conduction
22	BLDDTC(4)	Building cooling load from roof conduction
23	BLDDTC(5)	Building cooling load from window conduction
24	BLDDTC(6)	Building cooling load from solar radiation through windows
25	BLDDTC(7)	Building cooling sensible infiltration load
26	BLDDTC(8)	Building cooling load from conduction through interior walls
27	BLDDTC(9)	Building cooling load from conduction through underground walls and floors
28	BLDDTC(10)	Building lighting cooling load
29	BLDDTC(11)	Building cooling load from door conduction
30	BLDDTC(12)	Building equipment (electrical) cooling load (sensible)
31	BLDDTC(13)	Building source cooling load (sensible)
32	BLDDTC(14)	Building people cooling load (sensible)
33	BLDDTC(15)	Building people cooling load (latent)
34	BLDDTC(16)	Building equipment (electrical) load cooling (latent)
35	BLDDTC(17)	Building source cooling load (latent)
36	BLDDTC(18)	Building infiltration cooling load (latent)
37	QBELEC	Building electric total
38	QBGAS	Building gas total
39	QBHW	Building hot water total
40	QBEQEL	Building equipment electric total

LOADS

VARIABLE–TYPE = BUILDING (continued)

Variable-List Number	Variable in FORTRAN Code	Description
41	QBLTEL	Building light electric total
42	QBELR	Building electric from BUILDING–RESOURCE command
43	QBGASR	Building gas from BUILDING–RESOURCE command
44	QBHWR	Building hot water from BUILDING–RESOURCE command
45	QBELV	Building electric from elevators (included in No. 37, but not in No. 40)

LOADS

VARIABLE–TYPE = u-name of SPACE

All space gains and loads are in Btu/hr, including electric. "Sensible gain" means the instantaneous heat gain before application of weighting factors. "Sensible load" is the heat extraction from space air required to maintain constant air temperature; "loads" are obtained from corresponding gains by application of weighting factors that account for heat storage and release by building mass. "Walls" below are exterior surfaces with tilt greater than or equal to 45°; "roofs" are exterior surfaces with tilt less than 45°. (All sensible gains and loads reported here are calculated at **constant space air temperatures**. Corrections for variable space temperature are made in the SYSTEMS calculation.)

LOADS

VARIABLE–TYPE = u-name of SPACE

Variable-List Number	Variable in FORTRAN Code	Description
1	QWALQ	Quick wall conduction gain
2	QCELQ	Quick roof conduction gain
3	QWINC	Window conduction gain
4	QWALD	Delayed wall conduction gain
5	QCELD	Delayed roof conduction gain
6	QINTW	Interior wall conduction gain
7	QUGF	Underground floor conduction gain
8	QUGW	Underground wall conduction gain
9	QDOOR	Door conduction gain
10	QEQPS	Electrical equipment sensible gain
11	QEQPS2	Source sensible gain
12	QPPS	People sensible gain
13	QTSKL	Task light gain
14	QSOL	Glass solar gain
15	QPLENUM	Light heat gain to return air
16	QWALD	Quick wall conduction load
17	QCELQ	Quick roof conduction load
18	QWINC	Window conduction load
19	QWALD	Delayed wall conduction load
20	QCELD	Delayed roof conduction load

LOADS

VARIABLE–TYPE = u-name of SPACE (continued)

Variable-List Number	Variable in FORTRAN Code	Description
21	QINTW	Interior wall conduction load
22	QUGF	Underground floor conduction load
23	QUGW	Underground wall conduction load
24	QDOOR	Door conduction load
25	QEQPS	Equipment sensible load
26	QEQPS2	Source sensible load
27	QPPS	People sensible load
28	QPPL	People latent gain
29	QEQPL	Equipment latent gain
30	QEQPL2	Source latent gain
31	QINFL	Infiltration latent gain
32	QTSKL	Task lighting load
33	QSOL	Glass solar load
34	ZLTOTH	Light heat gain to other space
35	QLITE	Light gain
36	QLITEW	Light load
37	QINFS	Infiltration sensible gain
38	QELECT	Electric load for space
39	CFMINF	Infiltration flowrate (cfm)
40	QSUMW	Sum of all weighted loads except infiltration and latent
41	ZCOND	Space conductance (Btu/hr-°F)
42	QZS	Space sensible load
43	QZL	Space latent load
44	QZTOT	Space total load
45	QZLTEL	Space electric from lights

LOADS

VARIABLE–TYPE = u-name of SPACE (continued)

Variable-List Number	Variable in FORTRAN Code	Description
46	QZEQEL	Space electric from equipment
47	QZGAS	Space gas
48	QZHW	Space hot water
49	RDAYIL(1)	Daylight illuminance at LIGHT–REF–POINT1 (footcandles)
50	RDAYIL(2)	Daylight illuminance at LIGHT–REF–POINT2 (footcandles)
51	BACLUM(1)	Background luminance (footlamberts) for glare calculation at LIGHT–REF–POINT1.
52	BACLUM(2)	Background luminance (footlamberts) for glare calculation at LIGHT–REF–POINT2.
53	GLRNDX(1)	Daylight glare index at LIGHT–REF–POINT1 calculated after window management (if any) has been employed as a response to MAX–GLARE, MAX–SOLAR–SCH, and/or CONDUCT–TMIN–SCH.
54	GLRNDX(2)	Daylight glare index at LIGHT–REF–POINT2 calculated after window management (if any) has been employed as a response to MAX–GLARE, MAX–SOLAR–SCH, and/or CONDUCT–TMIN–SCH.
55	FPHRP(1)	Multiplier, due to daylighting, on electric lighting power for the lighting zone at LIGHT–REF–POINT1 (varies from 1.0 if no lighting energy reduction to 0.0 if lighting energy reduced to zero).
56	FPHRP(2)	Multiplier, due to daylighting, on electric lighting power for the lighting zone at LIGHT–REF–POINT2 (varies from 1.0 if no lighting energy reduction to 0.0 if lighting energy reduced to zero).
57	<POWER–RED–FAC>	Net multiplier, due to daylighting, on electric lighting power for the entire space (= FPHRP(1) * ZONE–FRACTION1 + FPHRP(2) * ZONE–FRACTION2 + [1- (ZONE–FRACTION1) – (ZONE–FRACTION2)]).

LOADS

VARIABLE–TYPE = u-name of EXTERIOR–WALL

Variable-List Number	Variable in FORTRAN Code	Description
1	SOLI	Total solar radiation on wall (direct and diffuse) after shading (Btu/hr-ft^2)
2	XGOLGE	Fraction of the wall that is shaded from direct solar radiation
3	FILMU	Outside air film U-value (Btu/hr-ft^2-°F)
4	PCO	Pressure difference across wall caused by wind velocity and stack effect (in. of water)
5	Q	Heat transfer from the wall to the zone, unweighted (Btu/hr)
6	T	Outside surface temperature for delayed walls (Rankine)
7	CFM	Crack method air flow for wall (cfm)
8	C2	Used in response factor determination of Q and T for delayed walls
9	C3	
10	SUMXDT	
11	SUMYDT	
12	DT	
13	XSXCMP	
14	XSQCMP	
15	ETA	Cosine of the angle between the direction of the sun and the surface outward normal
16	BG	Solar radiation reflected from ground (Btu/hr-ft^2) [total horizontal solar radiation × ground reflectance]
17	RDIR	Intensity of direct solar radiation on the surface, *before* shading (Btu/hr-ft^2)
18	RDIF	Intensity of diffuse solar radiation on the surface, *after* shading (Btu/hr-ft^2)

VARIABLE–TYPE = u-name of WINDOW

Except as noted, the following variables are applicable to both exterior windows (WINDOW in EXTERIOR–WALL) and interior windows (WINDOW in INTERIOR–WALL between a sunspace and a non-sunspace).

LOADS

VARIABLE–TYPE = u-name of WINDOW

Variable-List Number	Variable in FORTRAN Code	Description
1	UW	Net overall window U-value (glass U-value multiplied by CONDUCT–SCHEDULE if defined; includes inside and outside film coefficients of the glass) (Btu/hr-ft^2-$^\circ$F).
2	TDIR	Direct radiation transmission coefficient of all panes of glass in window.
3	ADIRO	Direct radiation absorption coefficient (outer pane(s)).
4	TDIF	Net diffuse radiation transmission coefficient of all panes of glass in window.
5	ADIFO	Diffuse radiation absorption coefficient (outer pane(s)).
6	ADIRI	Direct radiation absorption coefficient (inner pane(s)).
7	ADIFI	Diffuse radiation absorption coefficient (inner pane(s)).
8	FI	Inward flowing fraction of heat from solar radiation absorbed by inner pane(s).
9	FO	Inward flowing fraction of heat from solar radiation absorbed by outer pane(s).
10	AGOLGE	Fraction of window area that is shaded from direct solar radiation. [Exterior WINDOW only]
11	QDIR	Direct solar radiation incident on window (after shading by setback, overhang, etc.), divided by total window area (Btu/hr-ft^2).
12	QDIF	Diffuse solar radiation incident on window (after shading by setback, overhang, etc.) divided by total window area (Btu/hr-ft^2).

LOADS

VARIABLE–TYPE = u-name of WINDOW (continued)

Variable-List Number	Variable in FORTRAN Code	Description
13	QTRANS	Direct and diffuse solar energy transmitted through glass (after shading by setback, overhang, etc.) divided by total window area (Btu/hr-ft^2), before multiplication by glass shading coefficient, if applicable, and by SHADING–SCHEDULE value. [Exterior WINDOW only]
14	QABS	Direct and diffuse solar energy absorbed by glass (after shading by setback, overhang, etc.), and conducted into the space, divided by total window area (Btu/hr-ft^2), before multiplication by glass shading coefficient, if applicable, and by SHADING-SCHEDULE value. [Exterior WINDOW only]
15	QSOLG+QABSG	Heat gain by solar radiation through window (after shading by setback, overhang, etc.), (Btu/hr): For exterior WINDOW: (QTRANS+QABS) * (window area) * (shading coefficient of glass) * (SHADING–SCHEDULE value if defined and shade is in place). [Shading coefficient multiplier is 1.0 if GLASS–TYPE–CODE is used.]
16	GSHACO	Shading coefficient of glass; 1.0 if GLASS–TYPE–CODE is used
17	QCON–QABSG	Conduction heat gain through window (Btu/hr): = UW * (window area) * (outside DBT - zone temp) – (exterior IR radiation correction) [exterior WINDOW only; for interior WINDOWs, see Variable #58, VARIABLE–TYPE = ZONE, in SYSTEMS program.]
18	CFMW	Crack method infiltration air flow through window (Btu/hr). [Exterior WINDOW only]
19	SHMULT	Value by which shading-coefficient of glazing is multiplied when window is covered by a shading device. Determined by SHADING–SCHEDULE.
20	SOLGMX	Transmitted direct solar gain threshold for activation of window shading device (Btu/ft^2). Determined by MAX–SOLAR–SCH.

LOADS

VARIABLE–TYPE = u-name of WINDOW (continued)

Variable-List Number	Variable in FORTRAN Code	Description
21	<VIS–TRANS>	Visible transmittance (at normal incidence) of window glazing (excluding shading device). Given by VIS–TRANS keyword value. [Exterior WINDOW only]
22	TAU1	Value by which visible transmittance of glazing is multiplied when window is covered by a shading device. Determined by VIS–TRANS–SCH. [Exterior WINDOW only]
23	<SHADING–FLAG>	Disposition of window shading device: 0 = no shade assigned to window; 1 = shade assigned but open this hour; 2 = shade assigned and closed this hour due to solar-gain, outside-drybulb-temperature, or glare test, or for daylit spaces, because WIN–SHADE–TYPE = FIXED–INTERIOR or FIXED–EXTERIOR; 3 = shade assigned and closed this hour but no solar-gain, outside-drybulb-temperature, or glare test requested (preset schedule control).
24	$\langle$ILLUMW$\rangle_1$	Contribution of window to daylight illuminance at LIGHT–REF–POINT1 with no shading device on window (footcandles). [Exterior WINDOW only]
25	$\langle$ILLUMW$\rangle_2$	Contribution of window to daylight illuminance at LIGHT–REF–POINT2 with no shading device on window (footcandles). [Exterior WINDOW only]
26	$\langle$ILLUMW$\rangle_3$	Contribution of window to daylight illuminance at LIGHT–REF–POINT1 with window covered by shading device (footcandles). [Exterior WINDOW only]
27	$\langle$ILLUMW$\rangle_4$	Contribution of window to daylight illuminance at LIGHT–REF–POINT2 with window covered by shading device (footcandles). [Exterior WINDOW only]

LOADS

VARIABLE–TYPE = u-name of DOOR

Variable-List Number	Variable in FORTRAN Code	Description
1	FILMU	Outside air film U-value (Btu/hr-ft^2-°F)
2	DRGOLG	Fraction of door shaded from direct solar radiation
3	SOLID	Solar radiation on door (ft^2-°F)
4	TSOLD	Outside surface temperature (°R)
5	QD	Heat flow through door (Btu/hr-ft^2-°F)
6	CFMD	Crack method infiltration air flow (cfm)

SYSTEMS

VARIABLE–TYPE = GLOBAL

Variable-List Number	Variable in FORTRAN Code	Description
1	IYR	Year of simulation run
2	IMO	Month of simulation run
3	IDAY	Day of simulation run
4	IHR	Hour of simulation run
5	ISCDAY	Day-of-the-week for simulation run: 1-7 = Sunday through Saturday 8 = holiday
6	ISCHR	Current hour of simulation run plus daylight saving time flag (hour of schedule to be used)
7	WBT	Outdoor wet-bulb temperature (°F)
8	DBT	Outdoor dry-bulb temperature (°F)
9	PATM	Outdoor atmospheric pressure (in-Hg)
10	HUMRAT	Outdoor humidity ratio (lb H_20/lb dry air)
11	DENSTY	Outdoor air density (lb/ft^3)
12	ENTHAL	Outdoor air enthalpy (Btu/lb)

The above variables are appropriate to all SYSTEM–TYPEs

SYSTEMS

VARIABLE–TYPE = u-name of ZONE

Variable-List Number	Variable in FORTRAN Code	Description
1	<QS>	Sensible load at constant temp - from LOADS (Btu/hr)
2	<QL>	Latent load at constant temp, excluding infiltration - from LOADS (Btu/hr)
3	<ZKW>	Zone electrical load - from LOADS (kW)
4	<QP>	Light heat to return air - from LOADS (Btu/hr)
5	<CFMINF>	Outdoor air infiltration rate from LOADS (cfm)
6	<TNOW>	Current hour zone temp (°F)
7	<TSET>	Current hour zone thermostat setting - a diagnostic variable that is not meaningful when <TNOW> is not within HEAT–TEMP–SCH or COOL–TEMP–SCH throttling range (°F)
8	<QNOW>	Current hour heat extraction rate - a diagnostic variable that is not meaningful when <TNOW> is not within HEAT–TEMP–SCH or COOL–TEMP–SCH throttling range (Btu/hr); excludes heat extraction due to interzone convection across interior wall between sunspace and non-sunspace. For sunspaces, excludes heat extraction due to venting.
9	<CONDUCHR>	Sum of exterior wall + interior wall thermal conductances from LOADS (Btu/hr-°F)
10	Unused	Unused
11	EXCFM	Exhaust air flow rate (cfm)
12	FH	Hot air flow rate (cfm)
13	FC	Cold air flow rate (cfm)
14	CFMZ	Zone design supply air flow rate (cfm)
15	QHBZ	Baseboard heat output to zone (Btu/hr)

SYSTEMS

VARIABLE–TYPE = u-name of ZONE (continued)

Variable-List Number	Variable in FORTRAN Code	Description
16	QOVER	Amount of extra heat extraction needed to hold set point (Btu/hr)
17	THZ	Thermostat set point for heating (°F)
18	TCZ	Thermostat set point for cooling (°F)
19	ERMAX	Maximum heat extraction rate (meaningful) only within the current thermostat band (Btu/hr)
20	ERMIN	Minimum heat extraction rate (meaningful only within the current thermostat band) (Btu/hr)
21	TRY	Trial zone temperature (if no zone coil activity) (°F)
22	FTD	F in temperature variation calculation (TEMDEV subroutine) (Btu/hr)
23	CORINT	A part of the correction in SYSTEMS for the contribution to the zone load due to conduction from adjacent zones (partially calculated in LOADS) (Btu/hr)
24	G0	Air temperature weighting factors (Btu/hr-°F)
25	G1	Air temperature weighting factors (Btu/hr-°F)
26	G2	Air temperature weighting factors (Btu/hr-°F)
27	G3	Air temperature weighting factors (Btu/hr-°F)
28	SIGMAG	G0 + G1 + G2 + G3 (Btu/hr-°F)
29	TL	Induced air temperature for TPIU, FPIU, SZCI (°F)
30	ZQHR	Portion of reheat load that would bring the supply temperature to the zone temperature (Btu/hr)
31	TAVE	The average temperature during this hour (°F) This is the value used for the energy calculation
32	ZQH	Zone coil heating (Btu/hr)
33	ZQC	Zone coil cooling (Btu/hr)

This table is continued on the next page

Note: Variables 34 through 48 apply only to the systems indicated

		TPFC FPFC	HP	UHT	UVT	PTAC	
34	FCHPS (1)	TC	TS	—	TS	TS	Cold deck temp (°F)
35	FCHPS (2)	QH	ZQH	ZQH	ZQH	ZQH	Total + zone heating (Btu/hr)
36	FCHPS (3)	QC	ZQC	—	—	ZQC	Total + zone cooling (Btu/hr)
37	FCHPS (4)	SFKW+RFKW	ZFANKW	ZFANKW	ZFANKW	ZFANKW	Total + zone fan energy (Btu/hr)
38	FCHPS (5)	TM	TM	—	TM	TM	Mixed air temp (°F)
39	FCHPS (6)	WR	TC	—	—	TC	WR = return humidity ratio TC = coil leaving temp
40	FCHPS (7)	WM	WM	—	—	WM	Mixed air humidity ratio (lb H_2O/lb dry air)
41	FCHPS (8)	WCOIL	WCOIL	—	—	WCOIL	Humidity ratio of air leaving cooling coil (lb H_2O/lb dry air)
42	FCHPS (9)	PO	PO	—	PO	PO	Ratio of outside air to total supply air
43	FCHPS(10)	QCLAT	QCLATZ	—	—	QCLATZ	Latent load (Btu/hr)
44	FCHPS(11)	PLRC	PLRC	—	—	PLRC	Cap. part load ratio (clg)
45	FCHPS(12)	—	PLRH	—	—	PLRH	Cap. part load ratio (htg)
46	FCHPS(13)	—	EIR	—	—	EIR	Elec input ratio
47	FCHPS(14)	WBTZ	WBTZ	—	—	WBTZ	Zone wet-bulb temp (°F)
48	FCHPS(15)	—	—	—	—	EIRM3	Supplemental heat load for zone's heat pump this hour (Btu/hr)
49	ACFM						Weighted plenum flowrate (cuft/min)
50	ZKW						Total zone elec (kW)
51	TCMINZ						Minmum supply temperature for zone (°F)
52	THMAXZ						Maximum supply temperature for zone (°F)
53	ERMAXM		All air systems				Extraction rate, top of deadband (Btu/hr)
54	ERMINM		All air systems				Extraction rate, bottom of deadband (Btu/hr)
55	THR		All air systems				(THROTTLING–RANGE)/ 2.0 (°F)

SYSTEMS

VARIABLE–TYPE = u-name of ZONE (continued)

In the following descriptions, "sunspace" is a SPACE with SUNSPACE = YES; and "room" is a SPACE with SUNSPACE = NO (the default) that is adjacent to a sunspace.

Variable-List Number	Variable in FORTRAN Code	Description
56	<SGIW0>	For room only: total heat gain (unweighted) due to solar radiation coming from adjacent sunspaces through interior windows (Btu/hr).
57	<SLIW0>	For room only: total solar load (weighted) through interior windows from all adjacent sunspaces (Btu/hr).
58	QGWIN	For room or sunspace: heat gain by conduction (unweighted) through interior windows (Btu/hr), calculated with the air temperature of the zone in question fixed at the LOADS calculation temperature and actual temperatures for adjacent zones.
59	QSNABT	For room or sunspace: solar radiation absorbed on the sunspace side (opaque part) of interior walls (Btu/hr).
60	QGOPWL	For room or sunspace: heat gain by conduction (unweighted) through opaque part of interior walls (Btu/hr), calculated with the air temperature of the zone in question fixed at the LOADS calculation temperature and actual temperatures for adjacent zones.
61	QGVEC	For room or sunspace: heat extraction from convection across interior wall. For room, includes contribution from fan heat if AIR–FLOW–TYPE = FORCED–RECIRC (Btu/hr).
62	CFMCVT	For room or sunspace: average airflow due to convection across interior wall (cfm).
63	SSFPT	For sunspace only: sum of the power of venting fan (as specified by SS–VENT–KW) and fan moving air across interior wall (as specified by FAN–KW and AIR–FLOW–RATE in WALL–PARAMETERS) (KW).
64	<QGVNT>	For sunspace only: heat extraction due to venting (Btu/hr)

VARIABLES BY SYSTEM–TYPE FOR

VARIABLE–TYPE = u-name of ZONE

V-L No.	1	2	3	4	5	6	7	8	9	10	11
SYSTEM–TYPE	SENSIBLE LOAD –IN	LATENT LOAD –IN	ELEC LOAD –IN	PLENUM LOAD –IN	INFIL. CFM	ZONE TEMP	THERMO-STAT SET-POINT	EXTRAC-TION RATE	TOTAL UA FOR HR	UNUSED	EXH CFM
SUM	A	A	A	A	A	A	A	A	A	N	N
SZRH	A	A	A	A	A	A	A	A	A	N	A
MZS	A	A	A	A	A	A	A	A	A	N	A
DDS	A	A	A	A	A	A	A	A	A	N	A
SZCI	A	A	A	A	A	A	A	A	A	N	A
UHT	A	A	A	A	A	A	A	A	A	N	N
UVT	A	A	A	A	A	A	A	A	A	N	N
FPH	A	A	A	A	A	A	A	A	A	N	N
TPFC	A	A	A	A	A	A	A	A	A	N	A
FPFC	A	A	A	A	A	A	A	A	A	N	A
TPIU	A	A	A	A	A	A	A	A	A	N	A
FPIU	A	A	A	A	A	A	A	A	A	N	A
VAVS	A	A	A	A	A	A	A	A	A	N	A
PIU	A	A	A	A	A	A	A	A	A	N	A
RHFS	A	A	A	A	A	A	A	A	A	N	A
HP	A	A	A	A	A	A	A	A	A	N	A
HVSYS	A	A	A	A	A	A	A	A	A	N	A
CBVAV	A	A	A	A	A	A	A	A	A	N	A
RESYS	A	A	A	A	A	A	A	A	A	N	N
PSZ	A	A	A	A	A	A	A	A	A	N	A
PMZS	A	A	A	A	A	A	A	A	A	N	A
PVAVS	A	A	A	A	A	A	A	A	A	N	A
PTAC	A	A	A	A	A	A	A	A	A	N	N

Legend:
- A = Appropriate
- D = Used for program code debugging only
- N = Not appropriate
- S = System (or configuration) dependent
- X = Unused

VARIABLES BY SYSTEM–TYPE FOR

VARIABLE–TYPE = u-name of ZONE

V-L No.	12	13	14	15	16	17	18	19	20	21	22
SYSTEM-TYPE	HOT DECK CFM	COLD DECK CFM	SUPPLY CFM	BASE BOARD HEATING RATE	LOAD NOT MET	HEATING SET-POINT	COOLING SET-POINT	MAX COOL-ING	MAX HEAT-ING	FLOAT TEMP	F IN TEM-DEV
SUM	N	N	N	A	A	A	A	A	A	A	D
SZRH	N	N	A	A	A	A	A	A	A	A	D
MZS	A	A	A	A	A	A	A	A	A	A	A
DDS	A	A	A	A	A	A	A	A	A	A	D
SZCI	N	N	A	A	A	A	A	A	A	A	D
UHT	A	N	A	A	A	A	A	A	A	A	D
UVT	A	N	A	A	A	A	A	A	A	A	D
FPH	N	N	N	A	A	A	A	A	A	A	D
TPFC	N	N	A	A	A	A	A	A	A	A	D
FPFC	N	N	A	A	A	A	A	A	A	A	D
TPIU	N	N	A	A	A	A	A	A	A	A	D
FPIU	N	N	A	A	A	A	A	A	A	A	D
VAVS	N	N	A	A	A	A	A	A	A	A	D
PIU	N	N	A	A	A	A	A	A	A	A	D
RHFS	N	N	A	A	A	A	A	A	A	A	D
HP	A	A	A	A	A	A	A	A	A	A	D
HVSYS	N	N	A	A	A	A	A	A	A	A	D
CBVAV	N	N	A	A	A	A	A	A	A	A	D
RESYS	N	N	N	A	A	A	A	A	A	A	D
PSZ	N	N	A	A	A	A	A	A	A	A	D
PMZS	A	A	A	A	A	A	A	A	A	A	D
PVAVS	N	N	A	A	A	A	A	A	A	A	D
PTAC	A	A	A	A	A	A	A	A	A	A	D

Legend:
- A = Appropriate
- D = Used for program code debugging only
- N = Not appropriate
- S = System (or configuration) dependent
- X = Unused

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of ZONE

V-L No.	23	24	25	26	27	28	29	30	31	32	33
SYSTEM-TYPE	INT TRAN TO ZONE	TEMDEV VAR G0	TEMDEV VAR G1	TEMDEV VAR G2	TEMDEV VAR G3	TEMDEV SIGMAG	IND UNIT AIR TEMP	HEAT TO ZONE T	COOL TO ZONE T	HEAT ING BY COILS	COOL ING BY COILS
SUM	A	D	D	D	D	D	N	N	N	N	N
SZRH	A	D	D	D	D	D	N	A	N	A	N
MZS	D	D	D	D	D	D	N	N	N	N	N
DDS	A	D	D	D	D	D	N	N	N	N	N
SZCI	A	D	D	D	D	D	N	A	N	A	N
UHT	A	D	D	D	D	D	N	N	N	A	A
UVT	A	D	D	D	D	D	N	N	N	A	A
FPH	A	D	D	D	D	D	N	N	N	A	N
TPFC	A	D	D	D	D	D	N	N	N	A	A
FPFC	A	D	D	D	D	D	N	N	N	A	A
TPIU	A	D	D	D	D	D	A	N	N	A	N
FPIU	A	D	D	D	D	D	A	N	N	A	N
VAVS	A	D	D	D	D	D	N	A	N	A	N
PIU	A	D	D	D	D	D	N	A	N	A	N
RHFS	A	D	D	D	D	D	N	A	N	A	N
HP	A	D	D	D	D	D	N	N	N	A	A
HVSYS	A	D	D	D	D	D	N	A	N	A	N
CBVAV	A	D	D	D	D	D	N	A	N	A	N
RESYS	A	D	D	D	D	D	N	N	N	N	N
PSZ	A	D	D	D	D	D	N	A	N	A	N
PMZS	A	D	D	D	D	D	N	N	N	N	N
PVAVS	A	D	D	D	D	D	N	A	N	A	N
PTAC	A	D	D	D	D	D	N	N	N	A	A

Legend:
- A = Appropriate
- D = Used for program code debugging only
- N = Not appropriate
- S = System (or configuration) dependent
- X = Unused

VARIABLES BY SYSTEM–TYPE FOR

VARIABLE–TYPE = u-name of ZONE

V-L No.	34	35	36	37	38	39	40	41	42	43	44
SYSTEM-TYPE	UNIT SUP TEMP	UNIT HEAT-ING	UNIT COOL-ING	UNIT FAN KW	UNIT MIX TEMP	UNIT WR or TC	UNIT MIX HUM	UNIT COIL HUM	UNIT OA-RATIO	UNIT LAT COOL	UNIT COOL PLR
SUM	N	N	N	N	N	N	N	N	N	N	N
SZRH	N	N	N	N	N	N	N	N	N	N	N
MZS	N	N	N	N	N	N	N	N	N	N	N
DDS	N	N	N	N	N	N	N	N	N	N	N
SZCI	N	N	N	N	N	N	N	N	N	N	N
UHT	A	A	A	A	A	S	A	A	A	A	A
UVT	A	A	A	A	A	S	A	A	A	A	A
FPH	N	N	N	N	N	N	N	N	N	N	N
TPFC	A	A	A	A	A	S	A	A	A	A	A
FPFC	A	A	A	A	A	S	A	A	A	A	A
TPIU	N	N	N	N	N	N	N	N	N	N	N
FPIU	N	N	N	N	N	N	N	N	N	N	N
VAVS	N	N	N	N	N	N	N	N	N	N	N
PIU	N	N	N	N	N	N	N	N	N	N	N
RHFS	N	N	N	N	N	N	N	N	N	N	N
HP	A	A	A	A	A	A	A	A	A	A	A
HVSYS	N	N	N	N	N	N	N	N	N	N	N
CBVAV	N	N	N	N	N	N	N	N	N	N	N
RESYS	N	N	N	N	N	N	N	N	N	N	N
PSZ	N	N	N	N	N	N	N	N	N	N	N
PMZS	N	N	N	N	N	N	N	N	N	N	N
PVAVS	N	N	N	N	N	N	N	N	N	N	N
PTAC	A	A	A	A	A	S	A	A	A	A	A

Legend:
- A = Appropriate
- D = Used for program code debugging only
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- S = System (or configuration) dependent
- X = Unused

VARIABLES BY SYSTEM-TYPE FOR

VARIABLE-TYPE = u-name of ZONE

V-L No.	45	46	47	48	49	50	51	52	53	54	55
SYSTEM-TYPE	UNIT HEAT PLR	UNIT EIR	UNIT WET BULB	UNIT DE-FROST	WEIGHTED CFM	TOT ELEC	MIN COOL T	MAX HEAT T	DEAD BAND MAX EXTR	DEAD BAND MIN EXTR	THROT OVER TWO
SUM	N	N	N	N	N	A	N	N	N	N	N
SZRH	N	N	N	N	A	A	A	A	A	A	A
MZS	N	N	N	N	A	A	A	A	A	A	A
DDS	N	N	N	N	A	A	A	A	A	A	A
SZCI	N	N	N	N	A	A	A	A	A	A	A
UHT	A	A	A	N	N	A	A	A	A	A	A
UVT	A	A	A	N	N	A	A	A	A	A	A
FPH	N	N	N	N	N	A	N	N	N	N	N
TPFC	A	A	A	N	N	A	A	A	A	A	A
FPFC	A	A	A	N	N	A	A	A	A	A	A
TPIU	N	N	N	N	A	A	A	A	A	A	A
FPIU	N	N	N	N	A	A	A	A	A	A	A
VAVS	N	N	N	N	A	A	A	A	A	A	A
PIU	N	N	N	N	A	A	A	A	A	A	A
RHFS	N	N	N	N	A	A	A	A	A	A	A
HP	A	A	A	A	N	A	A	A	A	A	A
HVSYS	N	N	N	N	A	A	A	A	A	A	A
CBVAV	N	N	N	N	A	A	A	A	A	A	A
RESYS	N	N	N	N	N	A	A	A	A	A	A
PSZ	N	N	N	N	A	A	A	A	A	A	A
PMZS	N	N	N	N	A	A	A	A	A	A	A
PVAVS	N	N	N	N	A	A	A	A	A	A	A
PTAC	A	A	A	A	N	A	A	A	A	A	A

Legend:
- A = Appropriate
- D = Used for program code debugging only
- N = Not appropriate
- S = System (or configuration) dependent
- X = Unused

VARIABLES BY SYSTEM–TYPE FOR

VARIABLE–TYPE = u-name of ZONE

V-L No.	56	57	58	59	60	61	62	63	64	
SYSTEM-TYPE	COM WIN SOL GAIN BTU/HR	COM WIN SOL LOAD BTU/HR	COM WIN CON-DUC-TION BTU/HR	COM WIN ABSD SOL BTU/HR	COM WALL CON-DUC-TION BTU/HR	CON-VEC HEAT GAIN BTU/HR	CON-VEC AIR FLOW CFM	SUN-SPACE FAN PWR KW	SUN-SPACE VENT FLOW CFM	
SUM	A	A	A	A	A	A	A	A	A	A
SZRH	A	A	A	A	A	A	A	A	A	A
MZS	A	A	A	A	A	A	A	A	A	A
DDS	A	A	A	A	A	A	A	A	A	A
SZCI	A	A	A	A	A	A	A	A	A	A
UHT	A	A	A	A	A	A	A	A	A	A
UVT	A	A	A	A	A	A	A	A	A	A
FPH	A	A	A	A	A	A	A	A	A	A
TPFC	A	A	A	A	A	A	A	A	A	A
FPFC	A	A	A	A	A	A	A	A	A	A
TPIU	A	A	A	A	A	A	A	A	A	A
FPIU	A	A	A	A	A	A	A	A	A	A
VAVS	A	A	A	A	A	A	A	A	A	A
PIU	A	A	A	A	A	A	A	A	A	A
RHFS	A	A	A	A	A	A	A	A	A	A
HP	A	A	A	A	A	A	A	A	A	A
HVSYS	A	A	A	A	A	A	A	A	A	A
CBVAV	A	A	A	A	A	A	A	A	A	A
RESYS	A	A	A	A	A	A	A	A	A	A
PSZ	A	A	A	A	A	A	A	A	A	A
PMZS	A	A	A	A	A	A	A	A	A	A
PVAVS	A	A	A	A	A	A	A	A	A	A
PTAC	A	A	A	A	A	A	A	A	A	A

Legend:
A = Appropriate
D = Used for program code debugging only
N = Not appropriate
S = System (or configuration) dependent
X = Unused

SYSTEMS

VARIABLE–TYPE = u-name of SYSTEM

Variable-List Number	Variable in FORTRAN Code	Description
1	TH	Temperature of air leaving heating coil - hot deck temp (°F)
2	TC	Temperature of air leaving cooling coil - cold deck temp (°F)
3	TM	Temperature of air entering coil (°F)
4	TR	Return air temperature on the downstream side of the return fan and plenums (°F)
5	QH	Total central heating coil energy input (Btu/hr)
6	QC	Total central cooling coil energy input (Btu/hr)
7	QHZ	Total zone heating energy input (Btu/hr)
8	QCZ	Total zone cooling energy input (Btu/hr). Note: For SYSTEM–TYPE = RESYS this is the cooling and cooling by natural ventilation (excluding sunspace ventilation)
9	QHB	Total baseboard heating energy input (Btu/hr)
10	QHP	Total preheat coil energy input (Btu/hr)
11	QHUM	Humidification energy input (electrical resistance heat load for RESYS) (Btu/hr)
12	QDHUM	Sensible dehumidification reheat input (defrost load for RESYS) (Btu/hr)
13	TCMIN	Minimum temperature air handler could supply (°F)
14	THMAX	Maximum temperature air handler could supply (°F)
15	QLSUM	Total system latent heat load from LOADS (Btu/hr)
16	QPSUM	Total system light heat to return (Btu/hr)
17	CFM	Total system supply air flow rate (cfm)
18	CFMH	Total system hot supply air flow rate (DDS, MZS, PMZS) (cfm)
19	CFMC	Total system cold supply air flow rate (DDS, MZS, PMZS) (cfm)
20	RCFM	Total system return air flow rate (cfm)
21	ECFM	Total system exhaust air flow rate (cfm)
22	CINF	Outside air infiltration rate (cfm)
23	FON	Fan on/off flag (1 = on, 0 = off, − 1 = cannot cycle on for NIGHT–CYCLE–CTRL)
24	HON	Heating on/off flag (1 = on, 0 = off)
25	CON	Cooling on/off flag (1 = on, 0 = off)

SYSTEMS

VARIABLE–TYPE = u-name of SYSTEM (continued)

Variable-List Number	Variable in FORTRAN Code	Description
26	BON	Baseboard heater on-off flag (ratio from RESET–SCHEDULE)
27	CONS(1)	in the equation Q = CONS(1) * CFM * ΔT CONS(1) = (.24 + standard conditions
28	CONS(2)	in the equation CONS(2) = 1061.0 * 60.0/V(DBT, HUMRAT, PATM) = 4790. at standard conditions
29	CONS(3)	in the equation CONS(3) = .3996/CONS(1) = .363 at standard conditions
30	PH	For dual duct systems: Ratio of hot duct cfm to total cfm
31	PC	For dual duct systems: Ratio of cold duct cfm to total cfm
32	SKW	Hourly total electrical consumption (kW)
33	FANKW	Total of supply fan, return fan, and exhaust fan electrical consumption (kW)
34	DTREC	Makeup air temperature obtainable from recovery system (°F)
35	WR	Return air humidity ratio (lb H_2O/lb dry air)
36	WM	Mix air humidity ratio (lb H_2O/lb dry air)
37	WCOIL	Humidity ratio of air leaving cooling coil (lb H_2O/lb dry air)
38	WW	Moisture added or removed from air for (de)humidification (lb H_2O/lb dry air)
39	PO	Ratio of outside air to total supply air
40	D	Density of air x 60 min/hr (lb/ft^3 x min/hr)
41	FTEMP	Temperature of circulating fluid for HP system (°F)
42	TCR	Effect of controller on cooling coil set point (°F)
43	QHR	Adjusted capacity of heat pump this hour for RESYS and PTAC (Btu/hr)
44	QCR	Unused
45	SGAS	Total gas heating (Btu/hr)
46	SKWQH	Electrical input to heating (kW)
47	SKWQC	Electrical input to cooling (kW)
48	QCLAT	Latent part of total cooling (Btu/hr)
49	SFKW	Supply fan electrical (kW)
50	RFKW	Return fan electrical (kW)

SYSTEMS

VARIABLE–TYPE = u-name of SYSTEM (continued)

Variable-List Number	Variable in FORTRAN Code	Description
51	FONNGT	If system cycled on at night, = − 1 for heating, = 0 for no cycle, = +1 for cooling
52	WSURF	Humidity ratio at saturation at coil surface temperature
53	WSURFM	WSURF for coil temperature TSURFM
54	TSURF	coil surface temperature at supply set point (°F)
55	TSURFM	Minimum obtainable surface temp for humidity control (°F)
56	CBF	Coil bypass factor: (COIL–BF) * CBF1 * CBF2
57	CBF1	Temperature correction to COIL–BF
58	CBF2	Cfm correction to COIL–BF
59	SOIL	Oil consumption by system (Btu/hr)
60	PLRCFM	(Current hour cfm)/(design cfm)
61	PLRC	Capacity part load ratio for cooling
62	PLRH	Capacity part load ratio for heating
63	QCM1	Temperature correction to COOLING–CAPACITY
64	QCM2	Temperature correction to COOL–SH–CAP
65	QHM1	Temperature correction to HEATING–CAPACITY
66	EIRM1	Temperature correction to COOLING–EIR
67	EIRM2	Part load correction to COOLING–EIR
68	EIR	(COOLING–EIR) * EIRM1 * EIRM2 (Btu/Btu)
69	OFKW	Outside fan power (kW)
70	QCT	Total cooling capacity (Btu/hr)
71	QCS	Sensible cooling capacity (Btu/hr)
72	WRMAX	Maximum humidity set point (lbs. water/lbs. air)
73	WRMIN	Minimum humidity set point (lbs. water/lbs. air)
74	CFMRAT	Maximum ratio of zone cfm that can be obtained this hour (mainly for COINCIDENT-sized fans)
75	PCH	For DDS, MZS, and PMZS the current hour value of HCOIL–WIPE–FCFM. For RESYS the value of 1. indicates venting and the value of 0. indicates no venting

SYSTEMS

VARIABLE–TYPE = u-name of SYSTEM (continued)

Variable-List Number	Variable in FORTRAN Code	Description
76	unused	
77	unused	
78*	QHT	The total heating capacity (Btu/hr)
79*	TPOMIN	The mixed air temperature for minimum OA damper position (°F)
80*	POMIN	The minimum OA damper position (°F)
81	QHSUP	For RESYS, PSZ, and PTAC, the total supplemental heat load (Btu/hr)
82	QRSENS	Sensible heat gain to zone from refrigerated casework (PSZ only) (Btu/hr)
83	QRLAT	Latent heat gain to zone from refrigerated casework (PSZ only) (Btu/hr)
84	QRREC	Energy recovered from condenser and used for space heating in heat recovery mode (PSZ only) (Btu/hr)
85	QRREJ	Energy rejected from condenser (PSZ only) (Btu/hr)
86	RCOMKW	Electrical energy consumed by compressors (PSZ only) (kW)
87	RDEFKW	Electrical energy consumed by defrosters (PSZ only) (kW)
88	RAUXKW	Electrical energy consumed by lights, fans, and anti-sweat heaters in refrigerated casework (PSZ only) (kW)
89	ECFMP	Plenum exhaust flow rate (cfm)
90	SCGAS	Gas used for cooling (Btu/hr)

*These variables do not apply to SUM, FPH, or any zonal SYSTEM–TYPE.

SYSTEMS

VARIABLE–TYPE = u-name of SYSTEM (continued)

Variable-List Number	Variable in FORTRAN Code	Description
		91 through 111 are used by PTGSD only
91	QREG	Regeneration energy (Btu/hr)
92	WBR	Return air wet bulb temperature (°F)
93	WB8	Wet bulb entering direct evaporative cooler (°F)
94	T8	Dry bulb entering direct evaporative cooler (°F)
95	W8	Humidity ratio entering direct evaporative cooler (lb H_2O/lb dry air)
96	WB9	Supply air wet bulb (°F)
97	T9	Supply air dry bulb (°F)
98	W9	Supply air humidity ratio (lb H_2O/lb dry air)
99	EFF	Direct evaporative cooler effectiveness
100	DTON	Fraction of hour on
101-107	DMODE(7)	Operating mode flag (for debugging only)
108	ERMAX4	Maximum extraction rate mode 4
109	ERMAX5	Maximum extraction rate mode 5
110	ERMAX6	Maximum extraction rate mode 6
111	OPMODE	Operating mode

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No.	1	2	3	4	5	6	7	8	9	10
SYSTEM-TYPE	HTG COIL AIR TEMP	CLG COIL AIR TEMP	MIX AIR TEMP	RET AIR TEMP	TOT HTG COIL BTU	TOT CLG COIL BTU	TOT ZONE HTG BTU	TOT ZONE CLG BTU	TOT BASE-BOARD ENERGY	TOT PRE-HEAT ENERGY
SUM	N	N	N	N	A	A	N	N	N	N
SZRH	N	A	A	A	A	A	A	A	A	A
MZS	A	A	A	A	A	A	N	N	A	A
DDS	A	A	A	A	A	A	N	N	A	A
SZCI	N	A	A	A	A	A	A	A	A	A
UHT	N	N	N	N	A	A	A	N	A	N
UVT	N	N	N	N	A	A	A	N	A	N
FPH	N	N	N	N	A	N	A	N	A	N
TPFC	N	N	N	N	A	A	A	A	A	N
FPFC	N	N	N	N	A	A	A	A	A	N
TPIU	N	A	A	A	A	A	A	A	A	A
FPIU	N	A	A	A	A	A	A	A	A	A
VAVS	N	A	A	A	A	A	A	A	A	A
PIU	N	A	A	A	A	A	A	A	A	A
RHFS	N	A	A	A	A	A	A	A	A	A
HP	N	N	N	N	A	A	A	A	A	N
HVSYS	A	N	A	A	A	N	A	N	A	A
CBVAV	N	A	A	A	A	A	A	A	A	A
RESYS	A	A	A	A	A	A	A	A	A	A
PSZ	N	A	A	A	A	A	A	A	A	A
PMZS	A	A	A	A	A	A	N	N	A	A
PVAVS	N	A	A	A	A	A	A	A	A	A
PTAC	A	N	N	N	A	A	A	A	A	N
PTGSD	N	D	A	A	A	A	N	N	A	N

Legend:
A = Appropriate
D = Used for program code debugging only
N = Not appropriate
S = System (or configuration) dependent
X = Unused

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No.	11	12	13	14	15	16	17	18	19	20
SYSTEM-TYPE	HUMIDCN HEAT-ING	DE HUMID RE-HEAT	MIN SUP T	MAX SUP T	SUM ZONE LAT HEAT	SUM ZONE PLN HEAT	TOT SYS CFM	TOT HOT CFM	TOT COLD CFM	RET CFM
SUM	N	N	N	N	A	A	N	N	N	N
SZRH	A	A	A	A	A	A	A	N	N	A
MZS	A	A	A	A	A	A	A	A	A	A
DDS	A	A	A	A	A	A	A	A	A	A
SZCI	A	A	A	A	A	A	A	N	N	A
UHT	N	N	N	N	N	N	N	N	N	N
UVT	N	N	N	N	N	N	N	N	N	N
FPH	N	N	N	N	N	N	N	N	N	N
TPFC	A	A	N	N	N	N	N	N	N	N
FPFC	A	A	N	N	N	N	N	N	N	N
TPIU	A	A	A	A	A	A	A	N	N	A
FPIU	A	A	A	A	A	A	A	N	N	A
VAVS	A	A	A	A	A	A	A	N	N	A
PIU	A	A	A	A	A	A	A	N	N	A
RHFS	A	A	A	A	A	A	A	N	N	A
HP	N	N	N	N	N	N	N	N	N	N
HVSYS	A	N	A	A	A	A	A	N	N	A
CBVAV	A	A	A	A	A	A	A	N	N	A
RESYS	S	S	A	A	A	A	A	N	N	N
PSZ	A	A	A	A	A	A	A	N	N	A
PMZS	A	A	A	A	A	A	A	A	A	A
PVAVS	A	A	A	A	A	A	A	N	N	A
PTAC	N	N	N	N	N	N	N	N	N	N
PTGSD	N	N	A	A	A	A	A	N	N	A

Legend:
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VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No. SYSTEM-TYPE	21 EX-HAUST CFM	22 IN-FIL CFM	23 FANS ON/ OFF	24 HEAT ON/ OFF	25 COOL ON/ OFF	26 BASE-BOARD SCH RATIO	27 CON-STANT (1.08)	28 CON-STANT (.689)	29 CON-STANT (.363)	30 HOT AIR FRAC-TION
SUM	N	A	A	A	A	N	N	N	N	N
SZRH	A	A	A	A	A	A	A	A	A	N
MZS	A	A	A	A	A	A	A	A	A	A
DDS	A	A	A	A	A	A	A	A	A	A
SZCI	A	A	A	A	A	A	A	A	A	N
UHT	N	N	A	A	A	A	A	A	A	N
UVT	N	N	A	A	A	A	A	A	A	N
FPH	N	N	N	A	N	A	N	N	N	N
TPFC	N	N	A	A	A	A	A	A	A	N
FPFC	N	N	A	A	A	A	A	A	A	N
TPIU	A	A	A	A	A	A	A	A	A	N
FPIU	A	A	A	A	A	A	A	A	A	N
VAVS	A	A	A	A	A	A	A	A	A	N
PIU	A	A	A	A	A	A	A	A	A	N
RHFS	A	A	A	A	A	A	A	A	A	N
HP	N	N	A	A	A	A	A	A	A	N
HVSYS	A	A	A	A	A	A	A	A	A	N
CBVAV	A	A	A	A	A	A	A	A	A	N
RESYS	N	A	A	A	A	A	A	A	A	N
PSZ	A	A	A	A	A	A	A	A	A	N
PMZS	A	A	A	A	A	A	A	A	A	A
PVAVS	A	A	A	A	A	A	A	A	A	N
PTAC	N	N	A	A	A	A	A	A	A	N
PTGSD	A	A	A	A	N	A	A	A	A	N

Legend:
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VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No.	31	32	33	34	35	36	37	38	39	40
SYSTEM-TYPE	COLD AIR FRAC	TOTAL ELEC KW	TOTAL FAN ELEC	DELTA T RE-COV	RET HUMID	MIX HUMID	HUMID-ITY LVG COIL	MOIST CHANGE	OUT-SIDE/ TOT CFM	DENSITY (AIR*60)
SUM	N	A	N	N	N	N	N	N	N	N
SZRH	N	A	A	A	A	A	A	A	A	A
MZS	A	A	A	A	A	A	A	A	A	A
DDS	A	A	A	A	A	A	A	A	A	A
SZCI	N	A	A	A	A	A	A	A	A	A
UHT	N	A	A	N	N	N	N	N	N	N
UVT	N	A	A	N	N	N	N	N	N	N
FPH	N	A	N	N	N	N	N	N	N	N
TPFC	N	A	A	N	N	N	N	N	N	N
FPFC	N	A	A	N	N	N	N	N	N	N
TPIU	N	A	A	A	A	A	A	A	A	A
FPIU	N	A	A	A	A	A	A	A	A	A
VAVS	N	A	A	A	A	A	A	A	A	A
PIU	N	A	A	A	A	A	A	A	A	A
RHFS	N	A	A	A	A	A	A	A	A	A
HP	N	A	A	N	N	N	N	N	N	N
HVSYS	N	A	A	A	A	A	A	A	A	A
CBVAV	N	A	A	A	A	A	A	A	A	A
RESYS	N	A	A	N	N	A	A	A	N	N
PSZ	N	A	A	A	A	A	A	A	A	A
PMZS	A	A	A	A	A	A	A	A	A	A
PVAVS	N	A	A	A	A	A	A	A	A	A
PTAC	N	A	A	N	N	N	N	N	N	N
PTGSD	N	A	A	N	A	A	A	A	A	A

Legend:
A = Appropriate
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N = Not appropriate
S = System (or configuration) dependent
X = Unused

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No.	41	42	43	44	45	46	47	48	49	50
SYSTEM-TYPE	TEMP OF FLUID	COOL— CTR EFFECT	QHR	QCR	HEAT-ING GAS	HEAT-ING ELEC	COOL-ING ELEC	LATENT COOL-ING	SPLY ELEC	RET ELEC
SUM	N	N	N	N	A	A	N	N	N	N
SZRH	N	A	A	N	A	A	A	A	A	A
MZS	N	A	N	N	A	A	A	A	A	A
DDS	N	A	N	N	A	A	A	A	A	A
SZC	N	A	A	N	A	A	A	A	A	A
UHT	N	N	N	N	A	A	N	N	N	N
UVT	N	N	N	N	A	A	N	N	N	N
FPH	N	N	N	N	N	A	N	N	N	N
TPFC	N	N	N	N	A	A	N	A	N	N
FPFC	N	N	N	N	A	A	N	A	N	N
TPIU	N	A	N	N	A	A	N	A	A	A
FPIU	N	A	N	N	A	A	N	A	A	A
VAVS	N	A	A	N	A	A	N	A	A	A
PIU	N	A	A	N	A	A	N	A	A	A
RHFS	N	A	A	N	A	A	N	A	A	A
HP	A	N	N	N	N	A	A	A	A	N
HVSYS	N	N	N	N	A	A	N	N	A	A
CBVAV	N	A	A	N	A	A	N	A	A	A
RESYS	N	N	N	N	A	A	A	A	A	N
PSZ	N	A	A	N	A	A	A	A	A	A
PMZS	N	A	A	N	A	A	A	A	A	A
PVAVS	N	A	A	N	A	A	A	A	A	A
PTAC	N	N	N	N	A	A	A	A	N	N
PTGSD	N	A	N	N	A	N	N	A	A	A

Legend:
A = Appropriate
D = Used for program code debugging only
N = Not appropriate
S = System (or configuration) dependent
X = Unused

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No.	51	52	53	54	55	56	57	58	59	60
SYSTEM-TYPE	CYCLE ON/H OFF/C	SUR-FACE HUMID ITY	SUR-FACE MIN HUM	SUR-FACE TEMP	SUR-FACE MIN TEMP	BY-PASS FAC-TOR	CBF F (WB, DB)	CBF F CFM	HEAT-ING OIL	PLR CFM
SUM	A	N	N	N	N	N	N	N	A	N
SZRH	A	A	A	A	A	A	A	A	A	A
MZS	A	A	A	A	A	A	A	A	A	A
DDS	A	A	A	A	A	A	A	A	A	A
SZC	A	A	A	A	A	A	A	A	A	A
UHT	A	N	N	N	N	N	N	N	A	N
UVT	A	N	N	N	N	N	N	N	A	N
FPH	A	N	N	N	N	N	N	N	A	N
TPFC	A	N	N	N	N	N	N	N	A	N
FPFC	A	N	N	N	N	N	N	N	A	N
TPIU	A	A	A	A	A	A	A	A	A	A
FPIU	A	A	A	A	A	A	A	A	A	A
VAVS	A	A	A	A	A	A	A	A	A	A
PIU	A	A	A	A	A	A	A	A	A	A
RHFS	A	A	A	A	A	A	A	A	A	A
HP	A	N	N	N	N	N	N	N	A	N
HVSYS	A	N	N	N	N	N	N	N	A	N
CBVAV	A	A	A	A	A	A	A	A	A	A
RESYS	A	A	A	A	A	A	A	A	A	A
PSZ	A	A	A	A	A	A	A	A	A	A
PMZS	A	A	A	A	A	A	A	A	A	A
PVAVS	A	A	A	A	A	A	A	A	A	A
PTAC	A	N	N	N	N	N	N	N	A	N
PTGSD	A	N	N	N	N	N	N	N	N	A

Legend:
A = Appropriate
D = Used for program code debugging only
N = Not appropriate
S = System (or configuration) dependent
X = Unused

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No.	61	62	63	64	65	66	67	68	69	70
SYSTEM-TYPE	PLR COOL-ING	PLR HEAT-ING	COOL—CAP F (WB, DB)	COOL—SH F (WB, DB)	HEAT—CAP F (TEMP)	EIR F (WB, DB)	EIR F (PLR)	EIR FAN KW	OUT-SIDE CAPA-CITY	COOL-ING
SUM	N	N	N	N	N	N	N	N	N	N
SZRH	A	N	A	A	N	N	N	N	N	A
MZS	A	N	A	A	N	N	N	N	N	A
DDS	A	N	A	A	N	N	N	N	N	A
SZC	A	N	A	A	N	N	N	N	N	A
UHT	N	N	N	N	N	N	N	N	N	N
UVT	N	N	N	N	N	N	N	N	N	N
FPH	N	N	N	N	N	N	N	N	N	N
TPFC	N	N	N	N	N	N	N	N	N	N
FPFC	N	N	N	N	N	N	N	N	N	N
TPIU	A	N	A	A	N	N	N	N	N	A
FPIU	A	N	A	A	N	N	N	N	N	A
VAVS	A	N	A	A	N	N	N	N	N	A
PIU	A	N	A	A	N	N	N	N	N	A
RHFS	A	N	A	A	N	N	N	N	N	A
HP	N	N	N	N	N	N	N	N	N	N
HVSYS	N	N	N	N	N	N	N	N	N	A
CBVAV	A	N	A	A	N	N	N	N	N	A
RESYS	A	A	A	A	A	A	A	A	A	A
PSZ	A	N	A	A	N	A	A	A	A	A
PMZS	A	N	A	A	N	A	A	A	A	A
PVAVS	A	N	A	A	N	A	A	A	A	A
PTAC	N	N	N	N	N	N	N	N	N	A
PTGSD	N	N	N	N	N	N	N	N	N	A

Legend:
- A = Appropriate
- D = Used for program code debugging only
- N = Not appropriate
- S = System (or configuration) dependent
- X = Unused

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No.	71	72	73	74	75	76	77	78	79	80
SYSTEM-TYPE	SEN-SIBLE CAPA-CITY	MAX-HUMD SET-POINT	MIN-HUMD SET-POINT	VAV MAX CFM RATE	ITEM 75	NOT USED	NOT USED	HEAT-ING CAPA-CITY	TEMP AT MIN OA	MIN OA EST
SUM	N	N	N	N	N	X	X	N	N	N
SZRH	A	A	A	A	N	X	X	A	A	A
MZS	A	A	A	A	S	X	X	A	A	A
DDS	A	A	A	A	S	X	X	A	A	A
SZCI	A	A	A	N	N	X	X	A	A	A
UHT	N	N	N	N	N	X	X	N	N	N
UVT	N	N	N	N	N	X	X	N	N	N
FPH	N	N	N	N	N	X	X	N	N	N
TPFC	N	N	N	N	N	X	X	N	N	N
FPFC	N	N	N	N	N	X	X	N	N	N
TPIU	A	A	A	N	N	X	X	A	A	A
FPIU	A	A	A	N	N	X	X	A	A	A
VAVS	A	A	A	A	N	X	X	A	A	A
PIU	A	A	A	A	N	X	X	A	A	A
RHFS	A	A	A	A	N	X	X	A	A	A
HP	N	N	N	N	N	X	X	N	N	N
HVSYS	A	A	A	N	N	X	X	A	A	A
CBVAV	A	A	A	N	N	X	X	A	A	A
RESYS	A	A	A	N	A	X	X	N	N	N
PSZ	A	A	A	A	N	X	X	A	A	A
PMZS	A	A	A	A	S	X	X	A	A	A
PVAVS	A	A	A	A	N	X	X	A	A	A
PTAC	A	A	A	N	N	X	X	N	N	N
PTGSD	A	A	N	N	N	X	X	N	N	A

Legend:
A = Appropriate
N = Not appropriate
S = System (or configuration) dependent
X = Unused

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No.	81	82	83	84	85	86	87	88
SYSTEM-TYPE-	HP SUPP HEAT	REFG ZONE SENS HT	REFG ZONE LAT HT	REFG SYS REC HT	REFG SYS REJ HT	REFG SYS COMP KW	REFG SYS DEF KW	REFG SYS AUX KW
SUM	N	N	N	N	N	N	N	N
SZRH	N	N	N	N	N	N	N	N
MZS	N	N	N	N	N	N	N	N
DDS	N	N	N	N	N	N	N	N
SZC	N	N	N	N	N	N	N	N
UHT	N	N	N	N	N	N	N	N
UVT	N	N	N	N	N	N	N	N
FPH	N	N	N	N	N	N	N	N
TPFC	N	N	N	N	N	N	N	N
FPFC	N	N	N	N	N	N	N	N
TPIU	N	N	N	N	N	N	N	N
FPIU	N	N	N	N	N	N	N	N
VAVS	N	N	N	N	N	N	N	N
PIU	N	N	N	N	N	N	N	N
RHFS	N	N	N	N	N	N	N	N
HP	N	N	N	N	N	N	N	N
HVSYS	N	N	N	N	N	N	N	N
CBVAV	N	N	N	N	N	N	N	N
RESYS	A	N	N	N	N	N	N	N
PSZ	A	A	A	A	A	A	A	A
PMZS	N	N	N	N	N	N	N	N
PVAVS	N	N	N	N	N	N	N	N
PTAC	A	N	N	N	N	N	N	N
PTGSD	N	N	N	N	N	N	N	N

Legend:
- A = Appropriate
- D = Used for program code debugging only
- N = Not appropriate
- S = System (or configuration) dependent
- X = Unused

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No.	89	90	91	92	93	94
SYSTEM-TYPE-	PLEN EXH FLOW RATE	COOL GAS	REGEN POWER	RETURN WB TEMP	WB8	T8
SUM	N	N	N	N	N	N
SZRH	A	N	N	N	N	N
MZS	A	N	N	N	N	N
DDS	A	N	N	N	N	N
SZC	A	N	N	N	N	N
UHT	N	N	N	N	N	N
UVT	N	N	N	N	N	N
FPH	N	N	N	N	N	N
TPFC	N	N	N	N	N	N
FPFC	N	N	N	N	N	N
TPIU	A	N	N	N	N	N
FPIU	A	N	N	N	N	N
VAVS	A	N	N	N	N	N
PIU	A	N	N	N	N	N
RHFS	A	N	N	N	N	N
HP	N	N	N	N	N	N
HVSYS	A	N	N	N	N	N
CBVAV	A	N	N	N	N	N
RESYS	N	N	N	N	N	N
PSZ	A	N	N	N	N	N
PMZS	A	N	N	N	N	N
PVAVS	A	N	N	N	N	N
PTAC	N	N	N	N	N	N
PTGSD	A	N	A	A	A	A

Legend:
A = Appropriate
D = Used for program code debugging only
N = Not appropriate
S = System (or configuration) dependent
X = Unused

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No.	95	96	97	98	99	100	101	102	103
SYSTEM-TYPE	W8	WB9	T9	W9	EFF	DTON	MODE1	MODE2	MODE3
SUM	N	N	N	N	N	N	N	N	N
SZRH	N	N	N	N	N	N	N	N	N
MZS	N	N	N	N	N	N	N	N	N
DDS	N	N	N	N	N	N	N	N	N
SZC	N	N	N	N	N	N	N	N	N
UHT	N	N	N	N	N	N	N	N	N
UVT	N	N	N	N	N	N	N	N	N
FPH	N	N	N	N	N	N	N	N	N
TPFC	N	N	N	N	N	N	N	N	N
FPFC	N	N	N	N	N	N	N	N	N
TPIU	N	N	N	N	N	N	N	N	N
FPIU	N	N	N	N	N	N	N	N	N
VAVS	N	N	N	N	N	N	N	N	N
PIU	N	N	N	N	N	N	N	N	N
RHFS	N	N	N	N	N	N	N	N	N
HP	N	N	N	N	N	N	N	N	N
HVSYS	N	N	N	N	N	N	N	N	N
CBVAV	N	N	N	N	N	N	N	N	N
RESYS	N	N	N	N	N	N	N	N	N
PSZ	N	N	N	N	N	N	N	N	N
PMZS	N	N	N	N	N	N	N	N	N
PVAVS	N	N	N	N	N	N	N	N	N
PTAC	N	N	N	N	N	N	N	N	N
PTGSD	A	A	A	A	A	A	A	A	A

Legend:
- A = Appropriate
- D = Used for program code debugging only
- N = Not appropriate
- S = System (or configuration) dependent
- X = Unused

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of SYSTEM

V-L No.	104	105	106	107	108	109	110	111
SYSTEM-TYPE	MODE4	MODE5	MODE6	MODE7	ERMAX4	ERMAX5	ERMAX6	MODE4
SUM	N	N	N	N	N	N	N	N
SZRH	N	N	N	N	N	N	N	N
MZS	N	N	N	N	N	N	N	N
DDS	N	N	N	N	N	N	N	N
SZC	N	N	N	N	N	N	N	N
UHT	N	N	N	N	N	N	N	N
UVT	N	N	N	N	N	N	N	N
FPH	N	N	N	N	N	N	N	N
TPFC	N	N	N	N	N	N	N	N
FPFC	N	N	N	N	N	N	N	N
TPIU	N	N	N	N	N	N	N	N
FPIU	N	N	N	N	N	N	N	N
VAVS	N	N	N	N	N	N	N	N
PIU	N	N	N	N	N	N	N	N
RHFS	N	N	N	N	N	N	N	N
HP	N	N	N	N	N	N	N	N
HVSYS	N	N	N	N	N	N	N	N
CBVAV	N	N	N	N	N	N	N	N
RESYS	N	N	N	N	N	N	N	N
PSZ	N	N	N	N	N	N	N	N
PMZS	N	N	N	N	N	N	N	N
PVAVS	N	N	N	N	N	N	N	N
PTAC	N	N	N	N	N	N	N	N
PTGSD	A	A	A	A	A	A	A	A

Legend:
- A = Appropriate
- D = Used for program code debugging only
- N = Not appropriate
- S = System (or configuration) dependent
- X = Unused

SYSTEMS

VARIABLE–TYPE = u-name of PLANT–ASSIGNMENT

Variable-List Number	Variable in FORTRAN Code	Description
1	<QCPL>	Total cooling load (Btu/hr)
2	<QHPL>	Total heating load (Btu/hr)
3	<PKW>	Total electrical load (kW)
4	<PGAS>	Total gas load (Btu/hr)
5	<PKWQH>	Portion of <PKW> used for heating (kW)
6	<PKWQC>	Portion of <PKW> used for cooling (kW)
7	<PFANKW>	Portion of <PKW> used for fans (kW)
8	<POIL>	Total oil load (Btu/hr)
9		unused
10		unused
11	QHMP	Main coil heating load (Btu/hr)
12	TMP	Main coil average entering temperature (°F)
13	CFMP	Main coil flowrate (cfm)
14	QHPP	Preheat coil heating load (Btu/hr)
15	CFMPP	Preheat coil flowrate (if in outside air duct) (cfm)
16	QHZP	Zone coil load (Btu/hr)
17	TZP	Zone coil average entering temperature (°F)*
18	CFMZP	Zone coil flowrate (cfm)
19	QHBP	Baseboard load (Btu/hr)**
20		unused

* Loop temperature for HP or zone temperature for RESYS.

** Includes HP load for loop.

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of PLANT–ASSIGNMENT

V-L No.	1	2	3	4	5	6	7	8	9	10
SYSTEM-TYPE	COOL-ING LOAD	HEAT-ING LOAD	ELEC KW LOAD	HEAT-ING GAS	HEAT-ING ELEC KW	COOL-ING ELEC KW	FANS ELEC KW	HEAT-ING OIL	UN-USED	UN-USED
SUM	A	A	A	A	A	N	N	A	X	X
SZRH	A	A	A	A	A	N	A	A	X	X
MZS	A	A	A	A	A	N	A	A	X	X
DDS	A	A	A	A	A	N	A	A	X	X
SZC	A	A	A	A	A	N	A	A	X	X
UHT	A	A	A	A	A	N	A	A	X	X
UVT	A	A	A	A	A	N	A	A	X	X
FPH	A	A	A	A	A	N	A	A	X	X
TPFC	A	A	A	A	A	N	A	A	X	X
FPFC	A	A	A	A	A	N	A	A	X	X
TPIU	A	A	A	A	A	N	A	A	X	X
FPIU	A	A	A	A	A	N	A	A	X	X
VAVS	A	A	A	A	A	N	A	A	X	X
PIU	A	A	A	A	A	N	A	A	X	X
RHFS	A	A	A	A	A	N	A	A	X	X
HP	A	A	A	A	A	A	A	A	X	X
HVSYS	A	A	A	A	A	N	A	A	X	X
CBVAV	A	A	A	A	A	N	A	A	X	X
RESYS	A	A	A	A	A	A	A	A	X	X
PSZ	A	A	A	A	A	N	A	A	X	X
PMZS	A	A	A	A	A	N	A	A	X	X
PVAVS	A	A	A	A	A	N	A	A	X	X
PTAC	A	A	A	A	A	A	A	A	X	X

Legend:
A = Appropriate
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N = Not appropriate
S = System (or configuration) dependent
X = Unused

VARIABLES BY SYSTEM–TYPE FOR VARIABLE–TYPE = u-name of PLANT–ASSIGNMENT

V-L No.	11	12	13	14	15	16	17	18	19
SYSTEM-TYPE	MAIN HC CBS LOAD	MAIN HC CBS TEMP	MAIN HC CBS CFM	PRE-HEAT CBS LOAD	PRE-HEAT CBS CFM	ZONE HEAT CBS LOAD	ZONE HEAT CBS TEMP	ZONE HEAT CBS CFM	BASE-BOARD CBS LOAD
SUM	N	N	N	N	N	N	N	N	N
SZRH	A	A	A	A	A	A	A	A	A
MZS	A	A	A	A	A	N	A	A	A
DDS	A	A	A	A	A	N	A	A	A
SZC	A	A	A	A	A	A	A	A	A
UHT	N	N	N	N	N	A	A	A	A
UVT	N	N	N	N	N	A	A	A	A
FPH	N	N	N	N	N	N	N	N	N
TPFC	N	N	N	N	N	A	A	A	A
FPFC	N	N	N	N	N	A	A	A	A
TPIU	A	A	A	A	A	A	A	A	A
FPIU	A	A	A	A	A	A	A	A	A
VAVS	A	A	A	A	A	A	A	A	A
PIU	A	A	A	A	A	A	A	A	A
RHFS	A	A	A	A	A	A	A	A	A
HP	N	N	N	N	N	N	N	N	A
HVSYS	A	A	A	A	A	A	A	A	A
CBVAV	A	A	A	A	A	A	A	A	A
RESYS	A	A	A	N	N	A	A	A	A
PSZ	A	A	A	A	A	A	A	A	A
PMZS	A	A	A	A	A	A	A	A	A
PVAVS	A	A	A	A	A	A	A	A	A
PTAC	N	N	N	N	N	A	A	A	A

Legend:
- A = Appropriate
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- N = Not appropriate
- S = System (or configuration) dependent
- X = Unused

PLANT

VARIABLE–TYPE = GLOBAL

Variable-List Number	Variable in FORTRAN Code	Description
1	TAIR	Outside dry-bulb temperature (°F)
2	TWET	Outside wet-bulb temperature (°F)

PLANT

VARIABLE–TYPE = PLANT

Variable-List Number	Variable in FORTRAN Code	Description
1	ENGYLD(1,IHR)	SYSTEMS heating load (Btu/hr)
2	ENGYLD(2,IHR)	SYSTEMS cooling load (Btu/hr)
3	ENGYLD(3,IHR)	SYSTEMS electric load (Btu/hr)
4	IHON	Standby heating flag
5	ICON	Standby cooling flag
6	—	—
7	—	—
8	PDEM(1)	Total PLANT heating load (Btu/hr)
9	PDEM(2)	Total PLANT cooling load (Btu/hr)
10	PDEM(3)	Total PLANT electric load (Btu/hr)
11	—	—
12	Note 1	Total PLANT fuel use (Btu/hr)
13	HSOLAR	Space heating load satisfied by solar (Btu/hr)
14	LATYPE(1)	Heating LOAD–ASSIGNMENT pointer
15	LATYPE(2)	Cooling LOAD–ASSIGNMENT pointer
16	LATYPE(3)	Electric LOAD–ASSIGNMENT pointer
17	GAS+OIL	Gas and oil resource consumed elsewhere than PLANT (Btu/hr)
18	HWTR(1HR)	Hot water resource consumed elsewhere than PLANT (Btu/hr)

Note 1. EQDEM(4,1) + EQDEM(4,2) + EQDEM(4,5) +

EQDEM(4,6) + EQDEM(4,22) + EQDEM(4,21)

PLANT

VARIABLE–TYPE = HEAT–RECOVERY

Variable-List Number	Variable in FORTRAN Code	Description
1	Note 1	Demand at level 1 (Btu/hr)
2	Note 2	Demand at level 2 (Btu/hr)
3	Note 3	Demand at level 3 (Btu/hr)
4	Note 4	Demand at level 4 (Btu/hr)
5	Note 5	Demand at level 5 (Btu/hr)
6	EHEAT	Heating load to be addressed by HEAT–RECOVERY. This load is the total heating load as reduced by the solar contribution to the space heating loads identified in Reference Manual, Table V.31. (Btu/hr)
7	EBOILR	Heating load after all solar and heat recovery contribution, but before the contribution of hot water storage tank (Btu/hr)
8	ERECVR	Total recovered energy from all levels (Btu/hr)
9	EREJ	Total recoverable energy wasted (Btu/hr)
10	DBLEFT	Wasted recoverable double-bundle chiller heat (reject to tower) (Btu/hr)
11	STORED	Recovered energy stored in hot water storage tank this hour (Btu/hr)
12	HTREQD(19)	Energy demanded from boiler by hot water storage tank (Btu/hr)
13	HTAVAL(27)	Solar energy available for space heating (Btu/hr)
14	HTAVAL(28)	Solar energy available for process/dhw heating (Btu/hr)
15	HTAVAL(29)	Solar energy available for cooling (Btu/hr)
16	EXTSOL	Solar energy supplied through heat recovery (Btu/hr)

Note 1. HTREQD(KEY(1,2,1)) + HTREQD(KEY(2,2,1)) + HTREQD(KEY(3,2,1))

Note 2. HTREQD(KEY(1,2,2)) + HTREQD(KEY(2,2,2)) + HTREQD(KEY(3,2,2))

Note 3. HTREQD(KEY(1,2,3)) + HTREQD(KEY(2,2,3)) + HTREQD(KEY(3,2,3))

Note 4. HTREQD(KEY(1,2,4)) + HTREQD(KEY(2,2,4)) + HTREQD(KEY(3,2,4))

Note 5. HTREQD(KEY(1,2,5)) + HTREQD(KEY(2,2,5)) + HTREQD(KEY(3,2,5))

VARIABLE–TYPE = STM–BOILER (EQTYP = 1)

or HW–BOILER (EQTYP = 2)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Heating load (Btu/hr)
2	—	—
3	EQDEM(3,IEQTYP)	Electric input (Btu/hr)
4	EQDEM(4,IEQTYP)	Fuel input (Btu/hr)
5	—	—
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Nominal capacity (Btu/hr)
8	PLR	Average part-load ratio
9	FRAC	Fraction of hour boiler was on
10	HIRCOR	Fuel consumption correction factor

PLANT

VARIABLE–TYPE = ELEC–STM–BOILER (IEQTYP = 3), ELEC–HW–BOILER (IEQTYP = 4), or ELEC–DHW–HEATER (IEQTYP = 7)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Heating load (Btu/hr)
2	—	—
3	EQDEM(3,IEQTYP)	Electric energy consumption (Btu/hr)
4	—	—
5	—	—
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Nominal capacity (Btu/hr)
8	LOSS	Losses from machine (Btu/hr)

PLANT

VARIABLE–TYPE = ABSOR1–CHLR (IEQTYP = 13)

or ABSOR2–CHLR (IEQTYP = 14)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Cooling load (Btu/hr)
2	—	—
3	EQDEM(3,IEQTYP)	Electric energy consumed (Btu/hr)
4	EQDEM(4,IEQTYP)	Steam energy input (Btu/hr)
5	EQDEM(5,IEQTYP)	Cooling tower load (Btu/hr)
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Nominal capacity (Btu/hr)
8	RCAP	Available capacity ratio (Btu/Btu)
9	CAP	Available capacity (Btu/hr)
10	PL	Average part-load ratio
11	PLR	Operating part-load ratio
12	TTOWR	Entering condenser temperature (°F)
13	CHWT	Leaving chilled water temperature (°F)
14	HIR1	Heat input ratio temperature correction
15	HIR2	Heat input ratio part-load correction
16	HIR	Adjusted heat input ratio
17	HIRS	Solar correction to heat input ratio

PLANT

VARIABLE–TYPE = OPEN–CENT–CHLR (IEQTYP = 8),

OPEN REC–CHLR (IEQTYP = 9),

HERM–CENT–CHLR (IEQTYP = 10),

HERM–REC–CHLR (IEQTYP = 11)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Cooling load (Btu/hr)
2	EQDEM(2,IEQTYP)	False load (Btu/hr)
3	EQDEM(3,IEQTYP)	Electric energy consumed (Btu/hr)
4	—	—
5	EQDEM(5,IEQTYP)	Cooling tower load (Btu/hr)
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Nominal capacity (Btu/hr)
8	RCAP	Available capacity ratio
9	CAP	Available capacity (Btu/hr)
10	PLR	Operating part-load ratio
11	FRAC	Fraction of hour machine ran
12	ECT	Entering condenser temperature (°F)
13	CHWT	Leaving chilled water temperature (°F)
14	EIR1	Electric input ratio temperature correction
15	EIR2	Electric input ratio part-load correction
16	EIRN	Adjusted electric input ratio
17	ELECH	Rejected electrical heat (Btu/hr)
18	FANE	Condenser fan energy (Btu/hr)

PLANT

VARIABLE–TYPE = ABSORG–CHLR (IEQTYP = 15)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Cooling load (Btu/hr)
2	—	—
3	EQDEM(3,IEQTYP)	Electric energy consumed(Btu/hr)
4	EQDEM(4,IEQTYP)	Fuel input (cooling) (Btu/hr)
5	EQDEM(5,IEQTYP)	Cooling tower load (Btu/hr)
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Nominal capacity (Btu/hr)
8	RCAPI	Available capacity ratio (cooling) (Btu/Btu)
9	CAP	Available capacity (cooling) (Btu/hr)
10	PL	Average part-load ratio (cooling)
11	PLR	Operating part-load ratio (cooling)
12	TC	Entering condenser temperature (°F)
13	CHWT	Leaving chilled water temperature (°F)
14	HIR1	Heat input ratio chilled water correction
15	HIR2	Heat input ratio part-load correction
16	HIR3	Heat input ratio condenser temperature correction
17	HIR	Heat input ratio
18	HEAT	Heat input (cooling) (Btu/hr)
19	QCOND	Desiccant regeneration heat from condenser (Btu/hr)
20	QSUPL	Supplemental desiccant regeneration heat (Btu/hr)
21	QREG	Desiccant regeneration load (Btu/hr)
22	GABQC	Cooling Output (Btu/hr)
23	GABQH	Heating Output (Btu/hr)
24	GABFC	Fuel use (cooling); includes fuel used for regeneration
25	GABFH	Fuel use (heating) (Btu/hr)

PLANT

VARIABLE–TYPE = ABSORG–CHLR (IEQTYP = 15) (continued)

Variable-List Number	Variable in FORTRAN Code	Description
26	GABQSH	Heat output for space heating (Btu/hr)
27	GABQDH	Heat output for domestic hot water (Btu/hr)
28	GABFSH	Fuel used for space heating (Btu/hr)
29	GABFDH	Fuel used for domestic hot water (Btu/hr)
30	CAPH	Heating capacity (Btu/hr)
31	LOADH	Heating load (Btu/hr)

PLANT

VARIABLE–TYPE = ENG–CHLR (IEQTYP = 16)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Cooling load (Btu/hr)
2	—	—
3	EQDEM(3,IEQTYP)	Electric energy consumed (Btu/hr)
4	EQDEM(4,IEQTYP)	Fuel input (Btu/hr)
5	EQDEM(5,IEQTYP)	Cooling tower load (Btu/hr)
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Nominal capacity (Btu/hr)
8	RCAPI	Available capacity ratio
9	OPCAP*RCAPI	Available capacity (Btu/hr)
10	PLR	Operating part-load ratio
11	FRAC	Fraction of hour chiller ran
12	ECT	Entering condenser temperature (°F)
13	CHWT	Leaving chilled water temperature (°F)
14	COP1	COP temperature correction
15	COP2	COP part-load correction
16	COP	COP
17	ECFUEL	Fuel used (Btu/hr)
18	HREJ1	Recoverable heat efficiency temperature correction (Btu/hr)
19	HREJ2	Recoverable heat efficiency part load correction (Btu/hr)
20	HREJ	Recoverable heat (Btu/hr)

PLANT

VARIABLE–TYPE = DBUN–CHLR (IEQTYP = 12)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Cooling load (Btu/hr)
2	EQDEM(2,IEQTYP)	False load (Btu/hr)
3	EQDEM(3,IEQTYP)	Electric energy consumption (Btu/hr)
4	—	—
5	EQDEM(5,IEQTYP)	Cooling tower load (Btu/hr)
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Nominal capacity (Btu/hr)
8	RCAP	Available capacity ratio
9	CAP	Available capacity (Btu/hr)
10	PLR	Operating part-load ratio
11	FRAC	Fraction of hour machine ran
12	ECT	Entering condenser water temperature (°F)
13	CHWT	Leaving chilled water temperature (°F)
14	EIR1	Electric input ratio temperature correction factor
15	EIR2	Electric input ratio part-load correction factor
16	EIR3	Electric input ratio heat recovery correction factor
17	EIRW	Corrected electric input ratio (Btu/Btu)
18	HTREC	Recoverable heat (Btu/hr)

PLANT

VARIABLE–TYPE = COOLING–TWR (ITOWR = 17) or CERAMIC–TWR (ITOWR = 18)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,ITOWR)	Cooling tower load (Btu/hr)
2	—	—
3	EQDEM(3,ITOWR)	Electrical energy consumed (Btu/hr)
4	—	—
5	—	—
6	ISIZE	Number of cells running
7	OPCAP(ITOWR)	Nominal operating capacity (Btu/hr)
8	GPM	Water flow rate, gpm
9	MINCEL	Minimum number of cells that can run
10	RANGE	Temperature drop through tower (°R)
11	APP	Approach to wet-bulb (°R)
12	ISPEED	Fan speed index
13	R1	Rating factor correction for range
14	R2	Rating factor correction for approach and wet-bulb
15	RFACT	Rating factor at full cfm (TU/gpm)
16	RF	Rating factor at actual cfm (TU/gpm)
17	AREA	Tower area needed (TU/sqft)
18	NCELL	Number of cells running
19	TTOWR	Tower temperature (°F)
20	EFAN	Fan energy (Btu/hr)
21	EPUMP	Pump energy (Btu/hr)
22	RAPPLG	Approach needed when temperature floating
23	FRAC	Fraction of hour that fans ran at ISPEED
24	IDCSCH	Cooling tower direct cooling schedule
25	ISC	Cooling tower direct cooling flag

PLANT

VARIABLE–TYPE = DIESEL–GEN (IEQTYP = 21)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Electric load (Btu/hr)
2	—	—
3	—	—
4	EQDEM(4,IEQTYP)	Fuel energy consumed (Btu/hr)
5	—	—
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Nominal capacity (Btu/hr)
8	ELECD	Operating load (Btu/hr)
9	PLR	Part load ratio
10	ELECFD	Efficiency of diesel engine (Btu/Btu)
11	THLOF	Ratio of jacket/lube-oil heat to fuel (Btu/Btu)
12	EJLD	Jacket/lube oil heat recovered (Btu/hr)
13	THHIF	Ratio of exhaust heat recovered to fuel (Btu/Btu)
14	EEXHD	Exhaust heat recovered (Btu/hr)
15	TEXD	Temperature of the exhaust (°F)
16	THTOF	Ratio of total heat recovered to fuel (Btu/Btu)
17	ETOT	Total heat recovered (Btu/hr)
18	—	—
19	—	—
20	—	—
21	—	—
22	—	—

PLANT

VARIABLE–TYPE = GTURB–GEN (IEQTYP = 22)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Electric load (Btu/hr)
2	—	—
3	—	—
4	EQDEM(4,IEQTYP)	Fuel energy consumed (Btu/hr)
5	—	—
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Nominal capacity (Btu/hr)
8	ELECG	Operating load (Btu/hr)
9	PLR	Part load ratio
10	ELECFG	Efficiency of the gas turbine (Btu/Btu)
11	EEXHG	Exhaust heat recovered (Btu/hr)
12	EXHF	Ratio of exhaust heat recovered to fuel (Btu/Btu)
13	TEXG	Temperature of the exhaust (°F)
14	—	—

PLANT

VARIABLE–TYPE = STURB–GEN (IEQTYP = 23)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Electric load (Btu/hr)
2	—	—
3	—	—
4	EQDEM(4,IEQTYP)	Steam energy input (Btu/hr)
5	—	—
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Nominal capacity (Btu/hr)
8	PLR	Part load ratio
9	TURBF	Internal turbine efficiency (Btu/Btu)
10	ELEFF	Efficiency of the steam turbine (Btu/Btu)
11	ENREC	Ratio of recovered heat to steam input (Btu/Btu)
12	FSLOSS	Condenser losses (Btu/hr)
13	WASTE	Recovered heat (Btu/hr)

PLANT

VARIABLE–TYPE = HTANK–STORAGE (IEQTYP = 19)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Energy delivered (Btu/hr)
2	—	—
3	EQDEM(3,IEQTYP)	Electric energy consumed (Btu/hr)
4	EQDEM(4,IEQTYP)	Energy stored (Btu/hr)
5	—	—
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Operating capacity (Btu/hr)
8	HTGIVE	Heat available to be given out (Btu/hr)
9	HTASK	Heat requested for storage (Btu/hr)
10	HFREEZ–CFREEZ	Heat needed to prevent freezing (Btu/hr)
11	ISTORH	Storage demand flag
12	TEMPH	Tank temperature (°F)
13	HLOSS	Tank loss (Btu/hr)
14	REALHT	Heat in tank (relative to 0°F) (Btu/hr)
15	EHSTOR	Useful heat in tank (Btu/hr)

PLANT

VARIABLE–TYPE = CTANK–STORAGE (IEQTYP = 20)

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,IEQTYP)	Cooling energy delivered (Btu/hr)
2	—	—
3	EQDEM(3,IEQTYP)	Electric energy consumed (Btu/hr)
4	EQDEM(4,IEQTYP)	Cooling energy stored (Btu/hr)
5	—	—
6	ISIZE	Sizes running
7	OPCAP(IEQTYP)	Operating capacity (Btu/hr)
8	CDGIVE	Cooling energy available to be given out (Btu/hr)
9	CDASK	Cooling energy requested for storage (Btu/hr)
10	CFREEZ	Heat needed to prevent freezing (Btu/hr)
11	TEMPL	Tank temperature (°F)
12	CLOSS	Tank loss (Btu/hr)
13	REALCD	Heat in tank (relative to 0°F) (Btu/hr)
14	ECSTOR	Useful cold in tank (Btu/hr)

PLANT

VARIABLE–TYPE = FURNACE

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,5)	Space heating load (Btu/hr)
2	—	—
3	EQDEM(3,5)	Electric energy consumed (Btu/hr)
4	EQDEM(4,5)	Fuel consumed (Btu/hr)
5	—	—
6	ISIZE	Sizes running
7	OPCAP(5)	Operating capacity (Btu/hr)
8	PLR	Average part load ratio
9	HIRCOR	Fuel consumption correction factor

PLANT

VARIABLE–TYPE = DHW–HEATER

Variable-List Number	Variable in FORTRAN Code	Description
1	EQDEM(1,6)	Process or domestic hot water load (Btu/hr)
2	—	—
3	EQDEM(3,6)	Electricity consumed (Btu/hr)
4	EQDEM(4,6)	Fuel consumed (Btu/hr)
5	—	—
6	ISIZE	Sizes running
7	OPCAP(6)	Operating capacity (Btu/hr)
8	PLR	Part-load ratio
9	HIRCOR	Fuel consumption correction factor

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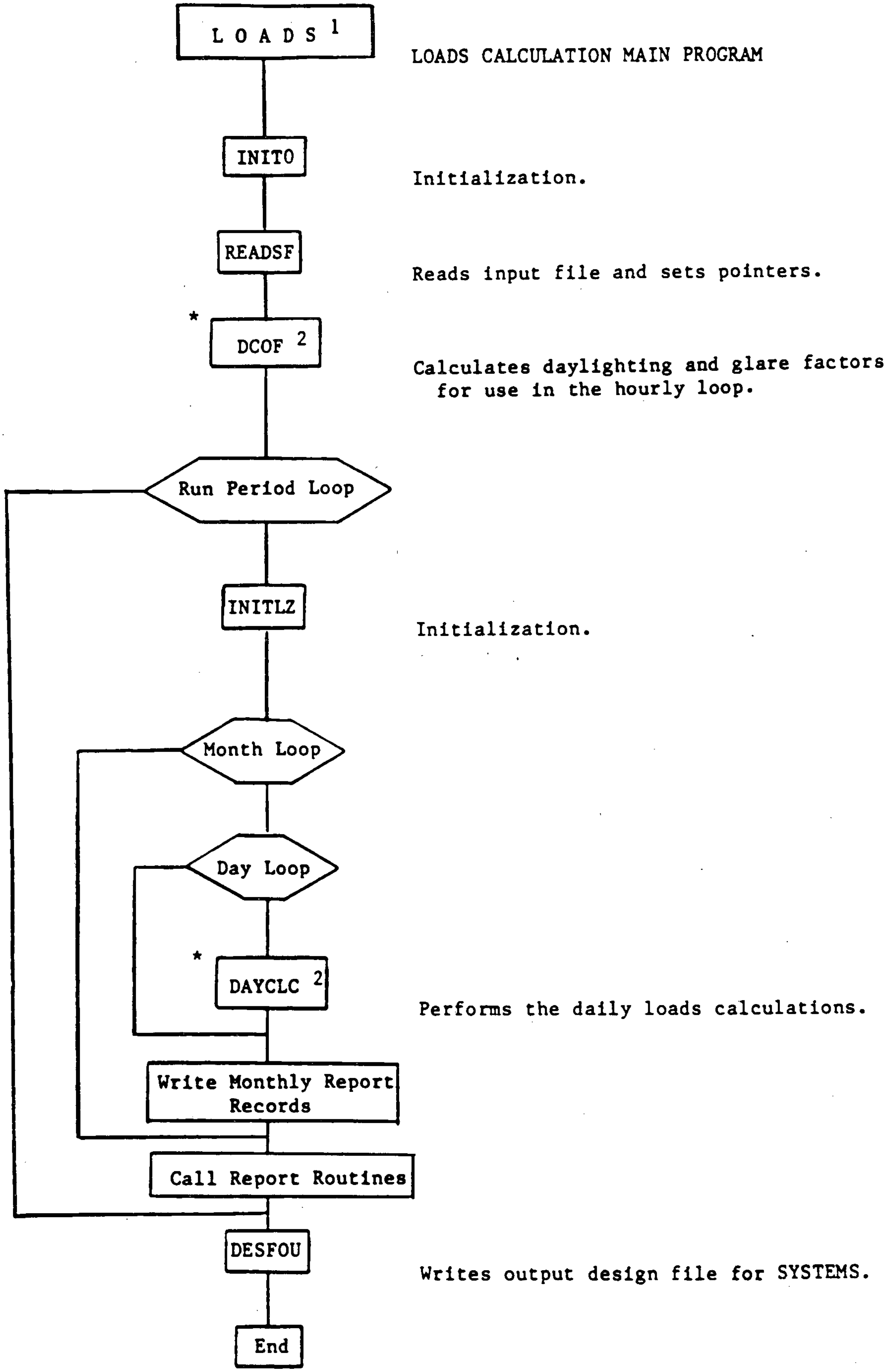
APPENDIX B

FUNCTIONAL VALUES

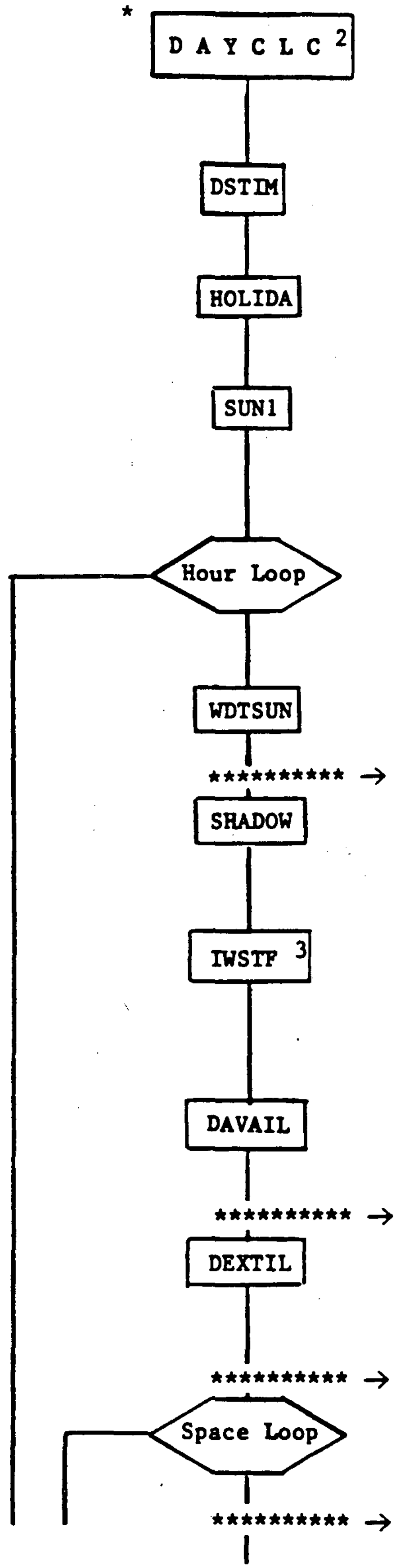
LOADS and SYSTEMS FLOWCHARTS

--- L E V E L 1 ---



* = function access location

--- L E V E L 2 ---



PERFORMS THE DAILY LOADS CALCULATIONS.

Defines the daylight savings flag.

Defines the schedule day.

Calculates solar declination angle, equation of time, solar constant, etc.

Defines hourly weather and solar data.

* Building "before" function.

Calculates the shadow ratios for exterior surfaces and attachments.

Calculates solar transfer factors between exterior windows in a sunspace and the interior surfaces.

Calculates availability of daylight for daylighting simulation; calculates luminous efficacv of solar radiation

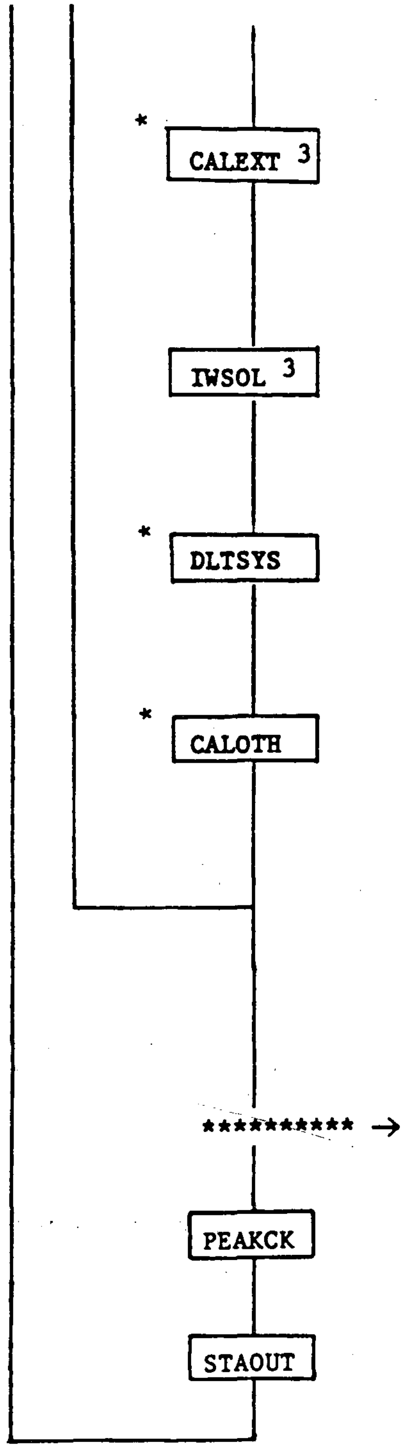
* Building daylight "before" function.

Calculates clear-sky and overcast-sky illuminance on an unobstructed exterior horizontal surface.

* Building daylight "after" function.

* Space "before" function.

* = function access location



Calculates loads due to solar gain through exterior windows, and conduction through exterior windows and walls.

For a sunspace, calculates solar radiation absorbed by interior walls and transmitted by interior windows into adjacent spaces.

Simulates lighting control system for daylit spaces; determines lighting power reduction factor due to daylighting.
* Space light control "before" function.
* Space light control "after" function.

* Underground surface "before" function.
Calculates heat gains due to heat transfer through underground surfaces.
* Underground surface "after" function.
Calculates heat gains due to interior walls, infiltration, people, lights, and equipment. Weights all heat gains (including exterior surface heat gains) to get loads.

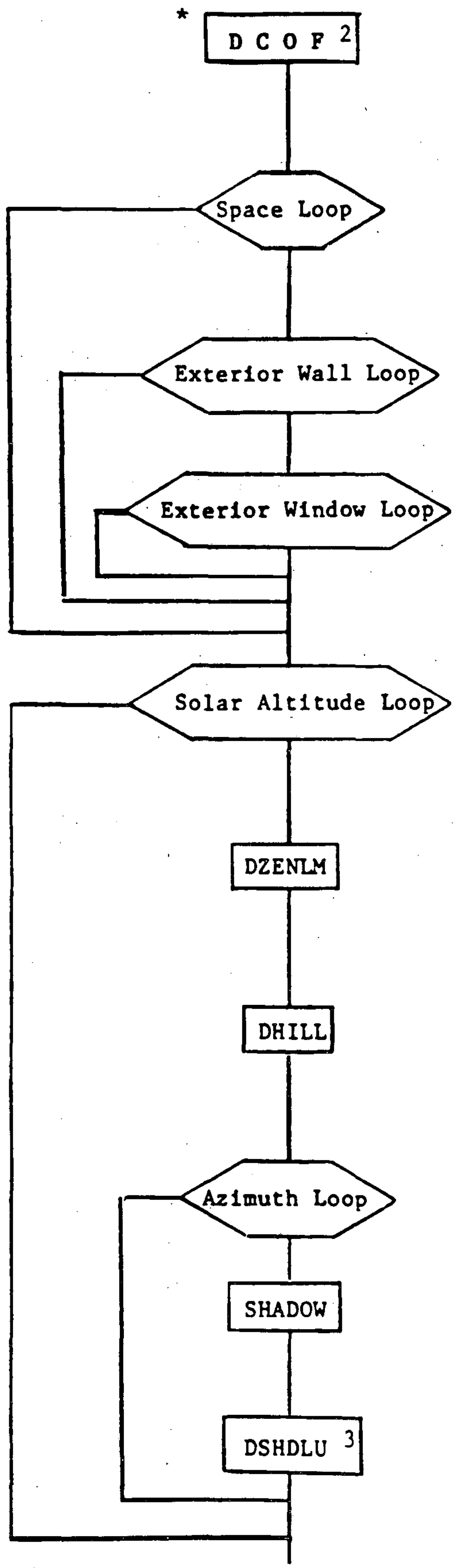
* Space "after" function is also contained in CALOTH.

* Building "after" function.

Determines building peak loads.

Computes hourly report averages and writes summary statistics to report file.

* = function access location



CALCULATES DAYLIGHTING AND GLARE FACTORS.

Initialization

Determines illuminance on ground, shadow ratios, and detached shade luminances.

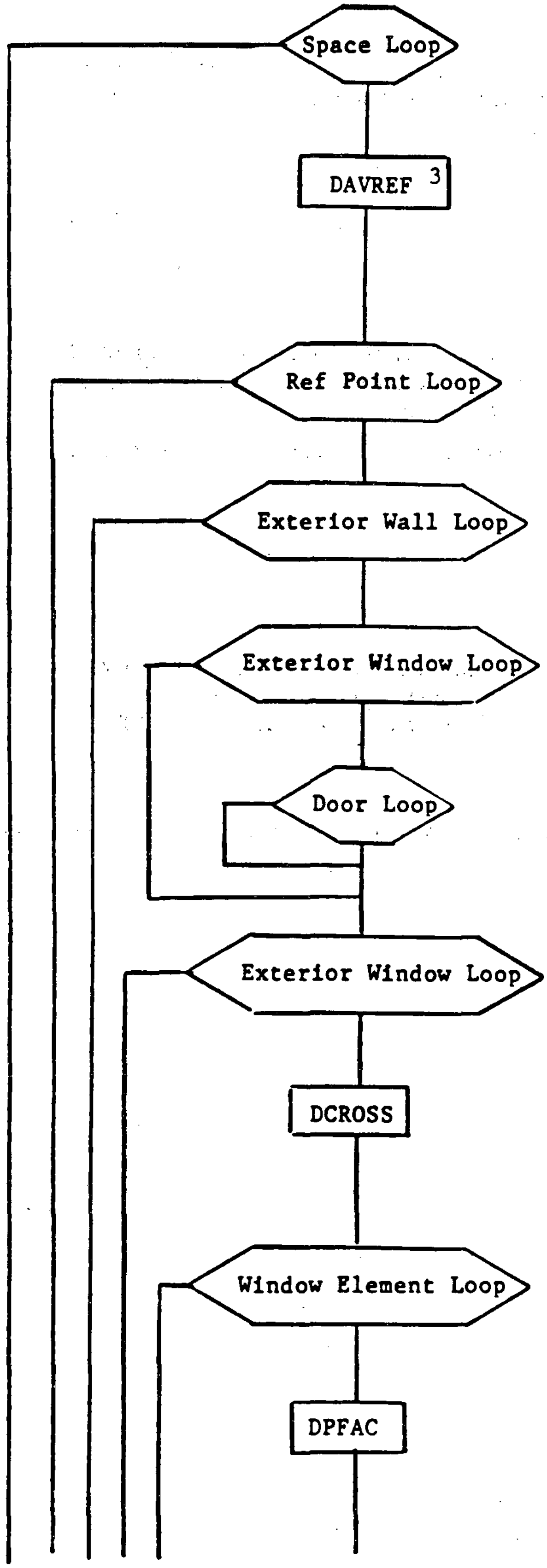
Sets turbidity coefficients and atmospheric moisture quantities.

Calculates illuminance on exterior horizontal surface.

Calculates shadow ratios for exterior surfaces.

Calculates luminance of detached building shades.

* = function access location



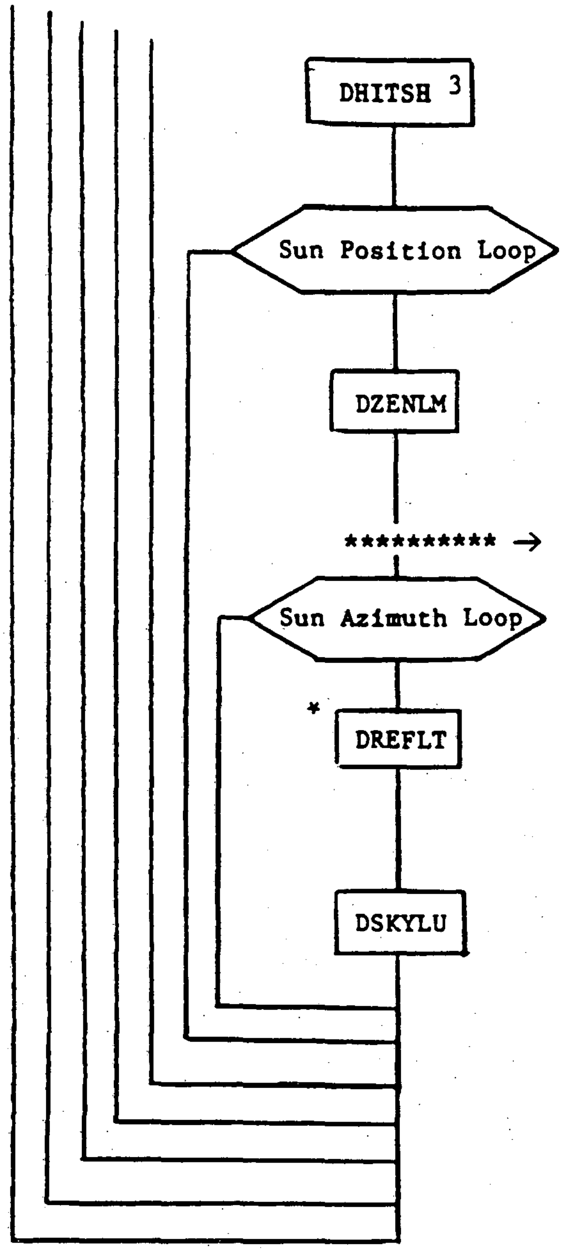
Performs main daylight and glare calculations.

Determines total area and average visible reflectance of inside surfaces of a space.

Calculates the cross product of two vectors.

Determines the Hopkinson position factor used in glare calculations.

* = function access location



Determines if ray from reference point to window elements intersects a building shade.

Sets turbidity coefficients and atmospheric moisture quantities; calculates clear sky zenith luminance.

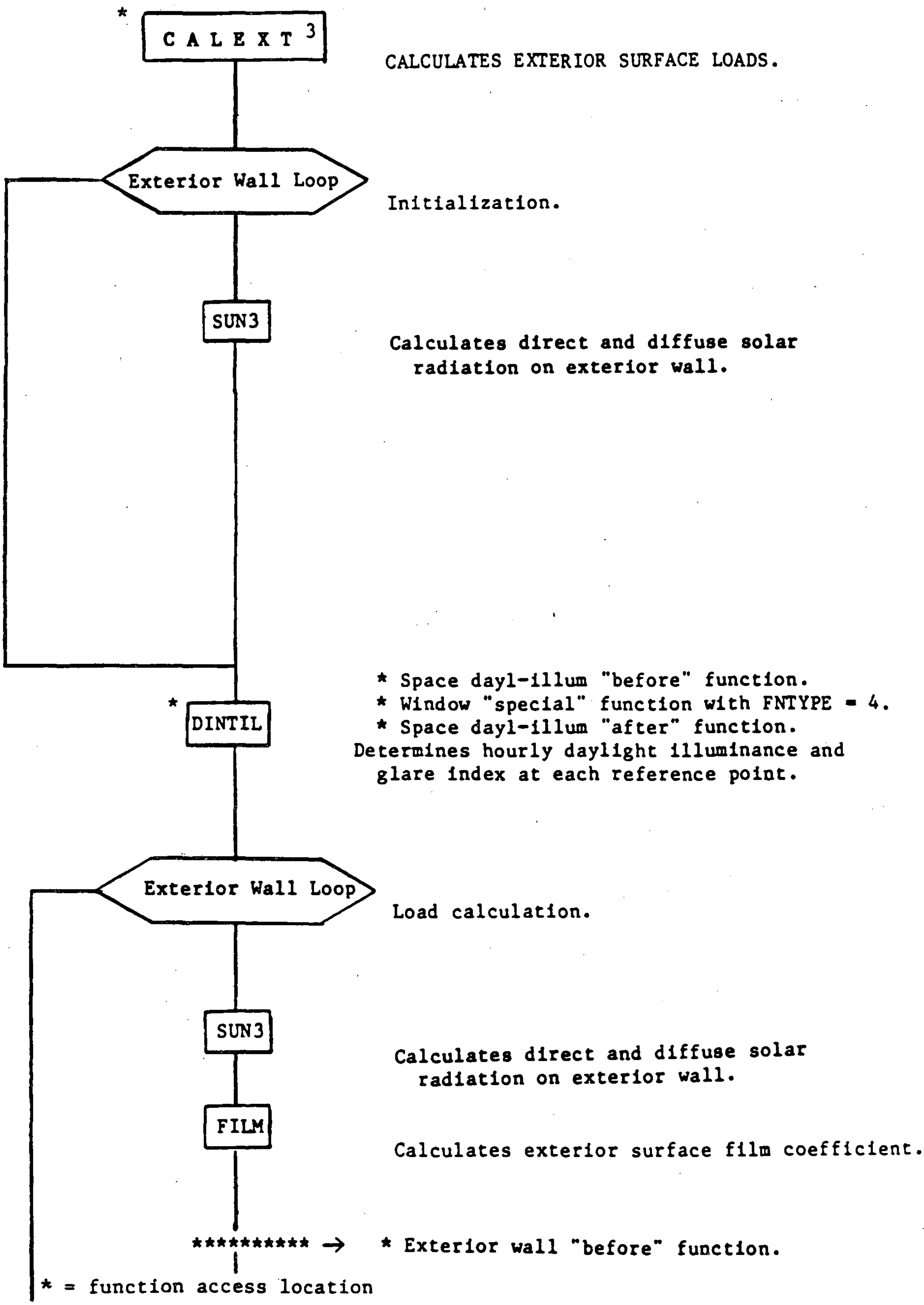
* Window "special" function with FNTYPE = 5.

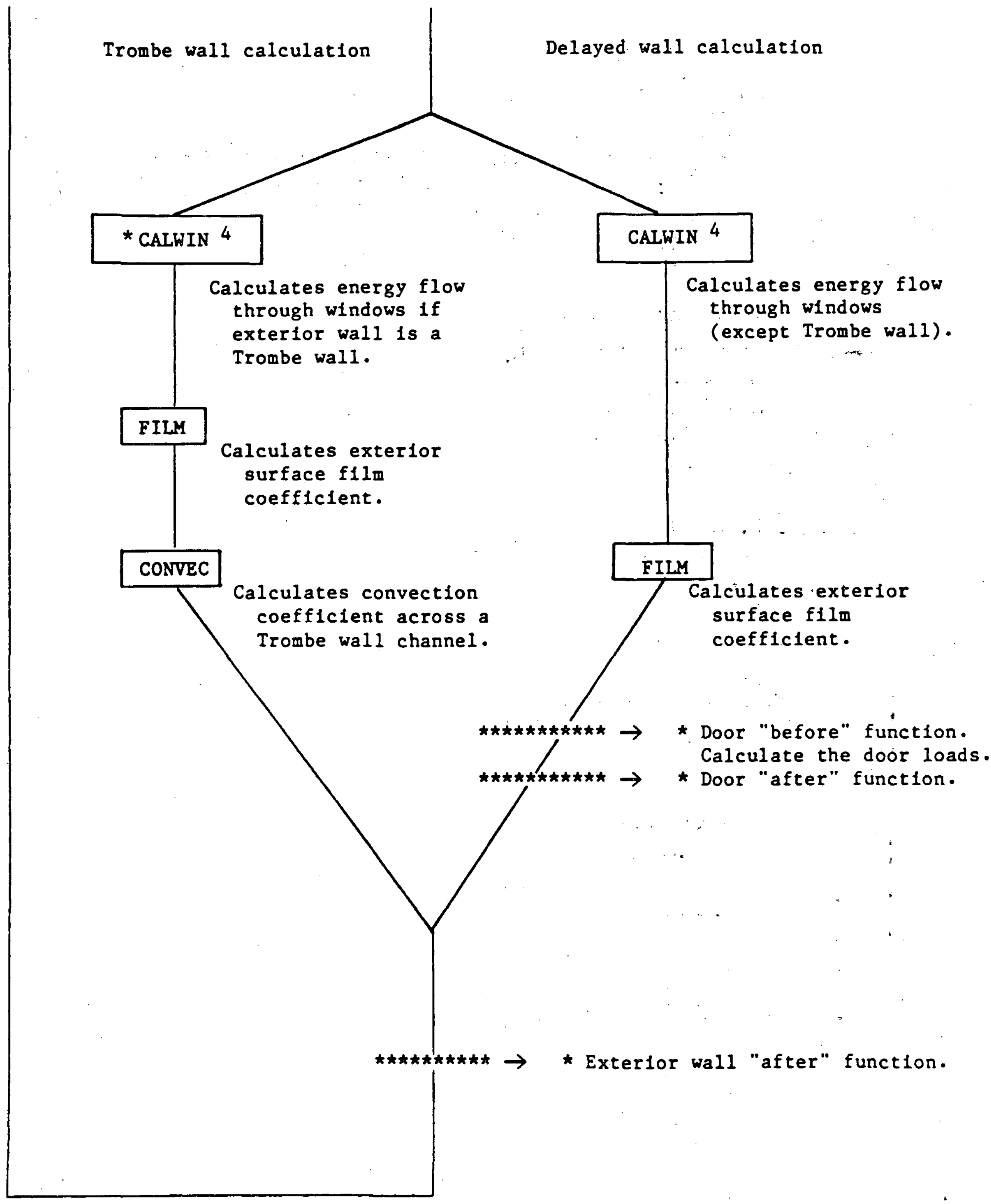
Calculates illuminance at reference point due to internally reflected light.
* Window "special" function with FNTYPE = 6.

Calculates luminance of clear and overcast sky.

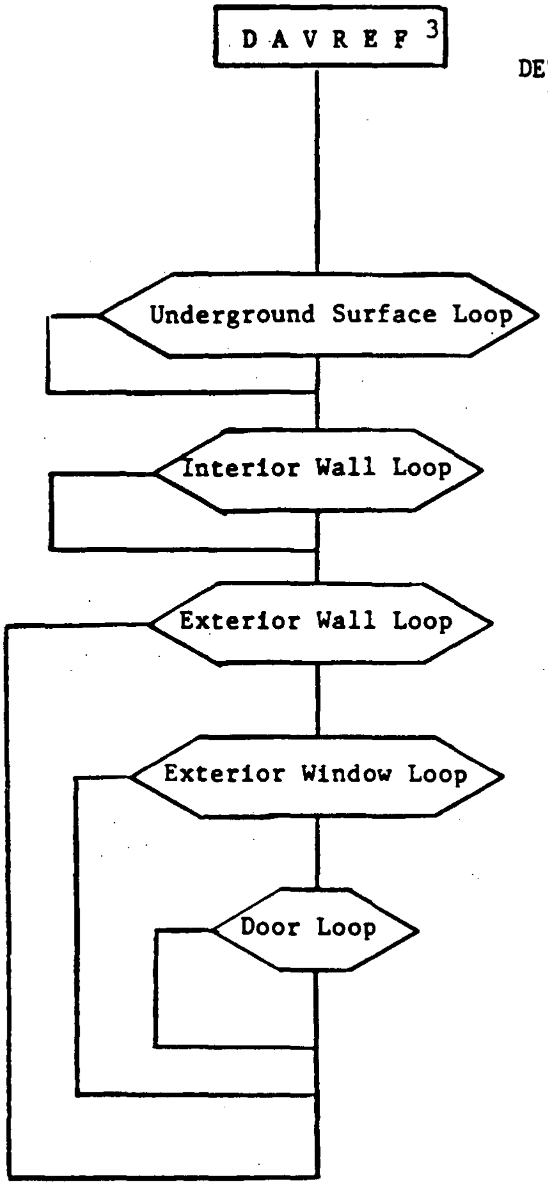
* = function access location

--- L E V E L 3 ---

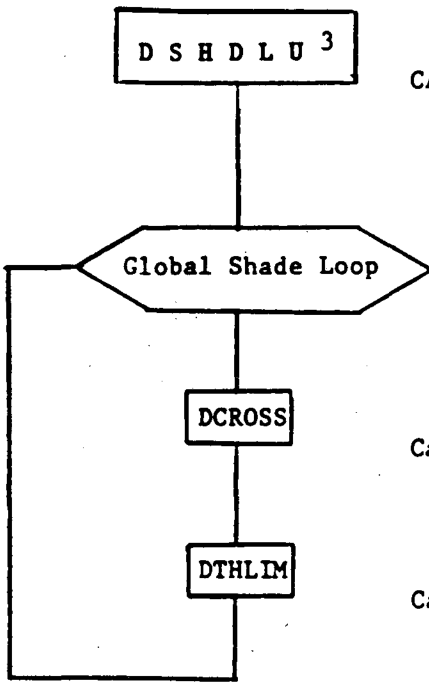

* CALEXT 3
CALCULATES EXTERIOR SURFACE LOADS.
Exterior Wall Loop
Initialization.
SUN3
Calculates direct and diffuse solar radiation on exterior wall.
* DINTIL
* Space dayl-illum "before" function.
* Window "special" function with FNTYPE = 4.
* Space dayl-illum "after" function.
Determines hourly daylight illuminance and glare index at each reference point.
Exterior Wall Loop
Load calculation.
SUN3
Calculates direct and diffuse solar radiation on exterior wall.
FILM
Calculates exterior surface film coefficient.
********** →
* Exterior wall "before" function.
* = function access location



* = function access location



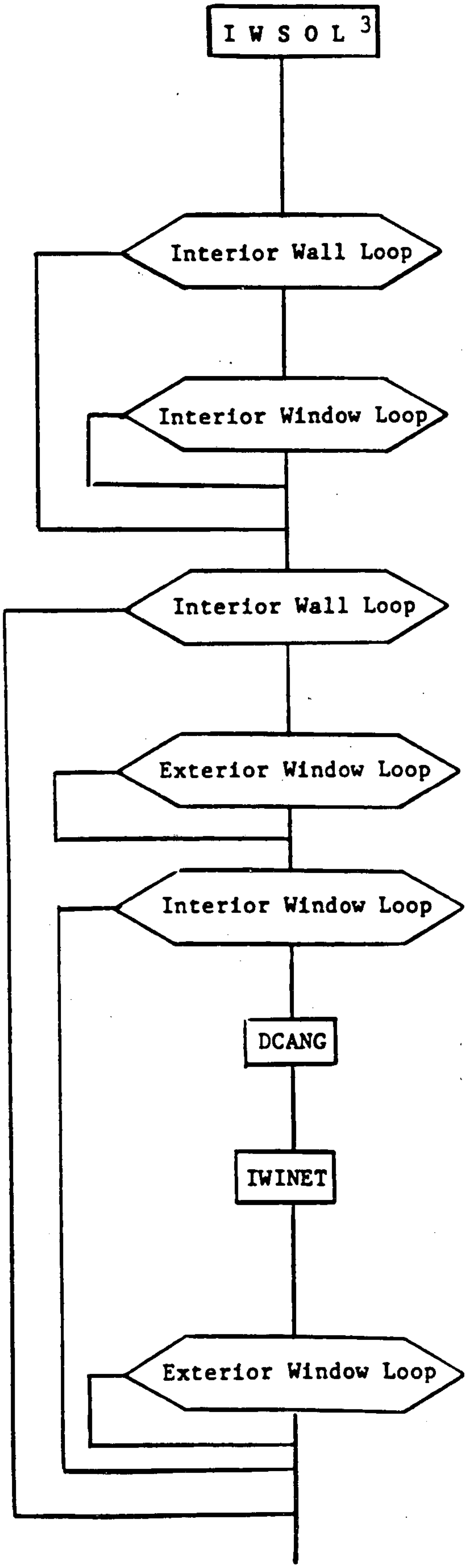
DETERMINES AREA WEIGHTED-AVERAGE VISIBLE REFLECTANCE AND TOTAL AREA OF ALL INSIDE SURFACES OF A SPACE.



CALCULATES LUMINANCE OF DETACHED BUILDING SHADES.

Calculates the cross product of two vectors.

Calculates the limits of integration of
sky azimuth angle.



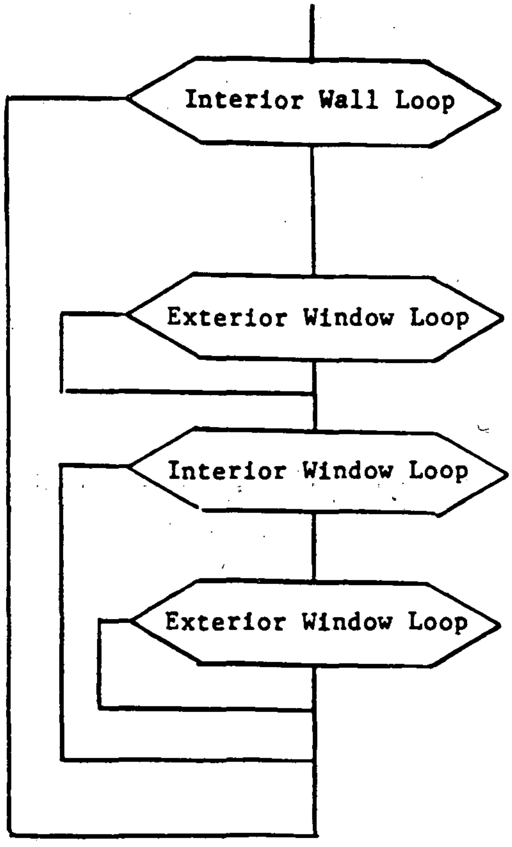
FOR A SUNSPACE, CALCULATES SOLAR RADIATION ABSORBED BY INTERIOR WALLS AND TRANSMITTED BY INTERIOR WINDOWS INTO ADJACENT SPACES.

Calculates UA sum for interior walls.

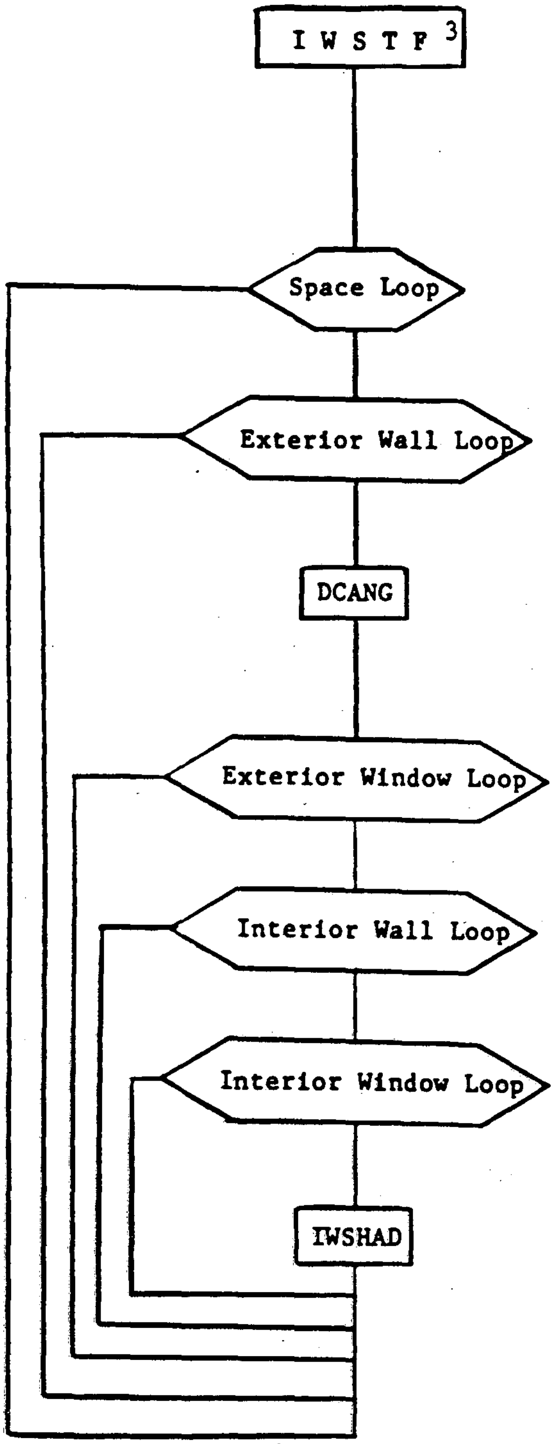
Calculates direct solar radiation absorbed by interior walls.

Calculates cosine of angle between sun and interior window.

Calculates effective solar transmittance of interior glazing.



Calculates diffuse solar radiation absorbed by interior walls.

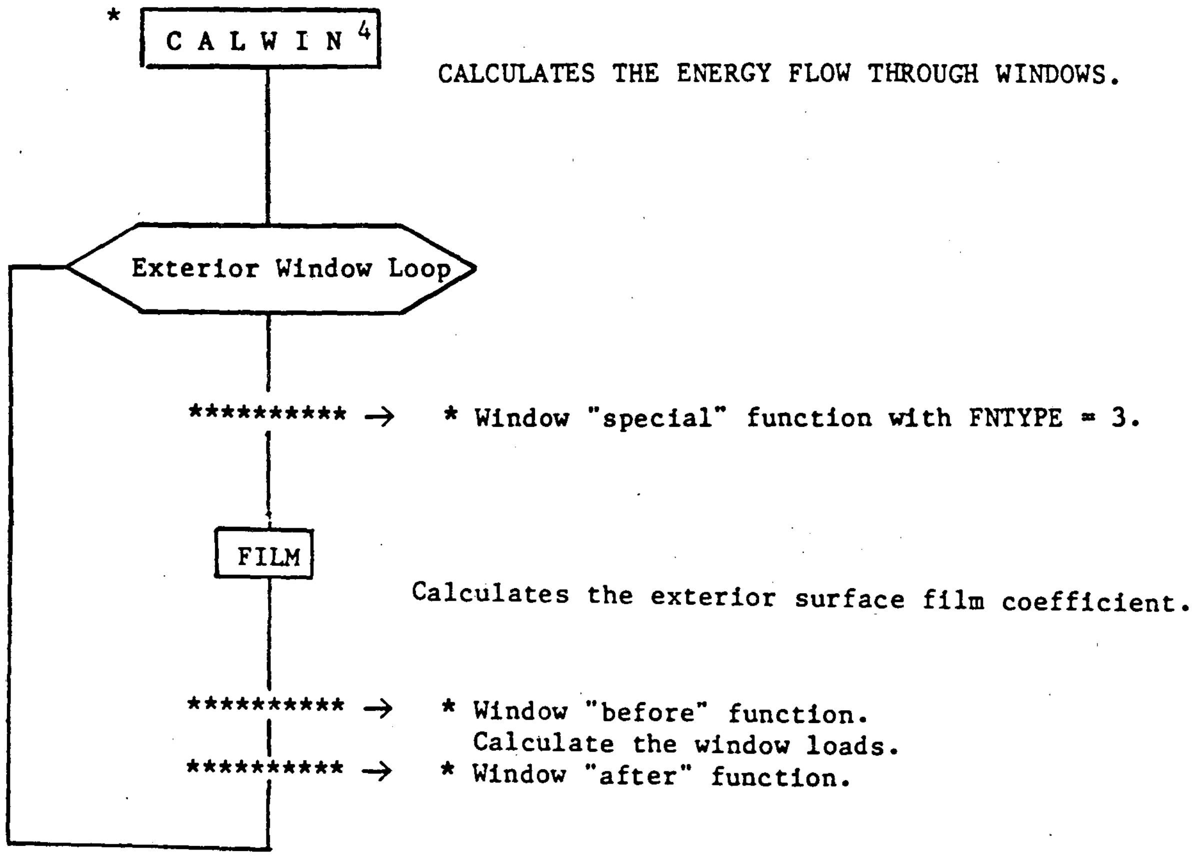


CALCULATES SOLAR TRANSFER FACTORS BETWEEN EXTERIOR WINDOWS IN A SUNSPACE AND THE INTERIOR SURFACES.

Calculates cosine of angle between sun and exterior wall.

Define sunlit area of interior wall.

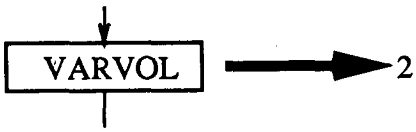
--- L E V E L 4 ---


* CALWIN 4
CALCULATES THE ENERGY FLOW THROUGH WINDOWS.
Exterior Window Loop
********** → * Window "special" function with FNTYPE = 3.
FILM
Calculates the exterior surface film coefficient.
********** → * Window "before" function.
Calculate the window loads.
********** → * Window "after" function.

SYSTEMS FLOWCHARTS

NOTES :

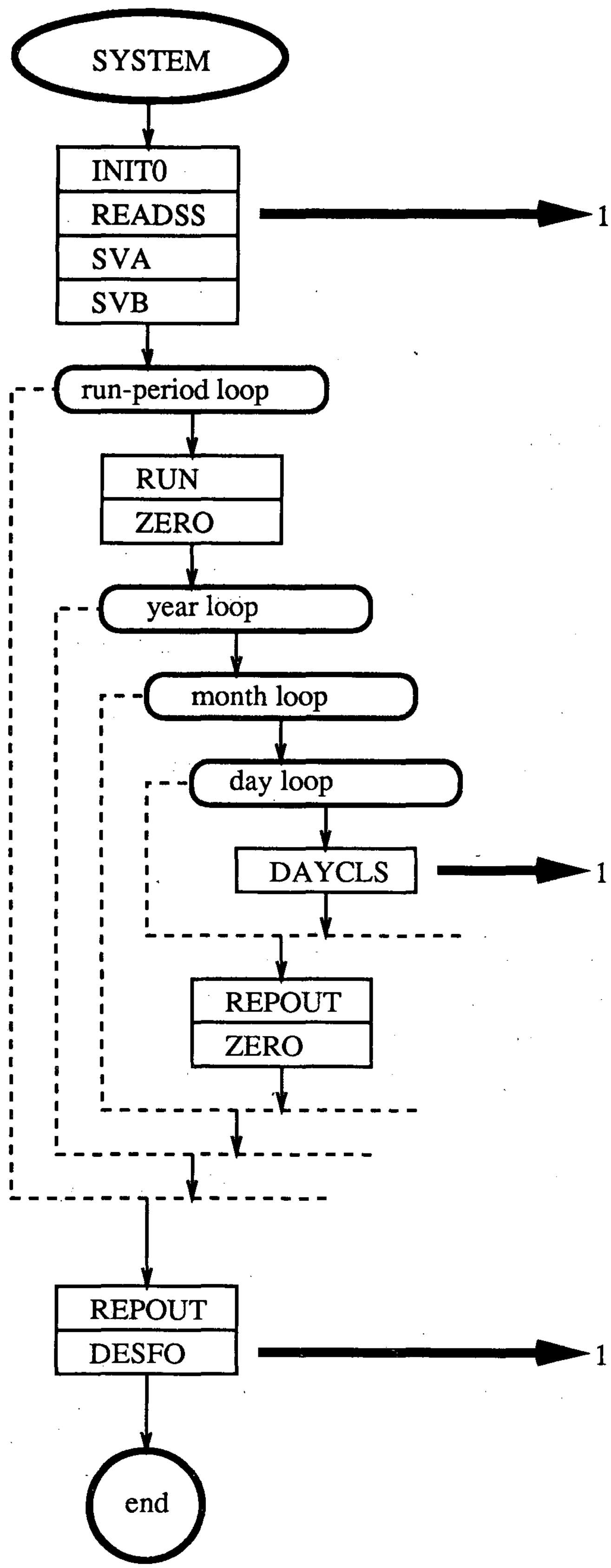
means there is a SUBR-FUNCTION named UNITV-1Z.

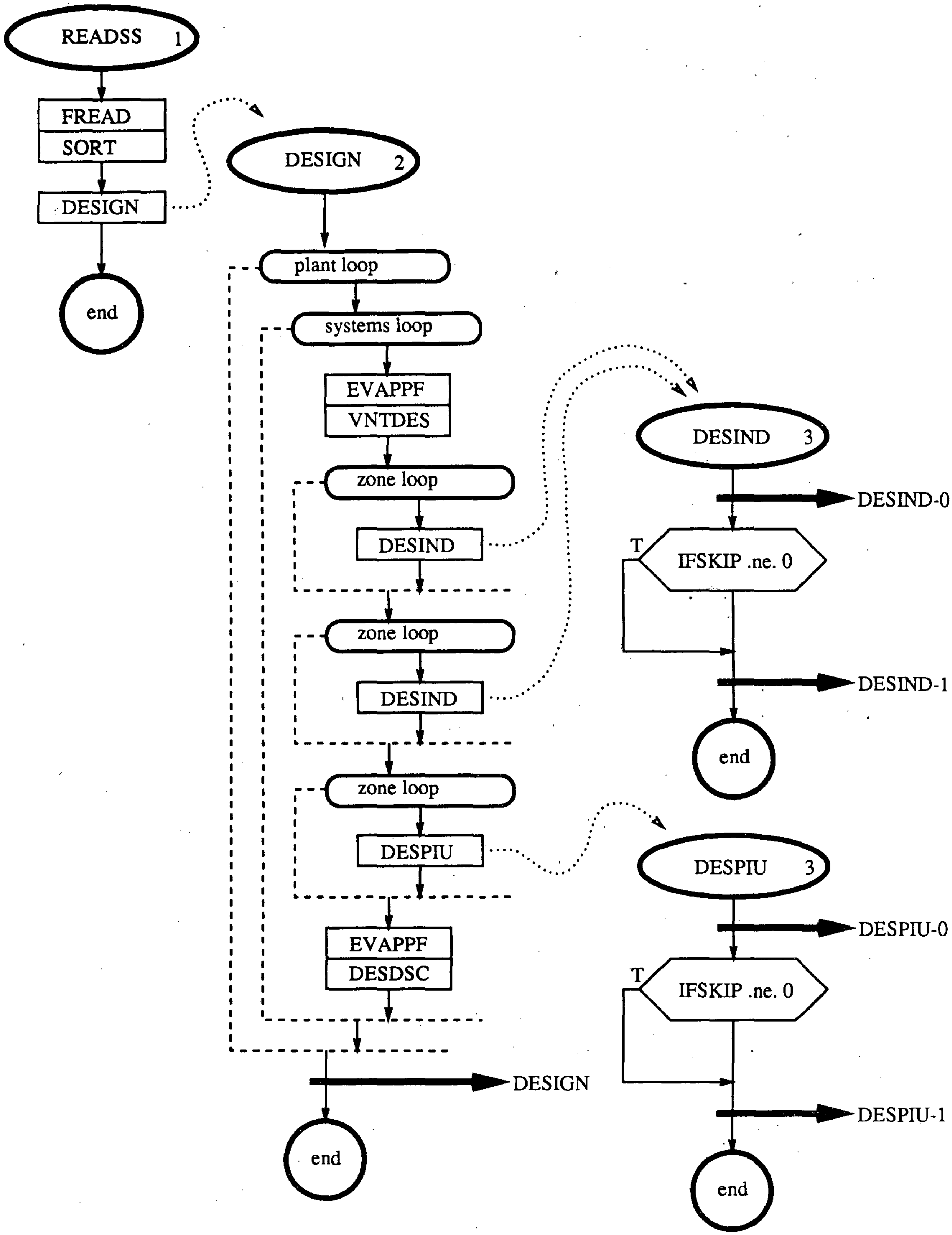


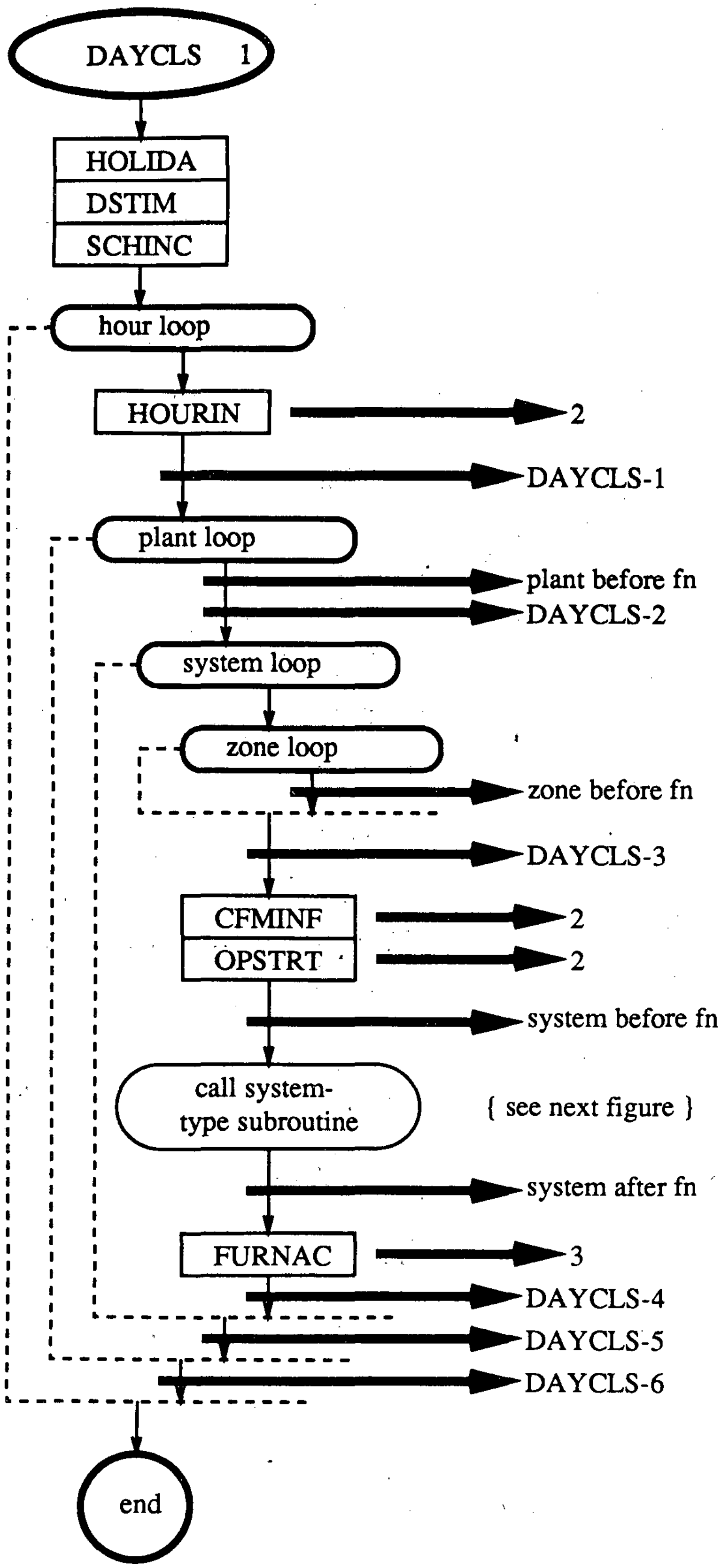
means there is a separate flowchart for subroutine VARVOL, and 2 is the level of the flowchart.

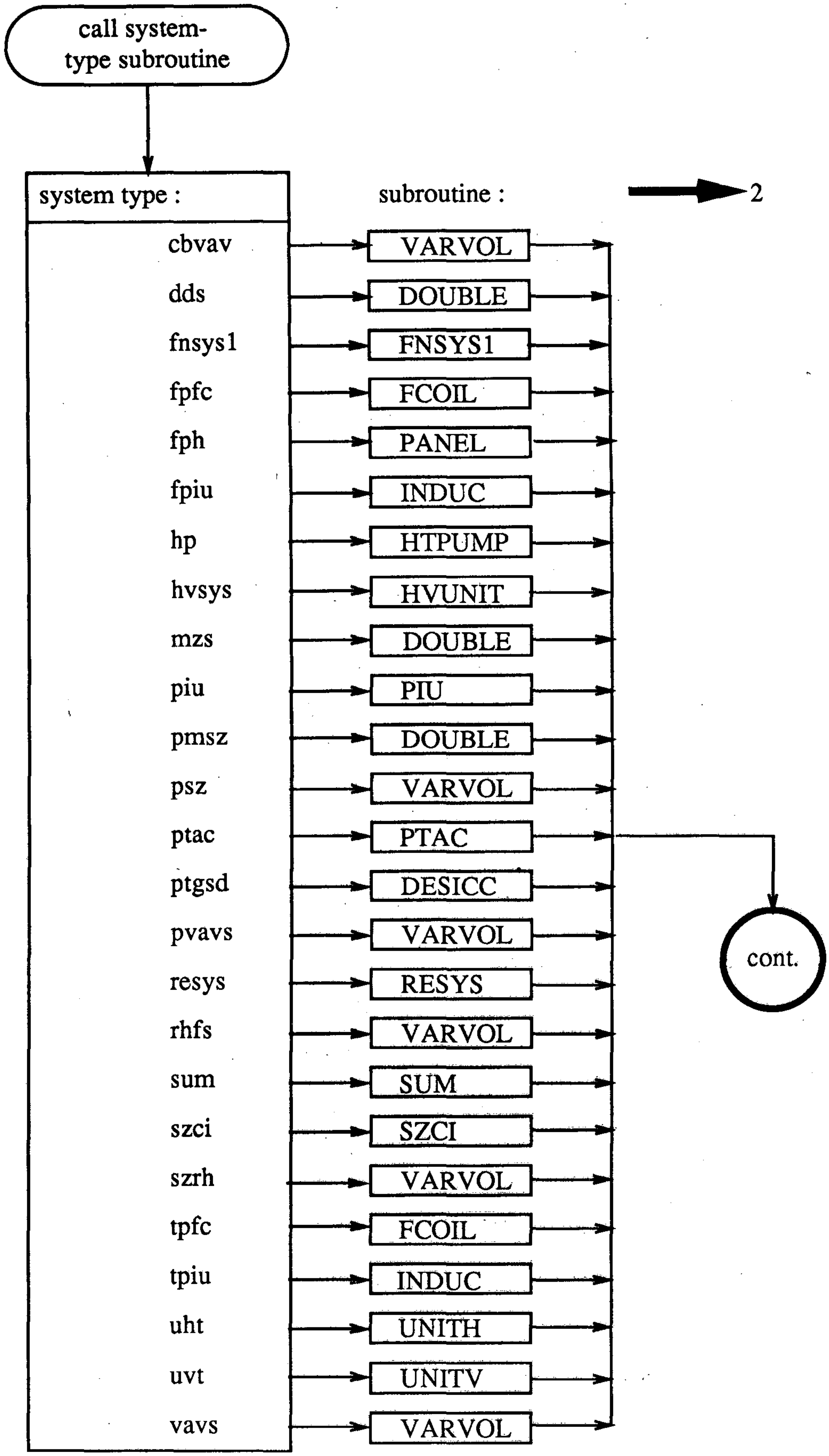
means there is a SUBR-FUNCTION named EBAL-1 in subroutine EBAL. But the separate flowchart for this subroutine is omitted.

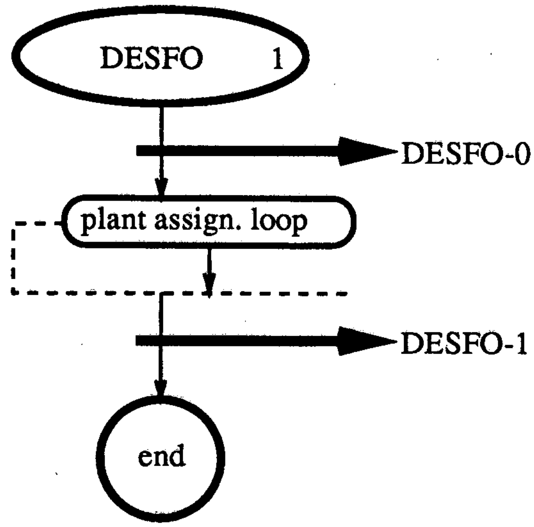
means the name of the subroutine is VARVOL , and its flowchart level is 2 .

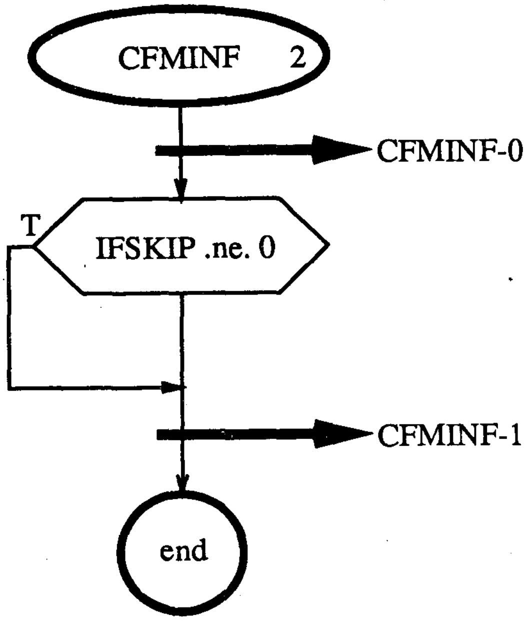

SYSTEM
INIT0
READSS
SVA
SVB
1
run-period loop
RUN
ZERO
year loop
month loop
day loop
DAYCLS
1
REPOUT
ZERO
REPOUT
DESFO
1
end

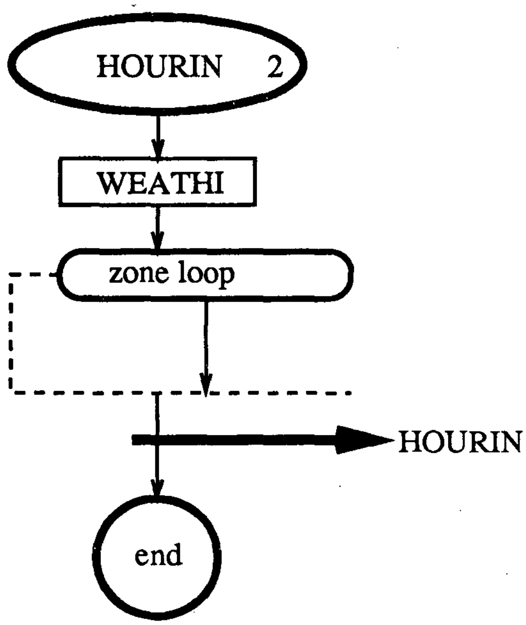

READSS 1
FREAD
SORT
DESIGN
end
DESIGN 2
plant loop
systems loop
EVAPPF
VNTDES
zone loop
DESIND
zone loop
DESIND
zone loop
DESPIU
EVAPPF
DESDSC
DESIGN
end
DESIND 3
DESIND-0
T
IFSKIP .ne. 0
DESIND-1
end
DESPIU 3
DESPIU-0
T
IFSKIP .ne. 0
DESPIU-1
end

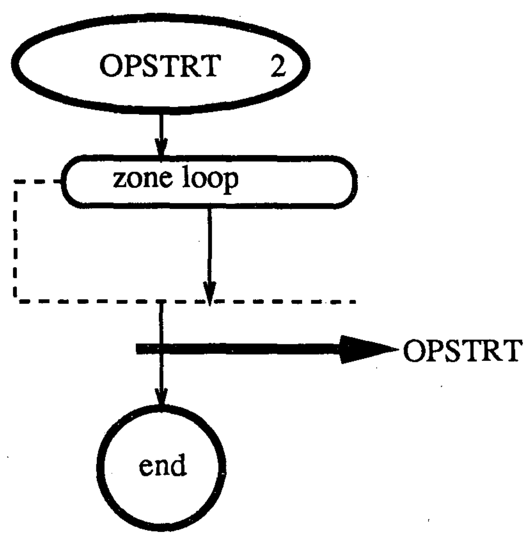

DAYCLS 1
HOLIDA
DSTIM
SCHINC
hour loop
HOURIN
2
DAYCLS-1
plant loop
plant before fn
DAYCLS-2
system loop
zone loop
zone before fn
DAYCLS-3
CFMINF
OPSTRT
2
2
system before fn
call system-type subroutine
{ see next figure }
system after fn
FURNAC
3
DAYCLS-4
DAYCLS-5
DAYCLS-6
end

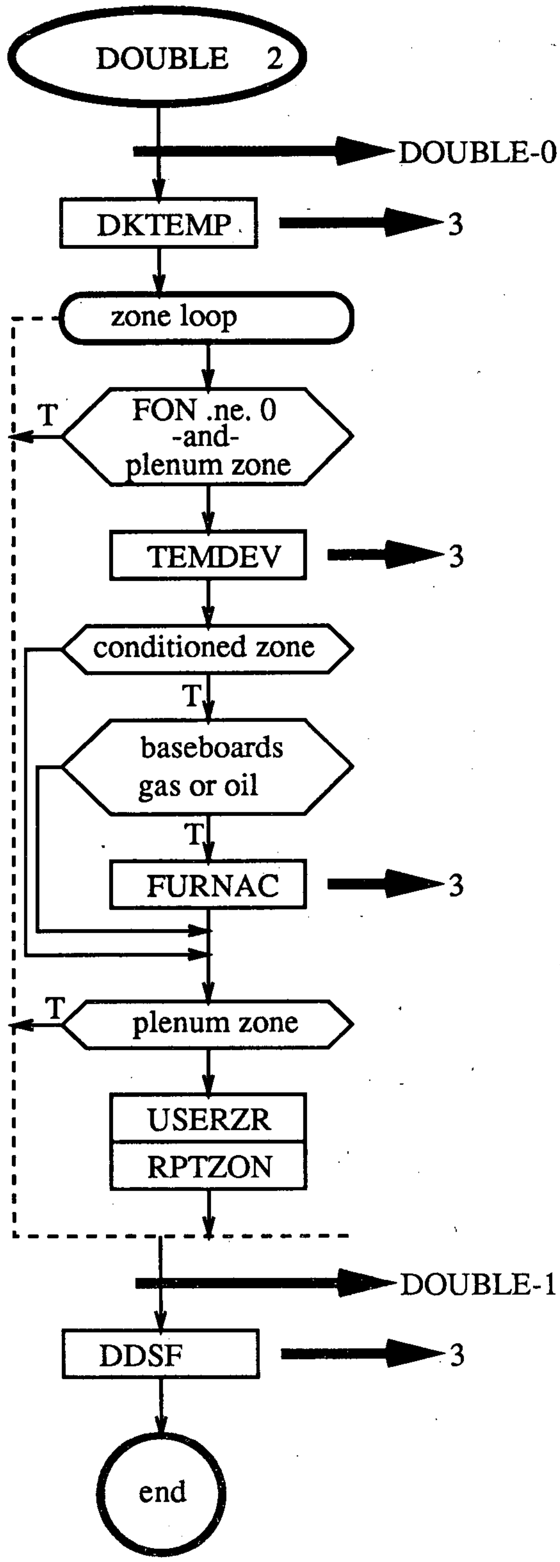

call system-
type subroutine
system type :
subroutine :
2
cbvav
VARVOL
dds
DOUBLE
fnsys1
FNSYS1
fpfc
FCOIL
fph
PANEL
fpiu
INDUC
hp
HTPUMP
hvsys
HVUNIT
mzs
DOUBLE
piu
PIU
pmsz
DOUBLE
psz
VARVOL
ptac
PTAC
ptgsd
DESICC
pvavs
VARVOL
resys
RESYS
rhfs
VARVOL
sum
SUM
szci
SZCI
szrh
VARVOL
tpfc
FCOIL
tpiu
INDUC
uht
UNITH
uvt
UNITV
vavs
VARVOL
cont.

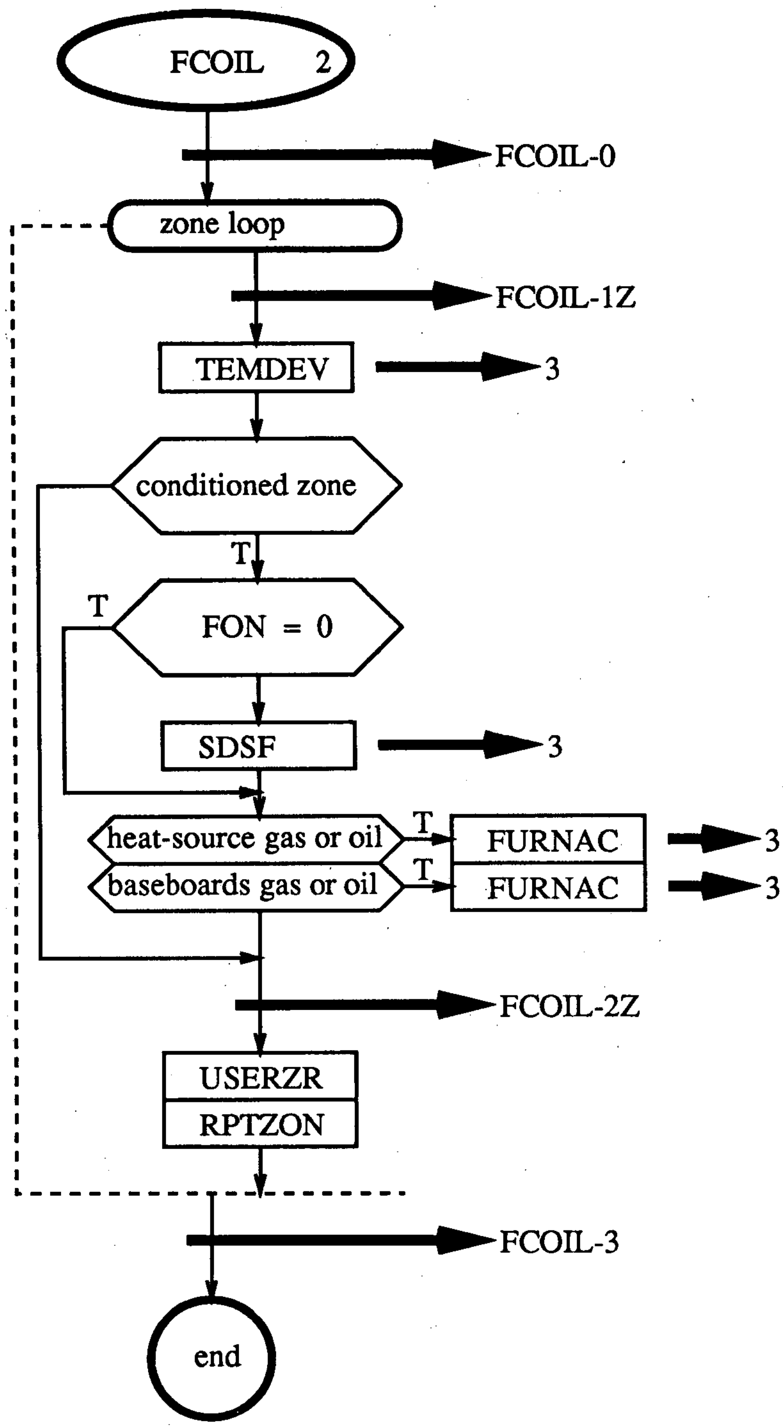

DESFO 1
DESFO-0
plant assign. loop
DESFO-1
end

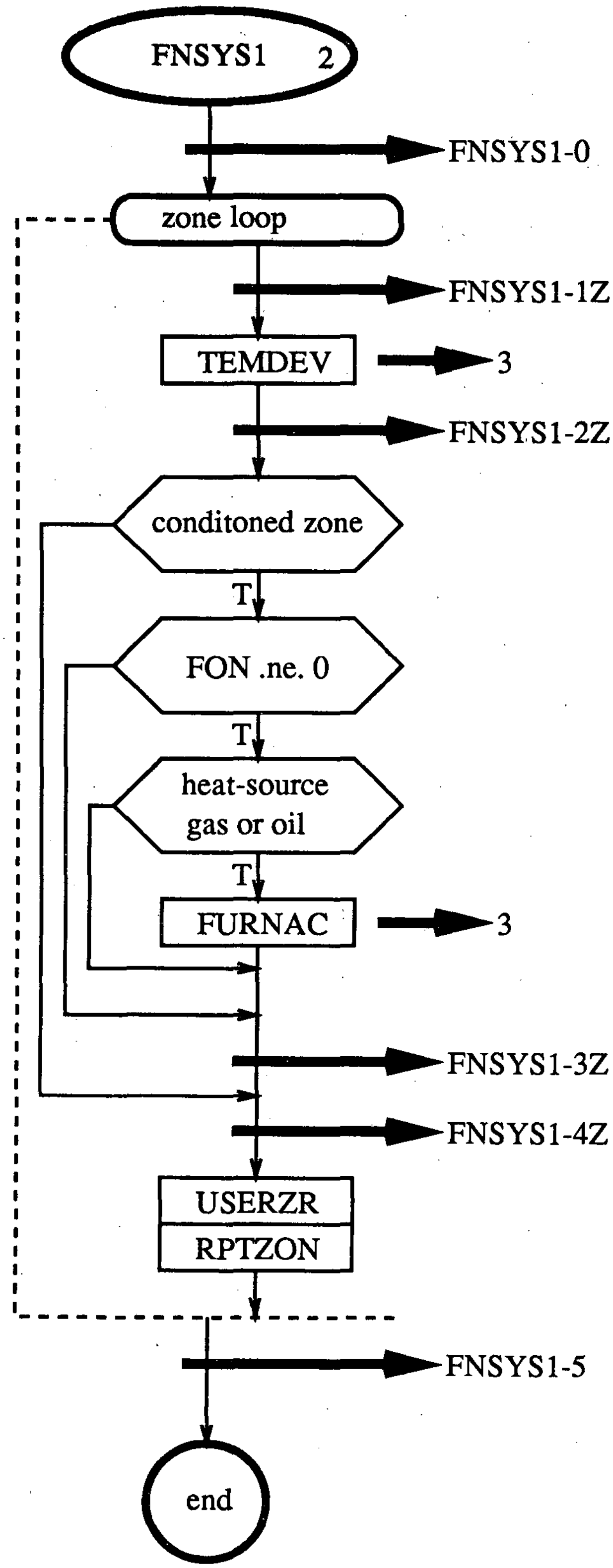

CFMINF 2
CFMINF-0
T
IFSKIP .ne. 0
CFMINF-1
end

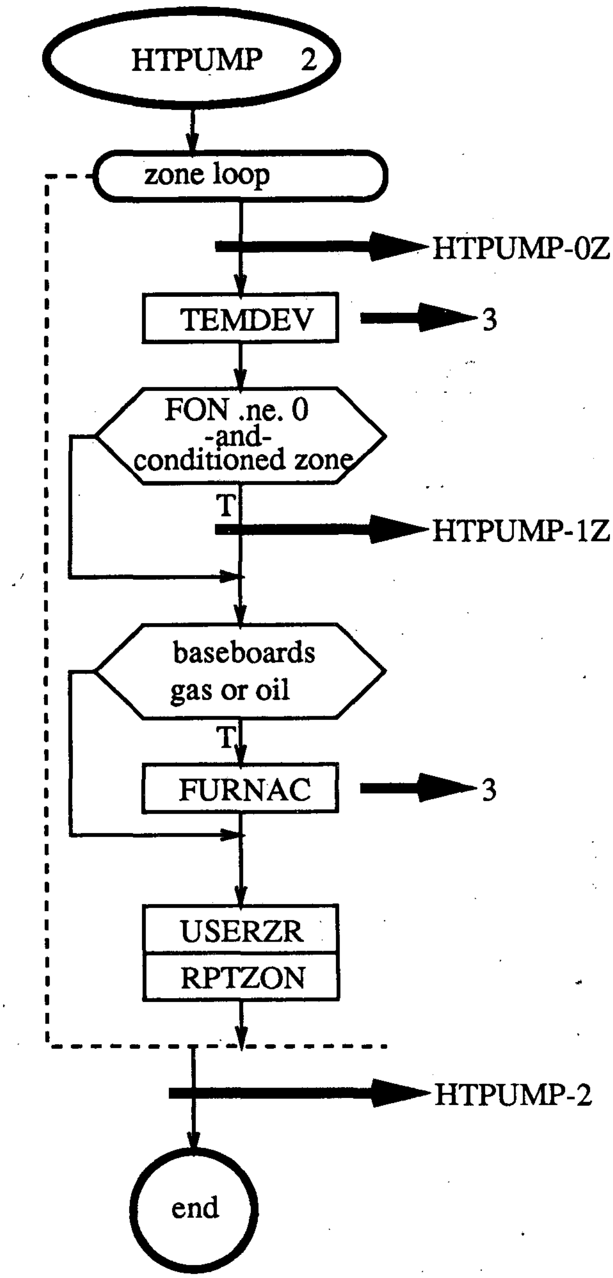

HOURIN 2
WEATHI
zone loop
HOURIN
end

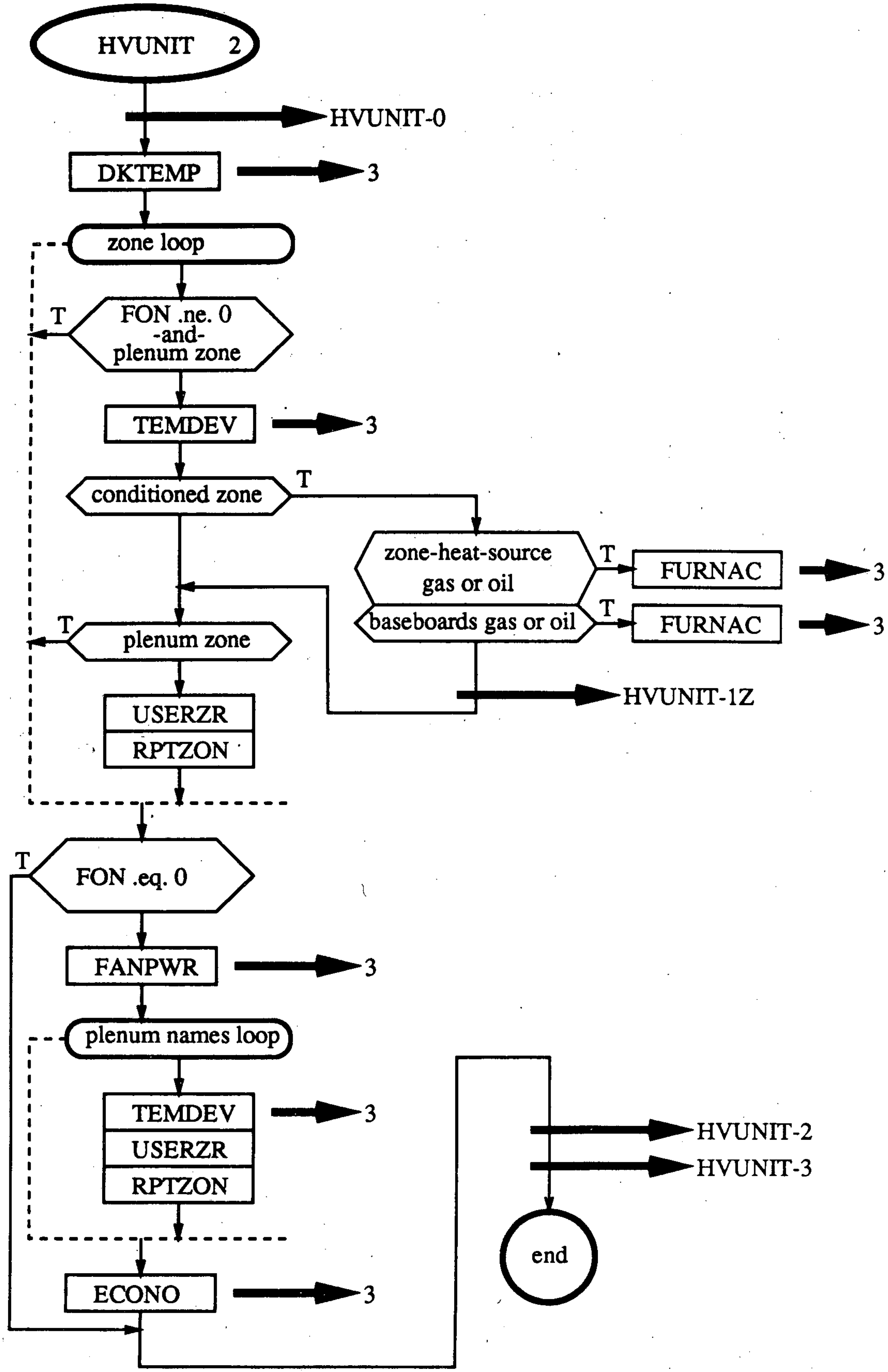

OPSTRT 2
zone loop
OPSTRT
end

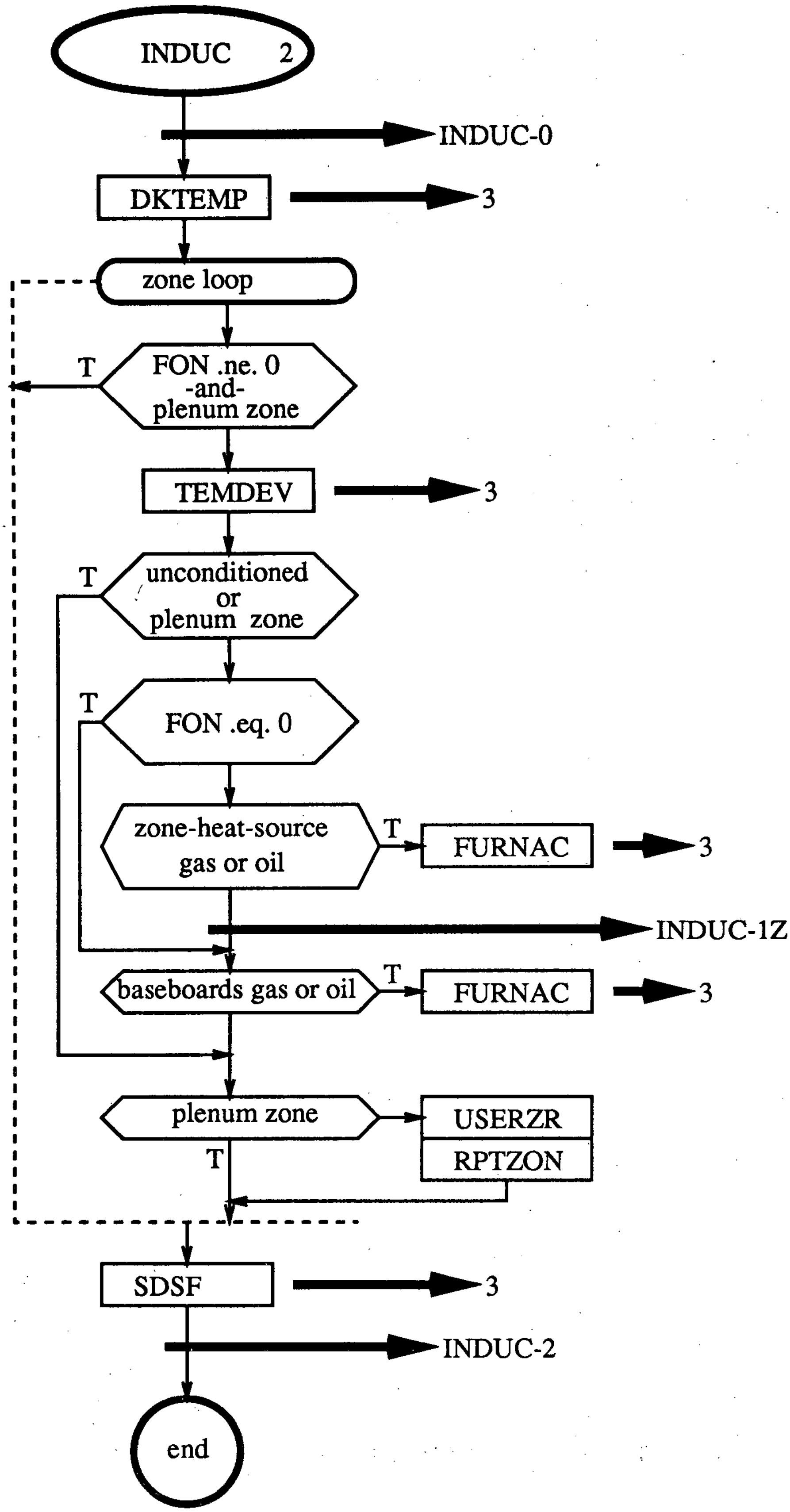

DOUBLE 2
DOUBLE-0
DKTEMP
3
zone loop
T
FON .ne. 0
-and-
plenum zone
TEMDEV
3
conditioned zone
T
baseboards
gas or oil
T
FURNAC
3
T
plenum zone
USERZR
RPTZON
DOUBLE-1
DDSF
3
end

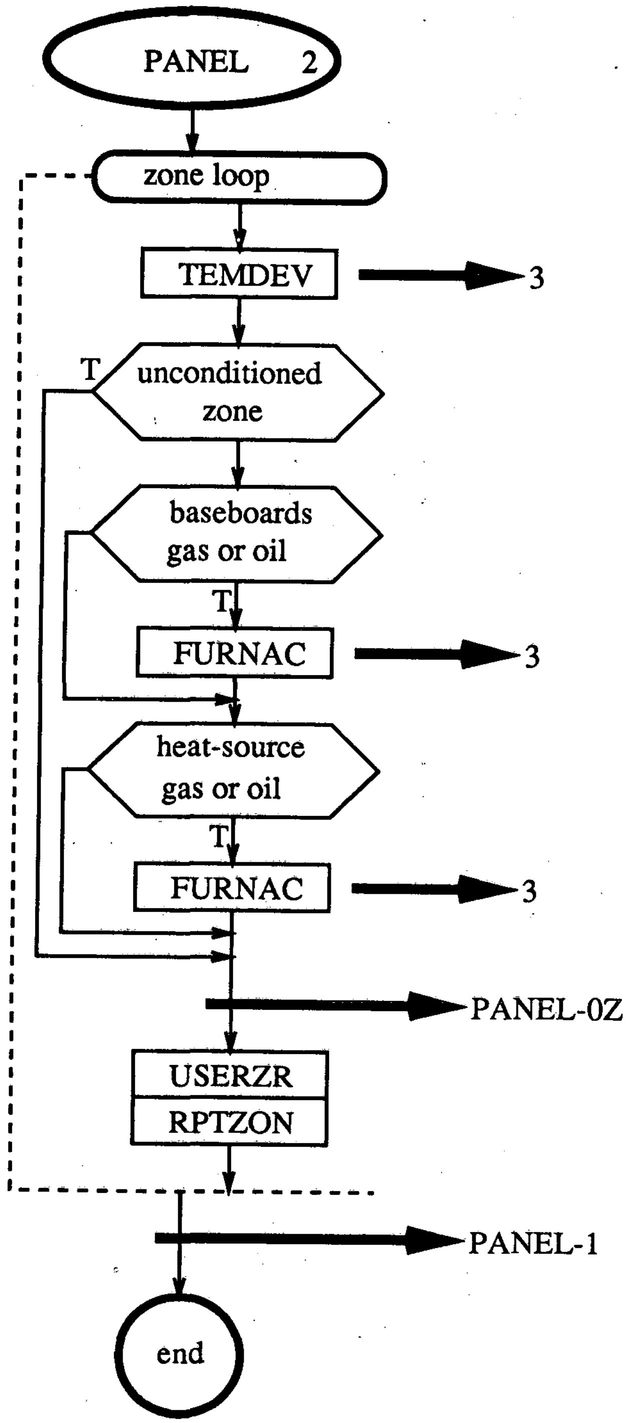

FCOIL 2
FCOIL-0
zone loop
FCOIL-1Z
TEMDEV
3
conditioned zone
T
T
FON = 0
SDSF
3
heat-source gas or oil
T
FURNAC
3
baseboards gas or oil
T
FURNAC
3
FCOIL-2Z
USERZR
RPTZON
FCOIL-3
end

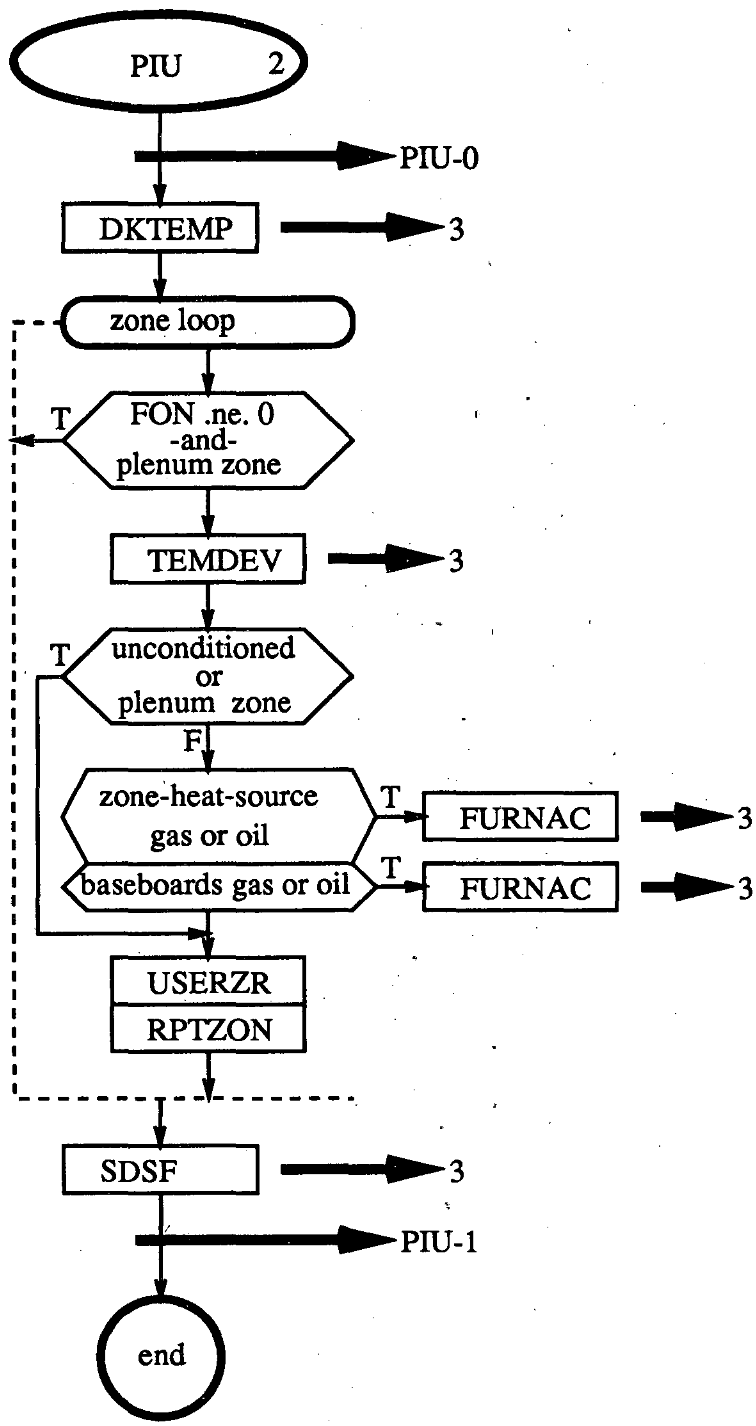

FNSYS1 2
FNSYS1-0
zone loop
FNSYS1-1Z
TEMDEV
3
FNSYS1-2Z
conditoned zone
T
FON .ne. 0
T
heat-source gas or oil
T
FURNAC
3
FNSYS1-3Z
FNSYS1-4Z
USERZR
RPTZON
FNSYS1-5
end


HTPUMP 2
zone loop
HTPUMP-0Z
TEMDEV
3
FON .ne. 0
-and-
conditioned zone
T
HTPUMP-1Z
baseboards
gas or oil
T
FURNAC
3
USERZR
RPTZON
HTPUMP-2
end

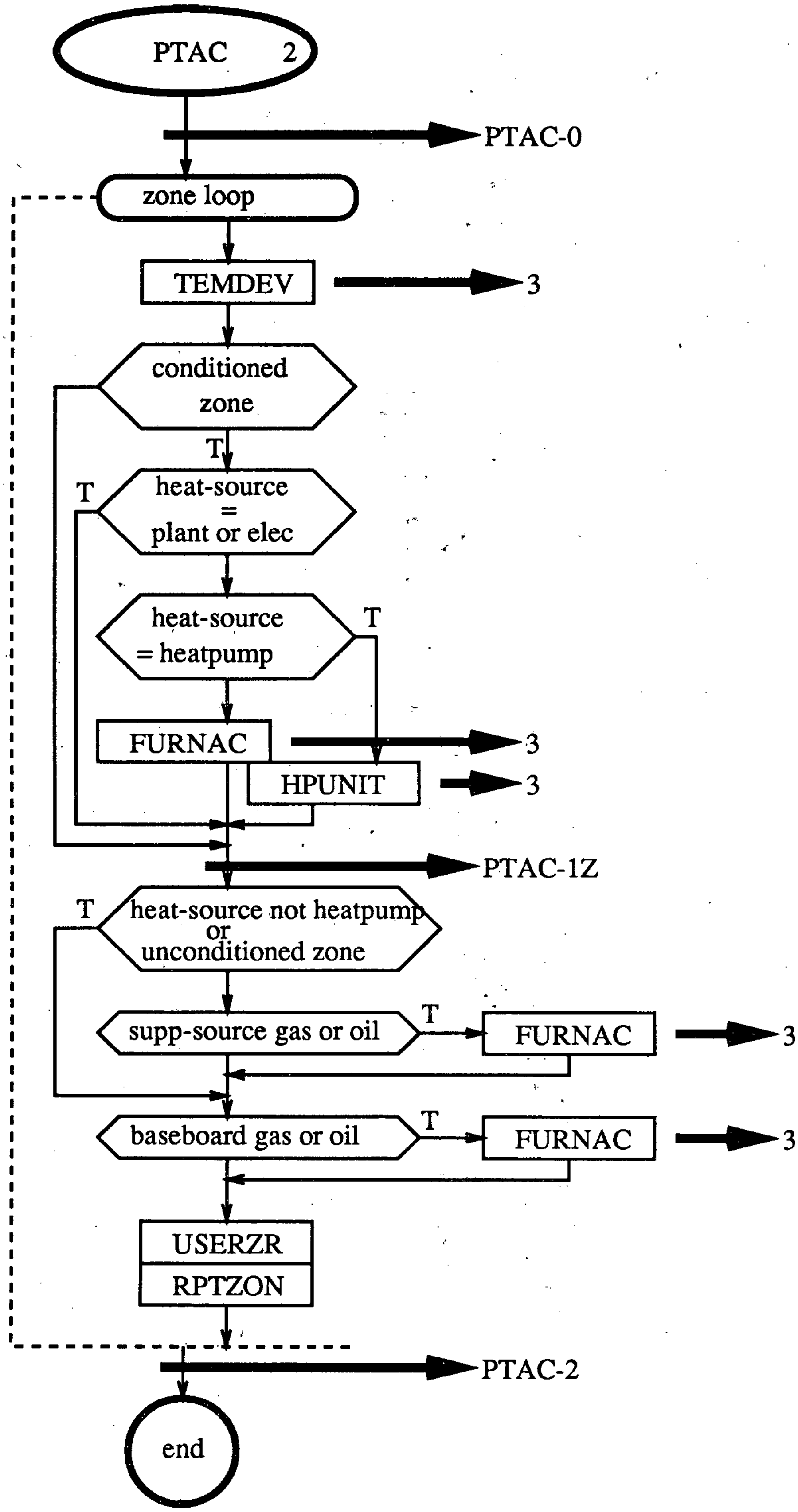

HVUNIT 2
HVUNIT-0
DKTEMP
3
zone loop
T
FON .ne. 0
-and-
plenum zone
TEMDEV
3
conditioned zone
T
zone-heat-source
gas or oil
T
FURNAC
3
baseboards gas or oil
T
FURNAC
3
T
plenum zone
USERZR
RPTZON
HVUNIT-1Z
T
FON .eq. 0
FANPWR
3
plenum names loop
TEMDEV
3
USERZR
RPTZON
HVUNIT-2
HVUNIT-3
end
ECONO
3

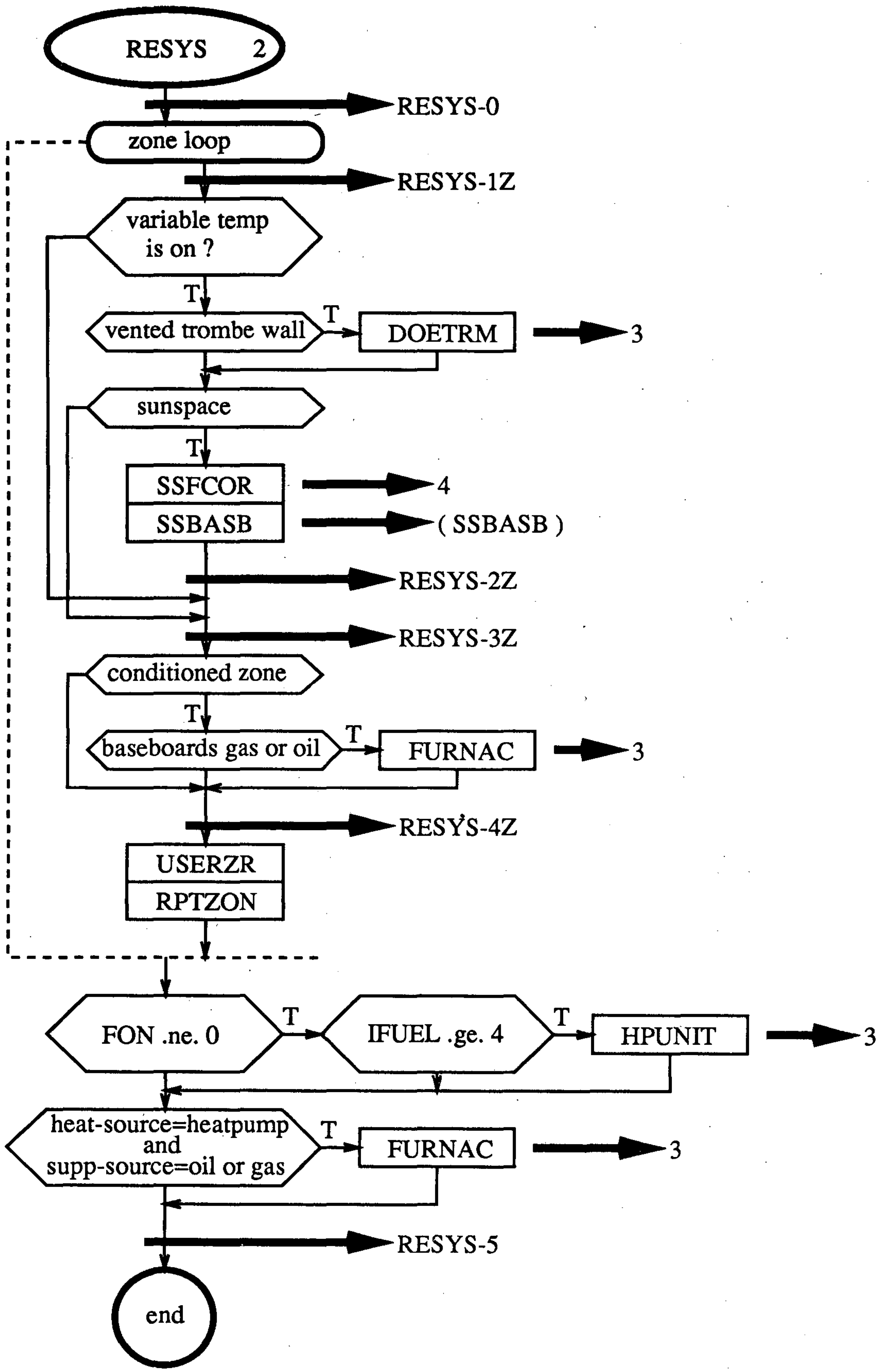

INDUC 2
INDUC-0
DKTEMP
3
zone loop
T
FON .ne. 0
-and-
plenum zone
TEMDEV
3
T
unconditioned
or
plenum zone
T
FON .eq. 0
zone-heat-source
gas or oil
T
FURNAC
3
INDUC-1Z
baseboards gas or oil
T
FURNAC
3
plenum zone
USERZR
RPTZON
T
SDSF
3
INDUC-2
end

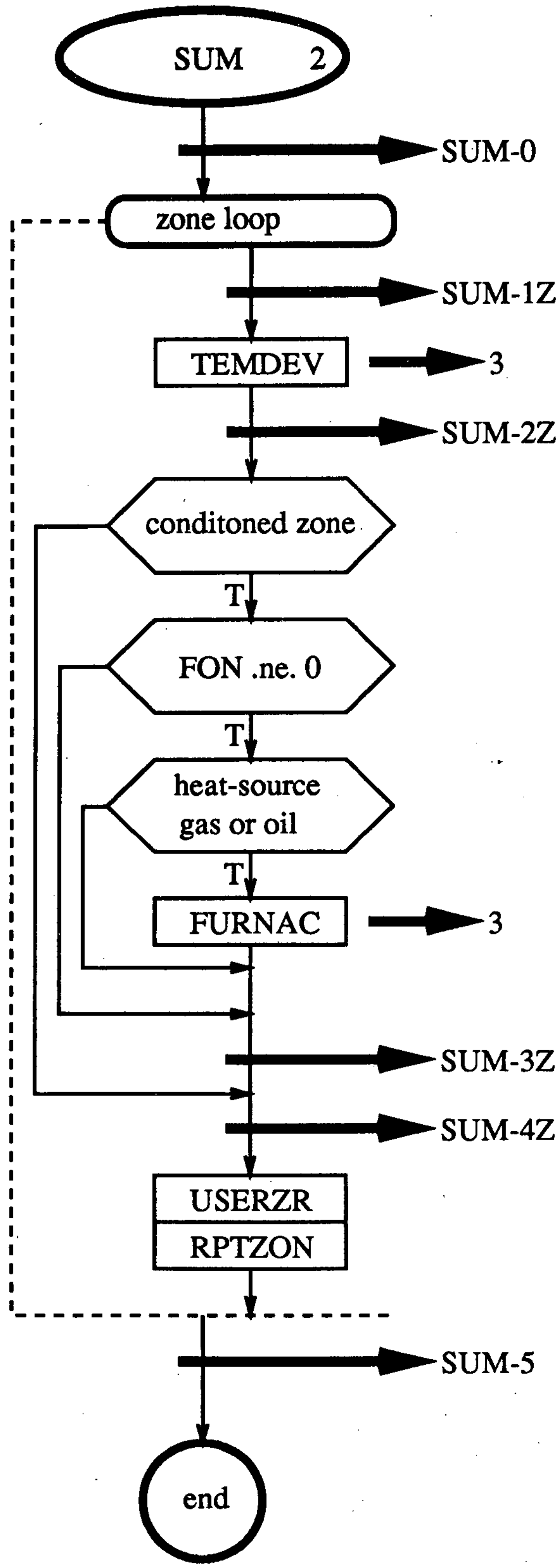

PANEL 2
zone loop
TEMDEV
3
T
unconditioned zone
baseboards gas or oil
T
FURNAC
3
heat-source gas or oil
T
FURNAC
3
PANEL-0Z
USERZR
RPTZON
PANEL-1
end



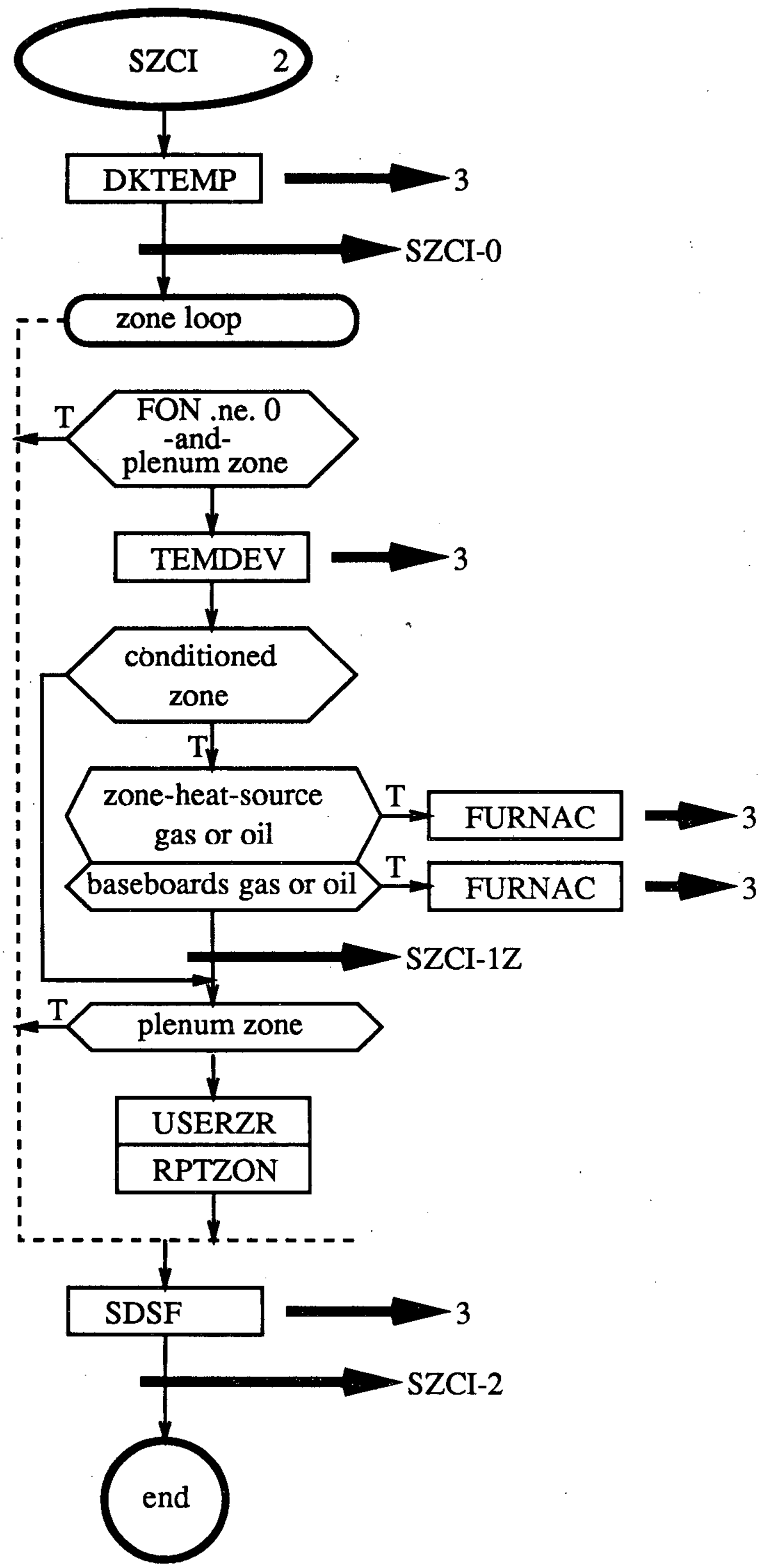
PIU 2
PIU-0
DKTEMP
3
zone loop
T
FON .ne. 0
-and-
plenum zone
TEMDEV
3
T
unconditioned
or
plenum zone
F
zone-heat-source
gas or oil
T
FURNAC
3
baseboards gas or oil
T
FURNAC
3
USERZR
RPTZON
SDSF
3
PIU-1
end

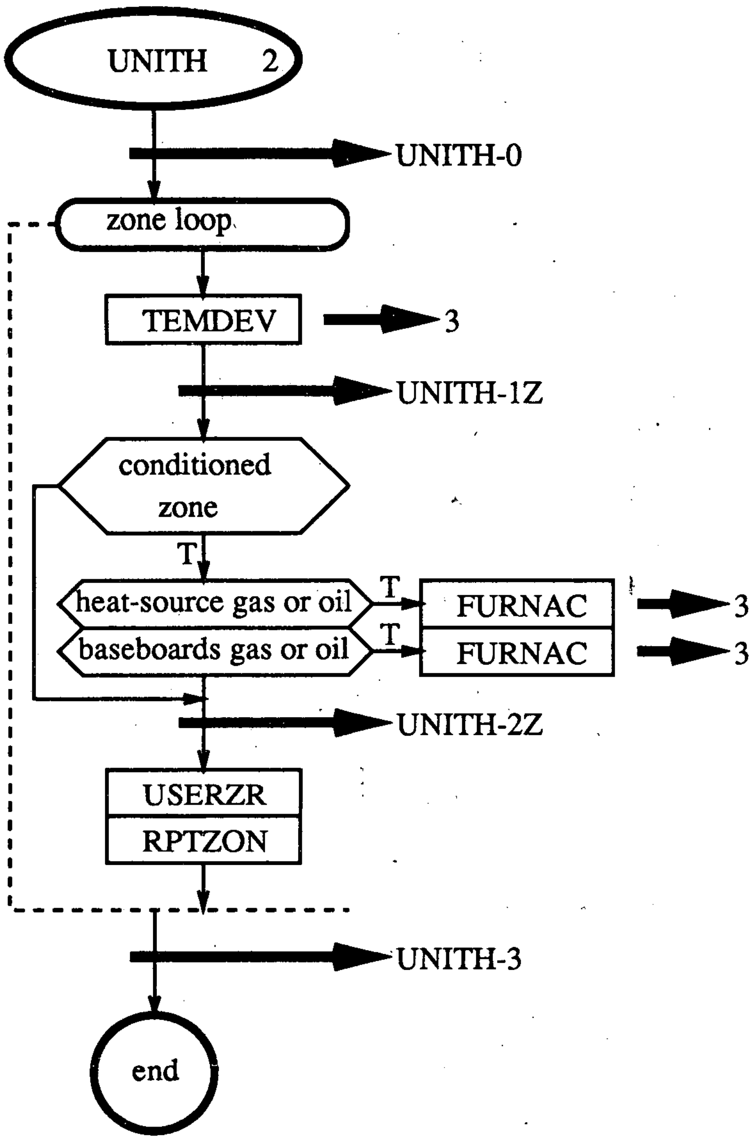

PTAC 2
PTAC-0
zone loop
TEMDEV
3
conditioned
zone
T
heat-source
=
plant or elec
T
heat-source
= heatpump
T
FURNAC
3
HPUNIT
3
PTAC-1Z
T
heat-source not heatpump
or
unconditioned zone
supp-source gas or oil
T
FURNAC
3
baseboard gas or oil
T
FURNAC
3
USERZR
RPTZON
PTAC-2
end

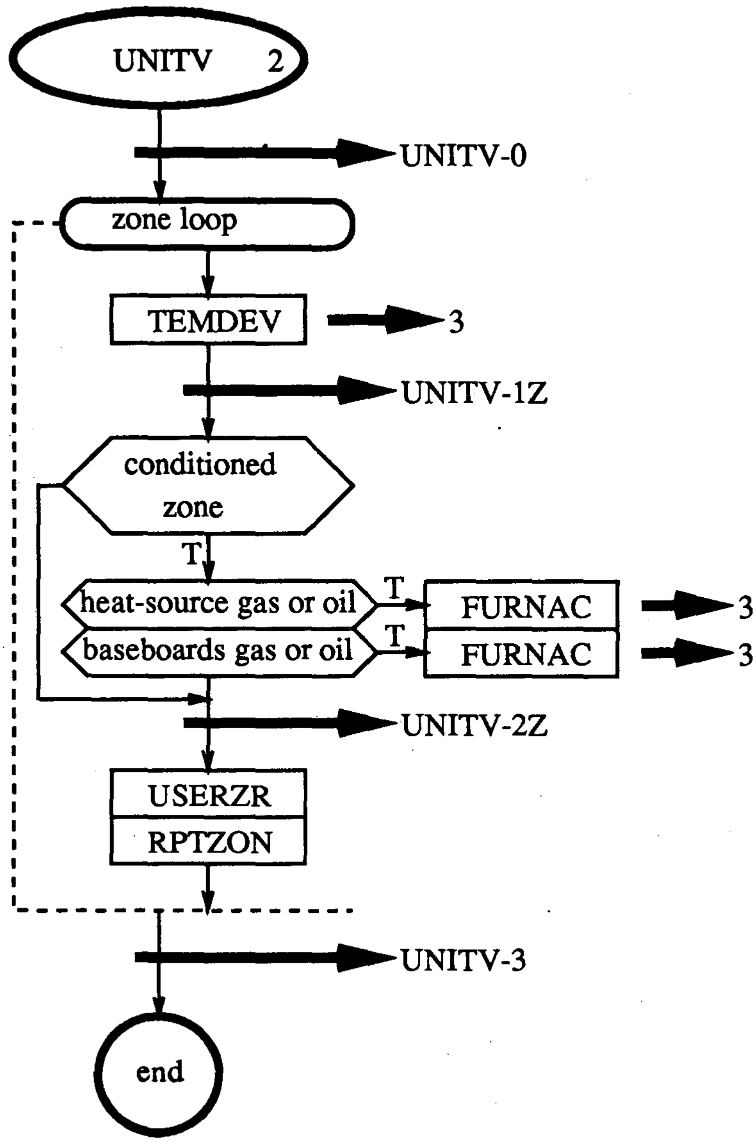

RESYS 2
RESYS-0
zone loop
RESYS-1Z
variable temp is on ?
T
vented trombe wall
T
DOETRM
3
sunspace
T
SSFCOR
SSBASB
4
(SSBASB)
RESYS-2Z
RESYS-3Z
conditioned zone
T
baseboards gas or oil
T
FURNAC
3
RESYS-4Z
USERZR
RPTZON
FON .ne. 0
T
IFUEL .ge. 4
T
HPUNIT
3
heat-source=heatpump and supp-source=oil or gas
T
FURNAC
3
RESYS-5
end

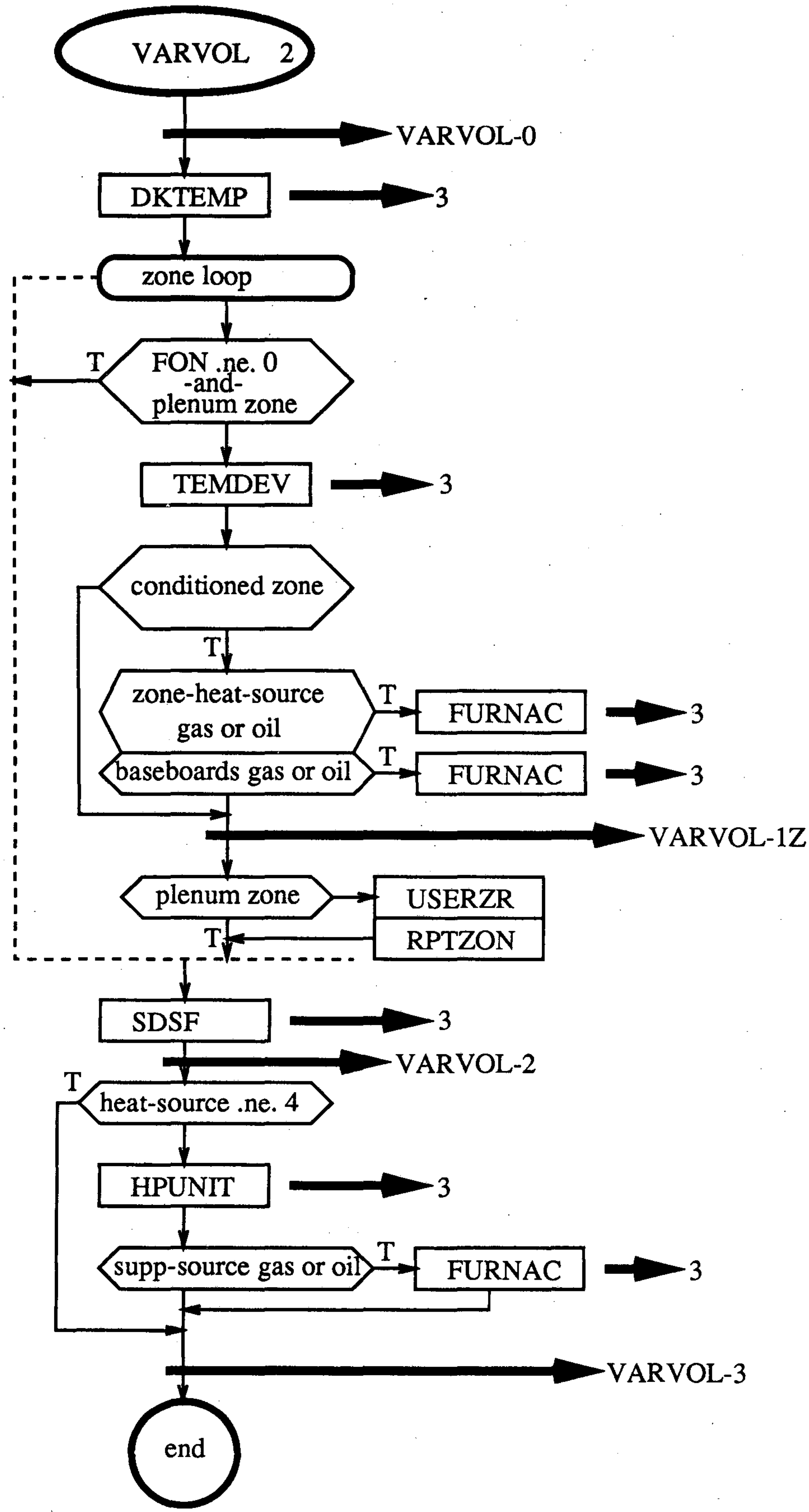


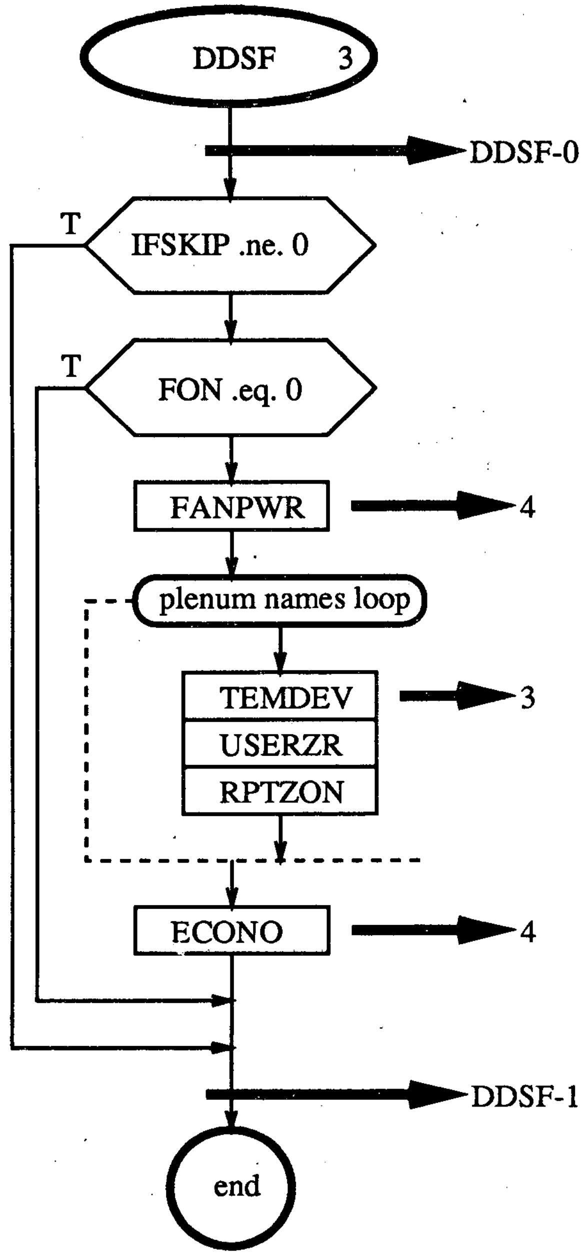
SUM 2
SUM-0
zone loop
SUM-1Z
TEMDEV
3
SUM-2Z
conditoned zone
T
FON .ne. 0
T
heat-source gas or oil
T
FURNAC
3
SUM-3Z
SUM-4Z
USERZR
RPTZON
SUM-5
end

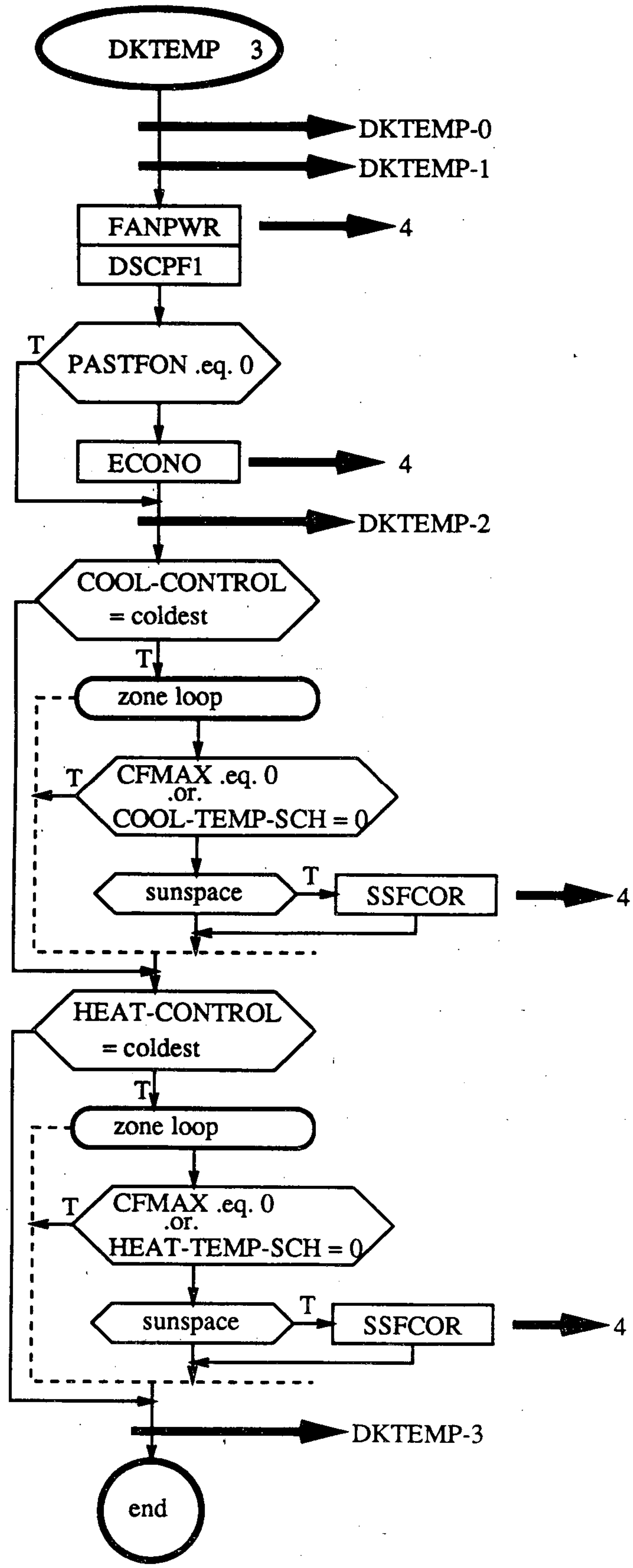

SZCI 2
DKTEMP
3
SZCI-0
zone loop
T
FON .ne. 0
-and-
plenum zone
TEMDEV
3
conditioned
zone
T
zone-heat-source
gas or oil
T
FURNAC
3
baseboards gas or oil
T
FURNAC
3
SZCI-1Z
T
plenum zone
USERZR
RPTZON
SDSF
3
SZCI-2
end

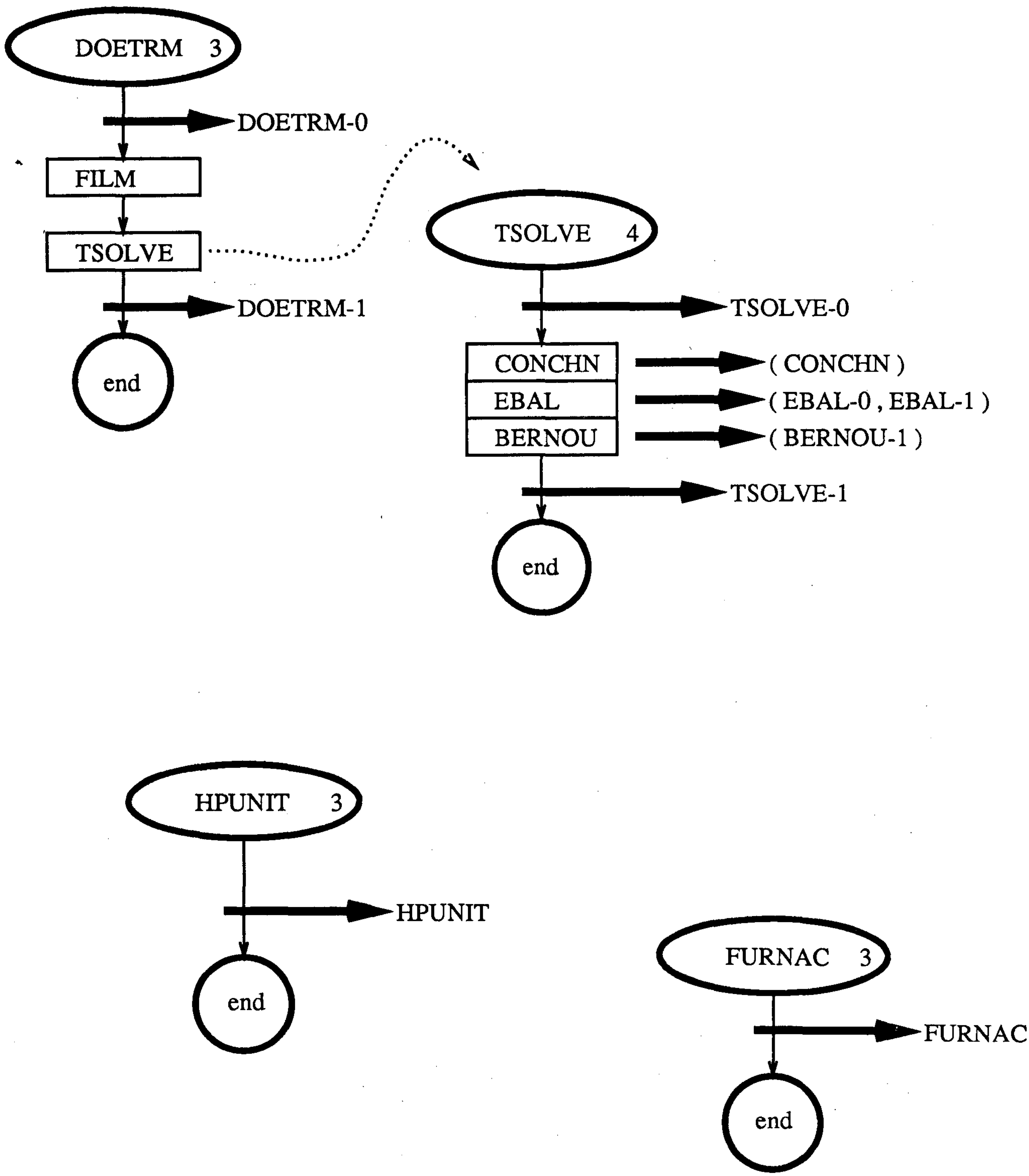

UNITH 2
UNITH-0
zone loop
TEMDEV
3
UNITH-1Z
conditioned zone
T
heat-source gas or oil
T
FURNAC
3
baseboards gas or oil
T
FURNAC
3
UNITH-2Z
USERZR
RPTZON
UNITH-3
end

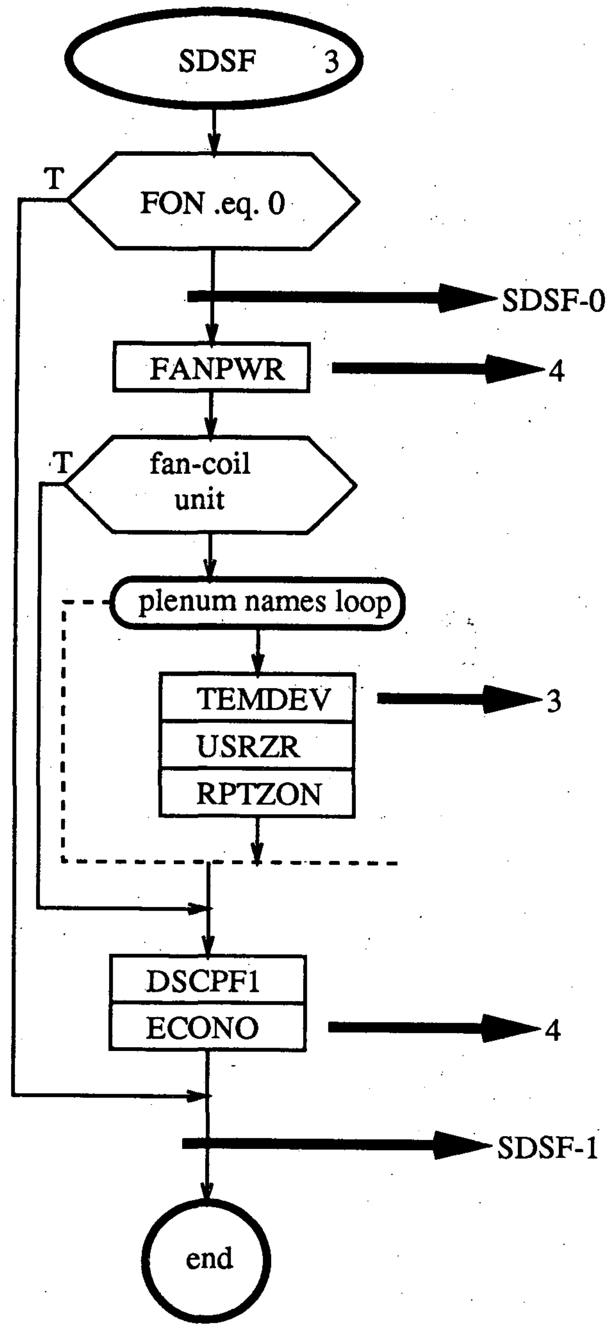

UNITV 2
UNITV-0
zone loop
TEMDEV
3
UNITV-1Z
conditioned zone
T
heat-source gas or oil
T
FURNAC
3
baseboards gas or oil
T
FURNAC
3
UNITV-2Z
USERZR
RPTZON
UNITV-3
end

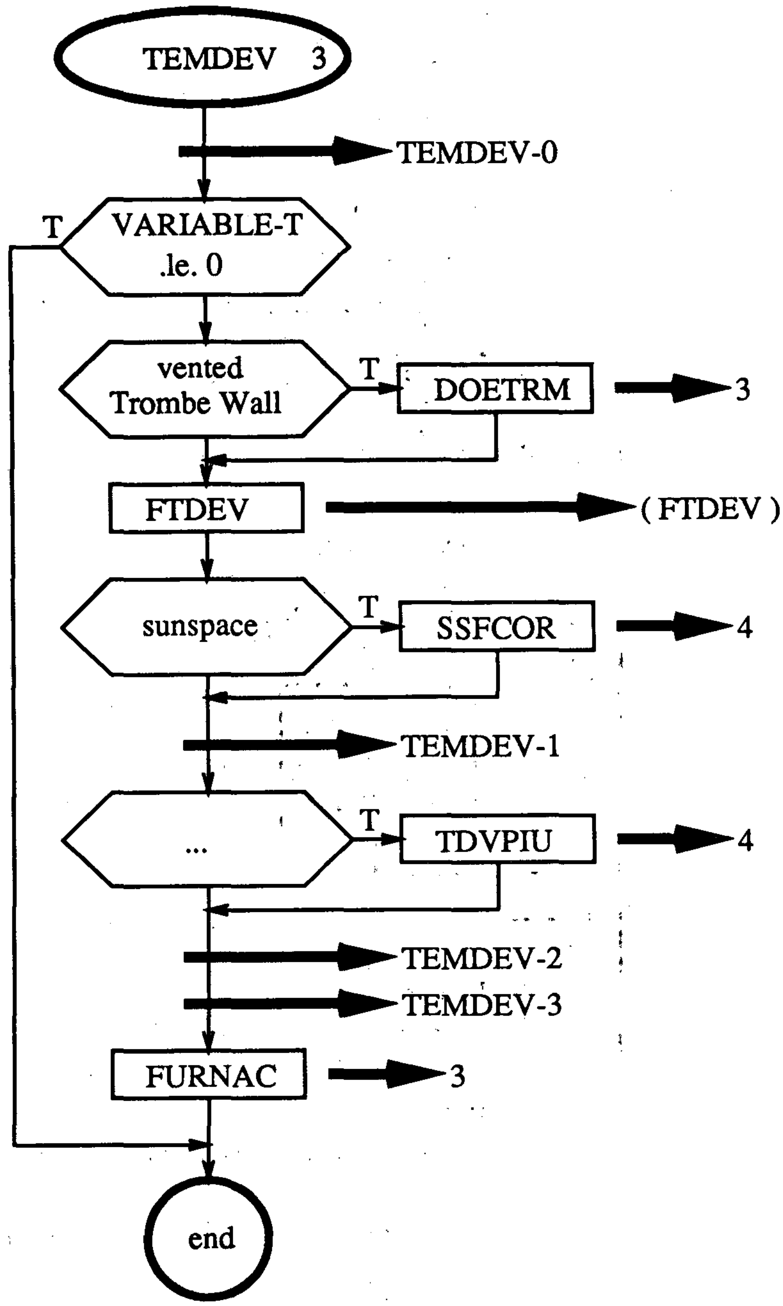

VARVOL 2
VARVOL-0
DKTEMP
3
zone loop
T
FON .ne. 0
-and-
plenum zone
TEMDEV
3
conditioned zone
T
zone-heat-source
gas or oil
T
FURNAC
3
baseboards gas or oil
T
FURNAC
3
VARVOL-1Z
plenum zone
USERZR
RPTZON
T
SDSF
3
VARVOL-2
T
heat-source .ne. 4
HPUNIT
3
supp-source gas or oil
T
FURNAC
3
VARVOL-3
end

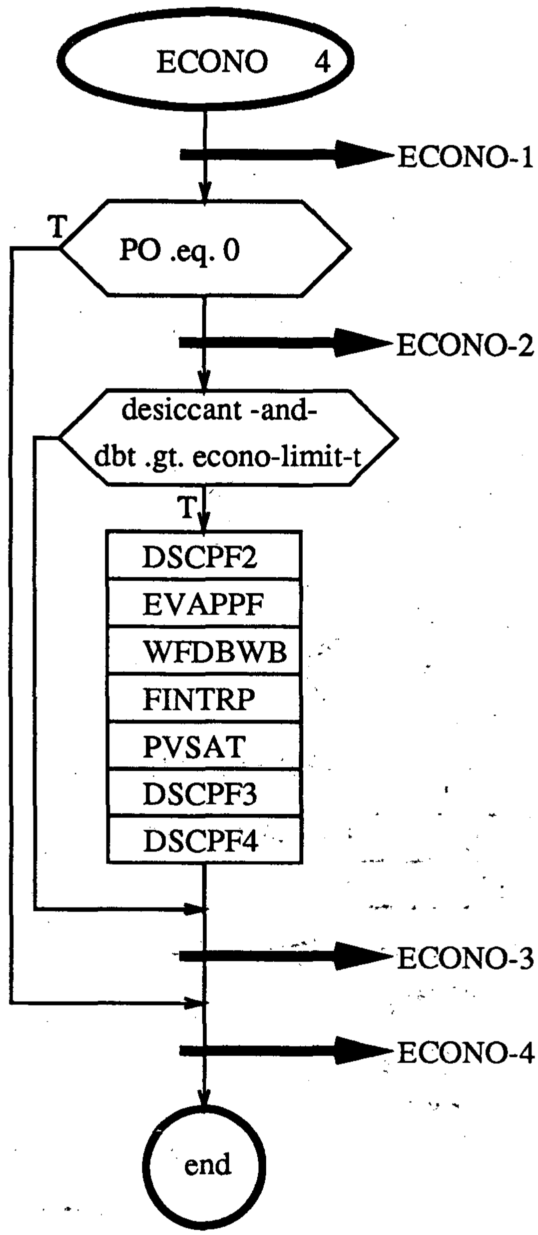

DDSF 3
DDSF-0
T
IFSKIP .ne. 0
T
FON .eq. 0
FANPWR
4
plenum names loop
TEMDEV
USERZR
RPTZON
3
ECONO
4
DDSF-1
end

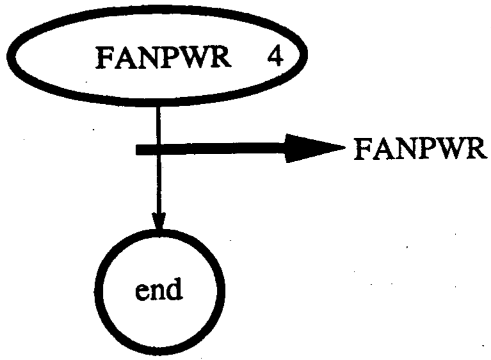

DKTEMP 3
DKTEMP-0
DKTEMP-1
FANPWR
DSCPF1
4
T
PASTFON .eq. 0
ECONO
4
DKTEMP-2
COOL-CONTROL
= coldest
T
zone loop
T
CFMAX .eq. 0
.or.
COOL-TEMP-SCH = 0
sunspace
T
SSFCOR
4
HEAT-CONTROL
= coldest
T
zone loop
T
CFMAX .eq. 0
.or.
HEAT-TEMP-SCH = 0
sunspace
T
SSFCOR
4
DKTEMP-3
end

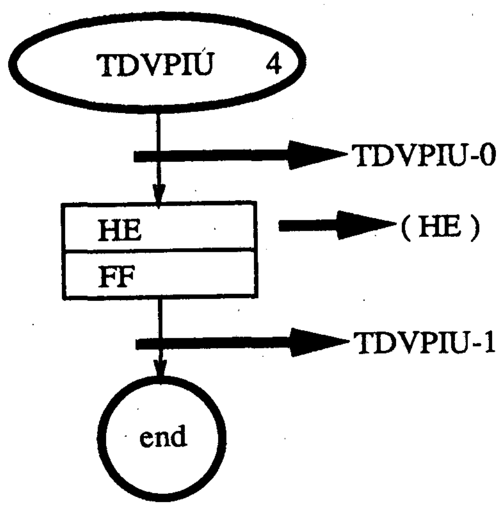

DOETRM 3
DOETRM-0
FILM
TSOLVE
DOETRM-1
end
TSOLVE 4
TSOLVE-0
CONCHN
EBAL
BERNOU
(CONCHN)
(EBAL-0 , EBAL-1)
(BERNOU-1)
TSOLVE-1
end
HPUNIT 3
HPUNIT
end
FURNAC 3
FURNAC
end

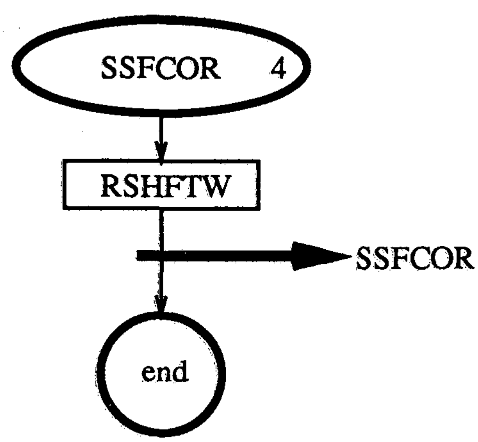

SDSF 3
T
FON .eq. 0
SDSF-0
FANPWR
4
T
fan-coil
unit
plenum names loop
TEMDEV
USRZR
RPTZON
3
DSCPF1
ECONO
4
SDSF-1
end


TEMDEV 3
TEMDEV-0
T
VARIABLE-T
.le. 0
vented
Trombe Wall
T
DOETRM
3
FTDEV
(FTDEV)
sunspace
T
SSFCOR
4
TEMDEV-1
...
T
TDVPIU
4
TEMDEV-2
TEMDEV-3
FURNAC
3
end


ECONO 4
ECONO-1
T
PO .eq. 0
ECONO-2
desiccant -and-
dbt .gt. econo-limit-t
T
DSCPF2
EVAPPF
WFDBWB
FINTRP
PVSAT
DSCPF3
DSCPF4
ECONO-3
ECONO-4
end


FANPWR 4
FANPWR
end


TDVPIU 4
TDVPIU-0
HE
FF
(HE)
TDVPIU-1
end


SSFCOR 4
RSHFTW
SSFCOR
end

APPENDIX C

Verification and Summary Reports for LOADS, SYSTEMS, PLANT, and ECONOMICS

Appendix C shows examples of the verification, summary, and hourly reports printed by the DOE-2 LOADS, SYSTEMS, PLANT, and ECONOMICS programs. A description of the contents of each summary report and selected verification reports is given. The corresponding input for these reports can be found in the DOE-2 Sample Run Book for the building indicated in the first line of the report title.

PERIOD OF STUDY

STARTING DATE	ENDING DATE	NUMBER OF DAYS
1 AUG 1974	1 AUG 1974	1
5 JAN 1974	5 JAN 1974	1
1 APR 1974	1 APR 1974	1
1 JAN 1974	31 DEC 1974	365

SITE CHARACTERISTIC DATA

STATION NAME	LATITUDE (DEG)	LONGITUDE (DEG)	ALTITUDE (FT)	TIME ZONE	BUILDING AZIMUTH (DEG)
TRY CHICAGO	42.0	88.0	610.	6 CST	30.0

REPORT- LV-B SUMMARY OF SPACES OCCURRING IN THE PROJECT WEATHER FILE- TRY CHICAGO

NUMBER OF SPACES 6 EXTERIOR 5 INTERIOR 1

SPACE	SPACE MULT	SPACE TYPE	AZIMUTH	LIGHTING (WATT / SQFT)	PEOPLE	EQUIP (WATT / SQFT)	INFILTRATION METHOD	AIR CHANGES PER HOUR	AREA (SQFT)	VOLUME (CUFT)
PLENUM-1	1.0	EXT	0.0	0.00	0.0	0.00	NO-INFILT.	0.00	5000.00	10000.00
SPACE1-1	1.0	EXT	0.0	3.00	11.0	1.00	AIR-CHANGE	0.25	1056.00	8448.00
SPACE2-1	1.0	EXT	0.0	3.00	5.0	1.00	AIR-CHANGE	0.25	456.00	3648.00
SPACE3-1	1.0	EXT	0.0	3.00	11.0	1.00	AIR-CHANGE	0.25	1056.00	8448.00
SPACE4-1	1.0	EXT	0.0	3.00	5.0	1.00	AIR-CHANGE	0.25	456.00	3648.00
SPACE5-1	1.0	INT	0.0	3.00	20.0	1.00	AIR-CHANGE	0.25	1976.00	15808.00
BUILDING TOTALS					52.0				10000.00	50000.00

DATA FOR SPACE   SPACE1-1

LOCATION OF ORIGIN IN BUILDING COORDINATES

XB (FT)	YB (FT)	ZB (FT)	SPACE AZIMUTH (DEG)	SPACE MULTIPLIER	HEIGHT (FT)	AREA (SQFT)	VOLUME (CUFT)
0.00	0.00	0.00	0.00	1.0	8.00	1056.00	8448.00

TOTAL NUMBER OF SURFACES	NUMBER OF EXTERIOR SURFACES	NUMBER OF INTERIOR SURFACES	NUMBER OF UNDERGROUND SURFACES	DAYLIGHTING	SUNSPACE
6	1	4	1	NO	NO

NUMBER OF SUBSURFACES

TOTAL	EXTERIOR WINDOWS	DOORS	INTERIOR WINDOWS
2	2	0	0

-C.4-

FLOOR WEIGHT (LB/SQFT)	CALCULATION TEMPERATURE (F)
70.0	70.0

INFILTRATION

SCHEDULE	INFILTRATION CALCULATION METHOD	FLOW RATE (CFM/SQFT)	AIR CHANGES PER HOUR	HEIGHT TO NEUTRAL ZONE (FT)
INFIL-SCH	AIR-CHANGE	0.00	0.25	0.0

PEOPLE

SCHEDULE	NUMBER	AREA PER PERSON (SQFT)	PEOPLE ACTIVITY (BTU/HR)	PEOPLE SENSIBLE (BTU/HR)	PEOPLE LATENT (BTU/HR)
OCCUPY-1	11.0	96.0	400.0	0.0	0.0

LIGHTING

SCHEDULE	LIGHTING TYPE	LOAD (WATTS/ SQFT)	LOAD (KW)	FRACTION OF LOAD TO SPACE
LIGHTS-1	REC-FLUOR-RV	3.00	0.00	0.80

ELECTRICAL EQUIPMENT

SCHEDULE	ELEC LOAD (WATTS/ SQFT)	ELEC LOAD (KW)	FRACTION OF LOAD TO SPACE SENSIBLE	FRACTION OF LOAD TO SPACE LATENT
EQUIP-1	1.00	0.00	1.00	0.00

INTERIOR SURFACES (U-VALUE INCLUDES BOTH AIR FILMS)

SURFACE	AREA (SQFT)	CONSTRUCTION	U-VALUE (BTU/HR-SQFT-F)	ADJACENT SPACE	SURFACE-TYPE	
C1-1	1056.00	CLNG-1	0.270	PLENUM-1	QUICK	STANDARD
SB12	135.76	SB-U	1.500	SPACE2-1	QUICK	AIR
SB14	135.76	SB-U	1.500	SPACE4-1	QUICK	AIR
SB15	608.00	SB-U	1.500	SPACE5-1	QUICK	AIR

-C.5-

EXTERIOR SURFACES (U-VALUE EXCLUDES OUTSIDE AIR FILM)

SURFACE	MULTIPLIER	AREA (SQFT)	WIDTH (FT)	HEIGHT (FT)	CONSTRUCTION	U-VALUE (BTU/HR-SQFT-F)	SURFACE TYPE
FRONT-1	1.0	800.00	100.00	8.00	WALL-1	0.069	DELAYED

SURFACE	AZIMUTH (DEG)	TILT (DEG)	LOCATION OF ORIGIN IN BUILDING COORDINATES XB (FT)	YB (FT)	ZB (FT)	LOCATION OF ORIGIN IN SPACE COORDINATES X (FT)	Y (FT)	Z (FT)
FRONT-1	180.0	90.0	0.00	0.00	0.00	0.00	0.00	0.00

UNDERGROUND SURFACES (U-VALUE INCLUDES INSIDE AIR FILM)

SURFACE	MULTIPLIER	AREA (SQFT)	CONSTRUCTION	U-VALUE (BTU/HR-SQFT-F)
F1-1	1.Ø	1Ø56.ØØ	FLOOR-1	Ø.Ø5

EXTERIOR WINDOWS

WINDOW	MULTIPLIER	AREA (SQFT)	SHADING COEFF	NUMBER OF PANES	GLASS TYPE INDEX	SET-BACK (FT)	WIDTH (FT)	HEIGHT (FT)	SKY FORM FACTOR	GROUND FORM FACTOR
WF-1	1.Ø	18Ø.ØØ	1.ØØ	1	3	Ø.ØØ	45.ØØ	4.ØØ		
DF-1	1.Ø	64.ØØ	1.ØØ	1	5	Ø.ØØ	8.ØØ	8.ØØ		

WINDOW	LOCATED IN SURFACE	LOCATION OF ORIGIN IN BUILDING COORDINATES XB (FT)	YB (FT)	ZB (FT)	LOCATION OF ORIGIN IN SURFACE COORDINATES X (FT)	Y (FT)
WF-1	FRONT-1	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
DF-1	FRONT-1	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ

SIMPLE STRUCTURE RUN 3, CHICAGO DOE-2.1D 3/ 8/1989 13:46:27 LDL RUN 3

REPORT- LV-D DETAILS OF EXTERIOR SURFACES IN THE PROJECT WEATHER FILE- TRY CHICAGO

NUMBER OF EXTERIOR SURFACES 9 RECTANGULAR 9 OTHER 0
(U-VALUE INCLUDES INSIDE AIR FILM PLUS OUTSIDE AIR FILM AT 7.5 MPH WINDSPEED)

		- - - - G L A S S - - - -		- - - - W A L L - - - -		- W A L L + G L A S S -		
SURFACE	SPACE	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	AZIMUTH
WALL-1PB	PLENUM-1	0.000	0.00	0.068	200.00	0.068	200.00	NORTH
BACK-1	SPACE3-1	1.021	229.00	0.068	571.00	0.341	800.00	NORTH
RIGHT-1	SPACE2-1	1.021	100.00	0.068	300.00	0.306	400.00	EAST
WALL-1PR	PLENUM-1	0.000	0.00	0.068	100.00	0.068	100.00	EAST
WALL-1PF	PLENUM-1	0.000	0.00	0.068	200.00	0.068	200.00	SOUTH
FRONT-1	SPACE1-1	1.021	244.00	0.068	556.00	0.359	800.00	SOUTH
WALL-1PL	PLENUM-1	0.000	0.00	0.068	100.00	0.068	100.00	WEST
LEFT-1	SPACE4-1	1.021	100.00	0.068	300.00	0.306	400.00	WEST
TOP-1	PLENUM-1	0.000	0.00	0.173	5000.00	0.173	5000.00	ROOF
F1-1	SPACE1-1	0.000	0.00	0.050	1056.00	0.050	1056.00	UNDERGRND
F2-1	SPACE2-1	0.000	0.00	0.050	456.00	0.050	456.00	UNDERGRND
F3-1	SPACE3-1	0.000	0.00	0.050	1056.00	0.050	1056.00	UNDERGRND
F4-1	SPACE4-1	0.000	0.00	0.050	456.00	0.050	456.00	UNDERGRND
F5-1	SPACE5-1	0.000	0.00	0.050	1976.00	0.050	1976.00	UNDERGRND

REPORT- LV-D DETAILS OF EXTERIOR SURFACES IN THE PROJECT WEATHER FILE- TRY CHICAGO

(CONTINUED)

	AVERAGE U-VALUE/GLASS (BTU/HR-SQFT-F)	AVERAGE U-VALUE/WALLS (BTU/HR-SQFT-F)	AVERAGE U-VALUE WALLS+GLASS (BTU/HR-SQFT-F)	GLASS AREA (SQFT)	OPAQUE AREA (SQFT)	GLASS+OPAQUE AREA (SQFT)
NORTH	1.021	0.068	0.286	229.00	771.00	1000.00
EAST	1.021	0.068	0.259	100.00	400.00	500.00
SOUTH	1.021	0.068	0.300	244.00	756.00	1000.00
WEST	1.021	0.068	0.259	100.00	400.00	500.00
ROOF	0.000	0.173	0.173	0.00	5000.00	5000.00
ALL WALLS	1.021	0.068	0.282	673.00	2327.00	3000.00
WALLS+ROOFS	1.021	0.140	0.214	673.00	7327.00	8000.00
UNDERGRND	0.000	0.050	0.050	0.00	5000.00	5000.00
BUILDING	1.021	0.103	0.151	673.00	12327.00	13000.00

NUMBER OF UNDERGROUND SURFACES 5

SURFACE NAME	MULTIPLIER	AREA (SQFT)	CONSTRUCTION NAME	U-VALUE (BTU/HR-SQFT-F)
F1-1	1.0	1056.00	FLOOR-1	0.050
F2-1	1.0	456.00	FLOOR-1	0.050
F3-1	1.0	1056.00	FLOOR-1	0.050
F4-1	1.0	456.00	FLOOR-1	0.050
F5-1	1.0	1976.00	FLOOR-1	0.050

NUMBER OF INTERIOR SURFACES 13
(U-VALUE INCLUDES BOTH AIR FILMS)

SURFACE NAME	AREA (SQFT)	CONSTRUCTION NAME	SURFACE TYPE		U-VALUE (BTU/HR-SQFT-F)	ADJACENT SPACES SPACE-1	SPACE-2
C1-1	1056.00	CLNG-1	QUICK	STANDARD	0.270	SPACE1-1	PLENUM-1
SB12	135.76	SB-U	QUICK	AIR	1.500	SPACE1-1	SPACE2-1
SB14	135.76	SB-U	QUICK	AIR	1.500	SPACE1-1	SPACE4-1
SB15	608.00	SB-U	QUICK	AIR	1.500	SPACE1-1	SPACE5-1
C2-1	456.00	CLNG-1	QUICK	STANDARD	0.270	SPACE2-1	PLENUM-1
SB23	135.76	SB-U	QUICK	AIR	1.500	SPACE2-1	SPACE3-1
SB25	208.00	SB-U	QUICK	AIR	1.500	SPACE2-1	SPACE5-1
C3-1	1056.00	CLNG-1	QUICK	STANDARD	0.270	SPACE3-1	PLENUM-1
SB34	135.80	SB-U	QUICK	AIR	1.500	SPACE3-1	SPACE4-1
SB35	608.00	SB-U	QUICK	AIR	1.500	SPACE3-1	SPACE5-1
C4-1	456.00	CLNG-1	QUICK	STANDARD	0.270	SPACE4-1	PLENUM-1
SB45	208.00	SB-U	QUICK	AIR	1.500	SPACE4-1	SPACE5-1
C5-1	1976.00	CLNG-1	QUICK	STANDARD	0.270	SPACE5-1	PLENUM-1

NUMBER OF SCHEDULES 4 (NON DIMENSIONLESS SCHEDULES ARE GIVEN IN ENGLISH UNITS)

SCHEDULE OCCUPY-1

THROUGH 31 12

FOR DAYS SUN SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FOR DAYS MON TUE WED THU FRI

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.80	0.40	0.80	1.00	1.00	1.00	1.00	0.50	0.10	0.10	0.00	0.00	0.00

SCHEDULE LIGHTS-1

THROUGH 31 12

FOR DAYS SUN SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

FOR DAYS MON TUE WED THU FRI

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.90	0.95	1.00	0.95	0.80	0.90	1.00	1.00	1.00	1.00	0.60	0.20	0.20	0.05	0.05	0.05

SCHEDULE EQUIP-1

THROUGH 31 12

FOR DAYS SUN SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

FOR DAYS MON TUE WED THU FRI

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.70	0.50	0.50	0.30	0.30	0.02	0.02	0.02	0.02

SCHEDULE INFIL-SCH

THROUGH 31 3

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

-C.12-

THROUGH 31 10

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

THROUGH 31 12

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

NUMBER OF WINDOWS 6 RECTANGULAR 6 OTHER Ø

RECTANGULAR WINDOWS

WINDOW NAME	MULTIPLIER	AREA (SQFT)	HEIGHT (FT)	WIDTH (FT)	LOCATION OF ORIGIN IN SURFACE COORDINATES X (FT)	Y (FT)
WF-1	1.Ø	18Ø.ØØ	4.ØØ	45.ØØ	Ø.ØØ	Ø.ØØ
DF-1	1.Ø	64.ØØ	8.ØØ	8.ØØ	Ø.ØØ	Ø.ØØ
WR-1	1.Ø	1ØØ.ØØ	4.ØØ	25.ØØ	Ø.ØØ	Ø.ØØ
WB-1	1.Ø	18Ø.ØØ	4.ØØ	45.ØØ	Ø.ØØ	Ø.ØØ
DB-1	1.Ø	49.ØØ	7.ØØ	7.ØØ	Ø.ØØ	Ø.ØØ
WL-1	1.Ø	1ØØ.ØØ	4.ØØ	25.ØØ	Ø.ØØ	Ø.ØØ

WINDOW NAME	SETBACK (FT)	X-DIVISIONS	SHADING COEFF	NUMBER OF PANES	GLASS TYPE CODE	INFILTRATION FLOW COEFF	SKY FORM FACTOR	GROUND FORM FACTOR
WF-1	Ø.ØØ	1Ø	1.ØØ	1	3	Ø.Ø		
DF-1	Ø.ØØ	1Ø	1.ØØ	1	5	Ø.Ø		
WR-1	Ø.ØØ	1Ø	1.ØØ	1	3	Ø.Ø		
WB-1	Ø.ØØ	1Ø	1.ØØ	1	3	Ø.Ø		
DB-1	Ø.ØØ	1Ø	1.ØØ	1	5	Ø.Ø		
WL-1	Ø.ØØ	1Ø	1.ØØ	1	3	Ø.Ø		

NUMBER OF CONSTRUCTIONS 5 DELAYED 2 QUICK 3

CONSTRUCTION NAME	U-VALUE (BTU/HR-SQFT-F)	SURFACE ABSORPTANCE	SURFACE ROUGHNESS INDEX	SURFACE TYPE	NUMBER OF RESPONSE FACTORS
WALL-1	0.069	0.70	3	DELAYED	9
ROOF-1	0.180	0.70	3	DELAYED	5
CLNG-1	0.270	0.70	3	QUICK	0
SB-U	1.500	0.70	3	QUICK	0
FLOOR-1	0.050	0.70	3	QUICK	0

NUMBER OF BUILDING SHADES Ø RECTANGULAR Ø OTHER Ø

REPORT LV–K -- WEIGHTING FACTOR SUMMARY

This report is automatically produced by a LIBRARY–INPUT LOADS run in which a Custom Weighting Factor library is created; it is also printed in an INPUT LOADS run if VERIFICATION = (LV–K) is specified in the LOADS–REPORT instruction. In the latter case, the entries in this report can be a combination of ASHRAE weighting factors, automatically calculated Custom Weighting Factors (for SPACEs with FLOOR–WEIGHT = 0), and Custom Weighting Factors from a previously created user library.

At the top of the report is the u-name of each SPACE (SP NAME) along with the u-name of the set of weighting factors for that space (WF NAME). WF NAME will be blank except for library creation runs and for those SPACEs in a LOADS run that use Custom Weighting Factors from a user library.

Down the left side of the report are six groupings of variable names that label the six types of weighting factors:

solar

general lighting

task lighting

people/equipment

conduction

air temperature

31-STORY OFFICE BLDG, CHICAGO - LOAD2 CUSTOM WEIGHTING FACTORS & DAYLIGHTING 3/ 9/1989 12:28:40 LDL RUN 2
OA RESET BASEBOARDS -

REPORT- LV-K WEIGHTING FACTOR SUMMARY

SP NAME-- / WF NAME--	A-STORAGE	RZ1	RZ2	RZ3	RZ4	RZ5	PLEN1
SOLAR							
V0	0.17292	0.17292	0.55442	0.55442	0.55442	0.55442	0.37616
V1	-0.11227	-0.11227	-0.45805	-0.45805	-0.45805	-0.45805	-0.40067
V2	0.00000	0.00000	0.08063	0.08063	0.08063	0.08063	0.07355
W1	0.93935	0.93935	1.01014	1.01014	1.01014	1.01014	1.20883
W2	0.00000	0.00000	-0.23342	-0.23342	-0.23342	-0.23342	-0.26420
GENERAL LIGHTING							
V0	0.51215	0.57446	0.75457	0.75457	0.75457	0.75457	0.30649
V1	-0.45150	-0.51380	-0.66439	-0.66439	-0.66439	-0.66439	-0.32317
V2	0.00000	0.00000	0.12400	0.12400	0.12400	0.12400	0.05836
W1	0.93935	0.93935	0.95917	0.95917	0.95917	0.95917	1.20884
W2	0.00000	0.00000	-0.20252	-0.20252	-0.20252	-0.20252	-0.26421
TASK LIGHTING							
V0	0.48093	0.48093	0.70465	0.70465	0.70465	0.70465	0.50761
V1	-0.42028	-0.42028	-0.60444	-0.60444	-0.60444	-0.60444	-0.58001
V2	0.00000	0.00000	0.10803	0.10803	0.10803	0.10803	0.11805
W1	0.93935	0.93935	0.95917	0.95917	0.95917	0.95917	1.20883
W2	0.00000	0.00000	-0.20252	-0.20252	-0.20252	-0.20252	-0.26420
PEOPLE-EQUIPMENT							
V0	0.67521	0.67521	0.70881	0.70881	0.70881	0.70881	0.51455
V1	-0.61455	-0.61455	-0.60943	-0.60943	-0.60943	-0.60943	-0.58887
V2	0.00000	0.00000	0.10936	0.10936	0.10936	0.10936	0.12011
W1	0.93935	0.93935	0.95917	0.95917	0.95917	0.95917	1.20883
W2	0.00000	0.00000	-0.20252	-0.20252	-0.20252	-0.20252	-0.26420
CONDUCTION							
V0	0.67521	0.67521	0.74539	0.74539	0.74539	0.74539	0.55208
V1	-0.61455	-0.61455	-0.65337	-0.65337	-0.65337	-0.65337	-0.63681
V2	0.00000	0.00000	0.12106	0.12106	0.12106	0.12106	0.13125
W1	0.93935	0.93935	0.95918	0.95918	0.95918	0.95918	1.20883
W2	0.00000	0.00000	-0.20252	-0.20252	-0.20252	-0.20252	-0.26420
AIR TEMP (BTU/HR-SQFT-F)							
G0*	1.84393	1.84393	0.40852	0.44454	0.40852	0.44454	0.43990
G1*	-1.99232	-1.99232	-0.57447	-0.62512	-0.57447	-0.62512	-0.59837
G2*	0.14838	0.14838	0.16545	0.18004	0.16545	0.18004	0.15878
G3*	0.00000	0.00000	0.00050	0.00055	0.00050	0.00055	-0.00031
P1	-0.93935	-0.93935	-0.93338	-0.93338	-0.93338	-0.93338	-1.25064
P2	0.00000	0.00000	0.18768	0.18768	0.18768	0.18768	0.30246

REPORT LV–L -- DAYLIGHT FACTOR SUMMARY

This report is printed for each combination of window and reference point in a daylit space. The first section of the report summarizes some of the daylighting-related input information for the space, window, and reference point. The second section lists the daylight factors which were calculated by the daylighting preprocessor for 20 values of solar altitude and azimuth covering the annual range of sun positions at the location being analyzed.

Section 1

SPACE-RELATED QUANTITIES

1. SPACE --
   is the u-name of space.

2. AREA
   is the floor area of space (before multiplication by space multiplier).

3. AV REFL
   is the area-weighted average inside surface visible reflectance of space which is calculated from INSIDE–VIS–REFL values for EXTERIOR–WALL, INTERIOR–WALL, UNDERGROUND–FLOOR, UNDERGROUND–WALL, and WINDOW.

4. MAX–GLARE
   is the threshold for closing window shades to control glare (MAX–GLARE keyword value; defaults to 100, which means no glare control).

5. VW–AZ
   (view azimuth) is the azimuth angle, measured clockwise from north, of the occupant's direction of view used to calculate the daylight glare index. It is entered (relative to the SPACE y-axis) with the VIEW–AZIMUTH keyword.

WINDOW-RELATED QUANTITIES

6. WINDOW --
   is the window u-name.

7. SH–COEF
   is the shading coefficient of glazing as entered with SHADING–COEF keyword under GLASS–TYPE.

8. VIS–TRANS
   is the visible transmittance of the window glazing at normal incidence, as entered with VIS–TRANS keyword under GLASS–TYPE.

9. H is the height of window.

10. W is the width of window.

11. AZIM and TILT
    are the azimuth and tilt angle, respectively, of the window outward normal in the building coordinate system. AZIM is measured clockwise from the building y-axis.

12. DAY–X–DIV and DAY–Y–DIV
    are the number of elements into which the window is divided along its WIDTH and HEIGHT, respectively, for the integration which determines the daylight reaching the reference point from the window. DAY–X–DIV and DAY–Y–DIV are automatically determined by the program to insure an accurate integration.

13. X,Y,Z
    are the coordinates of the window origin in the space coordinate system. For vertical windows, Z is the sill height.

14. WIN–SHADE–TYPE
is the type of shading device on the window, if any, as entered with the WIN–SHADE–TYPE keyword.

REFERENCE POINT RELATED QUANTITIES

15. REF PT NO. --
is the number of reference point (1 or 2)

16. X,Y,Z
are the coordinates of reference point in the space coordinate system.

17. ZONE–FRACTION
is the fraction of the space floor area controlled by the lighting system at this reference point (value of ZONE–FRACTION1 or ZONE–FRACTION2 keyword).

18. LTG–SET–POINT
is the illuminance set point as entered with keyword LIGHT–SET–POINT1 for reference point 1, or with LIGHT–SET–POINT2 for reference point 2.

19. LTG–CTRL–TYPE
is the lighting control type as entered with keyword LIGHT–CTRL–TYPE1 for reference point 1, or with or LIGHT–CTRL–TYPE2 for reference point 2.

Section 2

CALCULATED DAYLIGHT FACTORS

20. SUN POS NO.
(sun position number) is the sun-position index corresponding to different pairs of solar altitude and azimuth values (see SUN ALT and SUN AZIM, below).

21. DAY TYP
(day type) is 1 for clear sky and 2 for overcast sky. For the latter, the daylight factors for only one sun position are calculated.

22. WIN SHD IND
(window shade index) is 1 for bare window (shading device off), and 2 for window with shading device on. Visible transmittance of shade is taken to be 1.0 for daylight factor calculation.

23. SUN ALT
is the altitude of sun above the horizon. It has four equally-spaced values ranging from 10° to the maximum altitude the sun can reach at the location being analyzed.

24. SUN AZIM
is the azimuth of sun measured clockwise from North.

25. EXT ILL -SKY
is the exterior horizontal illuminance due to diffuse light from sky (excludes direct sun).

26. EXT ILL -SUN
is the exterior horizontal illuminance due to direct sun.

27. EXT ILL -SKY and EXT ILL -SUN
are calculated for standard CIE skies using, for clear sky, the atmospheric turbidity and moisture for the month of May.

The following quantities relate to the interior of the space. For WIN SHD IND = 2 (window with shade), the shade is assumed to have 100% transmittance; the actual shade transmittance is taken into account in the hourly loads calculation.

28. DIR ILL -SKY
(direct illuminance -sky) is the direct horizontal illuminance at the reference point produced by light which originates in the sky and reaches the reference point without reflection from the interior surfaces of the space. For an unshaded window (WIN SHD IND = 1), this

includes the light coming directly from the sky or by reflection of sky light from exterior BUILDING–SHADEs. For a window with shade (WIND SHD IND = 2 and WIN–SHADE–TYPE other than NO–SHADE), the light source is the shade itself, a diffusely transmitting surface illuminated by direct light from the sky, sky light reflected from the ground, and sky light reflected from exterior obstructions.

29. REFL ILL -SKY
(reflected illuminance -sky) is the illuminance at the reference point produced by daylight which originates in the sky and reaches the reference point after reflecting from the interior surfaces of the space.

30. DIR ILL -SUN
(direct illuminance -sun): for an unshaded window (WIN SHD IND = 1), this is the direct horizontal illuminance at the reference point produced by light from the sun reaching the reference point without reflection from the interior surfaces of the space. For a window with shade (WIN SHD IND = 2), the light source is the shade illuminated by direct sunlight and by sunlight reflected by the ground and exterior obstructions.

31. REFL ILL -SUN
(reflected illuminance -sun) is the indirect horizontal illuminance at the reference point produced by sunlight which reflects from interior surfaces before reaching the reference point.

32. DAY ILL FAC -SKY
(daylight illuminance factor -sky) is the ratio
(DIR ILL -SKY + REFL ILL -SKY)/(EXT ILL -SKY).

33. DAY ILL FAC -SUN
(daylight illuminance factor -sun) is the ratio
(DIR ILL -SUN + REFL ILL -SUN)/(EXT ILL -SUN).

34. WIN LUM FAC -SKY
(window luminance factor -sky) is the average luminance of the window (as seen from the reference point) due to light originating in the sky, divided by EXT ILL -SKY. It has units footlamberts/footcandle (English) or candelas/m^2/lux (metric).

35. WIN LUM FAC -SUN
(window luminance factor -sun) is the ratio between the average luminance of the window (as seen from the reference point) due to light originating at the sun, divided by EXT ILL -SUN. This quantity is not calculated for an unshaded window.

36. BACKG LUM FAC -SKY
(background luminance factor -sky) is the average luminance of interior surfaces due to light originating in the sky, divided by EXT ILL -SKY. It has units footlamberts/footcandle (English) or candelas/m^2/lux (metric).

37. BACKG LUM FAC -SUN
(background luminance factor -sun) is the average luminance of interior surfaces due to light originating at the sun, divided by EXT ILL -SUN.

38. GLARE INDEX
is the daylight glare index at the reference point due to this window. (It assumes 100% shade transmittance for a shaded window (WIN SHD IND = 2). The actual glare index in the hourly calculation will generally be lower for shade transmittance < 100%.)

DAYLIGHTING EXAMPLE FLOOR OF OFFICE BUILDING IN CHICAGO 3/ 9/1989 14:50:31 LDL RUN 1
30-FT DEEP PERIM OFFS DAYLIT TO 15 FT AUTO SHADE MANAGEMENT FOR SUN CONTROL
REPORT- LV-L DAYLIGHT FACTOR SUMMARY FOR SOUTHZONE

SPACE--SOUTHZONE
AREA(SQFT) 600.0
AV REFL 0.46
MAX-GLARE 100.0
VW-AZ(DEG) 270.0

WINDOW--SOUTHWIND
SH-COEF 0.83 VIS-TRANS 0.68
H(FT) 3.0 W(FT) 20.0
AZIM(DEG) 180.0 TILT(DEG) 90.0
DAY-X-DIV 8 DAY-Y-DIV 8
X(FT) 0.0 Y(FT) 0.0 Z(FT) 4.0
WIN-SHADE-TYPE MOVABLE-INTERIOR

REF PT NO.--1
X(FT) 10.0 Y(FT) 10.0 Z(FT) 2.5
ZONE-FRACTION 0.50
LTG-SET-POINT(FC) 50.0
LTG-CTRL-TYPE CONTINUOUS

SUN POS NO.	DAY TYP	WIN SHD IND	SUN ALT (DEG)	SUN AZIM (DEG)	EXT ILL -SKY (FC)	EXT ILL -SUN (FC)	DIR ILL -SKY (FC)	REFL ILL -SKY (FC)	DIR ILL -SUN (FC)	REFL ILL -SUN (FC)	DAY ILL FAC -SKY	DAY ILL FAC -SUN	WIN LUM FAC -SKY	WIN LUM FAC -SUN	BACKG LUM FAC -SKY	BACKG LUM FAC -SUN	GLARE INDEX
1	1	1	10.	290.	1331.8	164.6	43.1	14.3	0.0	0.5	0.0431	0.0029	1.1282	0.0000	0.0050	0.0013	13.7
1	1	2	10.	290.	1331.8	164.6	23.2	18.1	0.5	0.4	0.0311	0.0050	0.5635	0.0909	0.0063	0.0010	10.9
1	2	1	10.	290.	366.9	0.0	7.5	3.2	0.0	0.0	0.0291	0.0000	0.6355	0.0000	0.0041	0.0000	4.9
1	2	2	10.	290.	366.9	0.0	5.1	4.0	0.0	0.0	0.0246	0.0000	0.4461	0.0000	0.0050	0.0000	2.9
2	1	1	10.	235.	1331.8	164.6	90.7	25.7	0.0	8.8	0.0874	0.0535	2.5584	0.0000	0.0089	0.0248	16.5
2	1	2	10.	235.	1331.8	164.6	44.5	34.8	16.0	12.5	0.0595	0.1731	1.0793	3.1409	0.0121	0.0352	14.6
3	1	1	10.	180.	1331.8	164.6	197.8	36.4	164.1	15.9	0.1758	1.0938	4.4036	0.0000	0.0126	0.0448	18.1
3	1	2	10.	180.	1331.8	164.6	64.3	50.3	29.3	22.9	0.0860	0.3167	1.5609	5.7454	0.0175	0.0643	15.8
4	1	1	10.	125.	1331.8	164.6	90.7	25.7	0.0	8.8	0.0874	0.0535	2.5584	0.0000	0.0089	0.0248	16.5
4	1	2	10.	125.	1331.8	164.6	44.5	34.8	16.0	12.5	0.0595	0.1731	1.0793	3.1409	0.0121	0.0352	14.6
5	1	1	10.	70.	1331.8	164.6	43.1	14.3	0.0	0.5	0.0431	0.0029	1.1282	0.0000	0.0050	0.0013	13.7
5	1	2	10.	70.	1331.8	164.6	23.2	18.1	0.5	0.4	0.0311	0.0050	0.5635	0.0909	0.0063	0.0010	10.9
6	1	1	31.	290.	2104.9	2160.2	57.2	20.2	0.0	6.2	0.0367	0.0029	0.9412	0.0000	0.0044	0.0013	14.7
6	1	2	31.	290.	2104.9	2160.2	32.2	25.2	6.1	4.7	0.0273	0.0050	0.4949	0.0909	0.0055	0.0010	12.9
7	1	1	31.	235.	2104.9	2160.2	115.1	34.5	0.0	37.7	0.0711	0.0175	1.9308	0.0000	0.0076	0.0081	16.8
7	1	2	31.	235.	2104.9	2160.2	58.8	46.0	64.7	50.6	0.0498	0.0534	0.9034	0.9679	0.0101	0.0108	16.5
8	1	1	31.	180.	2104.9	2160.2	229.9	47.0	0.0	66.1	0.1316	0.0306	3.1907	0.0000	0.0103	0.0142	18.2
8	1	2	31.	180.	2104.9	2160.2	82.1	64.2	117.5	91.8	0.0695	0.0969	1.2605	1.7581	0.0141	0.0197	17.8
9	1	1	31.	125.	2104.9	2160.2	115.1	34.5	0.0	37.7	0.0711	0.0175	1.9308	0.0000	0.0076	0.0081	16.8
9	1	2	31.	125.	2104.9	2160.2	58.8	46.0	64.7	50.6	0.0498	0.0534	0.9034	0.9679	0.0101	0.0108	16.5
10	1	1	31.	70.	2104.9	2160.2	57.2	20.2	0.0	6.2	0.0367	0.0029	0.9412	0.0000	0.0044	0.0013	14.7
10	1	2	31.	70.	2104.9	2160.2	32.2	25.2	6.1	4.7	0.0273	0.0050	0.4949	0.0909	0.0055	0.0010	12.9
11	1	1	51.	290.	2565.4	4622.3	62.4	23.1	0.0	13.3	0.0333	0.0029	0.8317	0.0000	0.0042	0.0013	14.9
11	1	2	51.	290.	2565.4	4622.3	36.4	28.4	13.0	10.2	0.0253	0.0050	0.4585	0.0909	0.0051	0.0010	13.9
12	1	1	51.	235.	2565.4	4622.3	99.4	33.4	0.0	41.3	0.0518	0.0089	1.2972	0.0000	0.0060	0.0041	16.1
12	1	2	51.	235.	2565.4	4622.3	55.7	43.5	65.1	50.9	0.0387	0.0251	0.7013	0.4550	0.0079	0.0051	16.5
13	1	1	51.	180.	2565.4	4622.3	145.2	41.7	0.0	72.7	0.0729	0.0157	1.7541	0.0000	0.0075	0.0073	16.8
13	1	2	51.	180.	2565.4	4622.3	71.2	55.6	123.6	96.6	0.0494	0.0477	0.8964	0.8645	0.0100	0.0097	17.7
14	1	1	51.	125.	2565.4	4622.3	99.4	33.4	0.0	41.3	0.0518	0.0089	1.2972	0.0000	0.0060	0.0041	16.1
14	1	2	51.	125.	2565.4	4622.3	55.7	43.5	65.1	50.9	0.0387	0.0251	0.7013	0.4550	0.0079	0.0051	16.5
15	1	1	51.	70.	2565.4	4622.3	62.4	23.1	0.0	13.3	0.0333	0.0029	0.8317	0.0000	0.0042	0.0013	14.9
15	1	2	51.	70.	2565.4	4622.3	36.4	28.4	13.0	10.2	0.0253	0.0050	0.4584	0.0909	0.0051	0.0010	13.9
16	1	1	72.	290.	3143.7	6245.4	74.3	28.0	0.0	18.0	0.0325	0.0029	0.7923	0.0000	0.0041	0.0013	15.5
16	1	2	72.	290.	3143.7	6245.4	44.1	34.5	17.6	13.7	0.0250	0.0050	0.4534	0.0909	0.0051	0.0010	14.7
17	1	1	72.	235.	3143.7	6245.4	91.7	33.3	0.0	27.8	0.0398	0.0044	0.9617	0.0000	0.0049	0.0021	16.0
17	1	2	72.	235.	3143.7	6245.4	54.0	42.2	35.7	27.9	0.0306	0.0102	0.5556	0.1850	0.0062	0.0021	15.7
18	1	1	72.	180.	3143.7	6245.4	105.0	36.8	0.0	43.2	0.0451	0.0069	1.0806	0.0000	0.0054	0.0032	16.1
18	1	2	72.	180.	3143.7	6245.4	60.6	47.3	64.4	50.3	0.0343	0.0184	0.6226	0.3333	0.0070	0.0037	16.6
19	1	1	72.	125.	3143.7	6245.4	91.7	33.3	0.0	27.8	0.0398	0.0044	0.9617	0.0000	0.0049	0.0021	16.0
19	1	2	72.	125.	3143.7	6245.4	54.0	42.2	35.7	27.9	0.0306	0.0102	0.5556	0.1850	0.0062	0.0021	15.7
20	1	1	72.	70.	3143.7	6245.4	74.3	28.0	0.0	18.0	0.0325	0.0029	0.7923	0.0000	0.0041	0.0013	15.5
20	1	2	72.	70.	3143.7	6245.4	44.1	34.5	17.6	13.7	0.0250	0.0050	0.4534	0.0909	0.0051	0.0010	14.7

NOTE -- ABOVE VALUES ASSUME VISIBLE TRANSMITTANCE = 1.0 FOR WINDOW GLASS AND SHADING DEVICE.
ACTUAL TRANSMITTANCES ARE USED IN THE HOURLY CALCULATION.

DOE-2 UNITS TABLE

	ENGLISH	MULTIPLIED BY	GIVES METRIC	MULTIPLIED BY	GIVES ENGLISH
1		1.000000		1.000000	
2		1.000000		1.000000	
3	BTU	0.292875	WH	3.414426	BTU
4	BTU/HR	0.292875	WATT	3.414426	BTU/HR
5	BTU/LB-F	4183.830078	J/KG-K	0.000239	BTU/LB-F
6	BTU/HR-SQFT-F	5.674460	W/M2-K	0.176228	BTU/HR-SQFT-F
7	DEGREES	1.000000	DEGREES	1.000000	DEGREES
9	SQFT	0.092903	M2	10.763915	SQFT
10	CUFT	0.028317	M3	35.314724	CUFT
11	LB/HR	0.453592	KG/HR	2.204624	LB/HR
12	LB/CUFT	16.018459	KG/M3	0.062428	LB/CUFT
13	MPH	0.447040	M/S	2.236936	MPH
14	BTU/HR-F	0.527178	W/K	1.896893	BTU/HR-F
15	FT	0.304800	M	3.280840	FT
16	BTU/HR-FT-F	1.729600	W/M-K	0.578168	BTU/HR-FT-F
17	BTU/HR- SQFT	3.152480	WATT /M2	0.317211	BTU/HR- SQFT
18	IN	2.540000	CM	0.393701	IN
19	UNITS/IN	0.393700	UNITS/CM	2.540005	UNITS/IN
20	UNITS	1.000000	UNITS	1.000000	UNITS
21	LB	0.453592	KG	2.204624	LB
22	FRAC.OR MULT.	1.000000	FRAC.OR MULT.	1.000000	FRAC.OR MULT.
23	HOURS	1.000000	HRS	1.000000	HOURS
24	PERCENT-RH	1.000000	PERCENT-RH	1.000000	PERCENT-RH
25	CUFT/MIN	1.699010	M3/H	0.588578	CUFT/MIN
26	IN-WATER	25.400000	MM-WATER	0.039370	IN-WATER
27	LB/SQFT	4.882400	KG/M2	0.204817	LB/SQFT
28	KW	1.000000	KW	1.000000	KW
29	W/SQFT	10.763920	W/M2	0.092903	W/SQFT
30	THERMS	25.000000	THERMIES	0.040000	THERMS
31	KNOTS	0.514440	M/SEC	1.943861	KNOTS
32	HR-SQFT-F /BTU	0.176228	M2-K /W	5.674467	HR-SQFT-F /BTU
33	$DOLLARS	1.000000	$DOLLARS	1.000000	$DOLLARS
34	MBTU/HR	0.292875	MWATT	3.414426	MBTU/HR
35	YEARS	1.000000	YEARS	1.000000	YEARS
36	$/HR	1.000000	$/HR	1.000000	$/HR
37	HRS/YEARS	1.000000	HRS/YEARS	1.000000	HRS/YEARS
38	PERCENT	1.000000	PERCENT	1.000000	PERCENT
39	$/MONTH	1.000000	$/MONTH	1.000000	$/MONTH
40	GALLONS/MIN/TON	1.078000	LITERS/MIN/KW	0.927644	GALLONS/MIN/TON
41	BTU/LB	0.645683	WH/KG	1.548748	BTU/LB
42	LBS/SQIN-GAGE	68.947571	MBAR-GAGE	0.014504	LBS/SQIN-GAGE
43	$/UNIT	1.000000	$/UNIT	1.000000	$/UNIT
44	BTU/HR/PERSON	0.292875	W/PERSON	3.414426	BTU/HR/PERSON
45	LBS/LB	1.000000	KGS/KG	1.000000	LBS/LB
46	BTU/BTU	1.000000	KWH/KWH	1.000000	BTU/BTU
47	LBS/KW	0.453590	KG/KW	2.204634	LBS/KW
48	REV/MIN	1.000000	REV/MIN	1.000000	REV/MIN
49	UNUSED	1.000000	UNUSED	1.000000	UNUSED
50	MBTU	0.292875	MWH	3.414426	MBTU
51	GAL	3.785410	LITER	0.264172	GAL
52	GAL/MIN	3.785410	LITERS/MIN	0.264172	GAL/MIN

53	BTU/F	1897.800049	J/K	0.000527	BTU/F
54	UNITS/HR	1.000000	UNITS/HR	1.000000	UNITS/HR
55	$/UNIT-HR	1.000000	$/UNIT-HR	1.000000	$/UNIT-HR
56	KW/CFM	0.588500	KW/M3/HR	1.699235	KW/CFM
57	BTU/SQFT-F	20428.400391	J/M2-K	0.000049	BTU/SQFT-F
58	HR/HR	1.000000	HR/HR	1.000000	HR/HR
59	BTU/FT-F	6226.479980	J/M-K	0.000161	BTU/FT-F
60	R	0.555556	K	1.799999	R
61	INCH MER	33.863800	MBAR	0.029530	INCH MER
62	UNITS/GAL/MIN	0.264170	UNITS/LITER/MIN	3.785441	UNITS/GAL/MIN
63	(HR-SQFT-F/BTU)2	0.031056	(M2-K /W)2	32.199585	(HR-SQFT-F/BTU)2
64	KBTU/HR	0.292875	KW	3.414426	KBTU/HR
65	KBTU	0.292875	KWH	3.414426	KBTU
66	CFM	0.471900	L/S	2.119093	CFM
67	CFM/SQFT	18.288000	M3/H-M2	0.054681	CFM/SQFT
68	1/R	1.799900	1/K	0.555586	1/R
69	1/KNOT	1.943860	SEC/M	0.514440	1/KNOT
70	FOOTCANDLES	10.763910	LUX	0.092903	FOOTCANDLES
71	FOOTLAMBERT	3.426259	CANDELA/M2	0.291864	FOOTLAMBERT
72	LUMEN / WATT	1.000000	LUMEN / WATT	1.000000	LUMEN / WATT
73	KBTU/SQFT-YR	3.152480	KWH/M2-YR	0.317211	KBTU/SQFT-YR

REPORT LS–A -- SPACE PEAK LOADS SUMMARY

This report lists each space by u-name and shows the number of times each space is repeated (based on the keywords MULTIPLIER and FLOOR–MULTIPLIER) on the left of the report.

The individual space peak sensible cooling load with the month, day and hour it occurred is reported in the center. The sum of the cooling loads for all spaces (which is the non-coincident building peak load) is also reported.

The *coincident* building peak cooling load (the "block" load) is reported directly below the non-coincident peak, but it does not include the plenum load. The outside dry-bulb and wet-bulb temperatures are also reported for the time of the peak load in each space and for the building. All hours are given in *standard time*.

The heating peak loads are treated similarly on the right.

REPORT- LS-A SPACE PEAK LOADS SUMMARY WEATHER FILE- TRY CHICAGO

SPACE NAME	MULTIPLIER SPACE	MULTIPLIER FLOOR	COOLING LOAD (KBTU/HR)	TIME OF PEAK	DRY-BULB	WET-BULB	HEATING LOAD (KBTU/HR)	TIME OF PEAK	DRY-BULB	WET-BULB
PLENUM-1	1.	1.	55.706	JUL 7 5 PM	88.F	73.F	-73.158	JAN 12 9 AM	-8.F	-8.F
SPACE1-1	1.	1.	37.144	SEP 26 5 PM	82.F	61.F	-24.985	JAN 12 8 AM	-7.F	-7.F
SPACE2-1	1.	1.	15.396	JUL 9 12 NOON	88.F	75.F	-10.341	JAN 1 7 AM	-1.F	-1.F
SPACE3-1	1.	1.	25.627	JUL 9 4 PM	94.F	74.F	-24.558	JAN 12 8 AM	-7.F	-7.F
SPACE4-1	1.	1.	14.646	JUL 9 6 PM	97.F	73.F	-10.962	JAN 12 8 AM	-7.F	-7.F
SPACE5-1	1.	1.	22.925	AUG 30 4 PM	82.F	64.F	-9.525	MAR 24 4 AM	12.F	11.F
SUM			171.445				-153.530			
BUILDING PEAK			105.797	JUL 9 6 PM	97.F	73.F	-76.392	JAN 12 8 AM	-7.F	-7.F

REPORT LS–B -- SPACE PEAK LOAD COMPONENTS

This report gives a breakdown of cooling and heating peak loads, according to the source of the load, for each space. A "load" here is defined as the amount of heat that must be added or removed from the space air per hour to maintain a *constant* air temperature equal to the TEMPERATURE keyword value in SPACE–CONDITIONS. These loads are modified in the SYSTEMS program to account for time-varying air temperatures. There are several important points that the user should become acquainted with.

1. WALLS
correspond to exterior walls with TILT $\geq 45°$, whereas ROOFS correspond to exterior walls with TILT $< 45°$. The WALLS and ROOF loads (sensible) are due to conduction.

2. GLASS CONDUCTION
is the sum of the UAΔT heat gain through all the windows in the space plus solar energy absorbed by the glass and conducted into the space.

3. GLASS SOLAR
is the heat gain caused by direct and diffuse solar radiation transmitted by the windows into the space. Note that all sensible loads are calculated as *delayed in time with weighting factors* so that it is possible to have load contributions from GLASS SOLAR at night.

4. DOOR
loads are those due to conduction through external doors in the space.

5. INTERNAL SURFACES
loads are those due to conduction through INTERIOR–WALLs such as partitions and drop ceilings. These loads will be zero in this report if, as in the example, the user chooses the same LOADS calculation temperature for all spaces.

6. UNDERGROUND SURFACES
can be basement floors and walls or slabs on grade. The user should take care to adjust either the area or u-value to approach the anticipated heat transfer. For example, a slab-on-grade should ordinarily include only perimeter areas, since the soil under the central part of the building will not significantly conduct heat away from the slab. On the other hand, if the walls and basement floor are below the water table, they should not be adjusted, since water is a good conductor of heat.

7. The EQUIPMENT–TO–SPACE
load results from the user-supplied entries for EQUIP–SCHEDULE, EQUIPMENT–KW, EQUIPMENT–W/SQFT, EQUIP–SENSIBLE and EQUIP–LATENT.
The PROCESS–TO–SPACE load results from the user-supplied entries for SOURCE–SCHEDULE, SOURCE–TYPE, SOURCE–BTU/HR, SOURCE–SENSIBLE, and SOURCE–LATENT.

8. Latent loads do not account for moisture absorption and desorption by room surfaces.

9. The RUN number in the upper right hand corner refers to the number of the pass through the LOADS program. For example, if the user were doing parametric runs as part of the same job, successive passes through LOADS would be recorded as RUN 1, RUN 2, RUN 3, etc.

SPACE SPACE1-1

MULTIPLIER	1.0		FLOOR MULTIPLIER	1.0
FLOOR AREA	1056 SQFT	98 M2		
VOLUME	8448 CUFT	239 M3		

	COOLING LOAD		HEATING LOAD	
TIME	SEP 26	5PM	JAN 12	8AM
DRY-BULB TEMP	82F	28C	-7F	-22C
WET-BULB TEMP	61F	16C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (KW)	LATENT (KBTU/H)	LATENT (KW)	SENSIBLE (KBTU/H)	SENSIBLE (KW)
WALLS	0.790	0.232	0.000	0.000	-2.816	-0.825
ROOFS	0.000	0.000	0.000	0.000	0.000	0.000
GLASS CONDUCTION	2.280	0.668	0.000	0.000	-20.019	-5.863
GLASS SOLAR	22.091	6.470	0.000	0.000	0.873	0.256
DOOR	0.000	0.000	0.000	0.000	0.000	0.000
INTERNAL SURFACES	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURFACES	-0.317	-0.093	0.000	0.000	-1.584	-0.464
OCCUPANTS TO SPACE	2.879	0.843	1.020	0.299	0.141	0.041
LIGHT TO SPACE	7.549	2.211	0.000	0.000	0.927	0.272
EQUIPMENT TO SPACE	1.871	0.548	0.000	0.000	0.188	0.055
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.000	0.000	0.000	0.000	-2.694	-0.789
TOTAL	37.144	10.878	1.020	0.299	-24.985	-7.317
TOTAL LOAD	38.164 KBTU/H		11.177 KW		-24.985 KBTU/H	-7.317 KW
TOTAL LOAD / AREA	36.14BTU/H.SQFT		113.931 W / M2		23.660BTU/H.SQFT	74.587 W / M2

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***************************************************************
*                                                             *
*  NOTE   1) THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----      LOADS                                            *
*         2) TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*            IN CONSIDERATION                                 *
*                                                             *
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REPORT LS–C -- BUILDING PEAK LOAD COMPONENTS

This report is similar in format to LS–B. The major difference is that LS–C is generated at the "building level"; i.e., the space loads are summed each hour to give the building coincident load and the peak values of this load are shown here.

The building coincident peak load does not include plenums or other unconditioned spaces. Although no infiltration is indicated for the peak cooling load for the Example Building, the user should realize how DOE-2 treats infiltration loads. The sensible portion is treated as an instantaneous heat gain or loss. The latent portion is reported in LOADS, but is passed to SYSTEMS as a CFM with the calculated humidity ratio for each hour. The contribution of the latent heat (negative or positive in relation to room humidity) is then calculated from a mass balance of moisture in the space, to determine the return air humidity ratio. In dry climates the infiltration may actually result in a decreased space latent load and thus a decreased total SYSTEMS load. The opposite is true in humid climates where infiltration acts to increase the SYSTEMS load.

The heat gain or loss that occurs in plenums, including heat due to lights, is accounted for in the SYSTEMS simulation and causes a temperature change in the return air flowing through the plenum. Therefore, the user should **not** specify plenums unless they are actually return air plenums. Unconditioned, non-return-air spaces should be specified in the SPACE command with ZONE–TYPE = UNCONDITIONED.

*** BUILDING ***

FLOOR AREA	5000	SQFT	465	SQMT
VOLUME	50000	CUFT	1416	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 6PM		JAN 12 8AM	
DRY-BULB TEMP	97F	36C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE		LATENT		SENSIBLE	
	(KBTU/H)	(KW)	(KBTU/H)	(KW)	(KBTU/H)	(KW)
WALLS	3.484	1.021	0.000	0.000	-8.765	-2.567
ROOFS	0.000	0.000	0.000	0.000	0.000	0.000
GLASS CONDUCTION	15.348	4.495	0.000	0.000	-55.293	-16.194
GLASS SOLAR	29.407	8.613	0.000	0.000	1.975	0.578
DOOR	0.000	0.000	0.000	0.000	0.000	0.000
INTERNAL SURFACES	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURFACES	-1.500	-0.439	0.000	0.000	-7.500	-2.197
OCCUPANTS TO SPACE	13.845	4.055	4.824	1.413	0.668	0.196
LIGHT TO SPACE	36.401	10.661	0.000	0.000	4.390	1.286
EQUIPMENT TO SPACE	8.811	2.580	0.000	0.000	0.889	0.260
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.000	0.000	0.000	0.000	-12.756	-3.736
TOTAL	105.797	30.985	4.824	1.413	-76.392	-22.373

TOTAL LOAD	110.620 KBTU/H	32.398 KW	-76.392 KBTU/H	-22.373 KW
TOTAL LOAD / AREA	22.12BTU/H.SQFT	69.746 W /SQMT	15.278BTU/H.SQFT	48.165 W /SQMT

NOTE
1) THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR LOADS
2) TIMES GIVEN IN STANDARD TIME FOR THE LOCATION IN CONSIDERATION

REPORT LS–D -- BUILDING MONTHLY LOADS SUMMARY

This report gives a summary of monthly cooling, heating, and electrical requirements plus annual total energy requirements and maximum monthly peak loads. Unconditioned spaces are not included in this report's monthly load.

Once again, the user should be aware that these loads are based on a constant temperature within each SPACE (that is, no setback, no floating, and no variations within the SPACE). Additionally, these loads do not account for conditioning of outside ventilation air. Later, in SYSTEMS, these items will be accounted for.

1. COOLING, HEATING, and ELEC
   are the three sections of this building level report.

2. COOLING ENERGY
   (millions of Btu) is the monthly sensible load for all SPACEs in the building.

3. MAXIMUM COOLING LOAD
   (thousands of Btu/hr) is the peak sensible space cooling load. To the left of this column are the day and hour of the peak cooling load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

4. HEATING ENERGY
   (millions of Btu) is the monthly heating load.

5. MAXIMUM HEATING LOAD
   (thousands of Btu/hr) is the peak space heating load. To the left of this column are the day and hour of the peak heating load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

6. ELECTRICAL ENERGY (kWh)
   is the monthly electrical consumption for lights, convenience outlets, and non-HVAC equipment.

7. MAXIMUM ELEC LOAD (kW)
   is the monthly peak electrical consumption in a one-hour period for lights, convenience outlets, and miscellaneous equipment input as SOURCE.

8. TOTAL
   is the annual total for the cooling load, heating load, and electrical loads of the building.

9. MAX
   is the highest monthly peak cooling load, heating load, and electrical load.

REPORT- LS-D BUILDING MONTHLY LOADS SUMMARY WEATHER FILE- TRY CHICAGO

	COOLING						HEATING						ELEC	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	5.70232	25	16	48.F	42.F	57.971	-20.593	12	8	-7.F	-7.F	-76.392	4724.	18.992
FEB	4.93025	28	15	52.F	42.F	55.165	-19.260	4	6	7.F	6.F	-74.289	4104.	18.992
MAR	7.07495	5	17	57.F	46.F	63.691	-14.210	24	6	8.F	7.F	-75.314	4538.	18.992
APR	14.76894	26	17	74.F	60.F	86.882	-4.708	8	6	32.F	29.F	-36.579	4703.	18.992
MAY	17.98741	20	15	77.F	68.F	85.591	-2.365	6	6	38.F	34.F	-23.286	4724.	18.992
JUN	22.81802	20	15	90.F	77.F	98.366	-0.546	23	5	52.F	48.F	-12.343	4331.	18.992
JUL	30.30853	9	17	97.F	73.F	105.797	-0.021	5	5	60.F	54.F	-3.591	4724.	18.992
AUG	27.31644	19	17	90.F	71.F	104.667	-0.106	5	5	55.F	54.F	-7.761	4724.	18.992
SEP	20.02758	26	16	82.F	61.F	98.799	-1.631	22	6	35.F	31.F	-24.527	4331.	18.992
OCT	15.95192	10	16	68.F	53.F	88.337	-4.223	21	6	30.F	29.F	-31.426	4724.	18.992
NOV	7.53423	1	16	72.F	59.F	80.847	-12.212	15	6	28.F	26.F	-48.791	4145.	18.992
DEC	5.37496	10	15	41.F	35.F	57.528	-19.016	8	20	18.F	16.F	-64.290	4538.	18.992
TOTAL	179.796						-98.891						54308.	
MAX						105.797						-76.392		18.992

REPORT LS–E -- SPACE MONTHLY LOAD COMPONENTS IN MBTU

This report gives a breakdown of loads for each space on a monthly basis, according to the source of the load. All entries are in millions of Btu/month. Each load is broken down into three types: heating (HEATNG), sensible cooling (SEN CL), and latent cooling (LAT CL). Latent cooling loads are accumulated only for those hours in each month that have a net sensible cooling load. Positive entries correspond to heat gain, negative entries correspond to heat loss, and all sensible loads are calculated as *delayed in time with weighting factors*.

The load sources, listed across the top of the report, are described below. The corresponding headings from Report LS–B are given in brackets.

1. WALLS [WALLS plus DOOR]
   is the heat conduction through exterior walls with TILT greater than 45°, plus conduction through doors located in exterior walls.

2. ROOFS [ROOFS]
   is the heat conduction through exterior walls with TILT less than 45°.

3. INT SUR [INTERNAL SURFACES]
   is the heat conduction through interior walls. This entry will be non-zero only if there are one or more adjoining spaces with a loads calculation temperature that is different from that of the space being reported.

4. UND SUR [UNDERGROUND SURFACES]
   is the heat conduction through underground surfaces.

5. INFIL [INFILTRATION]
   is the load due to air infiltration.

6. GL CON [GLASS CONDUCTION]
   is the sum of the UAΔT load through the windows plus solar energy absorbed by the glass and conducted into the space.

7. GL SOL [GLASS SOLAR]
   is the load from direct and diffuse solar radiation transmitted by windows.

8. OCCUP [OCCUPANTS TO SPACE]
   is the heat gain from occupants.

9. LIGHTS [LIGHT TO SPACE]
   is the heat gain from lights.

10. EQUIP [EQUIPMENT TO SPACE]
    is the load resulting from equipment. These values are calculated from user-supplied entries for EQUIP-SCHEDULE, EQUIPMENT-KW, EQUIPMENT-W/SQFT, EQUIP-SENSIBLE and EQUIP-LATENT.

11. SOURCE [PROCESS TO SPACE]
    is the load resulting from internal heating loads other than people, lights, or equipment. These values are calculated from the user-supplied entries for SOURCE–SCHEDULE, SOURCE–TYPE, SOURCE–BTU/HR, SOURCE–SENSIBLE, and SOURCE–LATENT.

The LS–E Report is printed once for the combined DESIGN–DAY intervals (if one or more DESIGN–DAYs are specified) and once for the combined RUN–PERIOD intervals that use the weather file.
For DESIGN–DAYs, the months will be printed in the same order as they appear in the DESIGN–DAY RUN–PERIOD intervals.

To illustrate how the entries in this report are accumulated, consider a sequence of four hours in January in which the load components (in MBTU) from conduction through walls and heat from lights are as follows (the other load components are assumed to be zero):

	Walls	**Lights**
hour 1:	-0.01	0.03
hour 2:	-0.02	0.03
hour 3:	-0.04	0.03
hour 4:	-0.05	0.03

In hours 1 and 2 the net loads are (-0.01 + 0.03) = 0.02, and (-0.02 + 0.03) = 0.01, respectively. Thus, both these hours have a net (sensible) cooling load. In hours 3 and 4, on the other hand, the net loads are (-0.04 + 0.03) = -0.01 and (-0.05 + 0.03) = -0.02, respectively. Thus, these hours have a net heating load. The entries in the LS-E Report for January would then be (assuming all other hours have zero loads):

		WALLS	LIGHTS	TOTAL
	HEATNG	-0.09	0.06	-0.03 (from hours 3 and 4)
JAN	SEN CL	-0.03	0.06	0.03 (from hours 1 and 2)
	LAT CL	0.	0.	0.

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SIMPLE STRUCTURE RUN 3, CHICAGO   DOE-2.1D 3/ 8/1989 13:46:27 LDL RUN 3

REPORT- LS-E SPACE MONTHLY LOAD COMPONENTS IN MBTU FOR SPACE1-1   WEATHER FILE- TRY CHICAGO

(UNITS=MBTU)		WALLS	ROOFS	INT SUR	UND SUR	INFIL	GL CON	GL SOL	OCCUP	LIGHTS	EQUIP	SOURCE	TOTAL
JAN	HEATNG	-1.066	0.000	0.000	-0.947	-0.713	-6.949	1.639	0.370	1.272	0.368	0.000	-6.026
	SEN CL	-0.167	0.000	0.000	-0.231	-0.165	-1.376	1.592	0.325	0.914	0.291	0.000	1.182
	LAT CL					0.000			0.113		0.000	0.000	0.113
FEB	HEATNG	-0.888	0.000	0.000	-0.911	-0.864	-6.168	1.577	0.305	1.068	0.307	0.000	-5.576
	SEN CL	-0.157	0.000	0.000	-0.260	-0.199	-1.348	1.776	0.298	0.842	0.266	0.000	1.218
	LAT CL					0.000			0.104		0.000	0.000	0.104
MAR	HEATNG	-0.649	0.000	0.000	-0.819	-0.697	-4.625	1.585	0.175	0.727	0.184	0.000	-4.119
	SEN CL	-0.214	0.000	0.000	-0.399	-0.297	-1.738	1.978	0.494	1.394	0.452	0.000	1.670
	LAT CL					0.007			0.174		0.000	0.000	0.181
APR	HEATNG	-0.297	0.000	0.000	-0.411	0.000	-2.097	0.857	0.070	0.360	0.080	0.000	-1.438
	SEN CL	-0.168	0.000	0.000	-0.578	0.000	-1.587	3.271	0.626	1.817	0.577	0.000	3.958
	LAT CL					0.000			0.213		0.000	0.000	0.213
MAY	HEATNG	-0.196	0.000	0.000	-0.255	0.000	-1.338	0.685	0.037	0.240	0.048	0.000	-0.779
	SEN CL	-0.137	0.000	0.000	-0.492	0.000	-1.415	3.281	0.661	1.957	0.613	0.000	4.467
	LAT CL					0.000			0.218		0.000	0.000	0.218
JUN	HEATNG	-0.063	0.000	0.000	-0.067	0.000	-0.422	0.259	0.010	0.080	0.016	0.000	-0.189
	SEN CL	0.022	0.000	0.000	-0.390	0.000	-0.454	3.729	0.627	1.945	0.591	0.000	6.070
	LAT CL					0.000			0.198		0.000	0.000	0.198
JUL	HEATNG	-0.004	0.000	0.000	-0.004	0.000	-0.028	0.021	0.001	0.007	0.001	0.000	-0.006
	SEN CL	0.224	0.000	0.000	-0.233	0.000	0.579	4.266	0.695	2.181	0.658	0.000	8.371
	LAT CL					0.000			0.218		0.000	0.000	0.218
AUG	HEATNG	-0.015	0.000	0.000	-0.007	0.000	-0.102	0.065	0.002	0.022	0.004	0.000	-0.031
	SEN CL	0.131	0.000	0.000	-0.150	0.000	0.052	4.207	0.698	2.183	0.659	0.000	7.780
	LAT CL					0.000			0.218		0.000	0.000	0.218
SEP	HEATNG	-0.122	0.000	0.000	-0.053	0.000	-0.838	0.402	0.014	0.123	0.024	0.000	-0.449
	SEN CL	-0.050	0.000	0.000	-0.175	0.000	-0.998	4.326	0.618	1.884	0.578	0.000	6.184
	LAT CL					0.000			0.198		0.000	0.000	0.198
OCT	HEATNG	-0.267	0.000	0.000	-0.173	0.000	-1.821	0.738	0.042	0.270	0.056	0.000	-1.155
	SEN CL	-0.155	0.000	0.000	-0.258	0.000	-1.511	3.591	0.656	1.925	0.605	0.000	4.852
	LAT CL					0.000			0.216		0.000	0.000	0.216
NOV	HEATNG	-0.592	0.000	0.000	-0.463	-0.571	-4.097	1.040	0.172	0.712	0.186	0.000	-3.613
	SEN CL	-0.171	0.000	0.000	-0.221	-0.199	-1.474	2.101	0.434	1.228	0.393	0.000	2.090
	LAT CL					0.004			0.151		0.000	0.000	0.155
DEC	HEATNG	-0.900	0.000	0.000	-0.782	-0.805	-6.128	0.959	0.300	1.097	0.306	0.000	-5.953
	SEN CL	-0.181	0.000	0.000	-0.199	-0.172	-1.382	1.146	0.363	1.005	0.326	0.000	0.905
	LAT CL					0.000			0.130		0.000	0.000	0.130
TOT	HEATNG	-5.059	0.000	0.000	-4.891	-3.650	-34.614	9.828	1.499	5.975	1.579	0.000	-29.334
	SEN CL	-1.021	0.000	0.000	-3.587	-1.032	-12.652	35.265	6.494	19.274	6.007	0.000	48.748
	LAT CL					0.012			2.149		0.000	0.000	2.161

REPORT LS–F -- BUILDING MONTHLY LOAD COMPONENTS IN MBTU

This report gives a breakdown of loads on a monthly basis for the entire building, according to the source of the load. The loads in unconditioned spaces are not included; all entries are in millions of Btu/month.

Like Report LS–E, three types of loads are shown: heating (HEATNG), sensible cooling (SEN CL), and latent cooling (LAT CL). The reported sources of the load (WALLS, ROOFS, etc.) are defined in the LS-E report description.

For multizone buildings, the load components are obtained by summing the corresponding load components for each conditioned space after multiplication by the space MULTIPLIER or FLOOR–MULTIPLIER. For example, consider a building with two spaces, Z–1 and Z–2, with space MULTIPLIERs of 2 and 3, respectively. If the heating load components in January due to glass conduction are -5.90 MBTU for Z–1 and -2.30 MBTU for Z–2, then the corresponding building load component is 2 x (-5.90) + 3 x (-2.30) = -18.70 MBTU.

The total monthly heating and sensible cooling loads in the last column of this report are the same as those given in Report LS–D, Building Monthly Loads Summary, under the headings HEATING ENERGY and COOLING ENERGY.

SIMPLE STRUCTURE RUN 3, CHICAGO DOE-2.1D 3/ 8/1989 13:46:27 LDL RUN 3

REPORT- LS-F BUILDING MONTHLY LOAD COMPONENTS IN MBTU WEATHER FILE- TRY CHICAGO

(UNITS=MBTU)		WALLS	ROOFS	INT SUR	UND SUR	INFIL	GL CON	GL SOL	OCCUP	LIGHTS	EQUIP	SOURCE	TOTAL
JAN	HEATNG	-3.591	0.000	0.000	-4.044	-3.073	-20.620	3.148	1.362	4.856	1.369	0.000	-20.593
	SEN CL	-0.392	0.000	0.000	-1.536	-1.085	-2.695	2.241	1.924	5.495	1.750	0.000	5.702
	LAT CL					0.000			0.659		0.000	0.000	0.659
FEB	HEATNG	-3.024	0.000	0.000	-4.125	-3.810	-18.480	3.452	1.189	4.339	1.199	0.000	-19.260
	SEN CL	-0.356	0.000	0.000	-1.417	-1.223	-2.571	2.620	1.661	4.702	1.514	0.000	4.930
	LAT CL					0.000			0.580		0.000	0.000	0.580
MAR	HEATNG	-2.119	0.000	0.000	-3.756	-3.161	-13.380	3.745	0.679	3.037	0.745	0.000	-14.210
	SEN CL	-0.635	0.000	0.000	-2.011	-1.543	-4.378	3.887	2.484	7.006	2.265	0.000	7.075
	LAT CL					0.018			0.867		0.000	0.000	0.885
APR	HEATNG	-0.968	0.000	0.000	-1.897	0.000	-6.102	2.305	0.245	1.409	0.301	0.000	-4.708
	SEN CL	-0.533	0.000	0.000	-2.785	0.000	-4.227	7.562	3.043	8.899	2.811	0.000	14.769
	LAT CL					0.000			1.015		0.000	0.000	1.015
MAY	HEATNG	-0.597	0.000	0.000	-1.116	0.000	-3.666	1.834	0.118	0.887	0.175	0.000	-2.365
	SEN CL	-0.452	0.000	0.000	-2.422	0.000	-4.002	9.214	3.182	9.511	2.955	0.000	17.987
	LAT CL					0.000			1.029		0.000	0.000	1.029
JUN	HEATNG	-0.180	0.000	0.000	-0.386	0.000	-1.102	0.663	0.029	0.362	0.067	0.000	-0.546
	SEN CL	0.045	0.000	0.000	-1.778	0.000	-1.353	10.897	2.983	9.222	2.803	0.000	22.818
	LAT CL					0.000			0.936		0.000	0.000	0.936
JUL	HEATNG	-0.014	0.000	0.000	-0.013	0.000	-0.094	0.064	0.003	0.028	0.005	0.000	-0.021
	SEN CL	0.682	0.000	0.000	-1.107	0.000	1.563	12.441	3.285	10.329	3.115	0.000	30.309
	LAT CL					0.000			1.029		0.000	0.000	1.029
AUG	HEATNG	-0.053	0.000	0.000	-0.024	0.000	-0.321	0.193	0.008	0.077	0.015	0.000	-0.106
	SEN CL	0.360	0.000	0.000	-0.721	0.000	0.073	10.815	3.303	10.362	3.124	0.000	27.316
	LAT CL					0.000			1.029		0.000	0.000	1.029
SEP	HEATNG	-0.459	0.000	0.000	-0.195	0.000	-2.819	1.189	0.065	0.491	0.097	0.000	-1.631
	SEN CL	-0.195	0.000	0.000	-0.884	0.000	-2.476	8.892	2.924	9.013	2.754	0.000	20.028
	LAT CL					0.000			0.936		0.000	0.000	0.936
OCT	HEATNG	-0.964	0.000	0.000	-0.758	0.000	-5.816	1.757	0.175	1.145	0.237	0.000	-4.223
	SEN CL	-0.500	0.000	0.000	-1.285	0.000	-3.700	6.177	3.123	9.246	2.891	0.000	15.952
	LAT CL					0.000			1.021		0.000	0.000	1.021
NOV	HEATNG	-1.995	0.000	0.000	-2.052	-2.485	-12.177	2.247	0.660	2.863	0.726	0.000	-12.212
	SEN CL	-0.498	0.000	0.000	-1.184	-1.163	-3.465	3.305	2.203	6.322	2.014	0.000	7.534
	LAT CL					0.019			0.751		0.000	0.000	0.769
DEC	HEATNG	-2.987	0.000	0.000	-3.326	-3.503	-17.980	2.108	1.158	4.323	1.191	0.000	-19.016
	SEN CL	-0.450	0.000	0.000	-1.319	-1.121	-2.931	1.795	1.978	5.626	1.797	0.000	5.375
	LAT CL					0.000			0.681		0.000	0.000	0.681
TOT	HEATNG	-17.166	0.000	0.000	-21.870	-16.470	-104.030	23.025	5.697	23.904	6.143	0.000	-100.767
	SEN CL	-2.902	0.000	0.000	-18.617	-6.135	-30.211	80.742	32.386	96.602	30.063	0.000	181.928
	LAT CL					0.037			10.626		0.000	0.000	10.663

REPORT LS–G -- SPACE DAYLIGHTING SUMMARY

This report gives monthly-average lighting energy reduction, illuminance, and glare for each daylit space. If only one lighting reference point is specified, the entries under REF PT 2 will be zero. Task lighting energy, as determined by TASK–LIGHTING–KW or TASK–LT–W/SQFT, is not considered.

1. PERCENT LIGHTING ENERGY REDUCTION BY DAYLIGHTING (ALL HOURS)
   gives the percentage by which electric lighting energy is reduced, due to daylighting, for the entire space (TOTAL ZONE), and for the lighting zones at each lighting reference point (REF PT 1 and REF PT 2). In this section of the report, all hours of the day are taken into account, including nighttime hours when the lighting energy reduction due to daylighting is zero.

2. PERCENT LIGHTING ENERGY REDUCTION BY DAYLIGHTING (REPORT SCHEDULE HOURS)
   gives the percentage by which electric lighting energy is reduced, due to daylighting, for the entire space (TOTAL ZONE), and for the lighting zones at each lighting reference point (REF PT 1 and REF PT 2). In this section of the report, only those hours are taken into account for which the value of DAYLIGHT–REP–SCH for this space is non-zero (the default). If DAYLIGHT–REP–SCH is not defined the entries will be the same as those in Part 1 above.

In the following four sections, only those hours are taken into account for which *the sun is up* and the value of DAYLIGHT–REP–SCH is non-zero (the default).

3. AVERAGE DAYLIGHT ILLUMINANCE
   gives the average illuminance due to daylight at each lighting reference point.

4. PERCENT HOURS DAYLIGHT ILLUMINANCE ABOVE SETPOINT
   gives the percentage of hours that the illuminance from daylight exceeds the required illuminance level as specified by LIGHT–SET–POINT1 at REF PT 1 and LIGHT–SET–POINT2 at REF PT 2. (See Report LS–J for the frequency of occurrence distribution for daylight illuminance.)

5. AVERAGE GLARE INDEX
   gives the average daylight glare index at each lighting reference point (REF PT 1 and REF PT 2).

6. PERCENT HOURS GLARE TOO HIGH
   gives the percentage of hours at each lighting reference point that the daylight glare index exceeds the MAX–GLARE value (or a value of 22, the maximum recommended for general office work, if MAX–GLARE has not been specified).

DAYLIGHTING EXAMPLE FLOOR OF OFFICE BUILDING IN CHICAGO DOE-2.1D 3/ 9/1989 14:50:31 LDL RUN 1
30-FT DEEP PERIM OFFS DAYLIT TO 15 FT AUTO SHADE MANAGEMENT FOR SUN CONTROL
REPORT- LS-G SPACE DAYLIGHTING SUMMARY WEATHER FILE- TRY CHICAGO

SPACE SOUTHZONE

	PERCENT LIGHTING ENERGY REDUCTION BY DAYLIGHTING (ALL HOURS)			PERCENT LIGHTING ENERGY REDUCTION BY DAYLIGHTING (REPORT SCHEDULE HOURS)			REPORT SCHEDULE HOURS WITH SUN UP: AVERAGE DAYLIGHT ILLUMINANCE (FOOTCANDLES)		PERCENT HOURS DAYLIGHT ILLUMINANCE ABOVE SETPOINT		AVERAGE GLARE INDEX		PERCENT HOURS GLARE TOO HIGH	
MONTH	TOTAL ZONE	REF PT 1	REF PT 2	TOTAL ZONE	REF PT 1	REF PT 2	REF PT 1	REF PT 2	REF PT 1	REF PT 2	REF PT 1	REF PT 2	REF PT 1	REF PT 2
JAN	12.3	24.7	0.0	15.8	31.6	0.0	26.5	0.0	21.5	0.0	7.4	0.0	0.0	0.0
FEB	15.1	30.2	0.0	18.9	37.8	0.0	26.5	0.0	15.5	0.0	8.1	0.0	0.0	0.0
MAR	17.6	35.2	0.0	21.6	43.2	0.0	27.1	0.0	9.0	0.0	8.8	0.0	0.0	0.0
APR	22.7	45.4	0.0	27.3	54.6	0.0	36.5	0.0	23.0	0.0	10.3	0.0	0.0	0.0
MAY	25.2	50.4	0.0	29.6	59.3	0.0	41.5	0.0	24.7	0.0	11.1	0.0	0.0	0.0
JUN	28.5	56.9	0.0	32.6	65.2	0.0	53.1	0.0	40.0	0.0	12.0	0.0	0.0	0.0
JUL	29.7	59.4	0.0	33.6	67.2	0.0	62.1	0.0	57.7	0.0	12.5	0.0	0.0	0.0
AUG	27.3	54.6	0.0	31.5	63.0	0.0	47.4	0.0	40.9	0.0	11.6	0.0	0.0	0.0
SEP	26.8	53.6	0.0	31.4	62.8	0.0	50.4	0.0	47.4	0.0	11.4	0.0	0.0	0.0
OCT	22.6	45.1	0.0	27.5	55.0	0.0	46.5	0.0	38.0	0.0	10.7	0.0	0.0	0.0
NOV	15.0	30.0	0.0	18.9	37.9	0.0	36.1	0.0	30.0	0.0	8.8	0.0	0.0	0.0
DEC	12.1	24.2	0.0	15.3	30.6	0.0	22.4	0.0	11.8	0.0	6.9	0.0	0.0	0.0
ANNUAL	21.3	42.7	0.0	25.5	50.9	0.0	39.7	0.0	30.0	0.0	10.0	0.0	0.0	0.0

REPORT LS–H -- PERCENT LIGHTING ENERGY REDUCTION, <space>

For each daylit space this report gives the monthly lighting energy reduction due to daylighting for each hour of the day, and for all hours of the day combined (including nighttime hours). HOUR OF DAY is given in standard time, even if DAYLIGHT–SAVINGS = YES. Hour 1 is 12 pm to 1 am, hour 2 is 1 am to 2 am, etc. The schedule DAYLIGHT–REP–SCH has no effect on this report. Task lighting energy, as determined by TASK–LIGHTING–KW or TASK–LT–W/SQFT, is not considered.

See Report LS–I for lighting energy reduction vs. hour of day for the entire building.

DAYLIGHTING EXAMPLE FLOOR OF OFFICE BUILDING IN CHICAGO DOE-2.1D 3/ 9/1989 14:50:31 LDL RUN 1
30-FT DEEP PERIM OFFS DAYLIT TO 15 FT AUTO SHADE MANAGEMENT FOR SUN CONTROL
REPORT- LS-H PERCENT LIGHTING ENERGY REDUCTION BY DAYLIGHT SOUTHZONE WEATHER FILE- TRY CHICAGO

SPACE SOUTHZONE

HOUR OF DAY

MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	ALL HOURS
JAN	0	0	0	0	0	0	0	5	10	15	20	21	21	20	17	10	9	0	0	0	0	0	0	0	12
FEB	0	0	0	0	0	0	0	14	15	21	24	23	24	22	18	16	10	4	0	0	0	0	0	0	15
MAR	0	0	0	0	0	0	13	13	17	22	24	26	26	24	21	20	15	10	0	0	0	0	0	0	18
APR	0	0	0	0	0	8	15	21	26	28	31	30	31	29	27	24	19	14	3	0	0	0	0	0	23
MAY	0	0	0	0	3	16	23	27	29	30	32	32	32	30	28	27	21	17	9	0	0	0	0	0	25
JUN	0	0	0	0	8	19	25	30	33	34	34	34	33	33	33	31	28	23	18	3	0	0	0	0	28
JUL	0	0	0	0	7	24	29	32	33	34	34	34	34	33	34	33	32	28	21	3	0	0	0	0	30
AUG	0	0	0	0	0	16	25	29	31	32	33	33	33	32	31	31	29	24	12	0	0	0	0	0	27
SEP	0	0	0	0	0	8	26	29	30	33	32	33	32	32	31	30	27	20	1	0	0	0	0	0	27
OCT	0	0	0	0	0	1	18	24	28	28	30	31	31	29	26	25	17	2	0	0	0	0	0	0	23
NOV	0	0	0	0	0	0	5	15	21	23	24	25	24	21	17	12	4	0	0	0	0	0	0	0	15
DEC	0	0	0	0	0	0	0	10	14	18	21	21	21	18	15	9	3	0	0	0	0	0	0	0	12
ANNUAL	0	0	0	0	2	10	19	25	24	27	28	28	29	27	25	22	15	10	5	0	0	0	0	0	21

NOTE- THE ENTRIES IN THIS REPORT ARE NOT
SUBJECT TO THE DAYLIGHTING REPORT SCHEDULE

REPORT LS–I -- PERCENT LIGHTING ENERGY REDUCTION BY DAYLIGHT, BUILDING

For the building as a whole this report gives the monthly lighting energy reduction due to daylighting for each hour of the day and for all hours of the day combined (including nighttime hours). HOUR OF DAY is given in standard time, even if DAYLIGHT–SAVINGS = YES. Hour 1 is 12 pm to 1 am, hour 2 is 1 am to 2 am, etc. All spaces in the building are included in this report, even those which are not daylit (i.e. have DAYLIGHTING = NO). This report is not affected by DAYLIGHT–REP–SCH. Task lighting energy, as determined by TASK–LIGHTING–KW or TASK–LT–W/SQFT, is not considered.

See Report LS–H for lighting energy reduction vs. hour of day for individual daylit spaces.

*** BUILDING ***

HOUR OF DAY

MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	ALL HOURS
JAN	0	0	0	0	0	0	0	2	5	7	9	9	10	9	8	6	3	0	0	0	0	0	0	0	6
FEB	0	0	0	0	0	0	0	6	8	10	10	11	11	10	8	7	5	2	0	0	0	0	0	0	7
MAR	0	0	0	0	0	0	5	6	9	10	12	12	12	12	10	9	7	4	0	0	0	0	0	0	8
APR	0	0	0	0	0	4	6	10	12	13	14	14	14	14	12	11	9	6	2	0	0	0	0	0	11
MAY	0	0	0	0	2	8	11	12	13	14	15	15	15	14	13	12	9	8	5	0	0	0	0	0	12
JUN	0	0	0	0	5	9	12	13	15	15	16	16	16	15	15	14	13	11	9	2	0	0	0	0	13
JUL	0	0	0	0	4	11	13	15	15	16	16	16	16	16	16	15	14	13	11	2	0	0	0	0	14
AUG	0	0	0	0	0	8	11	13	14	14	15	16	15	15	14	14	13	11	7	0	0	0	0	0	13
SEP	0	0	0	0	0	4	12	13	14	15	15	15	16	15	14	14	12	9	1	0	0	0	0	0	12
OCT	0	0	0	0	0	0	8	11	13	13	14	14	14	13	12	11	8	1	0	0	0	0	0	0	10
NOV	0	0	0	0	0	0	2	8	9	11	11	11	11	10	8	5	2	0	0	0	0	0	0	0	7
DEC	0	0	0	0	0	0	0	4	7	8	9	9	9	8	7	5	1	0	0	0	0	0	0	0	6
ANNUAL	0	0	0	0	1	5	9	11	11	12	13	13	13	13	12	10	7	5	3	0	0	0	0	0	10

NOTE- THE ENTRIES IN THIS REPORT ARE NOT SUBJECT TO THE DAYLIGHTING REPORT SCHEDULE

REPORT LS–J -- DAYLIGHT ILLUMINANCE FREQUENCY OF OCCURRENCE

For each daylit space this report gives the monthly daylight-illuminance frequency-of-occurrence distribution at each lighting reference point. If only one lighting reference point is specified, the entries under REF PT 2 will be zero.

1. PERCENT OF HOURS IN ILLUMINANCE RANGE
   gives the percentage of hours (with sun up and DAYLIGHT–REP–SCH value non-zero) that the daylight illuminance falls in the indicated range: 0-10, 10-20, ..., 70-80, and greater than 80 footcandles. Note: because of roundoff, the sum of these percentages for any given month may not be exactly 100.

2. PERCENT OF HOURS ILLUMINANCE LEVEL EXCEEDED
   gives the percentage of hours (with sun up and DAYLIGHT–REP–SCH value non-zero) that the daylight illuminance is higher than the indicated illuminance level.

DAYLIGHTING EXAMPLE FLOOR OF OFFICE BUILDING IN CHICAGO DOE-2.1D 3/ 9/1989 14:50:31 LDL RUN 1
30-FT DEEP PERIM OFFS DAYLIT TO 15 FT AUTO SHADE MANAGEMENT FOR SUN CONTROL
REPORT- LS-J DAYLIGHT ILLUMINANCE FREQUENCY OF OCCURRENCE SOUTHZONE WEATHER FILE- TRY CHICAGO

SPACE SOUTHZONE

		PERCENT OF HOURS IN ILLUMINANCE RANGE									PERCENT OF HOURS ILLUMINANCE LEVEL EXCEEDED								
		ILLUMINANCE RANGE (FOOTCANDLES)									ILLUMINANCE LEVEL (FOOTCANDLES)								
MONTH	REF PT	0 -- 10	-- 20	-- 30	-- 40	-- 50	-- 60	-- 70	-- 80	-ABOVE	0	10	20	30	40	50	60	70	80
JAN	-1-	21	44	6	4	4	10	5	3	4	100	79	35	29	25	22	12	7	4
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FEB	-1-	12	40	19	8	6	6	5	4	0	100	88	48	30	22	15	9	4	0
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAR	-1-	7	30	36	10	8	4	3	1	1	100	93	63	27	17	9	5	2	1
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
APR	-1-	0	11	33	19	14	14	6	3	0	100	100	89	56	37	23	9	3	0
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAY	-1-	0	5	25	28	17	12	5	1	7	100	100	95	70	42	25	13	8	7
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JUN	-1-	0	0	10	26	24	13	6	4	17	100	100	100	90	64	40	27	21	17
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JUL	-1-	0	0	6	16	20	23	5	4	25	100	100	100	94	78	58	35	29	25
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AUG	-1-	0	3	13	30	13	17	13	5	6	100	100	97	84	54	41	24	11	6
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEP	-1-	0	4	19	16	14	14	11	10	12	100	100	96	78	61	47	33	22	12
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OCT	-1-	1	12	32	8	9	6	6	8	18	100	99	86	54	47	38	32	26	18
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NOV	-1-	15	26	21	4	4	7	5	6	11	100	85	59	39	34	30	23	17	11
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DEC	-1-	24	51	5	4	5	4	2	2	3	100	76	25	20	16	12	8	5	3
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNUAL	-1-	7	19	19	14	11	11	6	4	9	100	93	75	56	41	30	19	13	9
	-2-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NOTE- THE HOURS CONSIDERED IN THIS REPORT ARE THOSE
WITH SUN UP AND DAYLIGHTING REPORT SCHEDULE ON

REPORT LS–K -- SPACE INPUT FUELS SUMMARY

This report gives monthly summaries of the fuel inputs required by each space for lighting, equipment, and processes. Following the reports for each space is a separate building level report that gives the sum of the input fuels for the building as a whole.

Lighting, equipment, and process are the three major sections of this report, which is printed once for each space and once for the building as a whole.

1. TASK LIGHTING
(kilowatt hours) is the electricity used by the space for all task lighting.

2. TOTAL LIGHTING
(kilowatt hours) is the electricity used by the space for all lighting including task and overhead.

3. GENERAL EQUIPMENT
(kilowatt hours) is the electricity used by the space for running all equipment (i.e., computers, typewriters, etc.). For the building report, this includes building equipment such as elevators which may not be included in any space.

4. PROCESS ELECTRIC
(kilowatt hours) is all electricity used to maintain any of the processes in the space.

5. PROCESS GAS
(millions of Btu) is all gas used to maintain any of the processes in the space.

6. PROCESS HOT WATER
(millions of Btu) is the total hot water used in all processes in the space.

SPACE SPACE1-1

MONTH	----LIGHTING---- TASK LIGHTING (KWH)	TOTAL LIGHTING (KWH)	EQUIPMENT GENERAL EQUIPMENT (KWH)	----------PROCESS---------- PROCESS ELECTRIC (KWH)	PROCESS GAS (MBTU)	PROCESS HOT WATER (MBTU)
JAN	0.00	804.02	193.59	0.00	0.0000	0.0000
FEB	0.00	699.04	167.81	0.00	0.0000	0.0000
MAR	0.00	772.83	185.50	0.00	0.0000	0.0000
APR	0.00	800.22	193.08	0.00	0.0000	0.0000
MAY	0.00	804.02	193.59	0.00	0.0000	0.0000
JUN	0.00	737.83	176.91	0.00	0.0000	0.0000
JUL	0.00	804.02	193.59	0.00	0.0000	0.0000
AUG	0.00	804.02	193.59	0.00	0.0000	0.0000
SEP	0.00	737.83	176.91	0.00	0.0000	0.0000
OCT	0.00	804.02	193.59	0.00	0.0000	0.0000
NOV	0.00	706.64	168.83	0.00	0.0000	0.0000
DEC	0.00	772.82	185.50	0.00	0.0000	0.0000
ANNUAL	0.00	9246.93	2222.43	0.00	0.0000	0.0000

REPORT LS–L -- MANAGEMENT AND SOLAR SUMMARY FOR SPACE

The following report gives monthly summaries of window shade management and solar radiation into the space.

1. Column 1 is the count of the number of hours that window shade management would be employed in the space for each month. Management is employed under any of the following conditions:

   a) The shading schedule specifies management.

   b) If the transmitted direct solar gain into the space exceeds a pre-specified value MAX–SOLAR–SCH, then, with probability SUN–CTRL–PROB, shades will be in effect.

   c) If daylighting is requested (DAYLIGHTING=YES) and the daylight glare exceeds a pre-specified value MAX–GLARE, then the shades will be in effect.

2. Column 2 is the average solar radiation into the space through all glazing areas in Btu per day.

3. Column 3 is the maximum solar radiation into the space through all glazing areas for all hours in the month. The unit of measure is Btu per hour.

The entries in this report are solar heat gains, not solar loads; i.e., weighting factors to convert heat gains into delayed loads have *not* been applied. The solar heat gain is due to solar radiation transmitted through windows plus solar radiation absorbed by the windows and re-conducted into the space.

DATA FOR SPACE SPACE1-1

MONTH	NUMBER OF HOURS MANAGEMENT WOULD BE EMPLOYED	AVERAGE DAILY SOLAR RADIATION INTO SPACE (BTU/DAY)	MAXIMUM HOURLY SOLAR RADIATION INTO SPACE (BTU/HR)
JAN	0.	104311.516	49195.676
FEB	0.	119434.234	48452.582
MAR	0.	114433.258	44682.914
APR	0.	137469.266	35632.121
MAY	0.	127860.234	28263.387
JUN	0.	133281.531	22654.561
JUL	0.	138156.094	24060.967
AUG	0.	138102.578	29903.117
SEP	0.	157681.453	40195.328
OCT	0.	138886.734	45463.703
NOV	0.	104407.156	47651.418
DEC	0.	67875.867	47771.605
ANNUAL	0.	123418.641	49195.676

HOURLY REPORT

Hourly reports are user-designed; the variables that can be displayed are chosen by the user from the lists given in Appendix A. See the DOE-2 Reference Manual, Chap. II, for instructions on setting up hourly reports using the HOURLY–REPORT, REPORT–BLOCK and SCHEDULE commands.

Hourly reports can be printed from the LOADS, SYSTEMS and PLANT programs. The example shown here is from LOADS. The u-name of the HOURLY–REPORT command associated with the report is shown at the beginning of the third line. The first column of the report, headed by MMDDHH, gives the month, day, and hour (in *standard* time, even if DAYLIGHT–SAVINGS = YES). Succeeding columns give the following:

- variable type (GLOBAL, u-name of SPACE, etc.);
- variable name (DRY BULB TEMP, etc.);
- units (F, BTU/HR, etc.);
- variable-list number, in parentheses, chosen from Appendix A; and
- the values of the variable for hours 1 to 24.

Statistical summaries are printed at the bottom of the page. DAILY SUMMARY displays the minimum (MN), maximum (MX), sum (SM), and average (AV) values over the day for each variable. A MONTHLY SUMMARY and YEARLY SUMMARY are printed if this is the last scheduled day of the month and RUN–PERIOD, respectively. It is important to note that the MONTHLY SUMMARY includes only those days that satisfy three conditions:

(1) in the month indicated,
(2) in the RUN–PERIOD, *and*
(3) in the REPORT–SCHEDULE.

Similarly, YEARLY SUMMARY includes only the days that are

(1) in the RUN–PERIOD, *and*
(2) in the REPORT–SCHEDULE.

The user can choose to suppress printing of hourly data, and print only the DAILY, MONTHLY or YEARLY Summary by using REPORT–FREQUENCY (see "Hourly Report Frequencies and Summaries" in the BDL Section of this Supplement).

	GLOBAL	GLOBAL	GLOBAL	GLOBAL	GLOBAL	GLOBAL	GLOBAL	GLOBAL	GLOBAL	GLOBAL	GLOBAL	GLOBAL
	DRY BULB TEMP F	CLOUD AMOUNT	DIFFUSE SOLAR BTU/HR-SQFT	DIRECT NORM SOL BTU/HR-SQFT	GLOBAL SOLAR BTU/HR-SQFT	ATM TURBIDTY	ATM MOISTURE IN	SOLAR ALTITUDE DEGREES	SOLAR AZIMUTH DEGREES	DAYLIGHT CLD FAC	EXT ILL CLR SKY FOOTCANDLES	EXT ILL OVR SKY FOOTCANDLES
	----(4)	----(6)	----(13)	----(14)	----(15)	----(48)	----(49)	----(50)	----(51)	----(52)	----(53)	----(54)
424 1	36.0	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
424 2	36.0	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
424 3	36.0	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
424 4	36.0	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
424 5	36.0	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
424 6	32.0	0.0	0.0	0.0	8.4	0.180	0.53	5.1	78.0	1.00	1021.	0.
424 7	35.0	0.0	0.0	0.0	68.5	0.180	0.53	15.9	87.5	1.00	1373.	0.
424 8	39.0	0.0	0.0	0.0	131.8	0.180	0.53	27.0	97.8	1.00	1749.	0.
424 9	42.0	0.0	0.0	0.0	188.0	0.180	0.53	37.9	109.5	1.00	2151.	0.
42410	44.0	0.0	0.0	0.0	233.0	0.180	0.53	47.8	124.2	1.00	2306.	0.
42411	47.0	0.0	0.0	0.0	263.5	0.180	0.53	55.9	144.2	1.00	2395.	0.
42412	48.0	0.0	0.0	0.0	277.6	0.180	0.53	60.2	170.9	1.00	2474.	0.
42413	51.0	0.0	0.0	0.0	274.2	0.180	0.53	59.1	200.0	1.00	2464.	0.
42414	54.0	0.0	0.0	0.0	253.7	0.180	0.53	53.1	224.2	1.00	2377.	0.
42415	54.0	1.0	0.0	0.0	182.4	0.180	0.53	44.2	241.9	1.00	2294.	0.
42416	53.0	6.0	0.0	0.0	129.9	0.180	0.53	33.8	255.3	0.50	1036.	489.
42417	52.0	7.0	0.0	0.0	79.4	0.180	0.53	22.8	266.3	0.38	631.	404.
42418	52.0	8.0	0.0	0.0	29.5	0.180	0.53	11.6	276.2	0.25	317.	209.
42419	49.0	9.0	0.0	0.0	0.6	0.180	0.53	3.0	283.9	0.13	122.	51.
42420	43.0	8.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
42421	40.0	5.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
42422	38.0	2.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
42423	38.0	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
42424	37.0	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
DAILY SUMMARY (APR 24)												
MN	32.0	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
MX	54.0	9.0	0.0	0.0	277.6	0.180	0.53	60.2	283.9	1.00	2474.	489.
SM	1028.0	46.0	0.0	0.0	2120.5	2.520	7.42	477.4	2559.8	11.25	22709.	1154.
AV	42.8	1.9	0.0	0.0	88.4	0.105	0.31	19.9	106.7	0.47	946.	48.
MONTHLY SUMMARY (APR)												
MN	32.0	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
MX	54.0	9.0	0.0	0.0	277.6	0.180	0.53	60.2	283.9	1.00	2474.	489.
SM	1028.0	46.0	0.0	0.0	2120.5	2.520	7.42	477.4	2559.8	11.25	22709.	1154.
AV	42.8	1.9	0.0	0.0	88.4	0.105	0.31	19.9	106.7	0.47	946.	48.
YEARLY SUMMARY												
MN	1.0	0.0	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.00	0.	0.
MX	54.0	10.0	0.0	0.0	277.6	0.180	0.53	60.2	283.9	1.00	2474.	883.
SM	1246.0	251.0	0.0	0.0	2414.0	4.020	11.02	635.6	4371.0	11.25	22709.	6683.
AV	26.0	5.2	0.0	0.0	50.3	0.084	0.23	13.2	91.1	0.23	473.	139.

HOURLY REPORT PLOT

The following example is an HOURLY-REPORT in graphic form. The month, day, and hours appear in the left-hand column. The next entry to the right is the first *possible* value. A period (.) indicates that there is no value at or below this value; an asterisk (*) indicates that two or more values occupy this position. The numerical values appearing on the plot are correlated to the symbol numbers in the table above the plot. Component name, in the table, is the VARIABLE-TYPE of which the variable is a part. If a value appears at the last possible position on the right it means either that the value is at this point or that the value is higher than this point.

The original input that created the following sample plot is repeated here

```
PLOTER1   =REPORT–BLOCK
          VARIABLE–TYPE        =GLOBAL
          VARIABLE–LIST        =(15) .. $GLOBAL HORIZONTAL SOLAR$

PLOTER2   =REPORT–BLOCK
          VARIABLE–TYPE        =SOUTHZONE
          VARIABLE–LIST        =(49) .. $DAYL ILLUM, REF PT 1$

PLOTD     =HOURLY–REPORT
          REPORT–SCHEDULE      =PLTSCH
          REPORT–BLOCK         =(PLOTER1,PLOTER2)
          OPTION               =PLOT
          AXIS–ASSIGN          =(1,2)
          AXIS–TITLES          =(*EXTERIOR SOLAR, BTUH/FT2*,
                                *INTERIOR DAYLIGHT, FOOTCANDLES*)
          AXIS–MAX             =(500, 100)
          AXIS–MIN             =(0,0)
          DIVIDE               =(1,1,) ..
```

For more information on specifying this type of report see HOURLY–REPORT in Chap. III of the DOE-2 Reference Manual.

```
         SYMBOL    COMPONENT NAME       (NO.)  DESCRIPTION    AXIS     UNIT

           1       GLOBAL               (15)   GLOBAL  SOLAR    1    BTU/HR- SQFT
           2       SOUTHZONE            (49)   DAYL ILLREF PT 1 2    FOOTCANDLES

                                          INTERIOR DAYLITE
    0.00000E+00         0.20000E+02         0.40000E+02         0.60000E+02         0.80000E+02         0.10000E+03
          I......... .........I......... .........I......... .........I......... .........I......... .........I
                                          EXTERIOR SOLAR
    0.00000E+00         0.10000E+03         0.20000E+03         0.30000E+03         0.40000E+03         0.50000E+03
          I......... .........I......... .........I......... .........I......... .........I......... .........I
   424  7 .             1                                     2
   424  8 .                         1                                                 2                       .
   424  9 .                                     *                                                             .
   424 10 .                                             21                                                    .
   424 11 .                                                   21                                              .
   424 12 .                                                       1    2                                      .
   424 13 .                                                      1  2                                         .
   424 14 .                                                 21                                                .
   424 15 .                                   1       2                                                       .
   424 16 .                         1                            2                                            .
   424 17 .               1                 2                                                                 .
   424 18 .     1         2                                                                                   .
   424 19 1    2                                                                                              .
          I......... .........I......... .........I......... .........I......... .........I......... .........I
```

REPORT SV–A -- SYSTEM DESIGN PARAMETERS

This report echoes the user's input to the program as interpreted by the SYSTEMS design routines. See Section IV.D of the Reference Manual for a discussion of SYSTEMS design calculations.

1. SYSTEM NAME
   in the first line after the header is the u-name (SYST–1) of the HVAC system assigned by the user.

2. SUPPLY FAN (CFM)
   is the calculated system design air flow rate. It should be equal to the user-input SUPPLY–CFM multiplied by the value of ALTITUDE MULTIPLIER. If not user-specified, the value will be calculated from the peak loads. For a constant volume system or if SIZING–OPTION = NON–COINCIDENT, the number will be the sum of the design/cfms for the zones on the system. If the system is a variable-air-volume system, SIZING–OPTION = COINCIDENT, and this is the only system in the PLANT–ASSIGNMENT, the value is calculated from the building coincident peak load.

3. ELEC (KW)
   is the electrical energy consumed by the central system supply fan at design flow. It will be calculated from the value in column 1 and the user input (or default) for SUPPLY–KW or from the ratio of SUPPLY–STATIC and SUPPLY–EFF.

4. DELTA–T (F)
   is the value of SUPPLY–DELTA–T, the rise in temperature of the air caused by the supply fan.

5. The next three entries, RETURN FAN (CFM), ELEC (KW), AND DELTA–T (F) are the corresponding values for the return air fan. In the sample report these are all zero because no return fan has been specified.

6. OUTSIDE AIR RATIO
   is the outside air ratio for central systems. Its value is either the user input value of MIN–OUTSIDE–AIR or is calculated by SYSTEMS from the ventilation or exhaust input at the zone level divided by the supply fan cfm in column 1. This is a design quantity and so does not reflect values entered through the MIN–AIR–SCH keyword. For zonal systems, this value will be zero.

   When OUTSIDE AIR RATIO is determined from zone ventilation rates, it is the sum of the values under OUTSIDE AIR CFM (in column 6 opposite the zone u-names) divided by the value under SUPPLY FAN. This outside air ratio is what the program will use as the minimum outside air ratio. It is assumed that the outside air is brought in at the main system fan and is distributed to the individual zones in proportion to the supply air to each zone.

   Note: The SYSTEMS design routine does not examine the values entered in schedules. Consequently, if the user specified the outside air ratio through the MIN–AIR–SCH but wants SYSTEMS to size the equipment, a value should be specified for MIN–OUTSIDE–AIR.

7. COOLING CAPACITY (KBTU/HR)
   is either the value entered by the user for the keyword COOLING–CAPACITY at the system level or is computed by SYSTEMS from the total cooling capacity (sensible plus latent) from the peak loads. If the cfm chosen for the system is different from the user-specified value of RATED–CFM, COOLING CAPACITY may reflect a correction for off-rated performance.

8. SENSIBLE (SHR)
is the sensible heat ratio, i.e., the fraction of the total cooling capacity that is sensible cooling capacity at the peak or design condition, adjusted for RATED–CFM. If the user has not entered COOL–SH–CAP at the system level for a central system, this value is calculated from a simulation of the conditions at peak loads, adjusted for RATED–CFM.

9. HEATING CAPACITY (KBTU/HR)
is the maximum value for heating and again it reflects either the user input or a calculation from peak loads. Like the COOLING CAPACITY, this value will be zero for zonal systems, where the capacity is shown at the zone level.

10. COOLING EIR and HEATING EIR (BTU/BTU)
are the electric input ratios for cooling and for heat pumps, respectively. Values are taken from user input or are default values. Values may be modified if the supply cfm differs from the RATED–CFM.

The remainder of the report shows zone-level design values:

11. SUPPLY FLOW
is the calculated or user-specified supply cfm for each zone. Only if the user has specified a value for the ASSIGNED–CFM keyword in the ZONE–AIR command will the value here correspond to the user input. The ZONE–AIR keywords,
AIR-CHANGES/HR and CFM/SQFT,
will be accepted by SYSTEMS only if they are consistent with the user-supplied HEATING–CAPACITY and COOLING–CAPACITY, and are equivalent to a cfm larger than that of the exhaust from or the ventilation to the zone. If so, the cfm-equivalent values of the keywords AIR-CHANGES/HR and CFM/SQFT will be rounded up to the nearest 10 cfm. In any case, the ALTITUDE MULTIPLIER will be applied.

12. FAN (KW)
is the total of the zone supply and exhaust fan electrical consumption at design conditions. In the example shown, this is zero, as there are no zone fans.

13. MINIMUM FLOW RATIO
reflects the user's input for MIN–CFM–RATIO, unless that input is in conflict with exhaust or ventilation requirements. In the absence of user input, SYSTEMS will calculate the minimum cfm ratio for VAV systems from the minimum cfm needed to meet the the minimum ventilation requirements and the required heating capacity.

14. OUTSIDE AIR FLOW
reflects the user-specified outside air quantity entered at the zone level. If OUTSIDE–AIR–CFM is specified, its value is multiplied by the ALTITUDE MULTIPLIER and reported here. Otherwise the reported value is the maximum of the cfm-equivalent values of OA–CHANGES and OA–CFM/PER, rounded upward to the nearest 10 cfm and then multiplied by the ALTITUDE MULTIPLIER. For the actual amount of outside air delivered to the zone for central systems, see OUTSIDE AIR RATIO above.

15. COOLING CAPACITY (KBTU/HR),
at the zone level, will be zero for central systems. For zonal systems it will either be the value specified by the user for COOLING–CAPACITY or it will be calculated by SYSTEMS to meet the peak loads at the rated conditions for HP, PTAC, TPFC, and FPFC systems or at any conditions for FPIU and TPIU systems. This is done similarly for HEATING CAPACITY for the

above-mentioned systems and for UVT and UHT systems.

16. SENSIBLE (SHR)
is the sensible part of the cooling capacity for zonal systems.

17. EXTRACTION RATE (KBTU/HR)
is the extraction rate (cooling) at design conditions. This is not the value used in the simulation; that value is recalculated hourly and depends upon the loads, the conditions, the thermostat type, and the thermostatic throttling range. ADDITION RATE (heating) is treated similarly.

18. MULTIPLIER
is the user-specified number of identical zones.

REPORT- SV-A SYSTEM DESIGN PARAMETERS SYST-1 WEATHER FILE- TRY CHICAGO

SYSTEM NAME	ALTITUDE MULTIPLIER
SYST-1	1.020

SUPPLY FAN (CFM)	ELEC (KW)	DELTA-T (F)	RETURN FAN (CFM)	ELEC (KW)	DELTA-T (F)	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)
6579.	7.570	3.6	0.	0.000	0.0	0.059	189.907	0.806	0.000	0.00	0.00

ZONE NAME	SUPPLY FLOW	EXHAUST FLOW	FAN (KW)	MINIMUM FLOW RATIO	OUTSIDE AIR FLOW	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	MULTIPLIER
SPACE5-1	1663.	0.	0.000	0.300	143.	0.00	0.00	32.32	-104.15	-86.19	1.0
SPACE1-1	1877.	0.	0.000	0.300	82.	0.00	0.00	36.48	-117.56	-97.29	1.0
SPACE2-1	857.	0.	0.000	0.300	41.	0.00	0.00	16.66	-53.67	-44.42	1.0
SPACE3-1	1336.	0.	0.000	0.300	82.	0.00	0.00	25.98	-83.70	-69.27	1.0
SPACE4-1	847.	0.	0.000	0.300	41.	0.00	0.00	16.46	-53.03	-43.89	1.0
PLENUM-1	0.	0.	0.000	0.000	0.	0.00	0.00	0.00	0.00	0.00	1.0

REPORT SV–A -- SYSTEM DESIGN PARAMETERS

(REFRIGERATED EQUIP IN <space>)

When refrigerated equipment is input, an alternate SV–A report is printed. The top half of the report is identical to that as previously described. The bottom half, titled REFRIGERATED EQUIP IN <space>, covers the design parameters for three categories: ZONE, COMPRESSOR, and CONDENSER.

1. UNIT
   identifies the units input in the list of up to three entries of REFG–ZONE–LOAD.

2 DISCHARGE TEMP
   is the temperature inside the cases.

3. SENSIBLE LOADS TEMP
   is the sensible cooling effect to the space from air spilling from the case (rated at the temperatures of the space and inside the case).

4. SENSIBLE HEAT TEMP
   is the sensible cooling effect minus the heat of auxiliaries such as lights, fans, and anti-sweat heaters.

5. SENSIBLE COOL TEMP
   is the sensible cooling effect multiplied by REFG–SENS–SCH hourly values.

6. COMPRESSOR CAPACITY
   is the rated compressor capacity at a standard suction temperature of approximately 30°F depending on the manufacturer. Notice that when two or more compressors are multiplexed (using keyword REFG–COMP–GROUP), their combined capacity is indicated for the unit at the lowest evaporator temperature.

7. COMPRESSOR EFFICIENCY
   is the compressor EER (Energy Efficiency Ratio).

8. DESIGN HEAT REJ
   is the combined condenser heat rejection of all the compressors input.

9. FAN ENERGY
   is the tower fan or air cooled condenser fan rating.

10. PUMP ENERGY
   is the tower condenser pump rating; zero for air cooled applications.

SYSTEM NAME	ALTITUDE MULTIPLIER
FS-SYS1	1.020

SUPPLY FAN (CFM)	ELEC (KW)	DELTA-T (F)	RETURN FAN (CFM)	ELEC (KW)	DELTA-T (F)	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)
2366.	1.815	2.4	0.	0.000	0.0	0.287	90.738	0.636	-121.173	0.36	0.37

ZONE NAME	SUPPLY FLOW	EXHAUST FLOW	FAN (KW)	MINIMUM FLOW RATIO	OUTSIDE AIR FLOW	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	MULTIPLIER
ATZ1	2366.	0.	0.000	1.000	678.	0.00	0.00	48.56	0.00	-76.67	1.0

REFRIGERATED EQUIP IN ATZ1

	ZONE				COMPRESSOR		CONDENSER		
UNIT	DISCHARGE TEMP (F)	SENSIBLE LOADS TEMP (KBTU/HR)	SENSIBLE HEAT TEMP (KBTU/HR)	SENSIBLE COOL TEMP (KBTU/HR)	COMPRESSOR CAPACITY (KBTU/HR)	COMPRESSOR EFFICIENCY (BTU/WATT)	DESIGN HEAT REJ (KBTU/HR)	FAN ENERGY (KW)	PUMP ENERGY (KW)
1	-10.0	-8.894	-8.471	-8.894	14.547	3.8	51.693	0.271	0.064
2	23.0	-3.923	-3.615	-3.923	16.390	7.0			
3	30.0	-5.280	-4.800	-5.280	0.000	7.3			

REPORT SV–B -- ZONE FAN DATA FOR <system>

This report is produced whenever Powered Induction Units (PIUs) are specified.

1. The u-name of the HVAC system is given after ZONE FAN DATA.

2. ZONE NAME
   is the zone u-name.

3. FAN FLOW
   is the calculated (or input) capacity of the PIU box fan.

4. SUPPLY FLOW
   is the flow rate of air delivered by the central system.

5. MIN FLOW RATIO
   is the minimum stop position of primary air supply to the PIU box.

6. REHEAT–DELTA–T
   is the temperature rise of the reheat coil in the PIU box.

7. FAN–DELTA–T
   is the temperature rise due to the PIU box's fan motor.

8. FAN KW
   is the PIU box's fan motor electrical requirement.

ZONE NAME	FAN FLOW (CFM)	SUPPLY FLOW (CFM)	MIN FLOW RATIO	REHEAT DELTA-T (F)	FAN DELTA-T (F)	FAN KW
RZ1	0.	10924.	0.500	50.0	0.00	0.000
TZ1	0.	8497.	0.500	50.0	0.00	0.000
RZ2	628.	785.	0.200	50.0	1.02	0.207
RZ3	449.	408.	0.200	50.0	1.02	0.148
RZ4	620.	775.	0.200	50.0	1.02	0.205
RZ5	816.	1020.	0.200	50.0	1.02	0.269
TZ2	555.	694.	0.200	50.0	1.02	0.183
TZ3	381.	347.	0.200	50.0	1.02	0.126
TZ4	571.	714.	0.200	50.0	1.02	0.188
TZ5	677.	847.	0.200	50.0	1.02	0.224
PLEN1	0.	0.	0.000	0.0	0.00	0.000
PLEN2	0.	0.	0.000	0.0	0.00	0.000

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SYSTEMS SUMMARY REPORTS: OVERVIEW

Report SS–A is *always* printed for each system input; the following descriptions start with SS–A and end with SS–O (followed by special report REFG for refrigerated casework). However, the user should be aware that in a DOE-2 run, SYSTEMS reports are not printed alphabetically, but are grouped according to a PLANT, SYSTEMS, and ZONE hierarchy (see the output of Simple Structure Run 3 in the Sample Run Book).

The report hierarchy follows; the most often used reports are boldfaced.

Plant level:

SS–D PLANT MONTHLY LOADS SUMMARY

SS–E PLANT MONTHLY LOAD HOURS

SS–M FAN ELECTRIC ENERGY FOR PLANT

System level:

SS–A SYSTEM MONTHLY LOADS SUMMARY

SS–B SYSTEM MONTHLY LOADS SUMMARY

SS–C SYSTEM MONTHLY LOAD HOURS

SS–H SYSTEM MONTHLY LOADS SUMMARY

SS–I SYSTEM MONTHLY SOURCE–LATENT SUMMARY

SS–J SYSTEM PEAK HEATING AND COOLING DAYS

SS–K SPACE TEMPERATURE SUMMARY

SS–L FAN ELECTRIC ENERGY

SS–N RELATIVE HUMIDITY SCATTER PLOT

Zone level:

SS–G ZONE LOADS SUMMARY

SS–F ZONE DEMAND SUMMARY

SS–O TEMPERATURE SCATTER PLOT

The following reports are related and their formats are identical at the Plant, System and Zone levels.

Plant	System	Zone
SS–D	SS–A	SS–G
SS–E	SS–C	None
SS–M	SS–L	None

REPORT SS–A -- SYSTEM MONTHLY LOADS SUMMARY

This report is always printed by the program for each HVAC system modeled. It shows monthly cooling, heating, and electrical loads. The loads shown are the sum of zone-level loads and central air-handling-unit loads. (Zone-level loads are shown separately in Report SS–G.). This report is for comparison of monthly cooling and heating needs for the HVAC system. DX cooling loads are reported here (for PSZ, PMZS, PVAVS, PTAC, and RESYS systems) but are not passed to the PLANT program.

1. The title of the report shows the user name of the HVAC system being summarized (SYST–1).

2. COOLING, HEATING, and ELEC
are the three sections of this system-level report.

3. COOLING ENERGY
(millions of Btu) is the monthly sum of energy (sensible and latent) extracted by the HVAC system during the operation hours of the system and passed as a load to PLANT.

4. MAXIMUM COOLING LOAD
(thousands of Btu/hr) includes sensible and latent space cooling loads, ventilation air, and fan heat. The peak cooling load shown here is often the start-up load after the system has been shut down overnight. Notice, however, that when the system size is inadequate to meet the start-up load there is no indication of this problem on the report. The user should first inspect the PLANT program BEPS report, which shows the "Percent of Hours Any System Zone Outside of Throttling Range", for a macro view, and Report SS–O or SS–F for a zonal report of where "LOADS Not Met" conditions prevail.

To the left of the MAXIMUM COOLING LOAD column are the day and hour of the peak cooling load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

5. HEATING ENERGY
(millions of Btu) is the monthly sum of heat delivered by the secondary HVAC system during the operation hours of the system and passed as a load to PLANT.

6. MAXIMUM HEATING LOAD
(thousands of Btu/hr) includes space heating loads, ventilation, and humidification. Again, the peak heating load is often due to start-up conditions after the system has been shut down overnight. To the left of this column are the day and hour of the peak heating load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

7. ELECTRICAL ENERGY (kWh)
is the monthly electrical consumption for lights, convenience outlets, supply and return fans, and energy consumed by packaged HVAC units. The electrical consumption by the pumps is reported in the PLANT program.

8. MAXIMUM ELEC LOAD (kW)
is the monthly peak electrical consumption in a one-hour period for lights, convenience outlets, energy consumed by packaged HVAC units, and fans for the zones served by the HVAC system.

SIMPLE STRUCTURE RUN 3, CHICAGO DOE-2.1D 3/ 8/1989 13:46:27 SDL RUN 1

REPORT- SS-A SYSTEM MONTHLY LOADS SUMMARY FOR SYST-1 WEATHER FILE- TRY CHICAGO

	COOLING						HEATING						ELEC	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.00000					0.000	-30.719	7	8	-1.F	-1.F	-431.440	5049.	20.667
FEB	0.00000					0.000	-25.359	4	8	7.F	6.F	-413.184	4392.	20.465
MAR	0.00000					0.000	-14.635	25	8	14.F	12.F	-403.134	4768.	19.984
APR	1.80205	26	17	74.F	60.F	83.034	-3.630	8	8	30.F	27.F	-313.412	4912.	21.070
MAY	5.58681	21	14	85.F	75.F	124.419	-0.628	13	8	43.F	40.F	-108.709	5036.	22.659
JUN	16.05216	20	16	90.F	77.F	168.641	0.000					0.000	4909.	24.062
JUL	30.13193	8	16	92.F	74.F	197.482	0.000					0.000	5867.	26.268
AUG	25.57149	19	17	90.F	71.F	177.459	0.000					0.000	5630.	25.335
SEP	10.52759	11	16	86.F	72.F	148.139	-0.368	23	8	36.F	34.F	-163.061	4771.	24.223
OCT	3.11163	31	15	76.F	65.F	77.334	-2.319	21	8	30.F	29.F	-322.458	4939.	21.201
NOV	0.56733	1	16	72.F	59.F	82.860	-12.129	25	8	27.F	25.F	-378.298	4361.	21.814
DEC	0.00000					0.000	-24.666	9	8	13.F	12.F	-404.876	4833.	19.932
TOTAL	93.351						-114.452						59470.	
MAX						197.482						-431.440		26.268

REPORT SS–B -- SYSTEM MONTHLY LOADS SUMMARY

This is a summary of the heating and cooling required by all the zones (combined) served by the HVAC system. The items summarized are zone cooling, zone heating, zone baseboard heating, and preheat energy. Many HVAC systems have heating and cooling devices that serve only one zone; for example, in a single duct reheat system there are reheat coils for each zone. In addition, this report lists the preheat energy required and the peak preheat load. The preheat coils raise the temperature of the mixed air to a specified temperature. NOTE: When the user specifies baseboard heating in a zone, the modeling is similar to reheat coils, but the heating supplied is reported under the heading BASEBOARD HEATING ENERGY.

1. The u-name of the HVAC system (SYST–1) is printed on the title line.

2. ZONE COIL COOLING ENERGY (millions of Btu) and MAXIMUM ZONE COIL COOLING ENERGY (thousands of Btu/hr) are, respectively, the monthly total and peak sensible plus latent cooling. This is cooling supplied by coils located in the zone(s). The cooling of the primary supply air in the system is summarized in Report SS–A. Loads met by DX units are reported here and an electrical demand is passed to PLANT. (For RESYS system only: These columns report instead the cooling accomplished by natural ventilation.)

3. ZONE COIL HEATING ENERGY (millions of Btu) and MAXIMUM ZONE COIL HEATING ENERGY (thousands of Btu/hr) are the monthly total heating and peak heating, respectively, supplied by coils or a furnace (oil- or gas-fired) in the zones. The furnace loads, met here in SYSTEMS, are not passed to PLANT but rather a utility demand for oil or gas is passed to PLANT. Baseboard heating is not included. In this example, the zone coils are electric resistance coils and the electrical demand will be passed to PLANT. (For RESYS system only: These columns report the heating load on the furnace.)

4. BASEBOARD HEATING ENERGY (millions of Btu) and MAXIMUM BASEBOARD HEATING ENERGY (thousands of Btu/hr) are, respectively, the monthly total heating and peak heating supplied by baseboard heaters in all the zones served by the system (SYST–1). These loads are passed to PLANT unless BASEBOARD–SOURCE is set equal to ELECTRIC, GAS–FURNACE, or OIL–FURNACE, in which case the load is met here in SYSTEMS and a utility demand is passed to PLANT.

5. PRE–HEAT COIL ENERGY (millions of Btu) and MAXIMUM PRE–HEAT COIL ENERGY (thousands of Btu/hr) are, respectively, the monthly total heating and peak heating supplied by the preheat coil(s) to raise the temperature of the mixed air (return air plus makeup air) to a specified value, PREHEAT–T. These loads are passed to PLANT unless PREHEAT–SOURCE is set equal to ELECTRIC, GAS-FURNACE, or OIL–FURNACE, in which case the load is met here in SYSTEMS and a utility demand is passed to PLANT. (For RESYS system only: These columns report the electrical input, in Btu, for the furnace fan, when the fan is running.)

SIMPLE STRUCTURE RUN 3, CHICAGO   DOE-2.1D   3/ 8/1989   13:46:27 SDL RUN 1

REPORT- SS-B SYSTEM MONTHLY LOADS SUMMARY FOR   SYST-1   WEATHER FILE- TRY CHICAGO

	--ZONE COOLING--		--ZONE HEATING-		--BASEBOARDS--		----PRE-HEAT---	
MONTH	ZONE COIL COOLING ENERGY (MBTU)	MAXIMUM ZONE COIL COOLING LOAD (KBTU/HR)	ZONE COIL HEATING ENERGY (MBTU)	MAXIMUM ZONE COIL HEATING LOAD (KBTU/HR)	BASEBOARD HEATING ENERGY (MBTU)	MAXIMUM BASEBOARD HEATING LOAD (KBTU/HR)	PRE-HEAT COIL ENERGY (MBTU)	MAXIMUM PRE-HEAT COIL LOAD (KBTU/HR)
JAN	0.00000	0.000	-27.41811	-397.519	0.00000	0.000	-1.64688	-35.235
FEB	0.00000	0.000	-22.85556	-394.792	0.00000	0.000	-0.78010	-28.310
MAR	0.00000	0.000	-13.32423	-389.313	0.00000	0.000	-0.36436	-23.540
APR	0.00000	0.000	-3.34104	-304.859	0.00000	0.000	0.00000	0.000
MAY	0.00000	0.000	-0.54626	-98.216	0.00000	0.000	0.00000	0.000
JUN	0.00000	0.000	0.00000	0.000	0.00000	0.000	0.00000	0.000
JUL	0.00000	0.000	0.00000	0.000	0.00000	0.000	0.00000	0.000
AUG	0.00000	0.000	0.00000	0.000	0.00000	0.000	0.00000	0.000
SEP	0.00000	0.000	-0.33541	-142.896	0.00000	0.000	0.00000	0.000
OCT	0.00000	0.000	-2.09198	-311.340	0.00000	0.000	0.00000	0.000
NOV	0.00000	0.000	-11.31639	-366.174	0.00000	0.000	-0.05403	-12.124
DEC	0.00000	0.000	-22.53649	-390.628	0.00000	0.000	-0.37398	-18.940
TOTAL	0.000		-103.766		0.000		-3.219	
MAX		0.000		-397.519		0.000		-35.235

REPORT SS–C -- SYSTEM MONTHLY LOAD HOURS

The number of cooling and heating hours for each month are reported for each system. Included are the hours when both heating and cooling are required. In addition, this report gives the heating and electrical loads at the time of the cooling peak.

1. NUMBER OF COOLING LOAD HOURS
   and
   NUMBER OF HEATING LOAD HOURS
   give the total hours in each month when the HVAC system is operating with a heating load or a cooling load.

2. HOURS COINCIDENT COOL-HEAT LOAD
   gives the number of hours in each month when the HVAC system is operating with simultaneous heating and cooling loads.

The above two numbers do not include hours when the only load was from pilot lights and crankcase heating.

3. HEATING LOAD AT COOLING PEAK
   is self-explanatory.
   ELECTRIC LOAD AT COOLING PEAK
   will be the electrical load at the last hour of the month if there was no cooling that month.

4. HOURS FLOATING
   is the total hours with fans on or off that space temperatures are not at thermostat setpoints.

5. HOURS HEATING AVAIL
   is the number of hours that heating equipment is available, as determined by HEATING–SCHEDULE.

6. HOURS COOLING AVAIL
   is the number of hours that cooling equipment is available, as determined by COOLING–SCHEDULE.

7. HOURS FANS ON
   is the fan operating hours including fans cycled on to maintain night setback or setup or for NIGHT VENTING.

8. HOURS FANS CYCLE ON
   is the hours fans were on for night setback or setup.

9. HOURS NIGHT VENTING
   is the hours fans were on in order to maintain night venting set point.

10. HOURS FLOATING WHEN FANS ON
    is the hours space temperatures were within the space thermostat's deadband.

11. HEATING LOAD AT COOLING PEAK
    provides an assessment of oversizing for simultaneous heating/cooling systems (e.g., REHEAT systems).

12. ELECTRIC LOAD AT COOLING PEAK
    is the electric demand of all electric equipment calculated in LOADS+SYSTEMS coincident with the cooling peak.

SIMPLE STRUCTURE RUN 3, CHICAGO DOE-2.1D 3/ 8/1989 13:46:27 SDL RUN 1

REPORT- SS-C SYSTEM MONTHLY LOAD HOURS FOR SYST-1 WEATHER FILE- TRY CHICAGO

	NUMBER OF HOURS										COINCIDENT LOADS	
MONTH	HOURS COOLING LOAD	HOURS HEATING LOAD	HOURS COINCIDENT COOL-HEAT LOAD	HOURS FLOATING	HOURS HEATING AVAIL.	HOURS COOLING AVAIL.	HOURS FANS ON	HOURS FANS CYCLE ON	HOURS NIGHT VENTING	HOURS FLOATING WHEN FANS ON	HEATING LOAD AT COOLING PEAK (KBTU/HR)	ELECTRIC LOAD AT COOLING PEAK (KW)
JAN	0	331	0	413	744	0	331	89	0	0	0.000	0.850
FEB	0	293	0	379	672	0	293	84	0	0	0.000	0.850
MAR	0	248	0	496	715	33	264	33	0	16	0.000	0.850
APR	69	81	0	570	516	216	234	1	0	84	0.000	19.813
MAY	115	25	1	605	485	292	225	0	0	86	0.000	20.732
JUN	201	0	0	519	171	573	205	0	0	4	0.000	24.031
JUL	240	0	0	504	7	742	240	0	0	0	0.000	25.989
AUG	236	0	0	508	43	714	236	0	0	0	0.000	24.341
SEP	154	14	0	552	346	406	205	0	0	37	0.000	23.825
OCT	99	68	1	578	511	250	231	0	0	65	0.000	21.201
NOV	12	202	0	506	686	44	226	18	0	12	0.000	21.440
DEC	0	311	0	433	744	0	311	80	0	0	0.000	0.850
ANNUAL	1126	1573	2	6063	5640	3270	3001	305	0	304		

REPORT SS–D -- PLANT MONTHLY LOADS SUMMARY

In DOE-2, multiple central plants for serving the building's HVAC systems can be simulated. The PLANT–ASSIGNMENT command is used to assign HVAC systems to central plants. The name of the plant is reported in the title line. In this example, no u-name was specified, and so a default name (DEFAULT–PLANT) is printed. The cooling, heating, and electrical energy required by the system(s) and zones served by the plant are reported monthly along with the peak cooling, heating, and electrical loads for the combined systems, and the time of occurrence. Note that these peak loads may result from startup after the building has been shut down overnight. Cooling done in SYSTEMS by DX units is not included here in cooling loads but in electrical loads.

1. COOLING ENERGY
(millions of Btu) is the sensible and latent monthly cooling required by the HVAC systems from the central plant specified in the PLANT–ASSIGNMENT command. For Unitary Heat Pumps (HP) the value reported here is the heat rejected to the plant's cooling tower.

2. TIME OF MAX
gives the day and hour that the maximum cooling load occurs.

3. DRY–BULB TEMP and WET–BULB TEMP
are the outside dry-bulb wet-bulb temperatures during the peak cooling load.

4. MAXIMUM COOLING LOAD
(thousands of Btu/hr) gives the peak cooling load for each month and for the year.

5. HEATING ENERGY
(millions of Btu) is the total monthly heating required by the HVAC systems from the specified central plant. For Unitary Heat Pumps (HP) the value reported here is the supplementary heat from the plant's hot water boiler.

6. TIME OF MAX
gives the day and hour that the maximum heating load occurs.

7. DRY–BULB TEMP and WET–BULB TEMP
are the outside dry-bulb wet-bulb temperatures during the peak heating load.

8. MAXIMUM HEATING LOAD
(thousands of Btu/hr) gives the peak heating load for each month and for the year.

9. ELECTRICAL ENERGY
(in kWh) is the monthly electrical requirement for lights and convenience outlets for the building *zones* served by the plant. In addition, the electrical energy contains the fan energy requirement for the HVAC system and electric energy for cooling and heating in packaged units. It does *not* include the electrical energy associated with pumps, cooling towers and chillers. These are reported in the PLANT program.

10. MAXIMUM ELEC LOAD
(kW) gives the monthly peak electrical consumption in a one-hour period for the items in 9 (ELECTRICAL ENERGY).

SIMPLE STRUCTURE RUN 3, CHICAGO DOE-2.1D 3/ 8/1989 13:46:27 SDL RUN 1

REPORT- SS-D PLANT MONTHLY LOADS SUMMARY FOR DEFAULT-PLANT WEATHER FILE- TRY CHICAGO

	- - - C O O L I N G - - -						- - - H E A T I N G - - -						- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.00000					0.000	-30.719	7	8	-1.F	-1.F	-431.440	5049.	20.667
FEB	0.00000					0.000	-25.359	4	8	7.F	6.F	-413.184	4392.	20.465
MAR	0.00000					0.000	-14.635	25	8	14.F	12.F	-403.134	4768.	19.984
APR	1.80205	26	17	74.F	60.F	83.034	-3.630	8	8	30.F	27.F	-313.412	4912.	21.070
MAY	5.58681	21	14	85.F	75.F	124.419	-0.628	13	8	43.F	40.F	-108.709	5036.	22.659
JUN	16.05216	20	16	90.F	77.F	168.641	0.000					0.000	4909.	24.062
JUL	30.13193	8	16	92.F	74.F	197.482	0.000					0.000	5867.	26.268
AUG	25.57149	19	17	90.F	71.F	177.459	0.000					0.000	5630.	25.335
SEP	10.52759	11	16	86.F	72.F	148.139	-0.368	23	8	36.F	34.F	-163.061	4771.	24.223
OCT	3.11163	31	15	76.F	65.F	77.334	-2.319	21	8	30.F	29.F	-322.458	4939.	21.201
NOV	0.56733	1	16	72.F	59.F	82.860	-12.129	25	8	27.F	25.F	-378.298	4361.	21.814
DEC	0.00000					0.000	-24.666	9	8	13.F	12.F	-404.876	4833.	19.932
TOTAL	93.351						-114.452						59470.	
MAX						197.482						-431.440		26.268

REPORT SS–E -- PLANT MONTHLY LOAD HOURS

Just as the monthly load hours are reported for an HVAC system in Report SS–C, the combined load hours for all of the HVAC systems served by the central plant are shown in this report. Heating and electrical loads for the plant at the time of the cooling peak are also reported.

1. NUMBER OF COOLING LOAD HOURS
   and
   NUMBER OF HEATING LOAD HOURS
   These hours, reported monthly, are the required operation hours of the central plant for supplying heating or cooling to the HVAC systems served.

2. HOURS COINCIDENT COOL–HEAT LOAD
   gives the number of hours in each month when the central plant is operating with simultaneous heating and cooling loads.

3. HOURS FLOATING
   is the total hours with fans on or off that space temperatures are not at thermostat setpoints.

4. HOURS HEATING AVAIL
   is the number of hours that heating equipment is available, as determined by HEATING–SCHEDULE.

5. HOURS COOLING AVAIL
   is the number of hours that cooling equipment is available, as determined by COOLING–SCHEDULE.

6. HOURS FANS ON
   is the fan operating hours including fans cycled on to maintain night setback or setup or for NIGHT VENTING.

7. HOURS FANS CYCLE ON
   is the hours fans were on for night setback or setup.

8. HOURS NIGHT VENTING
   is the hours fans were on in order to maintain night venting set point.

9. HOURS FLOATING WHEN FANS ON
   is the hours space temperatures were within the space thermostat's deadband.

10. HEATING LOAD AT COOLING PEAK
    provides an assessment of oversizing for simultaneous heating/cooling systems (e.g., REHEAT systems).

11. ELECTRIC LOAD AT COOLING PEAK
    is the electric demand of all electric equipment calculated in LOADS+SYSTEMS coincident with the cooling peak.

REPORT- SS-E PLANT MONTHLY LOAD HOURS FOR DEFAULT-PLANT WEATHER FILE- TRY CHICAGO

	N U M B E R O F H O U R S										--COINCIDENT LOADS--	
MONTH	HOURS COOLING LOAD	HOURS HEATING LOAD	HOURS COINCIDENT COOL-HEAT LOAD	HOURS FLOATING	HOURS HEATING AVAIL.	HOURS COOLING AVAIL.	HOURS FANS ON	HOURS FANS CYCLE ON	HOURS NIGHT VENTING	HOURS FLOATING WHEN FANS ON	HEATING LOAD AT COOLING PEAK (KBTU/HR)	ELECTRIC LOAD AT COOLING PEAK (KW)
JAN	0	331	0	413	744	0	331	89	0	0	0.000	0.850
FEB	0	293	0	379	672	0	293	84	0	0	0.000	0.850
MAR	0	248	0	496	715	33	264	33	0	16	0.000	0.850
APR	69	81	0	570	516	216	234	1	0	84	0.000	19.813
MAY	115	25	1	605	485	292	225	0	0	86	0.000	20.732
JUN	201	0	0	519	171	573	205	0	0	4	0.000	24.031
JUL	240	0	0	504	7	742	240	0	0	0	0.000	25.989
AUG	236	0	0	508	43	714	236	0	0	0	0.000	24.341
SEP	154	14	0	552	346	406	205	0	0	37	0.000	23.825
OCT	99	68	1	578	511	250	231	0	0	65	0.000	21.201
NOV	12	202	0	506	686	44	226	18	0	12	0.000	21.440
DEC	0	311	0	433	744	0	311	80	0	0	0.000	0.850
ANNUAL	1126	1573	2	6063	5640	3270	3001	305	0	304		

REPORT SS–F -- ZONE DEMAND SUMMARY

This report gives monthly values of eight different zone-related quantities. The user-name of the zone is given in the title of the report, along with the HVAC system which serves this zone. Found in this report are the monthly sums for zone heating and cooling demands from the HVAC system, minimum and maximum zone air temperatures, and the number of hours the loads are not met in the zone. The report is presented zone-by-zone.

1. HEAT EXTRACTION ENERGY
   and
   HEAT ADDITION ENERGY
   (millions of Btu) are the sensible cooling energy and heating energy requirements, respectively, of this zone during the HVAC system operation hours. For RESYS systems, the heat extraction may include natural ventilation. For plenums, these values are for heat removed from or added to the return air. For unconditioned zones, these values should be zero.

2. BASEBOARD ENERGY (millions of Btu)
   and
   MAXIMUM BASEBOARD LOAD (thousands of Btu/hr).
   When the keyword BASEBOARD–RATIO is used, the zone heating is supplied by baseboards. Monthly heating energy requirements for these baseboards are reported in addition to the peak heating requirement.

3. MAXIMUM ZONE TEMPERATURE (°F)
   and
   MINIMUM ZONE TEMPERATURE (°F).
   The monthly maximum and minimum air temperatures in this zone during system operation (when fans are operating) are reported for checking space temperature variations.

4. HOURS UNDERHEATED
   and
   HOURS UNDERCOOLED
   If the capacity of the HVAC system is less than the hourly heat extraction or heat addition load for this zone, a load-not-met is recorded as either an underheated or undercooled hour. The number of hours reported as underheated or undercooled may be startups after a night shutdown of the HVAC system.

SIMPLE STRUCTURE RUN 3, CHICAGO DOE-2.1D 3/ 8/1989 13:46:27 SDL RUN 1

REPORT- SS-F ZONE DEMAND SUMMARY IN SYST-1 FOR SPACE1-1 WEATHER FILE- TRY CHICAGO

	----DEMANDS-----		--BASEBOARDS---		--TEMPERATURES--		--LOADS NOT MET--	
MONTH	HEAT EXTRACTION ENERGY (MBTU)	HEAT ADDITION ENERGY (MBTU)	BASEBOARD ENERGY (MBTU)	MAXIMUM BASEBOARD LOAD (KBTU/HR)	MAXIMUM ZONE TEMP (F)	MINIMUM ZONE TEMP (F)	HOURS UNDER HEATED	HOURS UNDER COOLED
JAN	0.31682	-4.812	0.00000	0.000	75.8	55.4	0	0
FEB	0.29514	-4.066	0.00000	0.000	75.0	55.5	0	0
MAR	0.55134	-2.276	0.00000	0.000	75.9	55.5	0	0
APR	1.71604	-0.592	0.00000	0.000	78.0	55.9	6	0
MAY	2.46636	-0.097	0.00000	0.000	78.2	70.5	0	0
JUN	3.55059	0.000	0.00000	0.000	78.6	72.3	0	0
JUL	5.59195	0.000	0.00000	0.000	79.1	76.7	0	0
AUG	5.01445	0.000	0.00000	0.000	79.3	75.1	0	0
SEP	3.35776	-0.053	0.00000	0.000	78.8	70.4	0	0
OCT	2.15322	-0.312	0.00000	0.000	78.3	69.8	0	0
NOV	0.65381	-1.839	0.00000	0.000	78.3	55.8	0	0
DEC	0.13971	-4.038	0.00000	0.000	74.7	55.5	0	0

REPORT SS–G -- ZONE LOADS SUMMARY

Zone cooling, heating, and electrical requirements are reported in this monthly summary. The user name of the zone is in the title line with the name of the HVAC system serving the zone. The cooling and heating energy reported is supplied *only at the zone level* (such as for reheat coils). Often heating and cooling loads are reported as zero in this report when the central HVAC system (e.g., a dual duct system) provides all the heating and cooling.

1. COOLING ENERGY
   and
   HEATING ENERGY
   (millions of Btu). This is the monthly energy delivered by zone coils and baseboards during scheduled operation hours.

2. MAXIMUM COOLING LOAD
   and
   MAXIMUM HEATING LOAD
   (thousands of Btu/hr). The peak energy delivered by zone coils for cooling and heating, respectively. Includes sensible and latent space cooling loads, ventilation air, and fan heat. The peak cooling load shown here is often the start-up load after the system has been shut down overnight. Notice, however, that when the system size is inadequate to meet the start-up load there is no indication of this problem on the report. The user should first inspect the PLANT program BEPS report, which shows the "Percent of Hours Any System Zone Outside of Throttling Range", for a macro view, and at SS–O or SS–F for a zonal report of where "LOADS Not Met" conditions prevail. To the left of these columns are the day and hour of the peak cooling load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

3. TIME OF MAX (DY, HR) DRY–BULB TEMP
   and
   WET–BULB TEMP
   The day and hour of the peak zone coil loads are reported; these times may be for startup loads. The temperatures reported are the outdoor air temperatures at the time of the peak zone coil loads.

4. ELECTRICAL ENERGY
   and
   MAXIMUM ELECTRICAL LOAD (kWh)
   The monthly total and peaks of electrical energy use in this zone, including lights, fans, and compressors and electric coils in packaged HVAC units.

SIMPLE STRUCTURE RUN 3, CHICAGO DOE-2.1D 3/ 8/1989 13:46:27 SDL RUN 1

REPORT- SS-G ZONE LOADS SUMMARY IN SYST-1 FOR SPACE1-1 WEATHER FILE- TRY CHICAGO

	COOLING						HEATING						ELEC	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.00000					0.000	-6.861	7	8	-1.F	-1.F	-105.025	998.	4.011
FEB	0.00000					0.000	-5.742	4	8	7.F	6.F	-103.214	867.	4.011
MAR	0.00000					0.000	-3.358	25	8	14.F	12.F	-103.646	958.	4.011
APR	0.00000					0.000	-0.901	8	8	30.F	27.F	-70.532	993.	4.011
MAY	0.00000					0.000	-0.188	13	8	43.F	40.F	-26.723	998.	4.011
JUN	0.00000					0.000	0.000					0.000	915.	4.011
JUL	0.00000					0.000	0.000					0.000	998.	4.011
AUG	0.00000					0.000	0.000					0.000	998.	4.011
SEP	0.00000					0.000	-0.095	23	8	36.F	34.F	-34.899	915.	4.011
OCT	0.00000					0.000	-0.520	21	8	30.F	29.F	-70.706	998.	4.011
NOV	0.00000					0.000	-2.909	25	8	27.F	25.F	-90.063	875.	4.011
DEC	0.00000					0.000	-5.863	9	8	13.F	12.F	-103.190	958.	4.011
TOTAL	0.000						-26.436						11471.	
MAX						0.000						-105.025		4.011

REPORT SS–H -- SYSTEM MONTHLY LOADS SUMMARY

This report gives monthly values of electrical energy for fans, gas/oil energy for heating and cooling, and electrical energy for heating and cooling for an HVAC system. The name of the system (SYST–1) is shown in the title.

1. FAN ELEC
   shows the total and maximum hourly electrical consumption of the supply, return, exhaust, and zonal fans.

2. FUEL HEAT
   shows the total oil and gas consumption by the system for heating, in Btu-equivalents. This will be zero unless the user has made at least one of the heat sources OIL–FURNACE or GAS–FURNACE.

3. FUEL COOL
   shows the total oil and gas consumption by the system for cooling, in Btu-equivalents.

4. ELEC HEAT
   shows the electrical consumption for heating. This will include electric baseboards and reheat coils as well as the electrical load attributable to the heating cycle of a heat pump.

5. ELEC COOL
   shows the electrical consumption and hourly maxima for cooling.

REPORT- SS-H SYSTEM MONTHLY LOADS SUMMARY FOR SYST-1 WEATHER FILE- TRY CHICAGO

	--FAN ELEC---		--FUEL HEAT--		--FUEL COOL--		-ELEC HEAT--		-ELEC COOL--	
MONTH	FAN ENERGY (KWH)	MAXIMUM FAN LOAD (KW)	GAS OIL ENERGY (MBTU)	MAXIMUM GAS OIL LOAD (KBTU/HR)	GAS OIL ENERGY (MBTU)	MAXIMUM GAS OIL LOAD (KBTU/HR)	ELECTRIC ENERGY (KWH)	MAXIMUM ELECTRIC LOAD (KW)	ELECTRIC ENERGY (KWH)	MAXIMUM ELECTRIC LOAD (KW)
JAN	326.	6.683	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
FEB	287.	6.554	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
MAR	230.	6.303	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
APR	209.	4.277	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
MAY	312.	3.961	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
JUN	578.	5.566	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
JUL	1143.	7.554	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
AUG	906.	6.926	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
SEP	440.	5.332	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
OCT	215.	4.304	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
NOV	216.	5.646	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
DEC	295.	6.423	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
TOTAL	5158.		0.000		0.000		0.		0.	
MAX		7.554		0.000		0.000		0.000		0.000

REPORT SS–I -- SYSTEM MONTHLY SENSIBLE–LATENT SUMMARY

This is a summary of the monthly cooling energy provided by each HVAC system. Shown are sensible cooling, latent cooling, maximum cooling (sensible plus latent) with the corresponding sensible heat ratio, and the day and hour the maximum cooling occurs. Also shown are sensible heating, latent heating, and maximum heating (sensible plus latent).

1. SENSIBLE COOLING ENERGY
   (millions of Btu) is the monthly sum of sensible energy extracted by the HVAC system.

2. LATENT COOLING ENERGY
   (millions of Btu) is the monthly sum of latent energy extracted by the HVAC system.

   The sum of 1 and 2 should equal COOLING ENERGY in SS–A.

3. MAX TOTAL COOLING ENERGY
   (thousands of Btu/hr) is the hourly peak energy (sensible plus latent) extracted by the system during the month.

4. SENSIBLE HEAT RATIO AT MAX
   is the sensible heat ratio (sensible cooling/total cooling) for the hour that the maximum total cooling occurs.

5. TIME OF MAX DY HR
   is the day and hour during which the total peak cooling load occurred.

6. SENSIBLE HEATING ENERGY
   (millions of Btu) is the monthly sum of sensible energy added by the HVAC system.

7. LATENT HEATING ENERGY
   (millions of Btu) is the monthly sum of latent energy extracted by the HVAC system.

   The sum of 6 and 7 should equal HEATING ENERGY in SS–A.

SIMPLE STRUCTURE RUN 3, CHICAGO DOE-2.1D 3/ 8/1989 13:46:27 SDL RUN 1

REPORT- SS-I SYSTEM MONTHLY SENSIBLE LATENT SUMMARY FOR SYST-1 WEATHER FILE- TRY CHICAGO

MONTH	SENSIBLE COOLING ENERGY (MBTU)	LATENT COOLING ENERGY (MBTU)	MAX TOTAL COOLING ENERGY (KBTU/HR)	SENSIBLE HEAT RATIO AT MAX	TIME OF MAX DY	TIME OF MAX HR	SENSIBLE HEATING ENERGY (MBTU)	LATENT HEATING ENERGY (MBTU)	MAX TOTAL HEATING ENERGY (KBTU/HR)
JAN	0.00000	0.00000	0.000				-30.71931	0.00000	-431.43988
FEB	0.00000	0.00000	0.000				-25.35903	0.00000	-413.18353
MAR	0.00000	0.00000	0.000				-14.63480	0.00000	-403.13419
APR	1.73492	0.06714	83.034	0.908	26	17	-3.62994	0.00000	-313.412
MAY	5.16988	0.41693	124.419	0.880	21	14	-0.62770	0.00000	-108.709
JUN	15.28713	0.76503	168.641	0.890	20	16	0.00000	0.00000	0.000
JUL	28.55825	1.57368	197.482	0.920	8	16	0.00000	0.00000	0.000
AUG	24.11166	1.45983	177.459	0.922	19	17	0.00000	0.00000	0.000
SEP	10.10364	0.42395	148.139	0.911	11	16	-0.36764	0.00000	-163.061
OCT	2.91786	0.19377	77.334	0.927	31	15	-2.31899	0.00000	-322.458
NOV	0.56386	0.00347	82.860	1.000	1	16	-12.12918	0.00000	-378.298
DEC	0.00000	0.00000	0.000				-24.66556	0.00000	-404.87579
TOTAL	88.447	4.904					-114.452	0.000	
MAX			197.482	0.906					-431.440

REPORT SS–J -- SYSTEM PEAK HEATING AND COOLING DAYS

For each HVAC system, this report gives an hourly profile of three types of peak day that occur during the RUN–PERIOD:

- Under -- COOLING --, the day that contains the hour with the maximum (sensible plus latent) cooling energy.
- Under -- HEATING --, the day that contains the hour with the maximum heating energy.
- Under DAY COOLING PEAK, the day whose *integrated* cooling load (i.e. load summed over 24 hours) is maximum. This day can be used to size thermal energy storage systems; however, to insure that the peak integrated load shown here is truly represented, the user is advised to also examine Reports SS–O and SS–F, which show the number of hours that cooling loads are *not* met.

1. HOUR
   gives the hour of the day, ranging from hour 1 (midnight to 1 am) to hour 24 (11 pm to midnight). Even if DAYLIGHT–SAVINGS = YES, summer hours will *not* reflect daylight saving time.

2. HOURLY COOLING LOAD
   (thousands of Btu) is the total hourly energy, sensible plus latent, extracted by the HVAC system.

3. SENSIBLE HEAT RATIO
   is the ratio of sensible to total cooling energy for the given hour.

4. DRY–BULB TEMP and WET–BULB TEMP
   are the outside dry- and wet-bulb temperatures, respectively, for the given hour.

5. HOURLY HEATING LOAD
   (thousands of Btu) is the hourly heating energy delivered by the HVAC system. For SYSTEM–TYPE = RESYS, this includes baseboard heating energy.

SIMPLE STRUCTURE RUN 3, CHICAGO DOE-2.1D 3/ 8/1989 13:46:27 SDL RUN 1

REPORT- SS-J SYSTEM PEAK HEATING AND COOLING DAYS FOR SYST-1 WEATHER FILE- TRY CHICAGO

	- - - - - C O O L I N G - - - - -				- - - H E A T I N G - - -			D A Y C O O L I N G P E A K			
	JUL 8				JAN 7			JUL 8			
HOUR	HOURLY COOLING LOAD (KBTU)	SENSIBLE HEAT RATIO	DRY-BULB TEMP	WET-BULB TEMP	HOURLY HEATING LOAD (KBTU)	DRY-BULB TEMP	WET-BULB TEMP	HOURLY COOLING LOAD (KBTU)	SENSIBLE HEAT RATIO	DRY-BULB TEMP	WET-BULB TEMP
1	0.000	0.000	76.F	68.F	0.000	6.F	6.F	0.000	0.000	76.F	68.F
2	0.000	0.000	76.F	68.F	-153.945	4.F	4.F	0.000	0.000	76.F	68.F
3	0.000	0.000	75.F	68.F	0.000	2.F	2.F	0.000	0.000	75.F	68.F
4	0.000	0.000	74.F	68.F	-162.655	2.F	2.F	0.000	0.000	74.F	68.F
5	0.000	0.000	73.F	67.F	0.000	2.F	2.F	0.000	0.000	73.F	67.F
6	0.000	0.000	72.F	67.F	-173.979	1.F	1.F	0.000	0.000	72.F	67.F
7	148.805	0.968	72.F	67.F	0.000	0.F	0.F	148.805	0.968	72.F	67.F
8	165.409	0.928	77.F	70.F	-431.440	-1.F	-1.F	165.409	0.928	77.F	70.F
9	163.720	0.926	83.F	72.F	-284.432	0.F	0.F	163.720	0.926	83.F	72.F
10	172.581	0.920	86.F	74.F	-233.131	2.F	1.F	172.581	0.920	86.F	74.F
11	176.679	0.934	89.F	74.F	-175.775	4.F	3.F	176.679	0.934	89.F	74.F
12	175.982	0.955	90.F	73.F	-144.534	6.F	5.F	175.982	0.955	90.F	73.F
13	185.129	0.948	91.F	73.F	-127.622	8.F	6.F	185.129	0.948	91.F	73.F
14	192.559	0.947	92.F	73.F	-105.245	9.F	7.F	192.559	0.947	92.F	73.F
15	197.482	0.941	92.F	74.F	-83.226	10.F	8.F	197.482	0.941	92.F	74.F
16	195.420	0.950	93.F	73.F	-75.539	9.F	7.F	195.420	0.950	93.F	73.F
17	191.869	0.950	93.F	73.F	-82.473	8.F	6.F	191.869	0.950	93.F	73.F
18	0.000	0.000	92.F	73.F	-87.617	5.F	4.F	0.000	0.000	92.F	73.F
19	0.000	0.000	90.F	72.F	0.000	4.F	3.F	0.000	0.000	90.F	72.F
20	0.000	0.000	83.F	70.F	0.000	2.F	1.F	0.000	0.000	83.F	70.F
21	0.000	0.000	82.F	68.F	0.000	3.F	2.F	0.000	0.000	82.F	68.F
22	0.000	0.000	82.F	70.F	0.000	4.F	3.F	0.000	0.000	82.F	70.F
23	0.000	0.000	82.F	70.F	0.000	4.F	3.F	0.000	0.000	82.F	70.F
24	0.000	0.000	80.F	69.F	0.000	5.F	4.F	0.000	0.000	80.F	69.F
	--------				--------			---------			
SUM								1965.635			
MAX	197.482				-431.440						

REPORT SS–K -- SPACE TEMPERATURE SUMMARY

This report gives monthly summaries of various temperature quantities for the spaces served by the HVAC system shown in the report title. This report is intended to assist users in determining the potential for night ventilation as a cooling strategy. Blank entries in the report indicate that no hours existed in a particular category.

1. AVERAGE SPACE TEMP ALL HOURS
   gives the temperature averaged over all hours in the run.

2. AVERAGE SPACE TEMP COOLING HOURS
   gives the temperature only in hours when cooling was required.

3. AVERAGE SPACE TEMP HEATING HOURS
   gives the average temperature only in hours when heating was required.

4. AVERAGE SPACE TEMP FAN ON HOURS
   gives the average temperature only when the fans are running.

5. AVERAGE SPACE TEMP FAN OFF HOURS
   gives the average temperature only when the fans are not running.

6. AVERAGE TEMPERATURE DIFFERENCE BETWEEN OUTDOOR&ROOM AIR, ALL HOURS
   takes the sum of (outdoor temperature - room air temperature) over all hours and divides this quantity by the number of hours.

7. AVERAGE TEMPERATURE DIFFERENCE BETWEEN OUTDOOR&ROOM AIR, FAN ON HOURS
   takes the sum of (outdoor temperature - room air temperature) over hours when the fans are on and divides this quantity by the number of hours the fans are on.

8. AVERAGE TEMPERATURE DIFFERENCE BETWEEN OUTDOOR&ROOM AIR, FAN OFF HOURS
   takes the sum of (outdoor temperature - room air temperature) over hours when the fans are off and divides this quantity by the number of hours the fans are off.

9. SUMMED TEMP DIFFERENCE BETWEEN OUTDOOR&ROOM AIR, HEATING HOURS
   takes the sum of the absolute value of (outdoor temperature - room air temperature) over all hours when heating is required and divides by 24.

10. SUMMED TEMP DIFFERENCE BETWEEN OUTDOOR&ROOM AIR, ALL HOURS
    takes the sum of the absolute value of (outdoor temperature - room air temperature) over all hours in the run and divides by 24.

    Note: 9 and 10 above and "degree-day"-like quantities.

11. HUMIDITY RATIO DIFFERENCE BETWEEN OUTDOOR AND ROOM AIR
    gives the average of
    (outdoor humidity ratio - room air humidity ratio)
    over all hours in the run.

SIMPLE STRUCTURE RUN 3, CHICAGO   DOE-2.1D   3/ 8/1989   13:46:27 SDL RUN 1

REPORT- SS-K SPACE TEMPERATURE SUMMARY   SYST-1   WEATHER FILE- TRY CHICAGO

MONTH	AVERAGE SPACE TEMP ALL HOURS (F)	COOLING HOURS (F)	HEATING HOURS (F)	FAN ON HOURS (F)	FAN OFF HOURS (F)	AVERAGE TEMPERATURE DIFFERENCE BETWEEN OUTDOOR& ROOM AIR ALL HOURS (F)	BETWEEN OUTDOOR& ROOM AIR FAN ON HOURS (F)	BETWEEN OUTDOOR& ROOM AIR FAN OFF HOURS (F)	SUMMED TEMP DIFFERENCE BETWEEN OUTDOOR& ROOM AIR HEATING HOURS (F)	BETWEEN OUTDOOR& ROOM AIR ALL HOURS (F)	HUMIDITY RATIO DIFFERENCE BETWEEN OUTDOOR AND ROOM AIR (FRAC.OR MULT.)
JAN	61.39		64.60	64.60	58.82	-36.05	-39.48	-33.29	544.50	1117.45	-0.00136
FEB	61.28		64.52	64.52	58.77	-33.76	-36.38	-31.74	444.11	945.33	-0.00113
MAR	64.30		67.38	67.70	62.43	-25.93	-30.31	-23.52	319.99	809.63	-0.00112
APR	71.06	74.66	69.53	72.59	70.32	-19.46	-19.98	-19.21	86.96	588.09	-0.00117
MAY	74.13	76.96	69.86	75.42	73.58	-17.36	-15.86	-18.01	25.19	540.14	-0.00048
JUN	78.65	78.01		77.92	78.95	-11.56	-6.03	-13.76		357.38	-0.00072
JUL	82.32	79.06		79.06	83.88	-6.75	-1.20	-9.40		274.25	0.00138
AUG	80.29	78.58		78.58	81.09	-8.45	-2.48	-11.22		296.47	0.00080
SEP	76.08	77.61	70.04	76.61	75.86	-14.69	-9.61	-16.71	12.65	452.45	-0.00126
OCT	71.55	75.59	69.92	73.46	70.68	-17.90	-16.59	-18.49	69.41	555.04	-0.00126
NOV	65.13	76.95	67.99	68.79	63.45	-24.18	-28.56	-22.18	253.73	725.46	-0.00094
DEC	61.80		65.07	65.07	59.46	-30.07	-33.26	-27.78	430.95	932.21	-0.00134
ANNUAL	70.14	77.76	66.17	71.33	70.40	-20.27	-21.55	-19.86	2187.48	7593.91	-0.00071

REPORT SS–L -- FAN ELECTRIC ENERGY FOR <system>

This report gives a breakdown of monthly fan electric energy for an HVAC system. The quantities are given for heating hours only, cooling hours only, simultaneous heating and cooling hours, and floating hours.

1. FAN ELECTRIC ENERGY DURING HEATING
   gives the total electric energy used by the fans in all hours when only heating is required.

2. FAN ELECTRIC ENERGY DURING COOLING
   gives the total electric energy used by the fans in all hours when only cooling is required.

3. FAN ELECTRIC ENERGY DURING HEATING-COOLING
   gives the total electric energy used by the fans in all hours when both heating and cooling are required.

4. FAN ELECTRIC ENERGY DURING FLOATING
   gives the total electric energy used by the fans when the system terminal is operating within the deadband range.

MONTH	FAN ELECTRIC ENERGY DURING HEATING (KWH)	FAN ELECTRIC ENERGY DURING COOLING (KWH)	FAN ELECTRIC ENERGY DURING HEATING-COOLING (KWH)	FAN ELECTRIC ENERGY DURING FLOATING (KWH)
JAN	325.847	0.000	0.000	0.000
FEB	287.322	0.000	0.000	0.000
MAR	218.387	0.000	0.000	12.080
APR	69.859	69.410	0.000	69.361
MAY	18.877	207.199	0.755	87.089
JUN	0.000	574.659	0.000	3.020
JUL	0.000	1143.307	0.000	0.000
AUG	0.000	906.347	0.000	0.000
SEP	10.832	391.090	0.000	37.996
OCT	55.554	106.211	0.755	54.010
NOV	182.891	22.321	0.000	10.373
DEC	295.438	0.000	0.000	0.000
ANNUAL	1465.022	3420.538	1.510	273.928

REPORT SS–M -- FAN ELECTRIC ENERGY FOR PLANT

This report gives a breakdown of fan electric energy for each month passed to PLANT. The quantities are given for heating hours only, cooling hours only, simultaneous heating and cooling hours, and floating hours. The quantities are calculated by summing the individual space quantities.

1. FAN ELECTRIC ENERGY DURING HEATING
   gives the total electric energy used by the fans in all hours when only heating is required.

2. FAN ELECTRIC ENERGY DURING COOLING
   gives the total electric energy used by the fans in all hours when only cooling is required.

3. FAN ELECTRIC ENERGY DURING HEATING-COOLING
   gives the total electric energy used by the fans in all hours when both heating and cooling are required.

4. FAN ELECTRIC ENERGY DURING FLOATING
   gives the total electric energy used by the fans when the system terminal is operating within the deadband range.

REPORT- SS-M FAN ELECTRIC ENERGY FOR PLANT DEFAULT-PLANT WEATHER FILE- TRY CHICAGO

MONTH	FAN ELECTRIC ENERGY DURING HEATING (KWH)	FAN ELECTRIC ENERGY DURING COOLING (KWH)	FAN ELECTRIC ENERGY DURING HEATING-COOLING (KWH)	FAN ELECTRIC ENERGY DURING FLOATING (KWH)
JAN	325.847	0.000	0.000	0.000
FEB	287.322	0.000	0.000	0.000
MAR	218.387	0.000	0.000	12.080
APR	69.859	69.410	0.000	69.361
MAY	18.877	207.199	0.755	87.089
JUN	0.000	574.659	0.000	3.020
JUL	0.000	1143.307	0.000	0.000
AUG	0.000	906.347	0.000	0.000
SEP	10.832	391.090	0.000	37.996
OCT	55.554	106.211	0.755	54.010
NOV	182.891	22.321	0.000	10.373
DEC	295.438	0.000	0.000	0.000
ANNUAL	1465.022	3420.538	1.510	273.928

REPORT SS–N -- RELATIVE HUMIDITY SCATTER PLOT

In this scatter plot, the ordinate, appearing in the left column, shows relative humidity bins. The abscissa, shown at the top, gives hours of the day. Entered in each cell of the plot is the number of hours during the RUN–PERIOD for which the relative humidity of the system return air was in the particular bin for this particular hour of the day. Hours when the fans are off do not show up in the plot.

The column at the far right is the sum of the entries in each row. It shows the frequency of relative humidity values for the RUN–PERIOD. (Because the relative humidity counts are made only for hours when the fans are on, summing the totals column will not sum to the number of hours in the run.)

-C.90- Note: If fans are on due to NIGHT–CYCLE–CTRL, the hours will not be counted in the plot.

SIMPLE STRUCTURE RUN 3, CHICAGO DOE-2.1D 3/ 8/1989 13:46:27 SDL RUN 1

REPORT- SS-N RELATIVE HUMIDITY SCATTER PLOT FOR SYST-1 WEATHER FILE- TRY CHICAGO

TOTAL HOURS AT RELATIVE HUMIDITY LEVEL AND TIME OF DAY

HOUR	1AM	2	3	4	5	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8	9	10	11	12	TOTAL
81-100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71-80	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	5
61-70	0	0	0	0	0	0	0	4	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	11
51-60	0	0	0	0	0	0	0	34	51	36	22	19	13	15	14	10	17	6	0	0	0	0	0	0	237
41-50	0	0	0	0	0	0	0	62	66	81	87	84	94	92	93	97	92	16	0	0	0	0	0	0	864
31-40	0	0	0	0	0	0	0	25	84	74	74	50	31	52	55	51	53	36	0	0	0	0	0	0	585
0-30	0	0	0	0	0	0	0	1	47	59	68	99	114	92	89	93	89	67	0	0	0	0	0	0	818

REPORT SS–O -- TEMPERATURE SCATTER PLOT

In this scatter plot, the ordinate, appearing in the left column, shows temperature bins. The abscissa, shown at the top, gives hours of the day. Entered in each cell of the plot is the number of hours during the RUN–PERIOD for which the zone air temperature was in the particular bin for this particular hour of the day. Hours when the fans are off do not show up in the plot.

The column at the far right is the sum of the entries in each row. It shows the frequency of temperature values for the RUN–PERIOD. (Because the temperature counts are only made for hours when the fans are on, summing the totals column will not sum to the number of hours in the run.)

Note: If fans are on due to NIGHT–CYCLE–CTRL, the hours will not be counted in the plot.

TOTAL HOURS AT TEMPERATURE LEVEL AND TIME OF DAY

HOUR	1AM	2	3	4	5	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8	9	10	11	12	TOTAL
ABOVE 85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
81-85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76-80	0	0	0	0	0	0	0	78	87	98	102	109	122	132	140	146	144	22	0	0	0	0	0	0	1180
71-75	0	0	0	0	0	0	0	48	163	151	150	143	129	119	111	105	107	103	0	0	0	0	0	0	1329
66-70	0	0	0	0	0	0	0	0	2	3	0	0	1	1	1	1	1	1	0	0	0	0	0	0	11
61-65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BELOW S0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

REPORT REFG -- REFRIGERATION EQUIPMENT SUMMARY

This report gives monthly energy use for each system in which there is refrigerated case work.

1. ZONAL SENSIBLE ENERGY (MBTU)
   is the sensible heat gain to the zone from the refrigerated case work.

2. ZONAL LATENT ENERGY (MBTU)
   is the latent heat gain to the zone from the refrigerated case work.

3. CONDENSER RECOVERED ENERGY (MBTU)
   is the energy recovered from the condensers and used for space heating in the heat recovery mode.

4. CONDENSER REJECTED ENERGY (MBTU)
   is the energy rejected from the condensers.

5. ELECTRIC COMPRESSOR ENERGY (KWH)
   is the electrical energy consumed by the compressors.

6. ELECTRIC DEFROST ENERGY (KWH)
   is the electrical energy consumed by the defrosters.

7. ELECTRIC AUXILIARY ENERGY (KWH)
   is the electrical energy consumed by lights, fans, and anti-sweat heaters in the refrigerated cases.

8. ELECTRIC TOTAL ENERGY (KWH)
   is the total electric energy used by the refrigerated case work.

REPORT- REFG REFRIGERATION EQUIPMENT SUMMARY IN FS-SYS1 FOR ATZ1 WEATHER FILE- TRY CHICAGO

	--- ZONAL ---		- CONDENSER -		---------- ELECTRIC ----------			
MONTH	SENSIBLE ENERGY (MBTU)	LATENT ENERGY (MBTU)	RECOVERED ENERGY (MBTU)	REJECTED ENERGY (MBTU)	COMPRESSOR ENERGY (KWH)	DEFROST ENERGY (KWH)	AUXILIARY ENERGY (KWH)	TOTAL ENERGY (KWH)
JAN	-8.039	-0.200	6.909	8.407	1793.752	34.976	424.873	2253.593
FEB	-7.325	-0.136	6.281	7.588	1624.845	27.499	363.958	2016.296
MAR	-8.383	-0.375	6.570	9.630	1879.695	58.011	507.071	2444.769
APR	-8.300	-0.586	3.447	12.743	1839.226	81.751	515.206	2436.171
MAY	-8.494	-0.856	1.897	14.986	1896.887	111.001	521.514	2529.388
JUN	-8.744	-1.019	0.114	17.452	1964.740	127.802	516.831	2609.359
JUL	-9.051	-1.091	0.000	18.554	2136.633	135.966	528.234	2800.820
AUG	-9.020	-1.128	0.000	18.443	2100.709	139.866	528.234	2768.801
SEP	-8.460	-0.853	0.910	15.841	1872.292	110.143	510.110	2492.531
OCT	-8.360	-0.686	3.186	13.249	1862.958	92.944	520.973	2476.862
NOV	-7.871	-0.446	5.600	9.715	1769.620	66.416	481.192	2317.218
DEC	-8.044	-0.255	7.051	8.378	1807.629	45.719	467.373	2320.713
TOTAL	-100.090	-7.630	41.965	154.986	22548.988	1032.096	5885.571	29466.523

EQUIPMENT	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL
HW-BOILER	0.440	1	1															
HERM-REC-CHLR	0.180	1	1															

REPORT- PV-B COST REFERENCE DATA (USED FOR DEFAULT COSTS) WEATHER FILE- TRY CHICAGO

E Q U I P M E N T	SIZE (MBTU)	UNIT COST (K$)	INSTALD COST FACTOR	CONSUM-ABLES ($/HR)	MAINTA-NANCE (HRS/YR)	EQPMT LIFE (HRS)	HOURS ALREADY USED	HRS TO MINOR OVHAUL	MINOR OVHAUL COST ($)	HRS TO MAJOR OVHAUL	MAJOR OVHAUL COST ($)
HW-BOILER	40.000	300.000	1.400	0.000	8.0	220000.	0.	10000.	2000.	50000.	25000.
HERM-REC-CHLR	12.000	100.000	1.200	0.000	16.0	100000.	0.	20000.	5000.	50000.	15000.

E Q U I P M E N T	SIZE (MBTU)	UNIT COST (K$)	INSTALD COST FACTOR	CONSUM-ABLES ($/HR)	MAINTA-NANCE (HRS/YR)	EQPMT LIFE (HRS)	HOURS ALREADY USED	HRS TO MINOR OVHAUL	MINOR OVHAUL COST ($)	HRS TO MAJOR OVHAUL	MAJOR OVHAUL COST ($)
HW-BOILER	0.440	14.617	1.400	0.000	3.2	140140.	0.	4058.	97.	20288.	1218.
HERM-REC-CHLR	0.180	5.998	1.200	0.000	6.9	65707.	0.	8635.	300.	21587.	900.

	PART LOAD RATIOS			
EQUIPMENT	MINIMUM	MAXIMUM	OPTIMUM	ELECTRIC INPUT TO NOMINAL CAPACITY RATIO (BTU/BTU)
HW-BOILER	0.2500	1.2000	1.0000	0.0220
HERM-REC-CHLR	0.2500	1.0000	1.0000	0.2740

N A M E	COEFF 1	COEFF 2	COEFF 3	COEFF 4	COEFF 5	COEFF 6
STM-BOILER-HIR-F	0.082597	0.996764	-0.079361	0.000000	0.000000	0.000000
HW-BOILER-HIR-FP	0.082597	0.996764	-0.079361	0.000000	0.000000	0.000000
FURNACE-HIR-FPLR	0.018610	1.094209	-0.112819	0.000000	0.000000	0.000000
DHW-HIR-FPLR	0.021826	0.977630	0.000543	0.000000	0.000000	0.000000
OPEN-CENT-CAP-FT	-1.742040	0.029292	-0.000067	0.048054	-0.000291	-0.000106
OPEN-REC-CAP-FT	-4.161461	0.207050	-0.001931	0.004723	-0.000040	-0.000087
HERM-CENT-CAP-FT	-1.742040	0.029292	-0.000067	0.048054	-0.000291	-0.000106
HERM-REC-CAP-FT	-4.161461	0.207050	-0.001931	0.004723	-0.000040	-0.000087
OPEN-CENT-EIR-FT	3.117500	-0.109236	0.001389	0.003750	0.000150	-0.000375
OPEN-REC-EIR-FT	4.720965	-0.187504	0.002192	0.009209	0.000098	-0.000322
HERM-CENT-EIR-FT	3.117500	-0.109236	0.001389	0.003750	0.000150	-0.000375
HERM-REC-EIR-FT	4.720965	-0.187504	0.002192	0.009209	0.000098	-0.000322
OPEN-CENT-EIR-FP	0.222903	0.313387	0.463710	0.000000	0.000000	0.000000
OPEN-REC-EIR-FPL	0.088065	1.137742	-0.225806	0.000000	0.000000	0.000000
HERM-CENT-EIR-FP	0.222903	0.313387	0.463710	0.000000	0.000000	0.000000
HERM-REC-EIR-FPL	0.088065	1.137742	-0.225806	0.000000	0.000000	0.000000
DBUN-CAP-FT	-1.742040	0.029292	-0.000067	0.048054	-0.000291	-0.000106
DBUN-EIR-FT	3.117500	-0.109236	0.001389	0.003750	0.000150	-0.000375
DBUN-EIR-FPLR	0.349032	0.263871	0.387097	0.000000	0.000000	0.000000
DBUN-CAP-FTRISE	1.000000	-0.005650	-0.000305	0.000000	0.000000	0.000000
DBUN-EIR-FTRISE	1.000000	0.012250	0.000175	0.000000	0.000000	0.000000
ABSOR1-CAP-FT	0.723412	0.079006	-0.000897	-0.025285	-0.000048	0.000276
ABSOR2-CAP-FT	-0.816039	-0.038707	0.000450	0.071491	-0.000636	0.000312
ABSORG-CAP-FT	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ABSORS-CAP-FT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ABSORS-CAP-FTS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

N A M E	COEFF 1	COEFF 2	COEFF 3	COEFF 4	COEFF 5	COEFF 6
ABSOR1-HIR-FT	0.652273	0.000000	0.000000	-0.000545	0.000055	0.000000
ABSOR2-HIR-FT	1.658750	0.000000	0.000000	-0.029000	0.000250	0.000000
ABSORG-HIR-FT	4.428713	-0.132986	0.001253	0.000000	0.000000	0.000000
ABSORS-HIR-FT	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ABSORS-HIR-FTS	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ABSOR1-HIR-FPLR	0.087773	0.744921	0.167306	0.000000	0.000000	0.000000
ABSOR2-HIR-FPLR	0.013994	1.240449	-0.914883	0.660441	0.000000	0.000000
ABSORG-HIR-FPLR	0.135512	0.617981	0.246513	0.000000	0.000000	0.000000
ABSORS-HIR-FPLR	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
TWR-RFACT-FRT	1.484326	0.129479	-0.004014	-0.054336	0.000312	-0.000147
TWR-RFACT-FAT	0.895328	-0.116550	0.001917	-0.001040	-0.000026	0.000398
TWR-APP-FRFACT	4.981467	-6.761789	24.709032	0.114499	-0.000612	-0.250651
TWR-FAN-ELEC-FTU	-395.140015	90.989998	-0.016000	0.000000	0.000000	0.000000
DIESEL-I/O-FPLR	0.107000	0.893000	0.000000	0.000000	0.000000	0.000000
DIESEL-EXH-FPLR	0.024516	0.332387	0.643097	0.000000	0.000000	0.000000
DIESEL-JCLB-FPLR	0.287936	1.020452	-0.308387	0.000000	0.000000	0.000000
DIESEL-TEX-FPLR	383.329987	466.670013	0.000000	0.000000	0.000000	0.000000
**	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
**	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GTURB-I/O-FPLR	0.442979	0.397400	0.156962	0.000000	0.000000	0.000000
GTURB-EXH-FPLR	0.295626	0.493019	0.211355	0.000000	0.000000	0.000000
GTURB-TEX-FPLR	442.091003	255.729996	144.000000	0.000000	0.000000	0.000000
GTURB-CAP-FT	1.240000	-0.004100	0.000000	0.000000	0.000000	0.000000
**	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
STURB-ENTH-FPLX	38.792358	-0.211386	0.000529	1.020087	0.000917	-0.003499
STURB-I/O-FPLR	0.488308	0.994154	-0.482462	0.000000	0.000000	0.000000

N A M E	COEFF 1	COEFF 2	COEFF 3	COEFF 4	COEFF 5	COEFF 6
TC-CHLR-CAP-FT	-0.351443	0.056583	-0.000054	-0.045625	-0.000043	-0.000012
ABSORG-HIR1-FTI	0.861737	-0.007089	0.000103	0.000000	0.000000	0.000000
ABSORG-HIR2-FTI	0.814450	0.000824	0.000013	0.000000	0.000000	0.000000
ABSORG-QCOND-FTI	0.640000	-0.001300	0.000000	0.000000	0.000000	0.000000
ABSG-HCAP-FQC	0.863599	-1.304953	0.441353	0.000000	0.000000	0.000000
ENG-CH-CAP-FT	0.573597	0.018680	0.000000	-0.004653	0.000000	0.000000
ENG-CH-COP-FPLR1	1.143357	0.022890	0.000000	0.000000	0.000000	0.000000
ENG-CH-COP-FPLR2	1.388614	-0.388614	0.000000	0.000000	0.000000	0.000000
ENG-CH-COP-FT	1.236238	0.016892	0.000000	-0.011524	0.000000	0.000000
ENG-CH-HREJ-FPLR	1.052699	-0.052699	0.000000	0.000000	0.000000	0.000000
ENG-CH-HREJ-FT	0.705841	0.003461	0.000000	0.000000	0.000000	0.000000
ENG-CH-COP-FPLRS	0.380200	2.360900	0.000000	0.000000	0.000000	0.000000
ENG-CH-COP-FTS	1.088152	0.014106	0.000000	-0.008339	0.000000	0.000000

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REPORT PS–A -- PLANT ENERGY UTILIZATION SUMMARY

This report gives site and source energy use in MBtu(10^6 Btu). For electrical energy an entry followed by an E is the energy in MWh (thousands of kWh).

1. MONTH
2. TOTAL HEAT LOAD
   Total heating energy = load from SYSTEMS + load from PLANT (absorption chillers + steam turbines + heat dissipated from storage tanks + domestic hot water + heat stored in tanks but not used) + circulation loop losses. The values here are identical to those in the HEATING ENERGY column of the SYSTEMS SS–D report except that the heat energy delivered to an absorption chiller, steam turbine, domestic hot water, and circulation losses is included. Also included is the heat input to a storage tank from a boiler.
3. TOTAL COOLING LOAD
   This is the total of the values shown in the SS–D report plus tank and circulation loop losses; it represents the cooling energy needed each month.
4. TOTAL ELECTR LOAD
   This is the total electrical energy consumed by lights, equipment, and system fans plus the additional energy consumed by chiller motors, pumps, cooling towers, and any other electrical site use including energy entered into the program under BUILDING–RESOURCE.
5. RECVRED ENERGY
   These values are recovered heat used to reduce heating loads. This is waste heat from turbines, diesels, and double-bundle chillers, and solar energy delivered to the load via HEAT–RECOVERY.
6. WASTED RECVRABL ENERGY
   The values in this column represent the heat that *could* have been recovered, had there been a need for it.
7. FUEL INPUT COOLING
   The fuel used to drive engine chillers and gas fired absorption chiller/heaters, and regeneration fuel for desiccant cooling systems.
8. ELEC INPUT COOLING
   The electric energy used to drive chillers and to supply power for peripheral cooling equipment, such as circulation pumps, cooling towers, and cold storage tanks.
9. FUEL INPUT HEATING
   This column reports the fuel used for heating by boilers, furnaces, and hot water heaters.
10. ELEC INPUT HEATING
    The electrical energy used in association with supplying heating, including the electrical consumption by draft fans, circulation pumps, electric boilers, and hot water storage pumps.
11. FUEL INPUT ELEC
    The fuel used by diesel and gas turbine generators.
12. TOTAL FUEL INPUT
    The sum of fossil fuels use.
13. TOTAL SITE ENERGY
    The sum of purchased fossil fuel, electricity, chilled water and steam.
14. TOTAL SOURCE ENERGY
    The energy used at the source. For each RESOURCE, the energy consumption at the site is divided by the corresponding SOURCE–SITE–EFF to arrive at the energy consumed and transmitted by the generating station; the results are summed.

	SITE ENERGY												SOURCE
	2	3	4	5	6	7	8	9	10	11	12	13	14
MONTH	TOTAL HEAT LOAD	TOTAL COOLING LOAD	TOTAL ELECTR LOAD	RCVRED ENERGY	WASTED RCVRABL ENERGY	FUEL INPUT COOLING	ELEC INPUT COOLING	FUEL INPUT HEATING	ELEC INPUT HEATING	FUEL INPUT ELECT	TOTAL FUEL INPUT	TOTAL SITE ENERGY	TOTAL SOURCE ENERGY
JAN	31.2	0.0	19.6 5.7E	0.0	0.0	0.0	0.0 0.0E	47.6	2.4 0.7E	0.0	47.6	67.3	106.5
FEB	25.8	0.0	17.0 5.0E	0.0	0.0	0.0	0.0 0.0E	39.5	2.0 0.6E	0.0	39.5	56.5	90.6
MAR	15.0	0.0	17.5 5.1E	0.0	0.0	0.0	0.0 0.0E	23.1	1.3 0.4E	0.0	23.1	40.7	75.8
APR	3.7	2.1	18.1 5.3E	0.0	0.0	0.0	1.0 0.3E	5.8	0.3 0.1E	0.0	5.8	23.9	60.1
MAY	0.7	6.0	19.7 5.8E	0.0	0.0	0.0	2.5 0.7E	1.1	0.1 0.0E	0.0	1.1	20.8	60.3
JUN	0.0	16.8	22.9 6.7E	0.0	0.0	0.0	6.2 1.8E	0.0	0.0 0.0E	0.0	0.0	22.9	68.8
JUL	0.0	31.0	30.3 8.9E	0.0	0.0	0.0	10.3 3.0E	0.0	0.0 0.0E	0.0	0.0	30.3	91.1
AUG	0.0	26.4	28.3 8.3E	0.0	0.0	0.0	9.1 2.7E	0.0	0.0 0.0E	0.0	0.0	28.3	85.1
SEP	0.4	11.1	20.5 6.0E	0.0	0.0	0.0	4.2 1.2E	0.6	0.0 0.0E	0.0	0.6	21.2	62.3
OCT	2.4	3.5	18.8 5.5E	0.0	0.0	0.0	1.7 0.5E	3.8	0.2 0.1E	0.0	3.8	22.5	60.1
NOV	12.4	0.6	16.2 4.7E	0.0	0.0	0.0	0.3 0.1E	19.1	1.0 0.3E	0.0	19.1	35.3	67.7
DEC	25.1	0.0	18.5 5.4E	0.0	0.0	0.0	0.0 0.0E	38.8	2.0 0.6E	0.0	38.8	57.3	94.4
	116.6	97.5	247.6 72.5E	0.0	0.0	0.0	35.2 10.3E	179.4	9.4 2.8E	0.0	179.4	427.0	922.9

NOTE-- ALL ENTRIES ARE IN MBTU EXCEPT
ENTRIES FOLLOWED BY E ARE IN MWH (THOUSANDS OF KWH)

REPORT PS–B -- MONTHLY PEAK AND TOTAL ENERGY USE

This report shows the monthly total consumption and peak hourly consumption (demand) of up to five of the following purchased fuels:

ELECTRICITY
CHILLED-WATER
STEAM
NATURAL-GAS
LPG
FUEL-OIL
DIESEL-OIL
COAL
METHANOL
BIOMASS

To calculate the peak electrical demand in kW, the user should divide PEAK (kBtuh) by 3.413 kBtuh/kW.

The final section of the report gives, for each "fuel", the total energy use for the run period (ONE YEAR USE), and, below this, the peak hourly energy use (PEAK) for the run period.

REPORT- PS-B MONTHLY PEAK AND TOTAL ENERGY USE WEATHER FILE- TRY CHICAGO

MO	UTILITY-	ELECTRICITY	NATURAL-GAS
JAN	TOTAL (MBTU)	19.620	47.632
	PEAK (KBTU)	81.007	542.457
	DY/HR	7/10	7/ 8
FEB	TOTAL (MBTU)	17.004	39.503
	PEAK (KBTU)	80.318	523.198
	DY/HR	11/10	4/ 8
MAR	TOTAL (MBTU)	17.535	23.130
	PEAK (KBTU)	78.678	512.533
	DY/HR	25/10	25/ 8
APR	TOTAL (MBTU)	18.088	5.783
	PEAK (KBTU)	102.032	415.293
	DY/HR	26/16	8/ 8
MAY	TOTAL (MBTU)	19.725	1.082
	PEAK (KBTU)	117.450	179.850
	DY/HR	22/16	13/ 8
JUN	TOTAL (MBTU)	22.918	0.000
	PEAK (KBTU)	138.902	0.000
	DY/HR	20/16	30/ 1
JUL	TOTAL (MBTU)	30.342	0.000
	PEAK (KBTU)	148.669	0.000
	DY/HR	8/15	31/ 1
AUG	TOTAL (MBTU)	28.340	0.000
	PEAK (KBTU)	144.503	0.000
	DY/HR	19/16	31/ 1
SEP	TOTAL (MBTU)	20.543	0.608
	PEAK (KBTU)	133.516	244.207
	DY/HR	11/15	23/ 8
OCT	TOTAL (MBTU)	18.758	3.786
	PEAK (KBTU)	104.298	425.261
	DY/HR	31/15	21/ 8
NOV	TOTAL (MBTU)	16.177	19.135
	PEAK (KBTU)	105.598	485.979
	DY/HR	1/15	25/ 8
DEC	TOTAL (MBTU)	18.534	38.772
	PEAK (KBTU)	78.499	514.384
	DY/HR	9/10	9/ 8
	ONE YEAR	247.582	179.430
	USE/PEAK	148.669	542.457

REPORT PS–C -- EQUIPMENT PART LOAD OPERATION

For each plant equipment type, this report shows the hours spent in each part load ratio range, in increments of 10%. If equipment is oversized, the equipment will never indicate any hours in the 100 to 110+ range.

The TOTAL HOURS entry differs from the total hours in other reports. Here, TOTAL HOURS refers to the total hours during which one or more units of a given equipment type are operating. This sum is independent of the *number* of units operating. For example, if three boilers are operating during a given hour, TOTAL HOURS is increased by one rather than three.

ANNUAL LOAD is the useful load handled by the equipment.

A FALSE LOAD is reported when a piece of equipment is forced to operate at its minimum unload ratio when the demand is less than this.

ELEC USED is the total electrical energy used by the indicated equipment type.

THERMAL USED refers either to the fuel consumed or the heat required for operation, from wherever it arises.

When there is more than one piece of equipment of the same type, staged for availability, the first line of HOURS AT PERCENT PART LOAD RATIO (for each type) is the hours spent in the partial load ratio range for the capacity of the equipment of that type which is *operating*. The second line is hours spent (for each type) in the partial load ratio range for the *total installed* capacity. Obviously, when only one piece of equipment is installed, the operating capacity and the total capacity are identical. (For example, if there are two 4-MBTU hot-water boilers and only one is operating, then the "operating capacity" is 4 MBTU and the "installed capacity" is 8 MBTU.)

REPORT- PS-C EQUIPMENT PART LOAD OPERATION WEATHER FILE- TRY CHICAGO

EQUIPMENT	HOURS AT PERCENT PART LOAD RATIO 0 -- 10	-- 20	-- 30	-- 40	-- 50	-- 60	-- 70	-- 80	-- 90	-- 100	- 110+	TOTAL HOURS	ANNUAL LOAD (MBTU)	FALSE LOAD (MBTU)	ELEC USED (MBTU)	THERMAL USED (MBTU)
HW-BOILER	617	494	239	101	48	26	12	19	9	8	0	1573	116.6	0.0	8.2	179.4
	617	494	239	101	48	26	12	19	9	8	0					
HERM-REC-CHLR	163	103	96	95	141	152	157	109	60	35	19	1130	97.5	0.0	32.8	0.0
	163	103	96	95	141	152	157	109	60	35	19					

HOT LOOP CIRCULATION PUMP ELECTRICAL USE = 1.2 MBTU
COLD LOOP CIRCULATION PUMP ELECTRICAL USE = 2.3 MBTU

NOTES TO TABLE
1) THE FIRST PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE HOURLY OPERATING CAPACITY

2) THE SECOND PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE TOTAL INSTALLED CAPACITY

REPORT PS–D -- PLANT LOADS SATISFIED

The intent of this report is to flag those situations where the plant is not able to meet the loads imposed by both systems and other plant equipment. This is of special importance in those cases where equipment is intentionally undersized in order to improve part load performance or to reduce costs.

MBTU supplied is the output energy from each piece of equipment.

PCT OF TOTAL LOAD is the following ratio (in percent): MBTU SUPPLIED divided by TOTAL LOAD ON PLANT. This will be 100% only if all of the load is satisfied.

When a hot or cold storage tank is included, additional entries are given at the bottom of the first page which describe the contribution to the heating and cooling demands made by the storage tank(s).

The TOTAL LOAD ON PLANT for heating (cooling) is the sum of the demand from SYSTEMS, the consumption by PLANT, the loss from the storage tank and the heat remaining in the storage tank at the end of the run. The last, of course, is still recoverable and is reported as RESIDUAL (not shown in this example; see the PS–D report for the 31-story Office Building, Run 2 in the Sample Run Book).

In the second part of this report, "SUMMARY OF LOADS MET", TOTAL OVERLOAD is that portion of a load that requires equipment to operate above its nominal rated capacity. PEAK OVERLOAD is the largest hourly OVERLOAD.

REPORT- PS-D PLANT LOADS SATISFIED WEATHER FILE- TRY CHICAGO

HEATING LOADS	MBTU SUPPLIED	PCT OF TOTAL LOAD
HW-BOILER	116.6	100.0
LOAD SATISFIED	116.6	100.0
TOTAL LOAD ON PLANT	116.6	

COOLING LOADS	MBTU SUPPLIED	PCT OF TOTAL LOAD
HERM-REC-CHLR	97.5	100.0
LOAD SATISFIED	97.5	100.0
TOTAL LOAD ON PLANT	97.5	

ELECTRICAL LOADS	MBTU SUPPLIED	PCT OF TOTAL LOAD
ELECTRICITY	247.6	100.0
LOAD SATISFIED	247.6	100.0
TOTAL LOAD ON PLANT	247.6	

SUMMARY OF LOADS MET

TYPE OF LOAD	TOTAL LOAD (MBTU)	LOAD SATISFIED (MBTU)	TOTAL OVERLOAD (MBTU)	PEAK OVERLOAD (MBTU)	HOURS OVERLOADED
HEATING LOADS	116.6	116.6	0.000	0.000	0
COOLING LOADS	97.5	97.5	0.191	0.023	19
ELECTRICAL LOADS	247.6	247.6	0.000	0.000	0

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REPORT PS–G -- ELECTRICAL LOAD SCATTER PLOT

In this scatter plot the ordinate, shown in the left-most column, is the electrical demand divided into 13 bins which range from zero to just above the peak electrical demand. The abscissa shown at the top is the hour of the day. Entered in each cell of the plot is the number of days during the year for which the electrical demand was less than the ordinate shown but larger than the next lower ordinate at that hour of the day.

The right-most column is the sum of the entries in each row and shows the frequency of the electrical demand throughout the run period.

The bottom row shows the distribution of electrical demand for each hour of the average day. The number here is the electrical consumption for the run period for a *particular* hour of the day divided by the total electrical consumption for *all hours of the day* for run period.

The chart at the bottom is a breakdown of the peak electrical demand into the contributing components. The SYSTEMS LOAD includes the lighting and equipment electrical loads from LOADS as well as that from system fans.

SIMPLE STRUCTURE RUN 3, CHICAGO   DOE-2.1D   3/ 8/1989   13:46:27 PDL RUN 1

REPORT- PS-G ELECTRICAL LOAD SCATTER PLOT   WEATHER FILE- TRY CHICAGO

TOTAL HOURS AT HOURLY DEMAND AND TIME OF DAY

	HOUR	1AM	2	3	4	5	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8	9	10	11	12	TOTAL
	43	0	0	0	0	0	0	0	0	0	1	4	3	0	2	10	11	7	6	0	0	0	0	0	0	44
	40	0	0	0	0	0	0	0	0	3	3	4	5	4	9	21	22	15	12	0	0	0	0	0	0	98
	36	0	0	0	0	0	0	0	0	3	10	16	17	8	22	30	31	29	33	0	0	0	0	0	0	199
	33	0	0	0	0	0	0	0	0	14	25	32	30	24	29	17	15	23	25	0	0	0	0	0	0	234
D	30	0	0	0	0	0	0	0	0	25	21	16	19	29	17	10	14	16	15	0	0	0	0	0	0	182
E	26	0	0	0	0	0	0	0	0	12	13	12	13	16	14	17	11	9	5	0	0	0	0	0	0	122
M K	23	0	0	0	0	0	0	0	2	112	121	139	104	16	42	113	71	22	24	2	0	0	0	0	0	768
A W	20	0	0	0	0	0	0	0	3	83	58	29	61	155	117	34	77	131	132	0	0	0	0	0	0	880
N	16	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
D	13	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	250	0	0	0	0	0	270
	10	0	0	0	0	0	0	0	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53
	6	11	13	13	13	14	16	16	94	7	5	7	5	7	4	7	5	8	6	8	259	9	11	10	11	559
	3	354	352	352	352	351	349	349	188	106	108	106	108	106	109	106	108	105	107	105	106	356	354	355	354	5346
PERCENT TOTAL DEMAND		0.5	0.5	0.5	0.5	0.5	0.5	0.5	2.1	8.0	8.4	8.8	8.6	7.9	8.6	9.2	9.2	8.8	8.8	3.9	1.7	1.3	0.5	0.5	0.5	

-C.115-

PEAK ELECTRICAL LOAD BREAKDOWN

SOURCE	KW	PCT
SYSTEMS LOAD	26.268	60.3
CIRCULATION PUMPS	0.605	1.4
HERM-REC-CHLR	16.668	38.3
TOTAL	43.541	

REPORT PS–H -- EQUIPMENT USE STATISTICS

This report gives the user an assessment of the appropriateness of the equipment selected.

1. AVG OPER RATIO
   is the point, on the average, at which the equipment operates on its part load curve.

2. MAX LOAD (MBTU) - MON-DAY-HR
   gives the maximum demand loading and the time of occurrence. This value should compare favorably with the size of the equipment selected.

3. SIZE (MBTU)
   is the equipment size selected either automatically by the program or as input by the user.

4. OPER HRS
   is the total number of equipment-hours the equipment was "on". If more than one unit is involved there is space to report four more units by size and operating hours. If there are two pieces of equipment of the same size, the value for OPER HRS is the sum of the number of hours that each operates.

REPORT- PS-H EQUIPMENT USE STATISTICS WEATHER FILE- TRY CHICAGO

E Q U I P M E N T	AVG OPER RATIO	MAX LOAD (MBTU)	MON	DAY	HR	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS
HW-BOILER	0.168	0.433	1	7	8	0.440	1573								
HERM-REC-CHLR	0.480	0.185	7	15	16	0.180	1130								

REPORT PS–I -- EQUIPMENT LIFE CYCLE COSTS

For each piece of equipment the report generates information as follows:

1. Nominal Size in MBtuh

2. Number Installed

3. First Cost of Equipment

4. Annual Cost is the present value of life cycle cost for maintenance and consumables.

5. Cyclical Cost gives the present value of the life cycle cost for major and minor overhauls and for equipment replacement.

The user must review Table V.1 in the DOE-2 Reference Manual to make sure that equipment-cost-related default values are appropriate. If not, the user should enter appropriate values.

The first column of numbers in this report gives the total life cycle cost for each equipment type. The second column gives the components of this total for all pieces of equipment of that type. The remaining column gives the cost components for each size of equipment. If there is only one size, columns two and three will be identical.

E Q U I P M E N T T O T A L S

HW-BOILER		22.7		
	NOMINAL SIZE (MBTU)			Ø.44Ø
	NUMBER INSTALLED			1
	FIRST COST (K$)		2Ø.5	2Ø.5
	ANNUAL COST (K$)		1.1	1.1
	CYCLICAL COST (K$)		1.1	1.1
	-----TOTAL----(K$)			22.7
HERM-REC-CHLR		1Ø.4		
	NOMINAL SIZE (MBTU)			Ø.18Ø
	NUMBER INSTALLED			1
	FIRST COST (K$)		7.2	7.2
	ANNUAL COST (K$)		2.4	2.4
	CYCLICAL COST (K$)		Ø.8	Ø.8
	-----TOTAL----(K$)			1Ø.4
EQUIPMENT TOTAL		33.2		

REPORT BEPS -- ESTIMATED BUILDING ENERGY PERFORMANCE

This report makes it possible to quickly review building energy performance. The breakdown of usage of up to five different types of energy sources is presented. These energy sources are user-specified through the ENERGY–RESOURCE command in PLANT.

HVAC auxiliary (shown as HVAC AUX) is defined as the energy required to operate non-solar fans, pumps, etc., which *transport* the conditioned air and water. AUX SOLAR is the energy required to operate the fans, pumps, etc. that *transport* the conditioned water or air associated with solar equipment. SPACE COOL and SPACE HEAT give the energy required to *produce* the conditioned water or air for SPACE heating or cooling.

Process and domestic hot water (shown as DOM HOT WTR) is the summation of the user input for hot water in the BUILDING–RESOURCE command and any entries for SOURCE–TYPE = HOT–WATER in the SPACE–CONDITIONS command.

Vertical transportation (shown as VERT TRANS) is the energy for elevators and escalators input through the BUILDING–RESOURCE command.

Loads that are input through SOURCE–TYPE = GAS or SOURCE–TYPE = ELECTRIC in the SPACE–CONDITIONS instruction will appear in this report as miscellaneous equipment (shown as MISC EQUIP). Loads entered as SOURCE–TYPE = PROCESS are assumed to have energy sources independent of the building utilities (e.g., wood stoves, acetylene welders, etc.) and are not reported in the BEPS report.

The distribution of ENERGY TYPE among the CATEGORY OF USE items is exact for every type of energy except electricity. Purchased electricity is apportioned correctly, but electricity generated on-site is apportioned on the basis of net yearly demands for electricity for each category of use.

It should also be pointed out that this report is not designed to work when there is a steam turbine among the specified plant equipment items. The numbers reported when a steam turbine is present will not be reliable.

The report of TOTAL SITE ENERGY and TOTAL SOURCE ENERGY provides a distinction between the energy used per *gross* square foot of building area and that used per *net* square foot of building area. The report generator takes the gross area from the keyword GROSS–AREA in the BUILDING–LOCATION command in LOADS. The default for this keyword is the net area, i.e., the sum of the floor areas of the CONDITIONED ZONEs.

When a hot storage tank is present, a note is printed on the BEPS report stating that the hot water storage tank can get energy from many sources. Any time there is residual energy in the storage tanks, the totals in the BEPS report will not agree with those in report PS–B, because the BEPS report includes only the energy used for the above categories, whereas PS–B includes the energy that is left in the tanks as well.

ENERGY TYPE IN SITE MBTU -	ELECTRICITY	NATURAL-GAS
CATEGORY OF USE		
SPACE HEAT	8.19	179.43
SPACE COOL	32.82	0.00
HVAC AUX	21.14	0.00
DOM HOT WTR	0.00	0.00
AUX SOLAR	0.00	0.00
LIGHTS	149.51	0.00
VERT TRANS	0.00	0.00
MISC EQUIP	35.93	0.00
TOTAL	247.59	179.43

TOTAL SITE ENERGY	427.01 MBTU	85.4 KBTU/SQFT-YR GROSS-AREA	85.4 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY	922.92 MBTU	184.6 KBTU/SQFT-YR GROSS-AREA	184.6 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 1.8
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.2

NOTE ELECTRICITY AND/OR FUEL USED TO GENERATE ELECTRICITY IS APPORTIONED BASED ON THE YEARLY DEMAND. ALL OTHER ENERGY TYPES ARE APPORTIONED HOURLY.

REPORT EV–A --

LIFE-CYCLE COSTING PARAMETERS AND BUILDING COMPONENT COST INPUT DATA

LIFE-CYCLE COSTING PARAMETERS

This report section echoes data originally specified by the user in PLANT and automatically passed to the ECONOMICS program.

1. DISCOUNT RATE
   is the rate in percent used in calculating present value.
2. LABOR INFLATION RATE
   is the annual inflation rate (relative to general inflation) of labor cost, in percent. Installation, maintenance, and overhaul costs are inflated at this rate in calculating present values.
3. MATERIALS INFLATION RATE
   is the annual inflation rate (relative to general inflation) of material costs, in percent. Capital replacement costs are inflated at this rate in calculating present values.
4. PROJECT LIFE
   is the period, in years, over which the life cycle cost analysis is performed. This number can range from 1 to 25 years.

BUILDING COMPONENT COST INPUT DATA

This report section echoes building (nonplant) component cost data input with each COMPONENT–COST command in ECONOMICS. The costs here are in *current dollars* that is, they correspond to the prices that apply at the start of the analysis period.

1. COST NAME
   is the u-name of the component.
2. NUMBER OF UNITS
   multiplies all costs. Defaults to 1.0 if not specified.
3. UNIT NAME
   is the name assigned to the unit (such as SQFT or CUFT) by the user to identify the size or type of the unit. This name is arbitrary and optional and is for user convenience only.
4. LIFE
   is the life expectancy of the component, in years. It is used in calculating replacement costs. Defaults to 999 years if not specified.
5. UNIT FIRST COST
   is the purchase price of each unit of the component, in dollars, exclusive of installation.
6. UNIT INSTALLATION COST
   is the installation cost for each unit of the component, in dollars.
7. UNIT ANNUAL MAINT COST
   is the yearly maintenance cost of each unit of the component, in dollars.
8. UNIT MINOR OVERHAUL COST
   is the cost, in dollars, of a minor overhaul for each unit of the component.
9. MINOR OVERHAUL INTERVAL
   is the number of years between minor overhauls.
10. UNIT MAJOR OVERHAUL COST
    is the cost, in dollars, of a major overhaul for each unit of the component.
11. MAJOR OVERHAUL INTERVAL
    is the number of years between major overhauls.

LIFE-CYCLE COSTING PARAMETERS

DISCOUNT RATE (PERCENT)	LABOR INFLATION RATE (PERCENT)	MATERIALS INFLATION RATE (PERCENT)	PROJECT LIFE (YRS)
5.Ø	Ø.Ø	Ø.Ø	25.Ø

BUILDING COMPONENT COST INPUT DATA (CURRENT DOLLARS)

-C.123-

COST NAME	NUMBER OF UNITS	UNIT NAME	LIFE (YRS)	UNIT FIRST COST ($)	UNIT INSTALL -ATION COST ($)	UNIT ANNUAL MAINT COST ($)	UNIT MINOR OVERHAUL COST ($)	MINOR OVERHAUL INTERVAL (YRS)	UNIT MAJOR OVERHAUL COST ($)	MAJOR OVERHAUL INTERVAL (YRS)

NO BUILDING COMPONENT COSTS SPECIFIED

REPORT EV–B -- COST OF FUELS AND UTILITIES

This verification report lists the user-input and defaulted values for each fuel or utility required by the previous PLANT run. The information is an echo of the inputs to the ENERGY–COST command for each fuel or utility, as understood by the ECONOMICS program.


```
SIMPLE STRUCTURE RUN 3, CHICAGO                                                    DOE-2.1D   3/ 8/1989    13:46:27  EDL  RUN 1
REPORT- EV-A  LIFE-CYCLE COSTING PARAMETERS AND BUILDING COMPONENT COST INPUT DATA
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REPORT- EV-B COST OF FUELS AND UTILITIES

ENERGY SOURCE	ENERGY UNIT (BTU)	UNIFORM COST /UNIT ($)	COST ESCLA-ATION RATE	MIN MNTHLY CHARGE ($)	RATE LIMIT /UNIT ($)	FIXED MNTHLY CHARG1 ($)	FIXED MNTHLY CHARG2 ($)	ASSIGN-SCHEDULE (U-NAME)	ASSIGN-CHARGE1 (U-NAME)	ASSIGN-CHARGE2 (U-NAME)
ELECTRIC	3412.97	0.0000	7.000	0.00	1000000.000	0.00	0.00	TIMEOFDAY		
NTRL-GAS	100000.00	0.6000	8.000	0.00	1000000.000	0.00	0.00			

REPORT ES–A -- ANNUAL ENERGY AND OPERATIONS COSTS AND SAVINGS

This report gives the present value of energy and operations costs for each year of the project lifetime. Costs are given both for the baseline and for the building being analyzed in the present run. Operations include costs of annual maintenance and major and minor overhauls. For the building being analyzed in this run, operations costs are given separately for plant equipment and for the building (non plant) components specified using COMPONENT–COST instructions.

The building being analyzed in the example shown is Simple Structure Run 3A; the baseline building is Simple Structure Run 3.

1. ENERGY COST BASELINE
   is the present value of the yearly baseline energy cost. These values echo those input using the BASELINE command.

2. ENERGY COST THIS RUN
   is the present value of the yearly energy cost for the building being analyzed in this run.

3. ENERGY COST SAVINGS
   is the difference between the above two quantities (1 minus 2).

4. OPRNS COST BASELINE
   is the present value of the yearly baseline operations cost.

5. OPRNS COST--THIS RUN
   gives the present value of the yearly operations cost for plant equipment and building components, and for the sum, for the building being analyzed in this run.

6. OPRNS COST SAVINGS
   is OPRNS COST BASELINE minus OPRNS COST--THIS RUN, TOTAL.

7. TOTAL SAVINGS-ENERGY PLUS OPRNS
   is the sum of ENERGY COST SAVINGS and OPRNS COST SAVINGS.

The bottom line of this report (TOTALS) gives the present value of the life cycle energy and operations costs and savings.

Note: The user must enter baseline cost data using the BASELINE command. Otherwise, the "savings" values in this report will not be meaningful.

SIMPLE STRUCTURE RUN 3A, CHICAGO DOE-2.1D 3/ 8/1989 13:46:27 EDL RUN 2

REPORT- ES-A ANNUAL ENERGY AND OPERATIONS COSTS AND SAVINGS

	E N E R G Y (K$)			O P E R A T I O N S (K$)					TOTAL SAVINGS- ENERGY PLUS OPRNS
	ENERGY COST	ENERGY COST	ENERGY COST	OPRNS COST	OPRNS COST -- THIS RUN			OPRNS COST	
YEAR	BASELINE	THIS RUN	SAVINGS	BASELINE	PLANT	BUILDING	TOTAL	SAVINGS	
1	5.68	5.57	0.11	0.24	0.24	0.00	0.24	0.00	0.11
2	5.80	5.68	0.12	0.23	0.23	0.00	0.23	0.00	0.12
3	5.92	5.80	0.12	0.31	0.22	0.00	0.22	0.09	0.21
4	6.04	5.92	0.12	0.21	0.21	0.00	0.21	0.00	0.12
5	6.17	6.04	0.13	0.20	0.20	0.00	0.20	0.00	0.13
6	6.30	6.17	0.13	0.27	0.19	0.00	0.19	0.08	0.22
7	6.43	6.29	0.14	0.18	0.18	0.00	0.18	0.00	0.14
8	6.56	6.42	0.14	0.45	0.17	0.00	0.17	0.28	0.42
9	6.70	6.55	0.15	0.16	0.16	0.00	0.16	0.00	0.14
10	6.84	6.69	0.15	0.16	0.16	0.00	0.16	0.00	0.16
11	6.98	6.83	0.15	0.21	0.15	0.00	0.15	0.06	0.22
12	7.13	6.97	0.16	0.14	0.14	0.00	0.14	0.00	0.16
13	7.28	7.11	0.17	0.84	0.13	0.00	0.13	0.71	0.88
14	7.43	7.26	0.17	0.13	0.13	0.00	0.13	0.00	0.18
15	7.59	7.41	0.18	0.12	0.12	0.00	0.12	0.00	0.18
16	7.75	7.56	0.19	0.30	0.12	0.00	0.12	0.18	0.37
17	7.91	7.72	0.19	0.11	0.11	0.00	0.11	0.00	0.19
18	8.08	7.87	0.21	0.11	0.11	0.00	0.11	0.00	0.21
19	8.25	8.04	0.21	0.14	0.10	0.00	0.10	0.04	0.25
20	8.43	8.20	0.23	0.45	0.10	0.00	0.10	0.35	0.58
21	8.60	8.37	0.23	0.13	0.09	0.00	0.09	0.04	0.27
22	8.79	8.55	0.24	0.09	0.09	0.00	0.09	0.00	0.25
23	8.97	8.72	0.25	0.18	0.08	0.00	0.08	0.10	0.34
24	9.16	8.91	0.25	0.11	0.08	0.00	0.08	0.03	0.29
25	9.36	9.09	0.27	0.07	0.07	0.00	0.07	0.00	0.26
TOTALS(K$)	184.15	179.73	4.42	5.54	3.58	0.00	3.58	1.96	6.38

REPORT ES–B -- LIFE-CYCLE BUILDING AND PLANT NON-ENERGY COSTS

This report summarizes life cycle costs (other than for energy) for plant equipment and for each building component.

1. FIRST COST
   is the initial purchase price, including installation.

2. REPLACEMENTS
   is the present value of the life cycle replacement costs.

3. OPERATIONS
   is the present value of the life cycle cost for annual maintenance and major and minor overhauls.

4. TOTAL
   gives the sum of the previous three quantities.

5. INVESTMENT
   is the sum of the first two quantities, FIRST COST and REPLACEMENTS. Note that the investment does not include operations or energy costs.

REPORT- ES-B LIFE-CYCLE BUILDING AND PLANT NON-ENERGY COSTS

LIFE-CYCLE BUILDING AND PLANT NON-ENERGY COSTS (K$)

COST NAME	FIRST COST (INCLUDING INSTALLATION)	REPLACEMENTS	OPERATIONS	TOTAL	INVESTMENT (FIRST COST PLUS REPLACEMENTS)
NO BUILDING COMPONENT COSTS SPECIFIED					
PLANT EQUIPMENT	27.66	0.00	5.52	33.18	27.66
TOTALS	27.66	0.00	5.52	33.18	27.66

REPORT ES–C --

ENERGY SAVINGS, INVESTMENT STATISTICS, AND OVERALL LIFE-CYCLE COSTS

ENERGY SAVINGS:

This section summarizes the annual energy use in millions of Btu and megawatt-hours at the site and at the source for the baseline and for the present building.

INVESTMENT STATISTICS:

1. INVESTMENT THIS RUN
   is the total investment associated with the present building. This number is the same as the total investment in building components and plant equipment given in Report ES-B.

The following quantities are meaningful only if baseline costs and energy use have been specified.

2. BASELINE REPLACEMENT COSTS
   gives the present value of life cycle replacement costs for the baseline. This quantity is specified by the keyword REPLACE–COST of the BASELINE command.

3. INCREMENTAL INVESTMENT
   is the INVESTMENT THIS RUN minus the sum of BASELINE REPLACEMENT COSTS and BASELINE FIRST COST (as given below under OVERALL LIFE-CYCLE COSTS).

4. COST SAVINGS
   is the present value of the life cycle savings in energy and operations costs. This number is also given in Report ES–A.

5. RATIO OF SAVINGS TO INCREMENTAL INVESTMENT (SIR)
   gives dollars saved per dollar invested. It is the ratio of COST SAVINGS and INCREMENTAL INVESTMENT. If this ratio is greater than 1.0, the investment may be cost effective.

6. DISCOUNTED PAYBACK PERIOD
   is the number of years it takes for the accumulated cost savings to equal the incremental investment. The shorter the payback period, the more cost effective is the investment.

7. RATIO OF LIFE CYCLE ENERGY SAVINGS (AT SITE) TO INCREMENTAL INVESTMENT
   gives the life cycle site energy saved per incremental investment dollar.

8. RATIO OF LIFE CYCLE ENERGY SAVINGS (AT SOURCE) TO INCREMENTAL INVESTMENT
   gives the life cycle source energy saved (in units of per incremental investment dollar.

OVERALL LIFE-CYCLE COSTS:

This section summarizes the life cycle costs and savings for the following categories: first cost (including installation), operations, replacements, energy, and sum of all these.

REPORT- ES-C ENERGY SAVINGS, INVESTMENT STATISTICS, AND OVERALL LIFE-CYCLE COSTS

ENERGY SAVINGS

	ANNUAL ENERGY USE BASELINE (MBTU)	(MWH)	ANNUAL ENERGY USE THIS RUN (MBTU)	(MWH)	ANNUAL ENERGY SAVINGS (MBTU)	(MWH)	ANNUAL ENERGY SAVINGS (PCT)
AT SITE	427.03	125.07	395.24	115.76	31.79	9.31	0.0
AT SOURCE	923.0	270.3	908.0	265.9	15.0	4.4	0.0

INVESTMENT STATISTICS

PROJECT LIFE 25.0 YEARS

-C.131-

INVESTMENT THIS RUN (K$)	BASELINE REPLACEMENT COSTS (K$)	INCREMENTAL INVESTMENT (K$)	COST SAVINGS (K$)	RATIO OF SAVINGS TO INCREMENTAL INVESTMENT (SIR)	DISCOUNTED PAYBACK PERIOD (YEARS)	RATIO OF LIFE CYCLE ENERGY SAVINGS (AT SITE) TO INCREMENTAL INVESTMENT (MBTU/$)	(MWH/$)	RATIO OF LIFE-CYCLE ENERGY SAVINGS (AT SOURCE) TO INCREMENTAL INVESTMENT (MBTU/$)	(MWH/$)
36.91	9.25	27.66	6.38	0.23	108.39	0.03	0.01	0.01	0.00

OVERALL LIFE-CYCLE COSTS (K$)

	FIRST COST	OPRNS COST	REPLACEMENTS	ENERGY COST	T O T A L
BASELINE	0.00	5.54	9.25	184.15	198.94
THIS RUN	36.91	3.58	0.00	179.73	220.22
SAVINGS(K$)	-36.91	1.96	9.25	4.42	-21.28
(PCT)	0.0	35.4	100.0	2.4	-10.7

REPORT ES–D -- SUMMARY OF FUEL AND UTILITY USE AND COSTS

This summary report lists the consumption, peak hourly demand, and total cost of each fuel and utility on a monthly and yearly basis. It is analogous to the PLANT summary report PS–B, but differs in that consumption and peak demand are reported in the units used for billing rather than MBtu. The unit, specified by the UNIT keyword in ENERGY–COST, is printed in the heading for each fuel or utility. In the example shown, the ELECTRIC UNIT (3412.97 Btu) is a kWh and the NTRL–GAS UNIT (100000.00 Btu) is a therm.

REPORT- ES-D SUMMARY OF FUEL AND UTILITY USE AND COSTS

MONTH	ELECTRIC UNIT= 3412.97	NTRL-GAS UNIT= 100000.00
JAN		
ENERGY CONSUMPTION (UNIT/MO)	5886.	372.
PEAK DEMAND (UNIT/HR)	24.	5.
TOTAL COST ($)	366.86	223.01
FEB		
ENERGY CONSUMPTION (UNIT/MO)	5116.	308.
PEAK DEMAND (UNIT/HR)	24.	5.
TOTAL COST ($)	318.48	184.92
MAR		
ENERGY CONSUMPTION (UNIT/MO)	5381.	198.
PEAK DEMAND (UNIT/HR)	24.	5.
TOTAL COST ($)	336.60	118.53
APR		
ENERGY CONSUMPTION (UNIT/MO)	5510.	45.
PEAK DEMAND (UNIT/HR)	29.	4.
TOTAL COST ($)	348.40	26.73
MAY		
ENERGY CONSUMPTION (UNIT/MO)	6015.	5.
PEAK DEMAND (UNIT/HR)	34.	1.
TOTAL COST ($)	381.66	2.74
JUN		
ENERGY CONSUMPTION (UNIT/MO)	6971.	0.
PEAK DEMAND (UNIT/HR)	39.	0.
TOTAL COST ($)	443.56	0.00
JUL		
ENERGY CONSUMPTION (UNIT/MO)	8983.	0.
PEAK DEMAND (UNIT/HR)	43.	0.
TOTAL COST ($)	571.14	0.00
AUG		
ENERGY CONSUMPTION (UNIT/MO)	8501.	0.
PEAK DEMAND (UNIT/HR)	41.	0.
TOTAL COST ($)	541.57	0.00
SEP		
ENERGY CONSUMPTION (UNIT/MO)	6336.	2.
PEAK DEMAND (UNIT/HR)	38.	1.
TOTAL COST ($)	402.97	1.19
OCT		
ENERGY CONSUMPTION (UNIT/MO)	5764.	19.
PEAK DEMAND (UNIT/HR)	31.	3.
TOTAL COST ($)	365.38	11.24
NOV		
ENERGY CONSUMPTION (UNIT/MO)	4957.	146.
PEAK DEMAND (UNIT/HR)	31.	4.
TOTAL COST ($)	310.33	87.83
DEC		
ENERGY CONSUMPTION (UNIT/MO)	5582.	299.
PEAK DEMAND (UNIT/HR)	24.	5.
TOTAL COST ($)	348.04	179.41
TOTAL		
ENERGY CONSUMPTION (UNIT/YR)	75001.	1393.
PEAK DEMAND (UNIT/HR)	43.	5.
TOTAL COST ($)	4734.98	835.60

REPORT ES–E -- SUMMARY OF ELECTRICITY CHARGES

This report contains detailed, month-by-month information on the components of the electricity charges for each CHARGE–ASSIGNMENT in the month.

1. CHARGE–ASSIGNMENT
   The u-name of each CHARGE–ASSIGNMENT for each month in which the CHARGE–ASSIGNMENT has been assigned and in which electricity is consumed.

2. LENGTH
   The number of hours that the CHARGE–ASSIGNMENT was accruing electricity consumption for charges.

3. CONSUMPTION BY C–A
   The total amount of electricity consumed.

4. ENERGY CHARGE
   The charges assessed for the electricity consumed.

5. MEASURED DEMAND
   The highest demand measured in the hours that the CHARGE–ASSIGNMENT was in effect.

6. BILLING DEMAND
   The demand used for assessing demand charges. This quantity is the greater of the measured demand or the ratchet in effect, adjusted by the power factor correction (POWER–FAC–CORR).

7. DEMAND CHARGE
   The charges assessed for electricity demand.

8. TOTAL CHARGES
   For each month, the sum of the demand and energy charges of each charge assignment, plus any FIXED–MONTH–CHGs, adjusted for MIN–MONTH–CHG and RATE–LIMITATION (see ENERGY–COST command). For the year, the sum of the monthly total charges.

REPORT- ES-E SUMMARY OF ELECTRICITY CHARGES

MONTH	CHARGE-ASSIGNMENT (U-NAME)	LENGTH (HR/MO)	CONSUMPTION BY C-A (KWH)	ENERGY CHARGE ($)	MEASURED DEMAND (KW)	BILLING DEMAND (KW)	DEMAND CHARGE ($)	TOTAL CHARGES ($)
JAN								
	NIGHT	400	854.	42.69	11.	11.	0.00	
	SHD-P	234	2806.	168.35	24.	24.	0.00	
	PEAK	110	2226.	155.81	22.	22.	0.00	
								366.86
FEB								
	NIGHT	370	770.	38.51	11.	11.	0.00	
	SHD-P	207	2425.	145.53	24.	24.	0.00	
	PEAK	95	1921.	134.44	22.	22.	0.00	
								318.48
MAR								
	NIGHT	405	694.	34.69	10.	10.	0.00	
	SHD-P	234	2620.	157.20	24.	24.	0.00	
	PEAK	105	2067.	144.71	22.	22.	0.00	
								336.60
APR								
	NIGHT	376	501.	25.03	7.	7.	0.00	
	SHD-P	234	2730.	163.79	28.	28.	0.00	
	PEAK	110	2280.	159.58	29.	29.	0.00	
								348.40
MAY								
	NIGHT	400	507.	25.37	4.	4.	0.00	
	SHD-P	234	2924.	175.41	33.	33.	0.00	
	PEAK	110	2584.	180.88	34.	34.	0.00	
								381.66
JUN								
	NIGHT	395	566.	28.28	10.	10.	0.00	
	SHD-P	225	3307.	198.43	38.	38.	0.00	
	PEAK	100	3098.	216.85	39.	39.	0.00	
								443.56
JUL								
	NIGHT	400	754.	37.71	23.	23.	0.00	
	SHD-P	234	4259.	255.51	43.	43.	0.00	
	PEAK	110	3970.	277.91	43.	43.	0.00	
								571.14
AUG								
	NIGHT	391	653.	32.67	16.	16.	0.00	
	SHD-P	243	4039.	242.36	41.	41.	0.00	
	PEAK	110	3808.	266.54	41.	41.	0.00	
								541.57
SEP								
	NIGHT	404	562.	28.11	11.	11.	0.00	
	SHD-P	216	2929.	175.72	35.	35.	0.00	
	PEAK	100	2845.	199.14	38.	38.	0.00	
								402.97
OCT								
	NIGHT	400	522.	26.09	6.	6.	0.00	
	SHD-P	234	2768.	166.09	29.	29.	0.00	
	PEAK	110	2474.	173.19	31.	31.	0.00	
								365.38

REPORT- ES-E SUMMARY OF ELECTRICITY CHARGES

CONTINUED

MONTH	CHARGE-ASSIGNMENT (U-NAME)	LENGTH (HR/MO)	CONSUMPTION BY C-A (KWH)	ENERGY CHARGE ($)	MEASURED DEMAND (KW)	BILLING DEMAND (KW)	DEMAND CHARGE ($)	TOTAL CHARGES ($)
NOV								
	NIGHT	409	631.	31.55	8.	8.	0.00	
	SHD-P	216	2402.	144.14	28.	28.	0.00	
	PEAK	95	1923.	134.64	31.	31.	0.00	
								310.33
DEC								
	NIGHT	414	803.	40.14	10.	10.	0.00	
	SHD-P	225	2663.	159.78	24.	24.	0.00	
	PEAK	105	2116.	148.13	22.	22.	0.00	
								348.04
TOTAL			75001.	4734.98			0.00	4734.98

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REPORT ES–F -- SUMMARY OF ELECTRICITY SALES

This report shows details of sales of electricity to the utility on a monthly basis for each CHARGE–ASSIGNMENT in the month. The report will only appear if the report is requested and ELEC–SALES–OPT in the COST–PARAMETERS command is set to NET–SALE or SIM–BUY/SELL.

1. CHARGE–ASSIGNMENT
   The u-name of each CHARGE–ASSIGNMENT in the month.

2. ENERGY AVAILABLE
   The total amount of electricity sold to the utility, as determined by ELEC–SALES–OPT.

3. PEAK GENERATION
   The greatest amount of electricity sold to the utility in one hour, as determined by ELEC–SALES–OPT.

4. TOTAL REVENUES
   The revenues generated by the sale of electricity to the utility. The year-end total includes any CAPACITY–PAYMENT specified for electricity sales.

31-STORY OFFICE BLDG, CHICAGO - LOAD2 RUN 5 POWERED INDUCTION UNITS DOE-2.1D 3/ 9/1989 12:28:40 EDL RUN 5
SINGLE ZONE UNIT IN BASEMENT

REPORT- ES-F SUMMARY OF ELECTRICITY SALES

MONTH	CHARGE-ASSIGNMENT (U-NAME)	LENGTH (HR/MO)	AVAILABLE FOR SALE (KWH)	PEAK GENERATION (KW)	TOTAL REVENUE ($)
JAN	SELLEC	744	296605.	1575.	23728.38
FEB	SELLEC	672	280023.	1575.	22401.81
MAR	SELLEC	744	299642.	1575.	23971.33
APR	SELLEC	720	264703.	1575.	21176.28
MAY	SELLEC	744	233301.	1575.	18664.12
JUN	SELLEC	720	326145.	1575.	26091.63
JUL	SELLEC	744	358526.	1575.	28682.06
AUG	SELLEC	744	363528.	1575.	29082.21
SEP	SELLEC	720	257253.	1575.	20580.24
OCT	SELLEC	744	229466.	1575.	18357.26
NOV	SELLEC	720	256955.	1575.	20556.39
DEC	SELLEC	744	304584.	1575.	24366.76
TOTAL			3470731.		353658.44