STEALTH: A Lagrange Explicit Finite-Difference Code for Solids, Structural, and Thermohydraulic Analysis.

Volume 1B: User's Manual—Input Instructions

MAS

NP-2080, Volume 1B
Formerly NP-260 and NP-2080-CCM
Research Project 307-1

Computer Code Manual, November 1981

Version 4-1A

Prepared by

SCIENCE APPLICATIONS, INCORPORATED
2450 Washington Avenue, Suite 120
San Leandro, California 94577

Principal Investigator
R. Hofmann

Prepared for

Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Project Managers
C. Chan
H. T. Tang

Risk Assessment Program
Nuclear Power Division

ORDERING INFORMATION
Requests for copies of this report should be directed to Research Reports Center (RRC), Box 50490, Palo Alto, CA 94303, (415) 965-4081. There is no charge for reports requested by EPRI member utilities and affiliates, contributing nonmembers, U.S. utility associations, U.S. government agencies (federal, state, and local), media, and foreign organizations with which EPRI has an information exchange agreement. On request, RRC will send a catalog of EPRI reports.

For further information about the code described in this report, contact the Electric Power Software Center, University Computing Company, 1930 Hi Line Drive, Dallas, Texas 75207, (214) 655-8883.

Prepared by
Science Applications, Incorporated
San Leandro, California

EPRI PERSPECTIVE

PROJECT DESCRIPTION

Through RP307-1, EPRI has made available to utilities and the industry at large the general-purpose and user-oriented explicit finite difference transient continuum mechanics computer code, STEALTH, based on the technology developed and tested in the defense community. As part of the EPRI research program to develop advanced nonlinear analysis methodology and computer codes for nuclear design and licensing analysis, successful completion of the general-purpose version of the STEALTH code has been followed by reduced versions for "specific" applications such as soil-structure interaction, piping flow, and fluid-structure interaction. The current documentation updates expanded capabilities, modeling improvement, and additional qualifications accomplished since the publication of the original STEALTH manuals, EPRI Computer Code Manual NP-260, in 1976.

PROJECT OBJECTIVE

The objective of the project is to develop a general, portable, modular, and machine-independent explicit finite difference code to address transient and quasi-static design situations such as water-hammer, soil-structure interaction, missile impact, piping flow, and fluid-structure interaction. State-of-the-art capabilities are developed, and extensive qualifications are performed. It is intended that, with extensive documentation and user-oriented modeling features, the code can be used by engineers with maximum efficiency and reliability.

PROJECT RESULTS

Since 1976, more than 100 copies of the STEALTH code have been distributed through three releases, to both domestic and foreign organizations, including utilities, vendors, architect-engineering firms, and research institutions. Version 4-1A is the fourth release of the general-purpose STEALTH code, in which three-dimensional capabilities are qualified and documented. In addition to the general-purpose code, special-purpose versions of STEALTH are developed using either mechanical-only or thermal-only subsets for efficient soil-structure interaction, piping flow, and fluid-structure interaction applications. The Introduction and Guide (Volume 0) of the STEALTH manuals provides an overview of the design and documentation structures of the entire STEALTH family codes.

This project has been managed by Conway Chan and H. T. Tang.

H. T. Tang, Project Manager
Nuclear Power Division

CONTENTS

VOLUME IA

CONTENTS (continued)

CONTENTS (continued)

This page intentionally left blank.

CONTENTS (continued)

CONTENTS (continued)

VOLUME IB

CONTENTS (continued)

This page intentionally left blank.

ILLUSTRATIONS

VOLUME IA

VOLUME IB

This page intentionally left blank.

TABLES

VOLUME IA

VOLUME IB

This page intentionally left blank.

STEALTH DOCUMENTATION REVISIONS

With each release of new or revised STEALTH documentation, the STEALTH user will receive a Newsletter and a set of "REVISIONS" pages, both of which will summarize changes to the documentation. The Newsletter will present general comments, while the REVISIONS pages will include a detailed summary of changes. The REVISIONS pages will be numbered so that they will have a permanent location in an appropriate volume of the STEALTH manuals. The volume number and date of each REVISIONS page will appear in the lower right-hand corner of the page. The format of the REVISIONS page is shown below.

Page	New Rev.#	New Date	COMMENTS	Old Rev.#	Old Date

The "Page" heading refers to the page number of the revised page. The "New" and "Old" headings refer to the information in the lower right-hand corner of each page. (If there is no information in the lower right-hand corner of a page, assume that the page was created on 15 AUG 75 and its revision number is 0.) Under the "COMMENTS" heading, there will be a string of coded letters with the following meanings:

EA = equation(s) added
EC = equation(s) changed
ED = equation(s) deleted

TA = text added
TC = text changed
TD = text deleted

PA = page added
PC = page changed
PD = page deleted

VA = variable(s) added
VC = variable(s) changed
VD = variable(s) deleted

NF = new figure
NT = new table
NE = new equation number
NR = new reference

SC = simple correction (usually correction of typo or spelling)

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
2.5	1	1 DEC 76	SC	0	15 AUG 75
3.2	1	1 DEC 76	EC	0	15 AUG 75
3.3	1	1 DEC 76	SC, EC	0	15 AUG 75
3.6	1	1 DEC 76	TA	0	15 AUG 75
3.8	1	1 DEC 76	SC, EC	0	15 AUG 75
4.7	1	1 DEC 76	EC	0	15 AUG 75
4.32	1	1 DEC 76	EC	0	15 AUG 75
4.38	1	1 DEC 76	TC	0	15 AUG 75
4.41	1	1 DEC 76	TA	0	15 AUG 75
5.3	1	1 DEC 76	TA	0	15 AUG 75
5.4	1	1 DEC 76	SC	0	15 AUG 75
5.6	1	1 DEC 76	EC	0	15 AUG 75
5.7	1	1 DEC 76	EC	0	15 AUG 75
5.10	1	1 DEC 76	EC	0	15 AUG 75
5.14	1	1 DEC 76	EC	0	15 AUG 75
5.39a	1	1 DEC 76	TD	0	15 AUG 75
5.39b	0	1 DEC 76	PA		
5.41	1	1 DEC 76	EC	0	15 AUG 75
5.47	1	1 DEC 76	TC	0	15 AUG 75
5.50	1	1 DEC 76	TA	0	15 AUG 75
6.11	0	1 DEC 76	PA		
6.12	0	1 DEC 76	PA		
6.13	0	1 DEC 76	PA		
7.1	1	1 DEC 76	TA	0	15 AUG 75
7.001	1	1 DEC 76	TA, TC	0	15 AUG 75
7.009	1	1 DEC 76	VA	0	15 AUG 75
7.010a	1	1 DEC 76	VA	0	15 AUG 75
7.010b	1	1 DEC 76	VA	0	15 AUG 75
7.010c	0	1 DEC 76	PA		

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
7.011	1	1 DEC 76	TA, TC	0	15 AUG 75
7.016b	1	1 DEC 76	TA	0	15 AUG 75
7.109	1	1 DEC 76	VA	0	15 AUG 75
7.110a	1	1 DEC 76	VA	0	15 AUG 75
7.110b	1	1 DEC 76	VA	0	15 AUG 75
7.110c	0	1 DEC 76	PA		
7.112b	1	1 DEC 76	TD	0	15 AUG 75
7.113	1	1 DEC 76	SC	0	15 AUG 75
7.123	1	1 DEC 76	TC	0	15 AUG 75
7.202	1	1 DEC 76	SC	0	15 AUG 75
7.206	1	1 DEC 76	TD	0	15 AUG 75
7.207	1	1 DEC 76	TA	0	15 AUG 75
7.208	0	1 DEC 76	PA, NF		
7.209a	1	1 DEC 76	VA, VC	0	15 AUG 75
7.209b	1	1 DEC 76	VA, VC	0	15 AUG 75
7.210a	1	1 DEC 76	VA	0	15 AUG 75
7.210b	1	1 DEC 76	VA	0	15 AUG 75
7.210c	0	1 DEC 76	PA		
7.212a	1	1 DEC 76	TC, TD	0	15 AUG 75
7.212b	1	1 DEC 76	TD	0	15 AUG 75
7.232	1	1 DEC 76	VC, TC	0	15 AUG 75
7.246a	1	1 DEC 76	VC, TC, NF	0	15 AUG 75
7.246b	1	1 DEC 76	VC, TC	0	15 AUG 75
7.247a	1	1 DEC 76	VC, TC, NF	0	15 AUG 75
7.247b	1	1 DEC 76	VC, TC	0	15 AUG 75
7.256a	1	1 DEC 76	VC, TC, NF	0	15 AUG 75
7.256b	1	1 DEC 76	VC, TC	0	15 AUG 75
7.257a	1	1 DEC 76	VC, TC, NF	0	15 AUG 75
7.257b	1	1 DEC 76	VC, TC	0	15 AUG 75
7.261a	1	1 DEC 76	VC, TC, NF	0	15 AUG 75

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
7.261b	1	1 DEC 76	VC, TC	0	15 AUG 75
7.262a	1	1 DEC 76	VC, TC, NF	0	15 AUG 75
7.262b	1	1 DEC 76	VC, TC	0	15 AUG 75
7.266a	1	1 DEC 76	VC, TC, NF	0	15 AUG 75
7.266b	1	1 DEC 76	VC, TC	0	15 AUG 75
7.267a	1	1 DEC 76	VC, TC, NF	0	15 AUG 75
7.267b	1	1 DEC 76	VC, TC	0	15 AUG 75
7.301	1	1 DEC 76	TC	0	15 AUG 75
7.302	0	1 DEC 76	TA		
7.309	1	1 DEC 76	VA	0	15 AUG 75
7.310a	1	1 DEC 76	VA	0	15 AUG 75
7.310b	1	1 DEC 76	VA	0	15 AUG 75
7.310c	0	1 DEC 76	PA		
7.321	1	1 DEC 76	TC	0	15 AUG 75
7.322	1	1 DEC 76	TC, VA	0	15 AUG 75
7.331	1	1 DEC 76	TC, VA	0	15 AUG 75
7.341	1	1 DEC 76	TC, VA	0	15 AUG 75
7.381	0	1 DEC 76	PA		
7.382	0	1 DEC 76	PA		
7.383a	0	1 DEC 76	PA		
7.383b	0	1 DEC 76	PA		
7.383c	0	1 DEC 76	PA		
7.409a	1	1 DEC 76	VA	0	15 AUG 75
7.410a	1	1 DEC 76	VA	0	15 AUG 75
7.410b	1	1 DEC 76	VA	0	15 AUG 75
7.410c	0	1 DEC 76	PA		
7.501	1	1 DEC 76	TC	0	15 AUG 76
7.503	1	1 DEC 76	TA	0	15 AUG 75
7.504	0	1 DEC 76	TA		

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
7.509	1	1 DEC 76	VA	0	15 AUG 75
7.510a	1	1 DEC 76	VA	0	15 AUG 75
7.510b	1	1 DEC 76	VA	0	15 AUG 75
7.510c	0	1 DEC 76	PA		
7.514	1	1 DEC 76	TC	0	15 AUG 75
7.609a	1	1 DEC 76	VA, VC	0	15 AUG 75
7.609b	0	1 DEC 76	PA, VA		
7.610a	1	1 DEC 76	VA	0	15 AUG 75
7.610b	1	1 DEC 76	VA	0	15 AUG 75
7.610c	0	1 DEC 76	PA		
7.614	1	1 DEC 76	SC	0	15 AUG 75
7.615	0	1 DEC 76	PA		
7.617	0	1 DEC 76	PA		
7.618	0	1 DEC 76	PA		
7.619	1	1 DEC 76	TC	0	15 AUG 75
7.621	1	1 DEC 76	TA	0	15 AUG 75
7.622	1	1 DEC 76	VA, TC	0	15 AUG 75
7.624	0	1 DEC 76	PA		
7.631	1	1 DEC 76	TA	0	15 AUG 75
7.641	1	1 DEC 76	TA	0	15 AUG 75
7.651	1	1 DEC 76	TA	0	15 AUG 75
7.652a	0	1 DEC 76	PA		
7.652b	0	1 DEC 76	PA		
7.653	0	1 DEC 76	PA		
7.654a	0	1 DEC 76	PA		
7.654b	0	1 DEC 76	PA		
7.661	0	1 DEC 76	PA		
7.662	0	1 DEC 76	PA		
7.663	1	1 DEC 76	TC	0	15 AUG 75

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
7.671	1	1 DEC 76	TA	0	15 AUG 75
7.674b	1	1 DEC 76	TC	0	15 AUG 75
7.675a	1	1 DEC 76	TC	0	15 AUG 75
7.675b	1	1 DEC 76	TC	0	15 AUG 75
7.677	0	1 DEC 76	PA		
FLS.1	1	1 DEC 76	TC, TA	0	15 AUG 75
IDS.1	1	1 DEC 76	TC	0	15 AUG 75
MAT.12	1	1 DEC 76	EC, TC	0	15 AUG 75
MAT.14	1	1 DEC 76	EC, TA	0	15 AUG 75
MAT.15	1	1 DEC 76	EC	0	15 AUG 75
MAT.17	1	1 DEC 76	EC, TC	0	15 AUG 75
MAT.19	1	1 DEC 76	SC, TA	0	15 AUG 75
MAT.21	1	1 DEC 76	SC, TA	0	15 AUG 75
MAX.1	1	1 DEC 76	TC, TA	0	15 AUG 75
OPT.1	1	1 DEC 76	TC, TA	0	15 AUG 75
OPT.2	1	1 DEC 76	TC, TA	0	15 AUG 75
OPT.3	1	1 DEC 76	TC, TA	0	15 AUG 75
OPT.4	1	1 DEC 76	SC	0	15 AUG 75
OPT.7	1	1 DEC 76	TA	0	15 AUG 75
OPT.10	1	1 DEC 76	TD	0	15 AUG 75
OPT.11	1	1 DEC 76	TA	0	15 AUG 75
OPT.13	1	1 DEC 76	TA, SC	0	15 AUG 75
OPT.14	1	1 DEC 76	TA	0	15 AUG 75
OPT.17	1	1 DEC 76	TA	0	15 AUG 75
OPT.18	1	1 DEC 76	TC	0	15 AUG 75
OPT.19	1	1 DEC 76	TC	0	15 AUG 75
OPT.20	1	1 DEC 76	TC	0	15 AUG 75
OPT.21	1	1 DEC 76	TC	0	15 AUG 75
OPT.22	1	1 DEC 76	SC	0	15 AUG 75

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
OPT.23	0	1 DEC 76	PA		
OPT.24	0	1 DEC 76	PA		
OPT.25	0	1 DEC 76	PA		
OPT.26	0	1 DEC 76	PA		
OPT.27	0	1 DEC 76	PA		
OPT.28	0	1 DEC 76	PA		
OPT.29	0	1 DEC 76	PA		
OPT.30	0	1 DEC 76	PA		
OPT.31	0	1 DEC 76	PA		
OPT.32	0	1 DEC 76	PA		
vi	1	1 DEC 76	TA	0	15 AUG 75
xiii	0	1 DEC 76	PA		
xiv	0	1 DEC 76	PA		
xv	0	1 DEC 76	PA		
xvi	0	1 DEC 76	PA		
xvii	0	1 DEC 76	PA		
xviii	0	1 DEC 76	PA		
xix	0	1 DEC 76	PA		

---

*Key to COMMENTS appears on Page xiii.

This page intentionally left blank.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
1.2	1	15 NOV 77	TA, TC	0	15 AUG 75
2.3	1	15 NOV 77	TC	0	15 AUG 75
2.4	1	15 NOV 77	TA	0	15 AUG 75
2.5	2	15 NOV 77	TA	1	1 DEC 76
2.6	1	15 NOV 77	VC	0	15 AUG 75
2.7	1	15 NOV 77	EC, SC	0	15 AUG 75
2.8	1	15 NOV 77	TC	0	15 AUG 75
2.9	1	15 NOV 77	VC, EC	0	15 AUG 75
2.10	1	15 NOV 77	TC, TA	0	15 AUG 75
2.11	1	15 NOV 77	TC, TA	0	15 AUG 75
2.12	1	15 NOV 77	TC	0	15 AUG 75
2.13	1	15 NOV 77	TC	0	15 AUG 75
2.14	1	15 NOV 77	TC, TA	0	15 AUG 75
2.15a	1	15 NOV 77	TC, TA, EC	0	15 AUG 75
2.15b	0	15 NOV 77	PA		
2.15c	0	15 NOV 77	PA		
2.15d	0	15 NOV 77	PA		
2.15e	0	15 NOV 77	PA		
2.15f	0	15 NOV 77	PA		
2.16	1	15 NOV 77	TC	0	15 AUG 75
2.17	1	15 NOV 77	TD	0	15 AUG 75
2.18	1	15 NOV 77	TD	0	15 AUG 75
2.22	1	15 NOV 77	NE	0	15 AUG 75
2.23	1	15 NOV 77	NE	0	15 AUG 75
2.24	1	15 NOV 77	NE	0	15 AUG 75
2.25	1	15 NOV 77	NE	0	15 AUG 75
2.26	1	15 NOV 77	NE, TC, EC	0	15 AUG 75
2.27	0	15 NOV 77	PA		
3.1a	1	15 NOV 77	TA	0	15 AUG 75
3.1b	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
3.2	2	15 NOV 77	EC, TC	1	1 DEC 76
3.3	2	15 NOV 77	EC, TC	1	1 DEC 76
3.4	1	15 NOV 77	TC	0	15 AUG 75
3.5	1	15 NOV 77	NF	0	15 AUG 75
3.6a	2	15 NOV 77	TA	1	1 DEC 76
3.6b	0	15 NOV 77	PA		
3.6c	0	15 NOV 77	PA		
3.6d	0	15 NOV 77	PA		
3.6e	0	15 NOV 77	PA		
3.6f	0	15 NOV 77	PA		
3.6g	0	15 NOV 77	PA		
3.7	1	15 NOV 77	EC, TC	0	15 AUG 75
3.8a	1	15 NOV 77	NF	0	15 AUG 75
3.8b	0	15 NOV 77	PA		
3.8c	0	15 NOV 77	PA		
3.8d	0	15 NOV 77	PA		
3.8e	0	15 NOV 77	PA		
3.8f	0	15 NOV 77	PA		
3.8g	0	15 NOV 77	PA		
3.8h	0	15 NOV 77	PA		
3.9	0	15 NOV 77	PA		
3.10	0	15 NOV 77	PA		
3.11	0	15 NOV 77	PA		
3.12	0	15 NOV 77	PA		
3.13	0	15 NOV 77	PA		
3.14	0	15 NOV 77	PA		
3.15	0	15 NOV 77	PA		
3.16	0	15 NOV 77	PA		
3.17	0	15 NOV 77	PA		
3.18	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
3.19	0	15 NOV 77	PA		
3.20	0	15 NOV 77	PA		
3.21	0	15 NOV 77	PA		
3.22	0	15 NOV 77	PA		
3.23	0	15 NOV 77	PA		
3.24	0	15 NOV 77	PA		
4.2	1	15 NOV 77	EC	0	15 AUG 75
4.3	1	15 NOV 77	EC, TA	0	15 AUG 75
4.4	1	15 NOV 77	EC	0	15 AUG 75
4.5	1	15 NOV 77	EC	0	15 AUG 75
4.7	2	15 NOV 77	EC	1	1 DEC 76
4.8	1	15 NOV 77	TC	0	15 AUG 75
4.17	1	15 NOV 77	EC, NE	0	15 AUG 75
4.18	1	15 NOV 77	NE	0	15 AUG 75
4.20	1	15 NOV 77	SC, NR	0	15 AUG 75
4.21	1	15 NOV 77	EC	0	15 AUG 75
4.22	1	15 NOV 77	EC, TC	0	15 AUG 75
4.23	1	15 NOV 77	VC, TC	0	15 AUG 75
4.25	1	15 NOV 77	EC	0	15 AUG 75
4.29	1	15 NOV 77	VC	0	15 AUG 75
4.34	1	15 NOV 77	VC	0	15 AUG 75
4.36	1	15 NOV 77	TC	0	15 AUG 75
4.42	0	15 NOV 77	PA		
4.43	0	15 NOV 77	PA		
4.44	0	15 NOV 77	PA		
4.45	0	15 NOV 77	PA		
4.46	0	15 NOV 77	PA		
4.47	0	15 NOV 77	PA		
5.1	1	15 NOV 77	TC	0	15 AUG 75
5.2	1	15 NOV 77	EC	0	15 AUG 75

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
5.3	2	15 NOV 77	EC	1	1 DEC 76
5.4	2	15 NOV 77	EC	1	1 DEC 76
5.5	1	15 NOV 77	EC	1	15 AUG 75
5.6	2	15 NOV 77	EC	1	1 DEC 76
5.7	2	15 NOV 77	EC, TC, TA	1	1 DEC 76
5.8	1	15 NOV 77	EC	0	15 AUG 75
5.10	2	15 NOV 77	EC	1	1 DEC 76
5.14	2	15 NOV 77	EC	1	1 DEC 76
5.17	1	15 NOV 77	TC	0	15 AUG 75
5.19	1	15 NOV 77	TA	0	15 AUG 75
5.20	1	15 NOV 77	EC, TC	0	15 AUG 75
5.22	1	15 NOV 77	TD, TC	0	15 AUG 75
5.24	1	15 NOV 77	TC, EC	0	15 AUG 75
5.25	1	15 NOV 77	EC, TC, NR	0	15 AUG 75
5.26	1	15 NOV 77	EC, VC, TC	0	15 AUG 75
5.27	1	15 NOV 77	NE, TC, VC	0	15 AUG 75
5.31	1	15 NOV 77	EC, TC	0	15 AUG 75
5.37	1	15 NOV 77	VC, TC	0	15 AUG 75
5.39b	1	15 NOV 77	EC	0	1 DEC 76
5.43	1	15 NOV 77	VC	0	15 AUG 75
5.44	1	15 NOV 77	VC	0	15 AUG 75
5.45	1	15 NOV 77	TC	0	15 AUG 75
5.51	0	15 NOV 77	PA		
5.52	0	15 NOV 77	PA		
5.53	0	15 NOV 77	PA		
5.54	0	15 NOV 77	PA		
5.55	0	15 NOV 77	PA		
5.56	0	15 NOV 77	PA		
6.1	0	15 NOV 77	PA		
6.2	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.3	0	15 NOV 77	PA		
6.4	0	15 NOV 77	PA		
6.5	0	15 NOV 77	PA		
6.6	0	15 NOV 77	PA		
6.7	0	15 NOV 77	PA		
6.8	0	15 NOV 77	PA		
6.9	0	15 NOV 77	PA		
6.10	0	15 NOV 77	PA		
6.11	0	15 NOV 77	PA		
6.12	0	15 NOV 77	PA		
6.13	0	15 NOV 77	PA		
6.14	0	15 NOV 77	PA		
6.15	0	15 NOV 77	PA		
6.16	0	15 NOV 77	PA		
6.17	0	15 NOV 77	PA		
6.18	0	15 NOV 77	PA		
6.19	0	15 NOV 77	PA		
6.20	0	15 NOV 77	PA		
6.21	0	15 NOV 77	PA		
6.22	0	15 NOV 77	PA		
6.23	0	15 NOV 77	PA		
6.24	0	15 NOV 77	PA		
6.25	0	15 NOV 77	PA		
6.26	0	15 NOV 77	PA		
6.27	0	15 NOV 77	PA		
6.28	0	15 NOV 77	PA		
6.29	0	15 NOV 77	PA		
6.30	0	15 NOV 77	PA		
6.31	0	15 NOV 77	PA		
6.32	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.33	0	15 NOV 77	PA		
6.34	0	15 NOV 77	PA		
6.35	0	15 NOV 77	PA		
6.36	0	15 NOV 77	PA		
6.37	0	15 NOV 77	PA		
6.38	0	15 NOV 77	PA		
6.39	0	15 NOV 77	PA		
6.40	0	15 NOV 77	PA		
6.41	0	15 NOV 77	PA		
6.42	0	15 NOV 77	PA		
6.43	0	15 NOV 77	PA		
6.44	0	15 NOV 77	PA		
6.45	0	15 NOV 77	PA		
6.46	0	15 NOV 77	PA		
6.47	0	15 NOV 77	PA		
6.48	0	15 NOV 77	PA		
6.49	0	15 NOV 77	PA		
6.50	0	15 NOV 77	PA		
6.51	0	15 NOV 77	PA		
6.52	0	15 NOV 77	PA		
6.53	0	15 NOV 77	PA		
6.54	0	15 NOV 77	PA		
6.55	0	15 NOV 77	PA		
6.56	0	15 NOV 77	PA		
6.57	0	15 NOV 77	PA		
6.58	0	15 NOV 77	PA		
6.59	0	15 NOV 77	PA		
6.60	0	15 NOV 77	PA		
6.61	0	15 NOV 77	PA		
6.62	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.63	0	15 NOV 77	PA		
6.64	0	15 NOV 77	PA		
6.65	0	15 NOV 77	PA		
6.66	0	15 NOV 77	PA		
6.67	0	15 NOV 77	PA		
6.68	0	15 NOV 77	PA		
6.69	0	15 NOV 77	PA		
6.70	0	15 NOV 77	PA		
6.71	0	15 NOV 77	PA		
6.72	0	15 NOV 77	PA		
6.73	0	15 NOV 77	PA		
6.74	0	15 NOV 77	PA		
6.75	0	15 NOV 77	PA		
6.76	0	15 NOV 77	PA		
6.77	0	15 NOV 77	PA		
6.78	0	15 NOV 77	PA		
6.79	0	15 NOV 77	PA		
6.80	0	15 NOV 77	PA		
6.81	0	15 NOV 77	PA		
6.82	0	15 NOV 77	PA		
6.83	0	15 NOV 77	PA		
6.84	0	15 NOV 77	PA		
6.85	0	15 NOV 77	PA		
6.86	0	15 NOV 77	PA		
6.87	0	15 NOV 77	PA		
6.88	0	15 NOV 77	PA		
6.89	0	15 NOV 77	PA		
6.90	0	15 NOV 77	PA		
6.91	0	15 NOV 77	PA		
6.92	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.93	0	15 NOV 77	PA		
6.94	0	15 NOV 77	PA		
6.95	0	15 NOV 77	PA		
6.96	0	15 NOV 77	PA		
6.97	0	15 NOV 77	PA		
6.98	0	15 NOV 77	PA		
6.99	0	15 NOV 77	PA		
6.100	0	15 NOV 77	PA		
6.101	0	15 NOV 77	PA		
6.102	0	15 NOV 77	PA		
6.103	0	15 NOV 77	PA		
6.104	0	15 NOV 77	PA		
6.105	0	15 NOV 77	PA		
6.106	0	15 NOV 77	PA		
6.107	0	15 NOV 77	PA		
6.108	0	15 NOV 77	PA		
6.109	0	15 NOV 77	PA		
6.110	0	15 NOV 77	PA		
6.111	0	15 NOV 77	PA		
6.112	0	15 NOV 77	PA		
6.113	0	15 NOV 77	PA		
6.114	0	15 NOV 77	PA		
6.115	0	15 NOV 77	PA		
6.116	0	15 NOV 77	PA		
6.117	0	15 NOV 77	PA		
6.118	0	15 NOV 77	PA		
6.119	0	15 NOV 77	PA		
6.120	0	15 NOV 77	PA		
6.121	0	15 NOV 77	PA		
6.122	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.123	0	15 NOV 77	PA		
6.124	0	15 NOV 77	PA		
6.125	0	15 NOV 77	PA		
6.126	0	15 NOV 77	PA		
6.127	0	15 NOV 77	PA		
6.128	0	15 NOV 77	PA		
6.129	0	15 NOV 77	PA		
6.130	0	15 NOV 77	PA		
6.131	0	15 NOV 77	PA		
6.132	0	15 NOV 77	PA		
6.133	0	15 NOV 77	PA		
6.134	0	15 NOV 77	PA		
6.135	0	15 NOV 77	PA		
6.136	0	15 NOV 77	PA		
6.137	0	15 NOV 77	PA		
6.138	0	15 NOV 77	PA		
6.139	0	15 NOV 77	PA		
6.140	0	15 NOV 77	PA		
6.141	0	15 NOV 77	PA		
6.142	0	15 NOV 77	PA		
6.143	0	15 NOV 77	PA		
6.144	0	15 NOV 77	PA		
6.145	0	15 NOV 77	PA		
6.146	0	15 NOV 77	PA		
6.147	0	15 NOV 77	PA		
6.148	0	15 NOV 77	PA		
6.149	0	15 NOV 77	PA		
6.150	0	15 NOV 77	PA		
6.151	0	15 NOV 77	PA		
6.152	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.153	0	15 NOV 77	PA		
6.154	0	15 NOV 77	PA		
6.155	0	15 NOV 77	PA		
6.156	0	15 NOV 77	PA		
6.157	0	15 NOV 77	PA		
6.158	0	15 NOV 77	PA		
6.159	0	15 NOV 77	PA		
6.160	0	15 NOV 77	PA		
6.161	0	15 NOV 77	PA		
7.a	1	15 NOV 77	PC	0	15 AUG 75
7.b	1	15 NOV 77	PC	0	15 AUG 75
7.c	1	15 NOV 77	PC	0	15 AUG 75
7.d	1	15 NOV 77	PC	0	15 AUG 75
7.e	1	15 NOV 77	PC	0	15 AUG 75
7.f	1	15 NOV 77	PC	0	15 AUG 75
7.g	1	15 NOV 77	PC, TC	0	15 AUG 75
7.h	1	15 NOV 77	PC	0	15 AUG 75
7.i	1	15 NOV 77	PC	0	15 AUG 75
7.j	1	15 NOV 77	PC, TC, TA	0	15 AUG 75
7.k	0	15 NOV 77	PA		
7.ℓ	1	15 NOV 77	PC	0	1 DEC 76
7.m	1	15 NOV 77	PC, TC	0	1 DEC 76
7.n	1	15 NOV 77	PC, TC	0	1 DEC 76
7.r	2	15 NOV 77	PC	1	1 DEC 76
7.s	1	15 NOV 77	PC	0	15 AUG 75
7.001	2	15 NOV 77	TC, TA	1	1 DEC 76
7.002	1	15 NOV 77	TC	0	15 AUG 75
7.009	2	15 NOV 77	VA	1	1 DEC 76
7.012	1	15 NOV 77	TC	0	15 AUG 75
7.013	1	15 NOV 77	TC	0	15 AUG 75

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
7.014	1	15 NOV 77	TC, TA	0	15 AUG 75
7.016b	2	15 NOV 77	TC	1	1 DEC 76
7.017	1	15 NOV 77	VA, TA	0	15 AUG 75
7.018a	1	15 NOV 77	VA, TA	0	15 AUG 75
7.018b	0	15 NOV 77	PA		
7.113	2	15 NOV 77	TC, TD	1	1 DEC 76
7.201	1	15 NOV 77	TA, TC	0	15 AUG 75
7.202a	2	15 NOV 77	PC	1	1 DEC 76
7.202b	0	15 NOV 77	PA		
7.202c	0	15 NOV 77	PA		
7.203	1	15 NOV 77	TC	0	15 AUG 75
7.204	1	15 NOV 77	TA, TC	0	15 AUG 75
7.207	2	15 NOV 77	TA, TC	1	1 DEC 76
7.208	1	15 NOV 77	TC	0	1 DEC 76
7.209a	2	15 NOV 77	VA	1	1 DEC 76
7.211	1	15 NOV 77	VC	0	15 AUG 75
7.212b	2	15 NOV 77	TC	1	1 DEC 76
7.221a	1	15 NOV 77	VA	0	15 AUG 75
7.221b	1	15 NOV 77	VA, TC, VC	0	15 AUG 75
7.301	2	15 NOV 77	TA, SC	1	1 DEC 76
7.302a	1	15 NOV 77	TA, TC	0	1 DEC 76
7.302b	0	15 NOV 77	PA		
7.302c	0	15 NOV 77	PA		
7.309	2	15 NOV 77	VC, VA	1	1 DEC 76
7.311a	1	15 NOV 77	VA	0	15 AUG 75
7.311b	1	15 NOV 77	VA, TA	0	15 AUG 75
7.381a	1	15 NOV 77	TC	0	1 DEC 76
7.381b	0	15 NOV 77	PA		
7.382a	1	15 NOV 77	TC	0	1 DEC 76
7.382b	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
7.382c	0	15 NOV 77	PA		
7.382d**	0	15 NOV 77	PA		
7.388	0	15 NOV 77	PA		
7.389	0	15 NOV 77	PA		
7.401	1	15 NOV 77	TC	0	15 AUG 75
7.402	1	15 NOV 77	TA	0	15 AUG 75
7.403	1	15 NOV 77	TC, TA	0	15 AUG 75
7.409a	2	15 NOV 77	VA	1	1 DEC 76
7.409b	1	15 NOV 77	VA	0	15 AUG 75
7.412c	1	15 NOV 77	TC	0	15 AUG 75
7.422	1	15 NOV 77	TC	0	15 AUG 75
7.423	1	15 NOV 77	TC	0	15 AUG 75
7.431a	1	15 NOV 77	TC	0	15 AUG 75
7.432	1	15 NOV 77	TC	0	15 AUG 75
7.441a	1	15 NOV 77	TC	0	15 AUG 75
7.442	1	15 NOV 77	TC	0	15 AUG 75
7.443a	1	15 NOV 77	TC	0	15 AUG 75
7.444	1	15 NOV 77	TC	0	15 AUG 75
7.445a	0	15 NOV 77	PA		
7.445b	0	15 NOV 77	PA		
7.446	0	15 NOV 77	PA		
7.451a	1	15 NOV 77	TC	0	15 AUG 75
7.452	1	15 NOV 77	TC	0	15 AUG 75
7.461a	1	15 NOV 77	TC	0	15 AUG 75
7.462	1	15 NOV 77	TC	0	15 AUG 75
7.463a	1	15 NOV 77	TC	0	15 AUG 75
7.464	1	15 NOV 77	TC	0	15 AUG 75
7.465a	0	15 NOV 77	PA		
7.465b	0	15 NOV 77	PA		
7.466	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

**Pages 7.383a, 7.383b, and 7.383c are to be removed from the manual.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
7.481	1	15 NOV 77	VC	0	15 AUG 75
7.482a	1	15 NOV 77	VA, TA	0	15 AUG 75
7.482b	1	15 NOV 77	VA, TA	0	15 AUG 75
7.601	1	15 NOV 77	TA	0	15 AUG 75
7.602	1	15 NOV 77	TC	0	15 AUG 75
7.609a	2	15 NOV 77	VA	1	1 DEC 76
7.609b	1	15 NOV 77	VA	0	1 DEC 76
7.621	2	15 NOV 77	TC	1	1 DEC 76
7.622a	2	15 NOV 77	VA, TC, VC	1	1 DEC 76
7.622b	0	15 NOV 77	PA		
7.624	1	15 NOV 77	TD	0	1 DEC 76
7.631	2	15 NOV 77	TC	1	1 DEC 76
7.632a	1	15 NOV 77	VA	0	15 AUG 75
7.632b	1	15 NOV 77	VC, VA, TA	0	15 AUG 75
7.641	2	15 NOV 77	TC	1	1 DEC 76
7.651	2	15 NOV 77	TC	1	1 DEC 76
7.652a	1	15 NOV 77	VC, VA, TA	0	1 DEC 76
7.652b	1	15 NOV 77	VC, VA, TA	0	1 DEC 76
7.661	1	15 NOV 77	TC	0	1 DEC 76
7.662	1	15 NOV 77	TC	0	1 DEC 76
7.663	2	15 NOV 77	TC	1	1 DEC 76
7.671	2	15 NOV 77	TC	1	1 DEC 76
7.672a	1	15 NOV 77	TC, TA	0	15 AUG 75
7.672b	1	15 NOV 77	TC, TA	0	15 AUG 75
7.674a	1	15 NOV 77	TC, TA	0	15 AUG 75
7.674b	2	15 NOV 77	TC, TA	1	1 DEC 76
7.675a	2	15 NOV 77	VC	1	1 DEC 76
7.677	1	15 NOV 77	TC	0	1 DEC 76

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
BIA.1	0	15 NOV 77	PA		
BIA.2	0	15 NOV 77	PA		
BIA.3	0	15 NOV 77	PA		
BIA.4	0	15 NOV 77	PA		
BIA.5	0	15 NOV 77	PA		
BIA.6	0	15 NOV 77	PA		
BIA.7	0	15 NOV 77	PA		
BIA.8	0	15 NOV 77	PA		
BIA.9	0	15 NOV 77	PA		
BIA.10	0	15 NOV 77	PA		
BIA.11	0	15 NOV 77	PA		
BIA.12	0	15 NOV 77	PA		
BIA.13	0	15 NOV 77	PA		
BIA.14	0	15 NOV 77	PA		
BIA.15	0	15 NOV 77	PA		
BIA.16	0	15 NOV 77	PA		
BIA.17	0	15 NOV 77	PA		
BIA.18	0	15 NOV 77	PA		
BIA.19	0	15 NOV 77	PA		
BIA.20	0	15 NOV 77	PA		
BIA.21	0	15 NOV 77	PA		
BIA.22	0	15 NOV 77	PA		
BIA.23	0	15 NOV 77	PA		
BIA.24	0	15 NOV 77	PA		
FLS.1	2	15 NOV 77	TC	1	1 DEC 76
GLS.2	1	15 NOV 77	TC, TA	0	15 AUG 75
IDS.1	2	15 NOV 77	TA	1	1 DEC 76
MAT.2	1	15 NOV 77	TC	0	15 AUG 75
MAT.3	1	15 NOV 77	TC, TA	0	15 AUG 75
MAT.4	1	15 NOV 77	TC	0	15 AUG 75

---

*Key to COMMENTS appears on Page xiii.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
MAT.5	1	15 NOV 77	TC	0	15 AUG 75
MAT.7	1	15 NOV 77	TC	0	15 AUG 75
MAT.10	1	15 NOV 77	TA	0	15 AUG 75
MAX.1	2	15 NOV 77	TA, TD, TC	1	1 DEC 76
MSG.1	1	15 NOV 77	TC	0	15 AUG 75
MSG.2	1	15 NOV 77	TA	0	15 AUG 75
NTN.1,2	1	15 NOV 77	VA, VC	0	15 AUG 75
REF.1	1	15 NOV 77	TC	0	15 AUG 75
iii	1	15 NOV 77	TA	0	15 AUG 75
v	1	15 NOV 77	TA, TC	0	15 AUG 75
vi	2	15 NOV 77	TA, TC	1	1 DEC 76
vii	1	15 NOV 77	TA, TC	0	15 AUG 75
viii	1	15 NOV 77	TA, TC	0	15 AUG 75
ix	1	15 NOV 77	TA, TC	0	15 AUG 75
xi	1	15 NOV 77	TC	0	15 AUG 75
xiii	1	15 NOV 77	TA	0	15 AUG 75
xxi	0	15 NOV 77	PA		
xxii	0	15 NOV 77	PA		
xxiii	0	15 NOV 77	PA		
xxiv	0	15 NOV 77	PA		
xxv	0	15 NOV 77	PA		
xxvi	0	15 NOV 77	PA		
xxvii	0	15 NOV 77	PA		
xxviii	0	15 NOV 77	PA		
xxix	0	15 NOV 77	PA		
xxx	0	15 NOV 77	PA		
xxxi	0	15 NOV 77	PA		
xxxii	0	15 NOV 77	PA		
xxxiii	0	15 NOV 77	PA		
xxxiv	0	15 NOV 77	PA		
xxv	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

This page intentionally left blank.

REVISIONS

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
i	3	30 SEP 80	TC	2	15 NOV 77
iii	2	30 SEP 80	TC	1	15 NOV 77
v	2	30 SEP 80	TA	1	15 NOV 77
vi	3	30 SEP 80	TA	2	15 NOV 77
vi.a	0	30 SEP 80	PA		
vii	2	30 SEP 80	TA	1	15 NOV 77
viii	2	30 SEP 80	TA, TC	1	15 NOV 77
viii.a	0	30 SEP 80	PA		
ix	2	30 SEP 80	TA, TC	1	15 NOV 77
1.1	1	30 SEP 80	TC, TA	0	15 AUG 75
1.2	2	30 SEP 80	TA, TD	1	15 NOV 77
1.3	0	30 SEP 80	PA		
1.4	0	30 SEP 80	PA		
1.5	0	30 SEP 80	PA		
1.6	0	30 SEP 80	PA		
1.7	0	30 SEP 80	PA		
2.3	2	30 SEP 80	TC	1	15 NOV 77
2.5	3	30 SEP 80	TC	2	15 NOV 77
2.12	2	30 SEP 80	TC	1	15 NOV 77
2.22	2	30 SEP 80	TC	1	15 NOV 77
2.23	2	30 SEP 80	TA, EA	1	15 NOV 77
2.25	2	30 SEP 80	TC, EC	1	15 NOV 77
2.26	2	30 SEP 80	EC	1	15 NOV 77
2.28	0	30 SEP 80	PA		
3.1a	2	30 SEP 80	TC	1	15 NOV 77
3.1b	1	30 SEP 80	TC	0	15 NOV 77
3.3	3	30 SEP 80	EC	2	15 NOV 77
3.7	2	30 SEP 80	TC, EC	1	15 NOV 77
3.8b	1	30 SEP 80	EC	0	15 NOV 77

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
3.8c	1	30 SEP 80	TA	0	15 NOV 77
3.8d	1	30 SEP 80	PC	0	15 NOV 77
3.8e	1	30 SEP 80	PC	0	15 NOV 77
3.8f	1	30 SEP 80	EC	0	15 NOV 77
3.8g	1	30 SEP 80	TC	0	15 NOV 77
3.8i	0	30 SEP 80	PA		
3.8j	0	30 SEP 80	PA		
3.8k	0	30 SEP 80	PA		
3.11	1	30 SEP 80	TC	0	15 NOV 77
3.17	1	30 SEP 80	TC	0	15 NOV 77
3.18	1	30 SEP 80	EC	0	15 NOV 77
3.24	1	30 SEP 80	TC	0	15 NOV 77
3.25	0	30 SEP 80	PA		
3.26	0	30 SEP 80	PA		
3.27	0	30 SEP 80	PA		
3.28	0	30 SEP 80	PA		
4.2	2	30 SEP 80	TC	1	15 NOV 77
4.3	2	30 SEP 80	TC	1	15 NOV 77
4.4	2	30 SEP 80	EC	1	15 NOV 77
4.5	2	30 SEP 80	EC	1	15 NOV 77
4.9	1	30 SEP 80	EC	0	15 AUG 75
4.11	1	30 SEP 80	EC	0	15 AUG 75
4.18	2	30 SEP 80	TC	1	15 NOV 77
4.20	2	30 SEP 80	TC	1	15 NOV 77
4.21	2	30 SEP 80	TC, TA	1	15 NOV 77
4.34	2	30 SEP 80	EC	1	15 NOV 77
4.35	1	30 SEP 80	EC	0	15 AUG 75
4.39	1	30 SEP 80	TA, EC	0	15 AUG 75

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
4.40	1	30 SEP 80	PC, NF	0	15 AUG 75
4.40a	0	30 SEP 80	PA		
4.40b	0	30 SEP 80	PA		
4.41	2	30 SEP 80	EC	1	01 DEC 76
4.45	1	30 SEP 80	TC	0	15 NOV 77
4.48	0	30 SEP 80	PA		
5.2	2	30 SEP 80	TC	1	15 NOV 77
5.3	3	30 SEP 80	TC	2	15 NOV 77
5.9	1	30 SEP 80	TC	0	15 AUG 75
5.18	1	30 SEP 80	TC	0	15 AUG 75
5.19	2	30 SEP 80	TC	1	15 NOV 77
5.24a	0	30 SEP 80	PA		
5.24b	0	30 SEP 80	PA		
5.25	2	30 SEP 80	TC, TA	1	15 NOV 77
5.26	2	30 SEP 80	NE, TA	1	15 NOV 77
5.26a	0	30 SEP 80	PA		
5.26b	0	30 SEP 80	PA		
5.29	1	30 SEP 80	EC, TC	0	15 AUG 75
5.43	2	30 SEP 80	EC	1	15 NOV 77
5.44	2	30 SEP 80	EC	1	15 NOV 77
5.48	1	30 SEP 80	TC, EC	0	15 AUG 75
5.49	1	30 SEP 80	PC, NF	0	15 AUG 75
5.49a	0	30 SEP 80	PA		
5.49b	0	30 SEP 80	PA		
5.50	2	30 SEP 80	EC	1	01 DEC 76
5.53	1	30 SEP 80	NE	0	15 NOV 77
5.54	1	30 SEP 80	EC, TC	0	15 NOV 77
5.57	0	30 SEP 80	PA		

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.1	1	30 SEP 80	PC	0	15 NOV 77
6.2	1	30 SEP 80	TC, EA	0	15 NOV 77
6.3	0	15 NOV 77	PA		
6.4	0	15 NOV 77	PA		
6.5	0	15 NOV 77	PA		
6.6	0	15 NOV 77	PA		
6.7	0	15 NOV 77	PA		
6.8	0	15 NOV 77	PA		
6.9	0	15 NOV 77	PA		
6.10	0	15 NOV 77	PA		
6.11	0	15 NOV 77	PA		
6.12	0	15 NOV 77	PA		
6.13	0	15 NOV 77	PA		
6.14	0	15 NOV 77	PA		
6.15	0	15 NOV 77	PA		
6.16	0	15 NOV 77	PA		
6.17	0	15 NOV 77	PA		
6.18	0	15 NOV 77	PA		
6.19	0	15 NOV 77	PA		
6.20	0	15 NOV 77	PA		
6.21	0	15 NOV 77	PA		
6.22	0	15 NOV 77	PA		
6.23	0	15 NOV 77	PA		
6.24	0	15 NOV 77	PA		
6.25	0	15 NOV 77	PA		
6.26	0	15 NOV 77	PA		
6.27	0	15 NOV 77	PA		
6.28	0	15 NOV 77	PA		
6.29	0	15 NOV 77	PA		
6.30	1	30 SEP 80	TC	0	15 NOV 77

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.31	0	15 NOV 77	PA		
6.32	1	30 SEP 80	EC	0	15 NOV 77
6.33	0	15 NOV 77	PA		
6.34	0	15 NOV 77	PA		
6.35	0	15 NOV 77	PA		
6.36	0	15 NOV 77	PA		
6.37	1	30 SEP 80	NE	0	15 NOV 77
6.38	0	15 NOV 77	PA		
6.39	0	15 NOV 77	PA		
6.40	0	15 NOV 77	PA		
6.41	0	15 NOV 77	PA		
6.42	0	15 NOV 77	PA		
6.43	0	15 NOV 77	PA		
6.44	0	15 NOV 77	PA		
6.45	0	15 NOV 77	PA		
6.46	0	15 NOV 77	PA		
6.47	0	15 NOV 77	PA		
6.48	0	15 NOV 77	PA		
6.49	0	15 NOV 77	PA		
6.50	0	15 NOV 77	PA		
6.51	0	15 NOV 77	PA		
6.52	0	15 NOV 77	PA		
6.53	0	15 NOV 77	PA		
6.54	0	15 NOV 77	PA		
6.55	0	15 NOV 77	PA		
6.56	0	15 NOV 77	PA		
6.57	0	15 NOV 77	PA		
6.58	0	15 NOV 77	PA		
6.59	0	15 NOV 77	PA		
6.60	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.61	0	15 NOV 77	PA		
6.62	0	15 NOV 77	PA		
6.63	0	15 NOV 77	PA		
6.64	0	15 NOV 77	PA		
6.65	0	15 NOV 77	PA		
6.66	0	15 NOV 77	PA		
6.67	0	15 NOV 77	PA		
6.68	0	15 NOV 77	PA		
6.69	0	15 NOV 77	PA		
6.70	0	15 NOV 77	PA		
6.71	0	15 NOV 77	PA		
6.72	0	15 NOV 77	PA		
6.73	0	15 NOV 77	PA		
6.74	0	15 NOV 77	PA		
6.75	0	15 NOV 77	PA		
6.76	0	15 NOV 77	PA		
6.77	0	15 NOV 77	PA		
6.78	0	15 NOV 77	PA		
6.79	0	15 NOV 77	PA		
6.80	0	15 NOV 77	PA		
6.81	0	15 NOV 77	PA		
6.82	0	15 NOV 77	PA		
6.83	0	15 NOV 77	PA		
6.84	0	15 NOV 77	PA		
6.85	0	15 NOV 77	PA		
6.86	0	15 NOV 77	PA		
6.87	0	15 NOV 77	PA		
6.88	0	15 NOV 77	PA		
6.89	0	15 NOV 77	PA		
6.90	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.91	0	15 NOV 77	PA		
6.92	0	15 NOV 77	PA		
6.93	0	15 NOV 77	PA		
6.94	0	15 NOV 77	PA		
6.95	0	15 NOV 77	PA		
6.96	0	15 NOV 77	PA		
6.97	0	15 NOV 77	PA		
6.98	0	15 NOV 77	PA		
6.99	0	15 NOV 77	PA		
6.100	0	15 NOV 77	PA		
6.101	0	15 NOV 77	PA		
6.102	0	15 NOV 77	PA		
6.103	0	15 NOV 77	PA		
6.104	0	15 NOV 77	PA		
6.105	0	15 NOV 77	PA		
6.106	0	15 NOV 77	PA		
6.107	0	15 NOV 77	PA		
6.108	0	15 NOV 77	PA		
6.109	0	15 NOV 77	PA		
6.110	0	15 NOV 77	PA		
6.111	0	15 NOV 77	PA		
6.112	0	15 NOV 77	PA		
6.112a	0	30 SEP 80	PA		
6.113	1	30 SEP 80	TC	0	15 NOV 77
6.114	1	30 SEP 80	NE	0	15 NOV 77
6.114a	0	30 SEP 80	PA		
6.114b	0	30 SEP 80	PA		
6.115	0	15 NOV 77	PA		
6.116	0	15 NOV 77	PA		
6.117	0	15 NOV 77	PA		
6.118	1	30 SEP 80	EC	0	15 NOV 77
6.119	0	15 NOV 77	PA		
6.120	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.121	0	15 NOV 77	PA		
6.122	0	15 NOV 77	PA		
6.123	0	15 NOV 77	PA		
6.124	0	15 NOV 77	PA		
6.125	0	15 NOV 77	PA		
6.126	0	15 NOV 77	PA		
6.127	0	15 NOV 77	PA		
6.128	0	15 NOV 77	PA		
6.129	0	15 NOV 77	PA		
6.130	0	15 NOV 77	PA		
6.131	0	15 NOV 77	PA		
6.132	0	15 NOV 77	PA		
6.133	0	15 NOV 77	PA		
6.134	0	15 NOV 77	PA		
6.135	0	15 NOV 77	PA		
6.136	0	15 NOV 77	PA		
6.137	0	15 NOV 77	PA		
6.138	0	15 NOV 77	PA		
6.139	0	15 NOV 77	PA		
6.140	0	15 NOV 77	PA		
6.141	0	15 NOV 77	PA		
6.142	0	15 NOV 77	PA		
6.143	0	15 NOV 77	PA		
6.144	0	15 NOV 77	PA		
6.145	0	15 NOV 77	PA		
6.146	0	15 NOV 77	PA		
6.147	0	15 NOV 77	PA		
6.148	0	15 NOV 77	PA		
6.149	0	15 NOV 77	PA		
6.150	0	15 NOV 77	PA		

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
6.151	0	15 NOV 77	PA		
6.152	0	15 NOV 77	PA		
6.153	0	15 NOV 77	PA		
6.154	1	30 SEP 80	EC	0	15 NOV 77
6.155	0	15 NOV 77	PA		
6.156	0	15 NOV 77	PA		
6.157	0	15 NOV 77	PA		
6.158	0	15 NOV 77	PA		
6.159	1	30 SEP 80	TC	0	15 NOV 77
6.159a	0	30 SEP 80	PA		
6.159b	0	30 SEP 80	PA		
6.160	1	30 SEP 80	TC	0	15 NOV 77
6.161	1	30 SEP 80	EC	0	15 NOV 77
6.162	0	30 SEP 80	PA		
6.163	0	30 SEP 80	PA		
6.164	0	30 SEP 80	PA		
6.165	0	30 SEP 80	PA		
6.166	0	30 SEP 80	PA		
6.167	0	30 SEP 80	PA		
6.168	0	30 SEP 80	PA		
6.169	0	30 SEP 80	PA		
6.170	0	30 SEP 80	PA		

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
7.c	2	30 SEP 80	TC, SC	1	15 NOV 77
7.d	2	30 SEP 80	TA	1	15 NOV 77
7.e	2	30 SEP 80	TC, TA	1	15 NOV 77
7.f	2	30 SEP 80	TA	1	15 NOV 77
7.g	2	30 SEP 80	SC	1	15 NOV 77
7.m	2	30 SEP 80	TC, TA	1	15 NOV 77
7.n	2	30 SEP 80	TC, TA	1	15 NOV 77
7.o	0	30 SEP 80	PA		
7.p	0	30 SEP 80	PA		
7.x/7.r	3	30 SEP 80	PA, PD	2	15 NOV 77
7.y/7.s	2	30 SEP 80	PA, PD	1	15 NOV 77
7.z	0	30 SEP 80	PA		
7.001	3	30 SEP 80	TC	2	15 NOV 77
7.011	2	30 SEP 80	TC	1	01 DEC 76
7.012	2	30 SEP 80	TA	1	15 NOV 77
7.013	2	30 SEP 80	TA	1	15 NOV 77
7.014	2	30 SEP 80	TA	1	15 NOV 77
7.016a	1	30 SEP 80	TC	0	15 AUG 75
7.018a	2	30 SEP 80	TA, SC	1	15 NOV 77
7.111a	1	30 SEP 80	SC, TC	0	15 AUG 75
7.112b	2	30 SEP 80	TA	1	01 DEC 76
7.203	2	30 SEP 80	TD	1	15 NOV 77
7.204	2	30 SEP 80	SC	1	15 NOV 77
7.205	1	30 SEP 80	SC, TC, TA	0	15 AUG 75
7.206	2	30 SEP 80	TA	1	01 DEC 76
7.207	3	30 SEP 80	TA	2	15 NOV 77
7.207a	0	30 SEP 80	PA		
7.209a	3	30 SEP 80	TA	2	15 NOV 77
7.209b	2	30 SEP 80	TA	1	01 DEC 76

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev. #	New Date	COMMENTS*	Old Rev.#	Old Date
7.211	2	30 SEP 80	TA, SC	1	15 NOV 77
7.221a	2	30 SEP 80	TA	1	15 NOV 77
7.221b	2	30 SEP 80	SC	1	15 NOV 77
7.233a	0	30 SEP 80	PA		
7.233b	0	30 SEP 80	PA		
7.248a	0	30 SEP 80	PA		
7.248b	0	30 SEP 80	PA		
7.249a	0	30 SEP 80	PA		
7.249b	0	30 SEP 80	PA		
7.257a	2	30 SEP 80	TA	1	01 DEC 76
7.271	0	30 SEP 80	PA		
7.301	3	30 SEP 80	TA	2	15 NOV 77
7.302	2	30 SEP 80	TC	1	15 NOV 77
7.303/7.302b	1	30 SEP 80	TC	0	15 NOV 77
7.304/7.302c	1	30 SEP 80	TC	0	15 NOV 77
7.305	0	30 SEP 80	PA		
7.309	3	30 SEP 80	TA	2	15 NOV 77
7.311a	2	30 SEP 80	TA	1	15 NOV 77
7.321	2	30 SEP 80	TA	1	01 DEC 76
7.381a	2	30 SEP 80	SC	1	15 NOV 77
7.382a	2	30 SEP 80	TA	1	15 NOV 77
7.388	1	30 SEP 80	TA	0	15 NOV 77
7.401	2	30 SEP 80	SC	1	15 NOV 77
7.402	2	30 SEP 80	TA	1	15 NOV 77
7.404	1	30 SEP 80	TA, TC	0	15 AUG 75
7.409a	3	30 SEP 80	TA	2	15 NOV 77
7.409b	2	30 SEP 80	TA	1	15 NOV 77
7.411a	1	30 SEP 80	TC, TA	0	15 AUG 75
7.412a	1	30 SEP 80	TC, TA	0	15 AUG 75
7.412b	1	30 SEP 80	TA	0	15 AUG 75
7.412c	2	30 SEP 80	TA	1	15 NOV 77

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
7.413a	0	30 SEP 80	PA		
7.413b	0	30 SEP 80	PA		
7.414a	0	30 SEP 80	PA		
7.414b	0	30 SEP 80	PA		
7.421b	1	30 SEP 80	TA	0	15 AUG 75
7.422	2	30 SEP 80	TA, TD	1	15 NOV 77
7.423	2	30 SEP 80	TA, TD	1	15 NOV 77
7.451b	1	30 SEP 80	SC	0	15 AUG 75
7.482a	2	30 SEP 80	TA	1	15 NOV 77
7.482b	2	30 SEP 80	TA, SC	1	15 NOV 77
7.483b	1	30 SEP 80	SC	0	15 AUG 75
7.484b	1	30 SEP 80	SC	0	15 AUG 75
7.503	2	30 SEP 80	TA	1	01 DEC 76
7.513a	1	30 SEP 80	TA	0	15 AUG 75
7.514	2	30 SEP 80	TA	1	01 DEC 76
7.609a	3	30 SEP 80	TA	2	15 NOV 77
7.610a	2	30 SEP 80	TC	1	01 DEC 76
7.616	1	30 SEP 80	TA	0	15 AUG 75
7.623	1	30 SEP 80	TC	0	15 AUG 75
7.624	2	30 SEP 80	TA	1	15 NOV 77
7.625	0	30 SEP 80	PA		
7.631	3	30 SEP 80	SC	2	15 NOV 77
7.641	3	30 SEP 80	SC	2	15 NOV 77
7.651	3	30 SEP 80	SC	2	15 NOV 77
7.653	1	30 SEP 80	TA, TD	0	01 DEC 76
7.654a	1	30 SEP 80	TA, TC	0	01 DEC 76
7.661	2	30 SEP 80	SC	1	15 NOV 77
7.663	3	30 SEP 80	SC	2	15 NOV 77
7.674a	2	30 SEP 80	TA, SC	1	15 NOV 77
7.674b	3	30 SEP 80	TA, TC	2	15 NOV 77
7.674c	0	30 SEP 80	PA		
7.675a	3	30 SEP 80	TA, TC	2	15 NOV 77
7.675b	2	30 SEP 80	TA	1	01 DEC 76

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
7.677	2	30 SEP 80	SC	1	15 NOV 77
BIA.1	1	30 SEP 80	TC	0	15 NOV 77
BIA.5	1	30 SEP 80	TC	0	15 NOV 77
BIA.9	1	30 SEP 80	TA	0	15 NOV 77
BIA.25	0	30 SEP 80	PA		
BIA.26	0	30 SEP 80	PA		
BIA.27	0	30 SEP 80	PA		
BIA.28	0	30 SEP 80	PA		
BIA.29	0	30 SEP 80	PA		
BIA.30	0	30 SEP 80	PA		
BIA.31	0	30 SEP 80	PA		
BIA.32	0	30 SEP 80	PA		
FLS.1	3	30 SEP 80	TA, TC	2	15 NOV 77
GLS.1	1	30 SEP 80	SC	0	15 AUG 75
GLS.2	2	30 SEP 80	TA	1	15 NOV 77
GLS.2a	0	30 SEP 80	PA		
GLS.3	1	30 SEP 80	TD	0	15 AUG 75
GLS.4	1	30 SEP 80	TA	0	15 AUG 75
GLS.6	1	30 SEP 80	TA	0	15 AUG 75
GLS.7	1	30 SEP 80	TA	0	15 AUG 75
GLS.8	1	30 SEP 80	TA	0	15 AUG 75
HYD.1	0	30 SEP 80	PA		
HYD.2	0	30 SEP 80	PA		
HYD.3	0	30 SEP 80	PA		
HYD.4	0	30 SEP 80	PA		
HYD.5	0	30 SEP 80	PA		
HYD.6	0	30 SEP 80	PA		
HYD.7	0	30 SEP 80	PA		
HYD.8	0	30 SEP 80	PA		
HYD.9	0	30 SEP 80	PA		
HYD.10	0	30 SEP 80	PA		

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
HYD.11	0	30 SEP 80	PA		
HYD.12	0	30 SEP 80	PA		
HYD.13	0	30 SEP 80	PA		
HYD.14	0	30 SEP 80	PA		
HYD.15	0	30 SEP 80	PA		
HYD.16	0	30 SEP 80	PA		
HYD.17	0	30 SEP 80	PA		
HYD.18	0	30 SEP 80	PA		
HYD.19	0	30 SEP 80	PA		
HYD.20	0	30 SEP 80	PA		
HYD.21	0	30 SEP 80	PA		
HYD.22	0	30 SEP 80	PA		
IDS.1	3	30 SEP 80	TA, TC	2	15 NOV 77
MAT.2	2	30 SEP 80	TC	1	15 NOV 77
MAT.7	2	30 SEP 80	TA	1	15 NOV 77
MAT.7a	0	30 SEP 80	PA		
MAT.7b	0	30 SEP 80	PA		
MAT.7c	0	30 SEP 80	PA		
MAT.7d	0	30 SEP 80	PA		
MAT.8	1	30 SEP 80	TA	0	15 AUG 75
MAT.9	1	30 SEP 80	TC	0	15 AUG 75
MAT.11	1	30 SEP 80	TA	0	15 AUG 75
MAT.14	2	30 SEP 80	TA	1	01 DEC 76
MAT.16	1	30 SEP 80	TA	0	15 AUG 75
MAT.18	1	30 SEP 80	TA	0	15 AUG 75
MAT.19	2	30 SEP 80	TA	1	01 DEC 76
MAT.21	2	30 SEP 80	TA	1	01 DEC 76
MAX.1	3	30 SEP 80	TC, TA	2	15 NOV 77
MSG.1	2	30 SEP 80	TA	1	15 NOV 77
MSG.2	2	30 SEP 80	TA	1	15 NOV 77
MSG.3	1	30 SEP 80	TA	0	15 AUG 75

---

*Key to COMMENTS appears on Page xiii.

Page	New Rev.#	New Date	COMMENTS*	Old Rev.#	Old Date
NTN.1	2	30 SEP 80	TC	1	15 NOV 77
NTN.2	2	30 SEP 80	TA	1	15 NOV 77
NTN.3	0	30 SEP 80	PA		
OPT.4	2	30 SEP 80	TA	1	01 DEC 76
OPT.5	1	30 SEP 80	TC	0	15 AUG 75
OPT.6	1	30 SEP 80	TC	0	15 AUG 75
OPT.6a	0	30 SEP 80	PA		
OPT.6b	0	30 SEP 80	PA		
OPT.7	2	30 SEP 80	TC	1	01 DEC 76
OPT.8	1	30 SEP 80	TC	0	15 AUG 75
OPT.9	1	30 SEP 80	TC	0	15 AUG 75
OPT.10	2	30 SEP 80	TC	1	01 DEC 76
OPT.10a	0	30 SEP 80	PA		
OPT.11	1	30 SEP 80	TC	0	01 DEC 76
OPT.11a	0	30 SEP 80	PA		
OPT.16	1	30 SEP 80	TA	0	15 AUG 75
OPT.18	2	30 SEP 80	TA	1	01 DEC 76
OPT.21	2	30 SEP 80	TC	1	01 DEC 76
OPT.22	2	30 SEP 80	TC	1	01 DEC 76
OPT.23	1	30 SEP 80	TA	0	01 DEC 76
OPT.25	1	30 SEP 80	TD	0	01 DEC 76
OPT.26	1	30 SEP 80	TD	0	01 DEC 76
OPT.28	1	30 SEP 80	TC	0	01 DEC 76
OPT.29	0	01 DEC 76	PD		
OPT.30	0	01 DEC 76	PD		
OPT.31	0	01 DEC 76	PD		
OPT.32	0	01 DEC 76	PD		
PHU.1	1	30 SEP 80	TC	0	15 AUG 75
PHU.2	0	30 SEP 80	PA		
REF.1	1	15 NOV 77	PD		

---

*Key to COMMENTS appears on Page xiii.

This page intentionally left blank.

SECTION 7

INPUT INSTRUCTIONS FOR THE STEALTH COMPUTER PROGRAMS

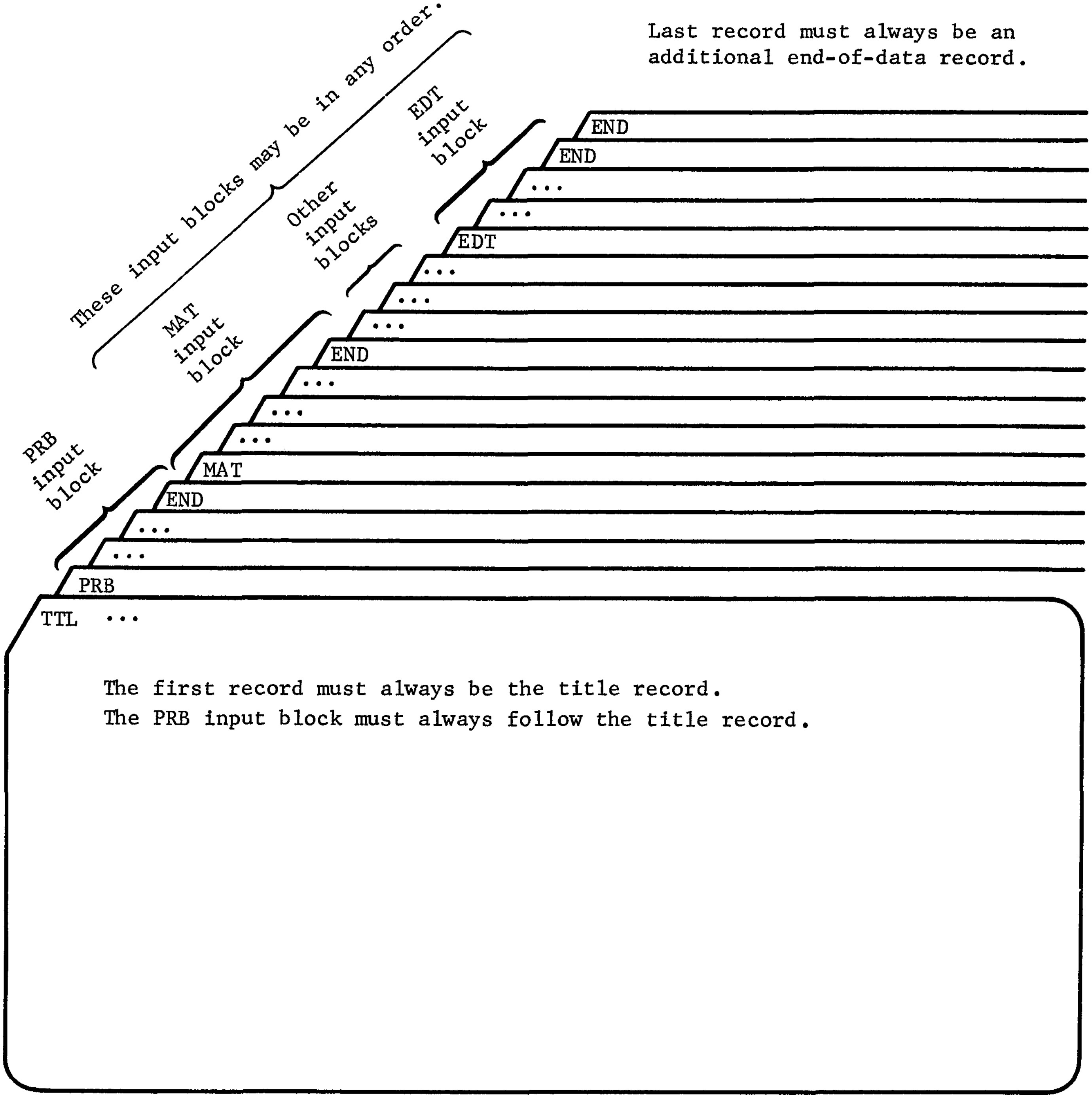
7.A INTRODUCTION

7.A.a Record Format. Input data for the STEALTH computer programs are provided as seven distinct blocks of input in addition to a title record. The title record must precede the seven input blocks and the first input block must always be the PRB input block. The remaining six input blocks may be in any order. The last record of the input data must always be an END record; this END record is in addition to the END record of the last input block.

The first input block is always the problem specification input block, denoted by the control characters PRB. The remaining six input blocks are as follows:

control characters	type of input
MAT	material specification input
GPT	grid-point specification input
ZON	zone initialization input
BDY	boundary specifications input
TIM	time specification input
EDT	edit specifications input

When prescribing input data for a particular input block, the first input record of the block is always the block specification (input control) record; the last input record of the block is always the end-of-data record, END. An additional END record must be placed at the end of the input deck following the END record of the last input block. Figure 7.1 shows the general structure of a STEALTH input deck.



Last record must always be an additional end-of-data record.

The first record must always be the title record.
The PRB input block must always follow the title record.

Figure 7.1. General structure of a STEALTH input deck.

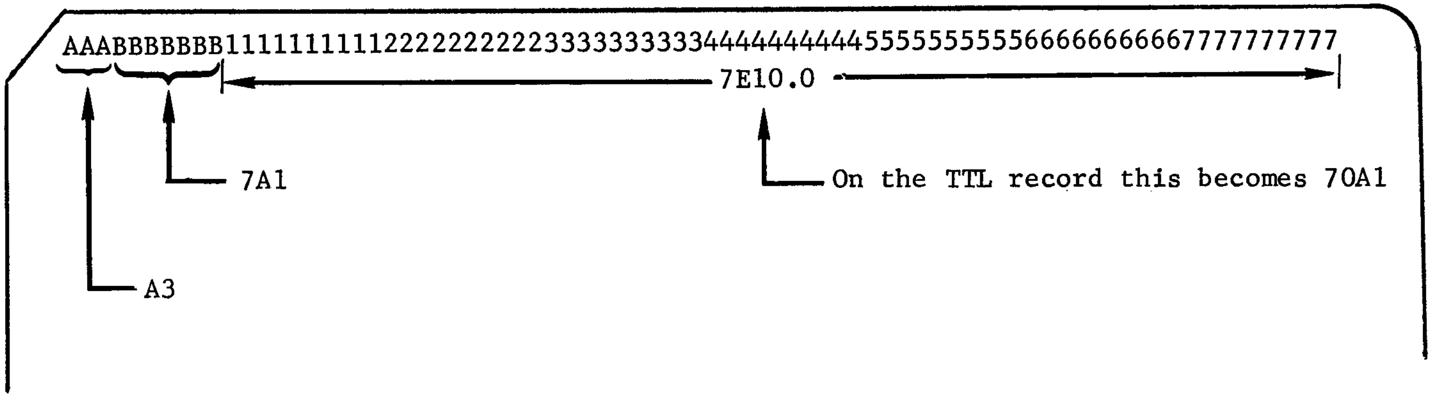
All input records between an input control record and the next end-of-data record encountered must be appropriate input data for that block. The non-optional input block (PRB) contains input records which are specified by alphabetic specification characters, e.g., SOR, SYM, etc. The six optional input blocks (MAT, GPT, ZON, BDY, TIM, EDT) use three-character numeric specification, e.g., 153, 621, etc. The first numeric character identifies the input block as follows:

MAT = 1__
GPT = 2__
ZON = 3__
BDY = 4__
TIM = 5__
EDT = 6__

The second numeric character identifies an input decade or sub-block, while the third numeric character helps make the specification unique.

The input format for all input data records (except the title input record) is the same. For a card or a keyboard input record, the first three columns are used for the control specification characters (format code A3); the next seven columns are used for miscellaneous information at the user's discretion (format code 7A1); and the last 70 columns are used for specific numerical input data (format code 7E10.0). All numerical data are input in floating point notation under the E-format, thus the input for the integers as well as for real numbers should be in E- or F-formats. Figure 7.2 is a schematic of the input format.

The input format for the title record is similar to the standard input record for numerical data described above. The difference is that the last 70 columns are used for alphanumeric title data (format code 70A1).



AAA ≡ record type
BBBBBBB ≡ comments

1111111111 ≡ field 1
2222222222 ≡ field 2
3333333333 ≡ field 3
4444444444 ≡ field 4
5555555555 ≡ field 5
6666666666 ≡ field 6
7777777777 ≡ field 7

Figure 7.2. Input record format.

7.A.b Manual Format. The input manual has been divided into sections corresponding to the input blocks. The section numbers and input blocks have the following correspondence:

Input Block	PRB	MAT	GPT	ZON	BDY	TIM	EDT	END
Section Number	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7

Each section contains (1) an overview of the input in the section, starting on Page 7._01, (2) a summary of the input records and input variables always on Page 7._09, and (3) detailed descriptions of the input variables by record type. The input record page numbers are of the form 7.ccc where ccc represents the three-character input record type when the record type is numeric. When the record type is non-numeric (i.e., control records and input for the PRB input phase), special values of ccc are used. The phase identifier input record (e.g., the MAT input record) is always described on Page 7._10 (i.e., Page 7.210 for the MAT input record). The END input record is always described on Page 7._99 (e.g., Page 7.399 contains information about the END input record for the ZON input phase). The page numbers for the PRB phase input records have been chosen arbitrarily. The order in which the PRB input records are found is seen on the input summary page of that phase, i.e., Page 7.009.

The format of the detailed input record documentation is shown in Figure 7.3. Most of the terminology used to describe a particular variable should be fairly clear. However, a convention is used to describe output error messages which requires some additional information. When an error message prints the value of a variable, the following notations are used:

floating point variable	eeeeeeeeeee
fixed point variable	iiiii
Hollerith variable	aaaaaa

where "e" represents an E format, "i" represents an I format, and "a" represents an A format. The number of e's, i's, or a's indicates the

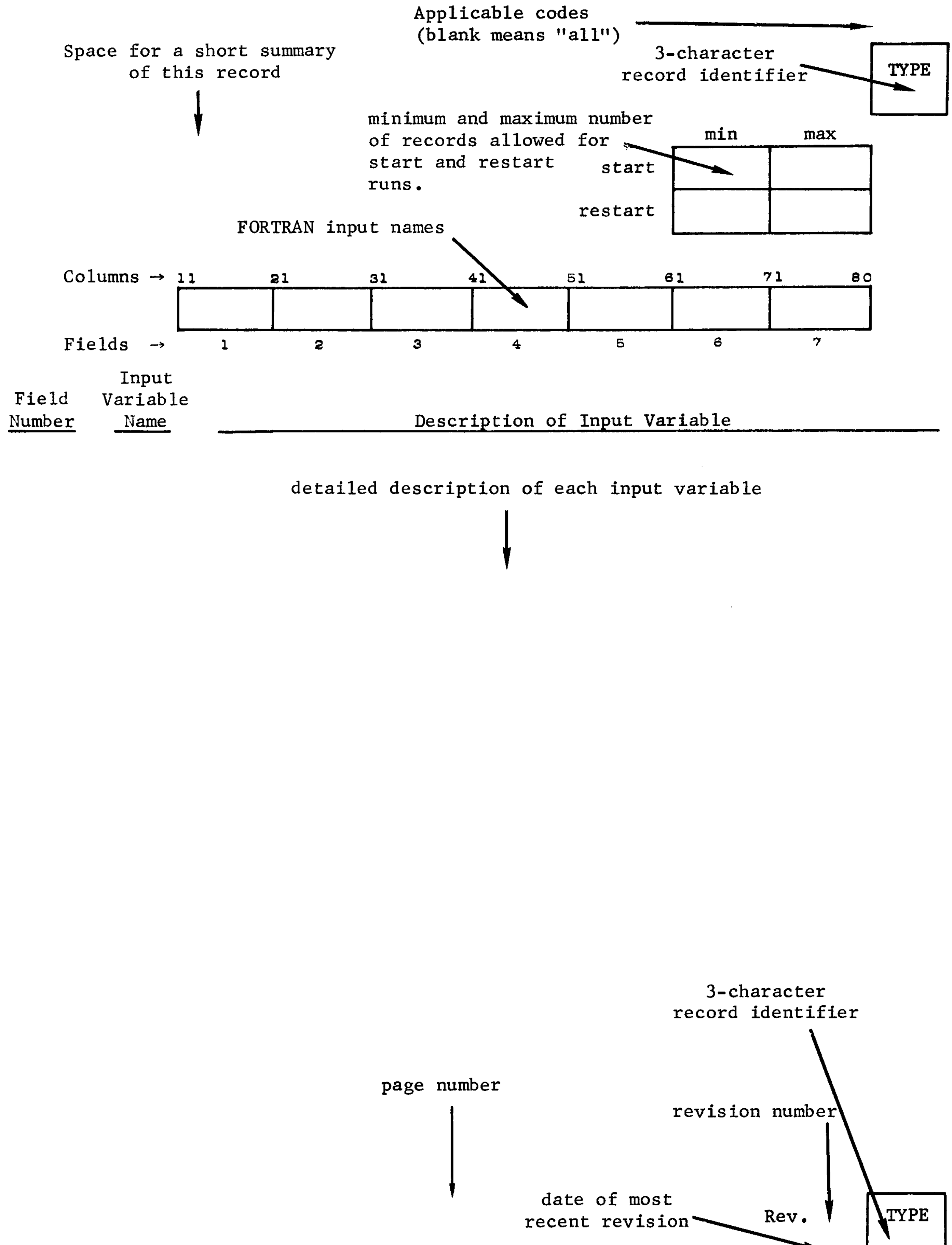


Figure 7.3. Input record documentation format.

field width. Thus, in the examples above, the notation corresponds to the formats E12, I5, and A6, respectively.

The discussion of the input variables relies heavily on the Appendixes which are ordered alphabetically according to the appendix name.

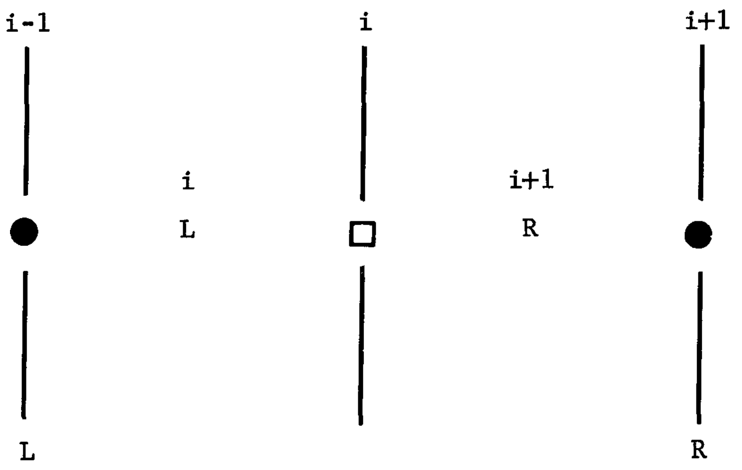
7.B INDEX SPACE

Providing the input data for a STEALTH run is primarily a process of inserting problem-related information into computer memory in such a way that it is consistent with STEALTH's memory addressing conventions. The STEALTH addressing system is such that contiguous mesh points in the physical space are also contiguous in the memory address or "index" space. For one-dimensional problems, the index space is an ordered string of points, while for a two-dimensional problem, the index space is a rectangular array of points. The three-dimensional index space is cubical. The contiguous storage approach eliminates any need for connectivity information.

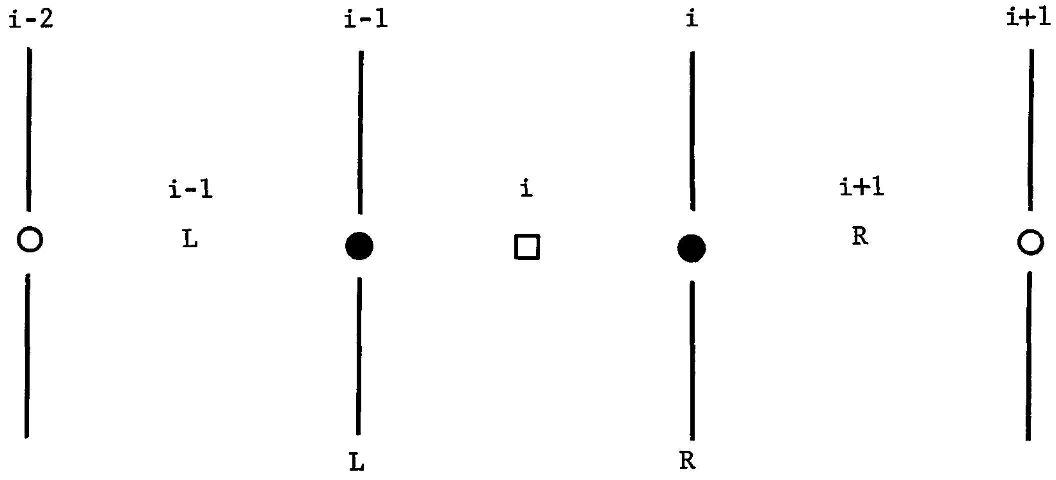
The one-dimensional index convention in STEALTH counts mesh points from left to right (i increases from left to right). The real space coordinate (x) also increases from left to right; thus, two consecutive points form a positive volume. (See Figure 7.4.) This convention does not restrict physical one-dimensional geometries in any way.

In a two-dimensional mesh, there are two indexes (i,j). One index increases from left to right, while the other increases from bottom to top. The left-to-right index is denoted by increasing i, while the bottom-to-top index is denoted by increasing j. (See Figure 7.5.) Real space coordinates can increase or decrease in any direction relative to the index space as long as the index space (i,j) and real space (x,y) coordinate systems are both right-handed, and as long as four contiguous mesh points always

GRID POINT CALCULATION CONVENTIONS (Interior Grid Point i)



ZONE CALCULATION CONVENTIONS (Zone i)

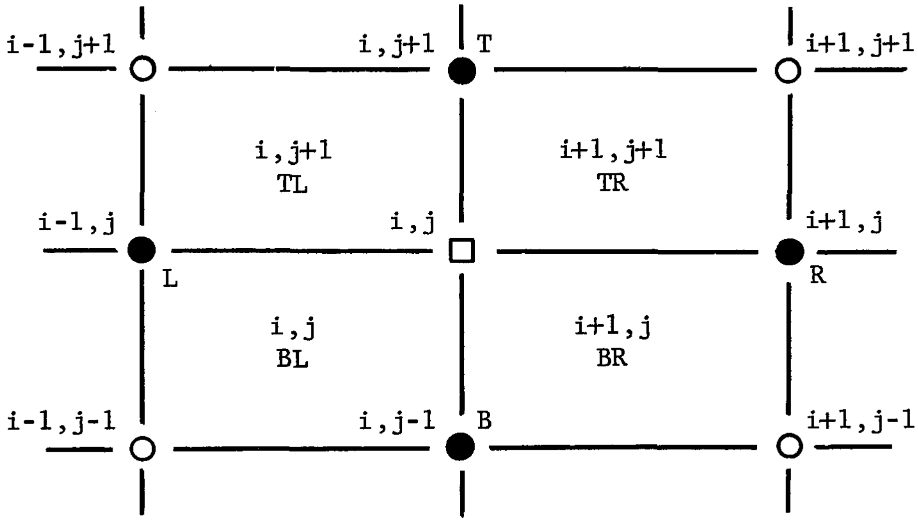


L = left; R = right.

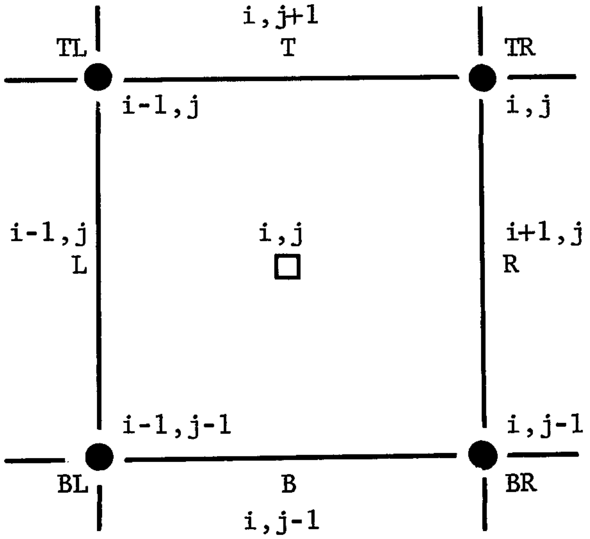
Figure 7.4. One-dimensional index conventions.

Rev. 1
15 NOV 77

GRID POINT CALCULATION CONVENTIONS (Interior Grid Point i,j)



ZONE CALCULATION CONVENTIONS (Zone i,j)



L = left, R = right, B = bottom, T = top, TL = top left, TR = top right,
BL = bottom left, BR = bottom right

Figure 7.5. Two-dimensional index conventions.

Rev. 1
15 NOV 77

form a positive volume in the real space. Just as in the one-dimensional case, these conventions do not limit the real space geometries in any significant way.

In a three-dimensional mesh, there are three indexes (i,j,k). The i and j indexes follow the same conventions described for the one- and two-dimensional codes. The k index increases from aft to front. (See Figure 7.6.) Real space coordinates (x,y,z) can increase or decrease in any direction with respect to the index space as long as eight contiguous mesh points in the index space always form a positive volume in the real space.

In all three cases, the indexing system for mesh points can also be used as an indexing system for zones. The following conventions apply:

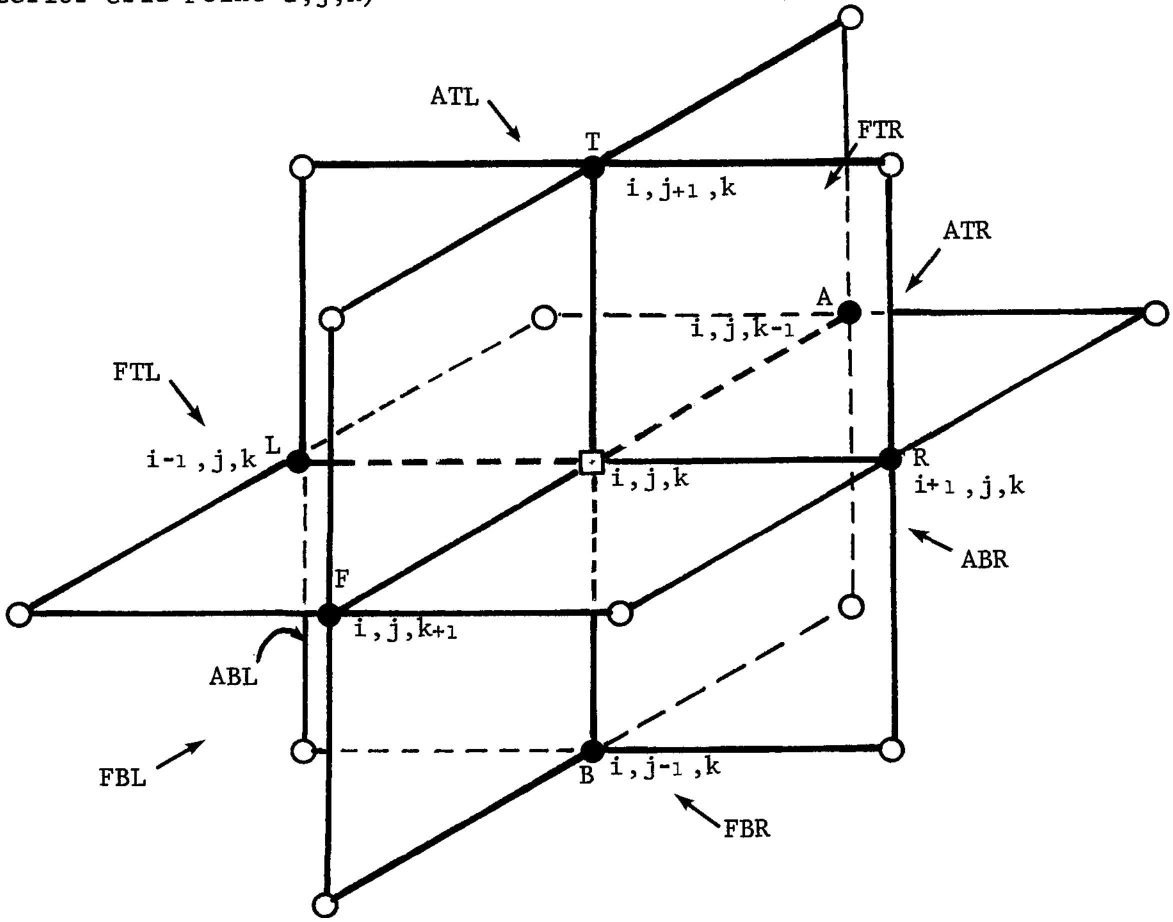
- In one dimension, the zone index value is defined to be the grid point index value of the grid point on its right. (See Figure 7.4.) Since two contiguous grid points define a zone, this is a unique specification. A consequence of this address notation is that the left boundary grid point of a grid never has a zone associated with its index value.

- In two dimensions, the zone index value is defined to be the grid point index value of the grid point at the upper right-hand corner of the zone. (See Figure 7.5.) This is also a unique specification since four contiguous grid points define a zone. A consequence of the two-dimensional address notation is that left-side and bottom-side grid points never have zones associated with those index values.

- In three dimensions, the zone index value is defined to be the grid point index value of the grid point at the upper right front corner of the zone. (See Figure 7.6.) This is a unique specification since eight contiguous grid points define a zone. A consequence of the three-dimensional address notation is that the left-side, bottom-side, and aft-side grid points never have zones associated with those index values.

GRID POINT CALCULATION CONVENTIONS

(Interior Grid Point i,j,k)



ZONE CALCULATION CONVENTIONS

(Zone i,j,k)

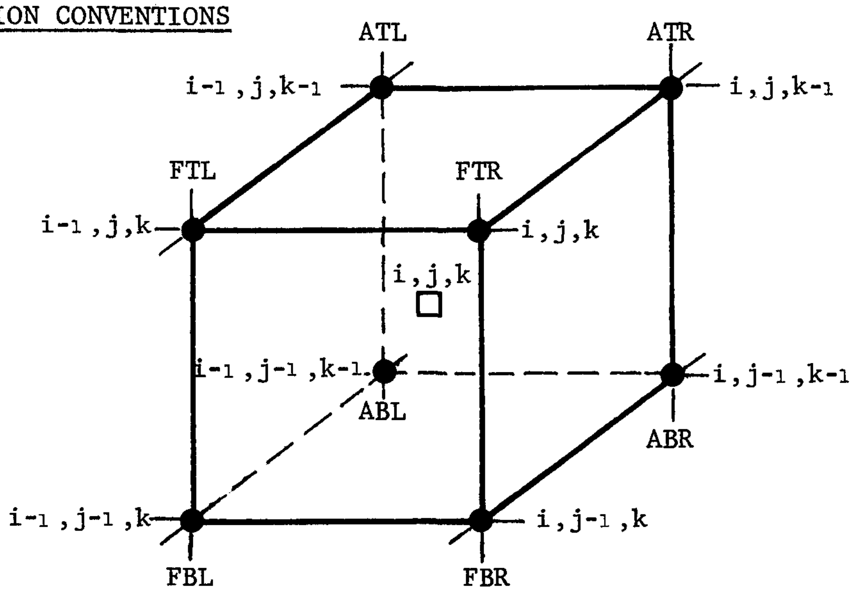


Figure 7.6. Three-dimensional index conventions.

7.C EFFICIENCY CONSIDERATIONS

A number of factors must be considered when evaluating the efficiency of a computer code. Among these are user efficiency in utilizing the code, computer programming efficiency in terms of properly using the FORTRAN language, and system resource efficiency with respect to minimizing computer charges.

The STEALTH codes have been designed to be most efficient for novice users. That is, in their present form, the codes are easy to learn and easy to use. In this form, computer programming tightness is sacrificed slightly to improve the user's ability to understand code logic. (The major programming inefficiency comes from modularity. Numerous subroutine calls result in an approximate 5-10% overhead on a CDC 7600.) However, system resource efficiency is maximized and no obvious misuse of FORTRAN exists.

For experienced users, STEALTH computer program efficiency can be improved by 15-25% by making a few very simple changes. The most significant increases in efficiency can be realized when one eliminates the flexibility of having available, through standard input, multiple boundary conditions and/or material models, and replacing them with "hard-wired" models. The simplest change from a coding viewpoint is achieved by hard-wiring the material model in subroutine ZONMDL. (See Appendix "Materials".) This is done by removing the existing logic from subroutine ZONMDL and replacing it with a more specific solution of the constitutive equations. For most cases, this is a trivial task, taking only a few hours of work and yielding a 20% decrease in computer cost. The cost savings are due in part to a significant reduction of subroutine calls as well as to the elimination of many model branches used in the standard capability. Hard-wiring boundary models can also reduce cost by decreasing the number of subroutine calls and model branches. However, fewer cases can benefit from hard-wiring boundary conditions.

On the Lawrence Berkeley Laboratory (LBL) CDC 7600, the standard version of STEALTH 2D runs at CPU speeds of between 0.5 to 0.8 milli-CP seconds per grid-point cycle. This number depends, to a large degree, on the ratio of boundary points to interior points. From a cost point of view, STEALTH 2D runs at ~20¢ per 1000 grid-point cycles (at standard priority). The simple efficiency changes discussed previously can lower costs to ~ 10¢ per 1000 grid-point cycles.

One should be very careful when comparing the efficiencies of codes. For example, there might be an interest in comparing STEALTH 2D to PISCES 2DL, HEMP 2D, REXCO, TOODY, or other similar codes. However, since STEALTH 2D carries heat conduction and a point-by-point rezoning capability in addition to its Lagrange continuum mechanics equations, STEALTH 2D ought to take longer per grid-point cycle. Recent timing tests have shown STEALTH to be reasonably competitive with all of the above codes (Reference 7.1).*

The STEALTH codes are conceived to be more than another set of computer programs to be used for a specific set of problems. They have been designed to help teach members of the engineering community about explicit-in-time codes and, in this context, they have been structured so that they can be easily "mined".

It is fully expected that many users will not use STEALTH in its most general mode. If only for improving its speed, it will be worthwhile to eliminate options from the code that are not pertinent to calculations which are mechanical only, thermal only, etc.* Some users may not want to use STEALTH at all, but will find a need for certain subroutines in STEALTH. These subroutines could be "mined" from the STEALTH program and put into the user's own program. The mining process might entail taking an entire subroutine out of STEALTH and putting it in another program, or just copying some logic from STEALTH.

---

*Special-purpose versions of STEALTH, which are faster and smaller than the corresponding general-purpose codes, are available. See Section 1.2 of this volume for references to special-purpose documentation. Also see Appendix HYD in this volume for documentation of hydro versions.

Explicit-in-time code technology is not well known outside of the defense community, so it is expected that many engineers and scientists will use the STEALTH codes as a basis for writing simpler (less general) explicit codes. Users who plan to perform production calculations may find a tremendous advantage in doing this. An example of a very simple explicit finite-difference code which is also based on HEMP* equations (Reference 7.2) is the code, LESS.** This code, although entirely hard-wired for a limited class of problems, is between 10 and 100 times faster than STEALTH. The cost savings comes from the fact that LESS does not have slideline capabilities, kinematic boundary capabilities, heat conduction, and many other STEALTH options, but it is explicit and it does the specific job for which it is designed.

---

*STEALTH 2D is based entirely on the HEMP code finite-difference equations.

**Linear Elastic Small Strain. Reference 7.3.

7.D ZONE SIZE CRITERIA, STABILITY AND NOISE CONSIDERATIONS

Fundamental criteria exist for choosing the proper nodalization for computing the mechanical response of a system. These are

- The implied frequency resolution must be high enough to pass both input signals and output response.
- The distance between nodes must be fine enough so that geometric shape resolution is adequate for defining material interfaces and physical boundaries.

Frequency considerations influence the choice of zone size for an explicit scheme as follows. The distance between two neighboring nodes or between the centers of two contiguous zones must be equal to one-half the wave length of the highest frequency that must be resolved at that point in the mesh. For an entire calculation, the highest frequency that can be resolved is the frequency associated with the greatest distance between neighboring mesh points or zone centers. Thus, if a particular boundary condition has a certain frequency content (in the Fourier sense), then a maximum zone size must be chosen that is small enough to pass the highest frequency of the input pulse.* Similarly, the output response has a frequency content which also must be resolved in the grid.

Shape and interface considerations are intimately related to frequency content. A discretized curved surface is a low pass filter in which the highest frequency passed is related to the discretization interval. Material interfaces also influence frequency content through impedance changes. Zones contiguous to a material interface should be sized for time-step matching in shock environments (large strain effects) and mass matching for small-strain loading.

---

*In the case of shocks (i.e., very high frequency pulses, a different technique involving artificial quadratic scalar viscosity is used instead of uneconomically fine zoning.

Economic factors are usually determined from an evaluation of the maximum stable time step, since the size of the time step controls the number of steps that must be taken for a particular simulation. The maximum stable time step is computed from the Courant condition which states that the activity in a zone can only affect its contiguous neighbors. Mathematically, the time step is limited by the quantity $\Delta\ell/c$ where $\Delta\ell$ is the characteristic length of the zone and c is the sound speed of the zone.

7.E INPUT RECORDS

The title record specifies the 70-character title under which the problem (to be specified on subsequent records) will be printed and/or plotted. The title record must be the first input record in every run, start or restart.

Any number of free (optional) comment cards with columns 1-10 left blank may precede the title record (TTL card). These cards may contain from 1 - 70 alphanumeric characters in columns 11 - 80. These characters are not saved but are printed once at the beginning of the output. The purpose of this capability is to allow a user to summarize specific features of the data deck.

Problem Title

The TTL input record specifies the problem title. The TTL input record is required as the first input record in every run, start or restart. The TTL input record must always be followed by a PRB input record or the run will be immediately terminated.

	min	max
start	1	1
restart	1	1

Columns →	11	21	31	41	51	61	71	80
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1-7		Problem title. Fields 1-7 may contain from 1-70 alphanumeric characters which will be stored as a problem title to be printed at the top of every page of printed output and on every plot.

REFERENCES FOR SECTION 7

7.1 Ronald Hofmann, "STEALTH, A Lagrange Explicit Finite-Difference Code for Solids, Structural, and Thermohydraulic Analysis", EPRI NP-176-1, Electric Power Researh Institute, Palo Alto California, June 1976 (revised April 1978). Prepared by Science Applications, Inc., San Leandro, California

7.2 Mark L. Wilkins, "Calculation of Elastic-Plastic Flow", UCRL-7322, Lawrence Livermore National Laboratory, Livermore, California, April 19, 1963. Also in Methods in Computatinal Physics, Berni Alder, Sidney Fernbach, and Manuel Rotenberg, eds., Vol. 3 of Fundamental Methods in Hydrodynamics, Academic Press, New York, 1964, pp.211-263.

7.3 Anthony J. Crispino, Ronald Hofmann, and John E. Reaugh, "LESS: A Linear Elastic Small-Strain Code System", EPRI RP-307, Electric Power Research Institute, Palo Alto, California, July 1980. Prepared by Science Applications, Inc., San Leandro, California.

This page intentionally left blank.

7.0 PROBLEM SPECIFICATION PHASE (PRB)

The problem specification phase (PRB) must be the first input block following the TTL record. The purpose of the PRB input block is to specify global properties of the problem. The minimum input records required for a start run are the PRB, GRD, and END records. These input records imply the default values shown below.

Record Identifier	Variable Name	Default Value	Default Meaning
PRO	NSPRO*	1.0	one-dimensional Lagrange
SOR	NSSOR	1.0	start run
SOR	TIMSOR	0.0	start time
DTS	NSDTS	1.0	stress wave dynamic
SYM	NSSYM*	1.0	plane strain 1D or 2D symmetry**
TOL	RELTOL	10^{-14}	60-bit word tolerance
TOL	SMLNUM	2.0×10^{-293}	60-bit word tolerance
TOL	BIGNUM	0.5×10^{293}	60-bit word tolerance
MIN	SSSMIN	10^{-4}	cm-g-μs cut-off
MIN	XVLMIN	10^{-30}	cm-g-μs cut-off
MIN	YVLMIN	10^{-30}	cm-g-μs cut-off
MIN	ZVLMIN	10^{-30}	cm-g-μs cut-off
MIN	DSTMIN	10^{-3}	cut-off for a zone size of 10^{-1}
GRV	GRVX	0.0	no gravity
GRV	GRVY	0.0	no gravity
GRV	GRVZ	0.0	no gravity

---

*Variables which may not be redefined at restart time.

**For 3D calculations, there are no symmetries. Therefore, the SYM record is not needed and the variable NSSYM is ignored.

In a restart run, the minimum set of input records includes the SOR record in addition to PRB and END. In a restart run, the SOR record must be the first input record in the PRB phase after the PRB card.

A summary of PRB phase input records and input variables appears in Table 7.0.

NOTE: Pages 7.003 through 7.008 will not appear in this report.

TABLE 7.0

SUMMARY OF PRB PHASE INPUT RECORDS AND INPUT VARIABLES

FIELDS 1-7

TYPE	1	2	3	4	5	6	7
PRB	NSINP	NSTRC	NSDBG	NSPLT	NSPRT		
PRO	NSPRO						
SOR	NSSOR	TIMSOR					
DTS	NSDTS						
SYM	NSSYM						
TOL	RELTOL	SMLNUM	BIGNUM				
MIN	SSSMIN	XVLMIN	YVLMIN	ZVLMIN	DSTMIN		
GRV	GRVX	GRVY	GRVZ				
GRD	LG	MSHTYP	NUMILN	NUMJLN	NUMKLN		
END							

Problem (PRB) Phase Control

The function of the PRB control record is to activate the PRB input phase. The PRB control record must follow the TTL input record and is required for all runs, start and restart. It is required whether or not PRB input records are used.

	min	max
start	1	1
restart	1	1

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable

1 NSINP

Input mode switch. The value of NSINP specifies the mode of input to be used in this input phase. The value of NSINP must be integral and less than or equal to 3. The following definitions apply:

≤ 1.0	card input (default)
= 2.0	library input
= 3.0	keyboard input

If the field containing NSINP is left blank, then the mode of input is assumed to be card input. If the value of NSINP is greater than 3.0, the message,

```
INPUT MODE SWITCH
IMPROPERLY DEFINED.
```

is written on the print and the message files, and the program terminates immediately in subroutine PRBGEN.

2 NSTRC

Trace mode switch. The value of NSTRC specifies whether or not the trace option is active. The value of NSTRC must be integral and less than or equal to 2. The following definitions apply:

≤ 1.0	trace is not active, off (default)
= 2.0	trace is active, on

If the field containing NSTRC is left blank, then the mode is assumed to be not active (off). If the value of NSTRC is greater than 2.0, the message,

```
TRACE MODE SWITCH
IMPROPERLY DEFINED.
```

is written on the print and the message files, and the program terminates immediately in subroutine PRBGEN. The trace logic, if active (on), will cause the name of the subroutine or logical phase just entered to be printed on both the print and message files. These actions are taken in subroutines SBRENT and PHSENT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable

3 NSDBG

Debug mode switch. The value of NSDBG specifies whether or not the debug option is active. The value of NSDBG must be integral and less than or equal to 2. The following definitions apply:

≤ 1.0	debug is not active, off (default)
= 2.0	debug is active, on

If the field containing NSDBG is left blank, then the debug mode is assumed to be not active (off). If the value of NSDBG is greater than 2.0, the message,

DEBUG MODE SWITCH
IMPROPERLY DEFINED.

is written on the print and the message files, and the program terminates immediately in subroutine PRBGEN. The debug logic, if active (on), will cause the common blocks associated with this input phase to be dumped at the end of each subroutine in the phase and at the end of the logical phase. These actions are taken in subroutines SBREXT and PHSEXT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

4 NSPLT

Plot mode switch. The value of NSPLT specifies whether or not plots will be produced by this generator phase. The value of NSPLT must be integral and less than or equal to 2.0. The following definitions apply:

≤ 1.0	no plots produced, option off (default)
= 2.0	plots produced, option on

If the field containing NSPLT is left blank, then no plots will be produced (off). If the value of NSPLT is greater than 2.0, the message,

PLOT MODE SWITCH
IMPROPERLY DEFINED.

is written on the print and the message files, and the program terminates immediately in subroutine PRBGEN.

Columns →	11	21	31	41	51	61	71	80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
5	NSPRT	Print mode switch. The value of NSPRT controls the printing in this generator phase. The value of NSPRT must be integral and less than or equal to 2.0. The following definitions apply: = 1.0 only input records and error messages are printed, option off = 2.0 full printing done, option on (default) If the field containing NSPRT is left blank, full printing is done (option on). If the value of NSPRT is greater than 2.0, the message, PRINT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine PRBGEN.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Processor Specification

Page 1 of 1

The PRO input record specifies the processor to be used for the problem. The PRO input record is optional at start time and is not allowed at restart time. When used, one, and only one, record is required; when not used, default values are assumed.

	min	max
start	0	1
restart	0	0

Columns →	11	21	31	41	51	61	71–80
	NSPRO	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NSPRO	Processor indicator switch. The value of NSPRO indicates the type of processor to be used for this problem. The value of NSPRO must be integral and less than or equal to 3. The following definitions apply:

≤ 1.0	one-dimensional Lagrange, STEALTH 1D (default)
= 2.0	two-dimensional Lagrange, STEALTH 2D
= 3.0	three-dimensional Lagrange, STEALTH 3D
=11.0	one-dimensional archive data processor, ADAPRO 1D
=12.0	two-dimensional archive data processor, ADAPRO 2D
=13.0	three-dimensional archive data processor, ADAPRO 3D

If the field containing NSPRO is left blank, then NSPRO is assumed to be equal to 1.0, i.e., one-dimensional Lagrange processor. If the value of NSPRO is between 3.0 and 11.0 or is greater than 13.0, the message,

```
PROCESSOR INDICATOR SWITCH
IMPROPERLY DEFINED.
```

is written on the print and the message files, and the program terminates immediately in subroutine PRBINP.

Field Number	Input Variable Name	Description of Input Variable
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Start or Restart Time

The SOR input record specifies the start or restart mode and time for the problem. It is optional for start runs but is required for restart runs. When used, one and only one record is required; when not used, default values are assumed. In a restart run, the SOR record must be the first input record in the PRB phase after the PRB input record.

Page 1 of 1

	min	max
start	0	1
restart	1	1

Columns →	11	21	31	41	51	61	71	80
	NSSOR	TIMSOR	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	NSSOR	Start or restart indicator switch. The value of NSSOR indicates if the run is a start or restart run. The value of NSSOR must be integral and less than or equal to 3. The following definitions apply: $\leq$ 1.0 start (default) = 2.0 standard restart = 3.0 special restart (dezone-nuzone)* If the field containing NSSOR is left blank, then NSSOR is assumed to be equal to 1.0, i.e., a start run. If the value of NSSOR is greater than 3.0, the message, START OR RESTART INDICATOR SWITCH IMPROPERLY DEFINED. is written on the print and the message files and the program terminates immediately in subroutine PRBINP.
2	TIMSOR	Start or restart time. The value of TIMSOR must be positive. When NSSOR = 1.0, TIMSOR is equal to start time; when NSSOR = 2.0 or 3.0, TIMSOR is equal to restart time.** Default is 0.0.
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*Currently only available for 2D. See record types 388 and 389.

**TIMSOR should be given to 5 significant figures. The following test is made in the code to find the restart cycle. If $|T_{SOR} - t| < |T_{SOR} * 10^{-4}|$, then t is the time of the restart cycle (T_{SOR} is TIMSOR).

Dynamic-Thermal-Static Control

The DTS input record specifies the time step stability criterion to be used for this problem. It is optional for both start and restart runs. When used, one and only one record is required; when not used, default values are assumed.

	min	max
start	0	1
restart	0	1

Columns → 11 21 31 41 51 61 71 80

NSDTS	--	--	--	--	--	--

Fields → 1 2 3 4 5 6 7

Field Number	Input Variable Name	Description of Input Variable
1	NSDTS	Dynamic-thermal-static indicator switch. The value of NSDTS indicates the type of time step control to be used. The value of NSDTS must be integral and less than or equal to 4. The following definitions apply: ≤ 1.0 stress wave dynamic only (default) = 2.0 static only (using dynamic relaxation)* = 3.0 thermal transient only = 4.0 complete mechanical and thermal response If the field containing NSDTS is left blank, then NSDTS is assumed to be equal to 1.0, i.e., stress wave dynamic. If the value of NSDTS is greater than 4.0, the message, DYNAMIC-THERMAL-STATIC INDICATOR SWITCH IMPROPERLY DEFINED is written on the print and the message files and the program termintes immediately in subroutine PRBINP.
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*This option requires the specification of the relaxation frequency parameter on input record type 514.

Symmetry Specification

The SYM input record specifies the symmetry for the problem. It is optional for start runs, but is not allowed for restart runs. When used, one and only one record is required; when not used, default values are assumed.

	min	max
start	0	1
restart	0	0

Columns →	11	21	31	41	51	61	71–80
	NSSYM	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NSSYM	Symmetry indicator switch. The value of NSSYM indicates the symmetry option to be used for this run. The value of NSSYM must be integral and less than or equal to 6. The following definitions apply: ≤ 1.0 plane 1D; plane strain 2D; or 3D[**] (default) = 2.0 cylindrical 1D or axial 2D[*] = 3.0 spherical 1D = 4.0 planar flume 1D[†] or plane stress 2D = 5.0 cylindrical flume 1D[†] = 6.0 thin rod and plate 1D[†] If the field containing NSSYM is left blank, then NSSYM is assume to be equal to 1.0, i.e., plane symmetry in one dimension and translational symmetry in two dimensions. If the value of NSSYM is greater than 6.0, the message, SYMMETRY INDICATOR SWITCH IMPROPERLY DEFINED. is written on the print and the message files and the program terminates immediately in subroutine PRBINP.
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] In 2D axial symmetry, the x-direction is the radial direction and the y-direction is the axial direction.

[**] For 3D calculations, there are no symmetries. Therefore, the SYM record is not needed and the variable NSSYM is ignored.

[†] See Appendix "Boundary Interaction Algorithms" for descriptions of these 1D symmetries.

Tolerances

The TOL input record specifies calculational tolerances for this problem. It is optional for both start and restart runs. When used, one and only one record is required; when not used, default values are assumed.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71	80
	RELTOL	SMLNUM	BIGNUM	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	RELTOL	Relative tolerance. The value of RELTOL must be positive. The purpose of RELTOL is to provide a "nearness" criterion when comparing two real numbers, neither of which is zero. If the TOL input record is omitted or if RELTOL is less than or equal to 10^{-14}, then the default value is assumed. The default value is machine-dependent. For a 60-bit word, 10^{-14} is used.
2	SMLNUM	Small number. The value of SMLNUM must be positive. The purpose of SMLNUM is to provide a "nearness" criterion when comparing the absolute value of a number to zero. If the TOL input record is omitted or if SMLNUM is less than or equal to zero, then the default value is assumed. The default value is machine-dependent. For a 60-bit word, 2.0×10^{-293} is used.
3	BIGNUM	Big number. The value of BIGNUM must be positive. The purpose of BIGNUM is to provide a "nearness" criterion when comparing the absolute value of a number to the largest number handled by a particular computer (machine infinity). If the TOL input record is omitted or if BIGNUM is less than or equal to SMLNUM, then the default value is assumed. The default value is machine-dependent. For a 60-bit word, 0.5×10^{293} is used.
4-7	--	Fields 4-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Velocity Cut-Offs

The MIN input record specifies minimum values of velocity. It is optional for both start and restart runs. When used, one and only one record is required; when not used, default values are assumed.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71 80
	SSSMIN	XVLMIN	YVLMIN	ZVLMIN	DSTMIN	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	SSSMIN	Sound-speed squared minimum value. The value of SSSMIN is the minimum allowable value of sound-speed squared. During a calculation, if the absolute value of sound-speed squared goes below this value, it is set equal to SSSMIN. The value of SSSMIN must be a positive number. The default value is 10^{-4}, which is a reasonable number for cm-g-μs problem units.
2	XVLMIN	x-component of material velocity minimum value. The value of XVLMIN is the minimum allowable absolute value of x-component material velocity before values of material velocity in the x-direction are set to zero. That is, the absolute value of an x-component material velocity below XVLMIN is set to zero, exactly. The value of XVLMIN must be a positive number. The default value is 10^{-30}, which is a reasonable number for cm- g-μs problem units.
3	YVLMIN	y-component of material velocity minimum value. The value of YVLMIN is the minimum allowable absolute value of y-component material velocity before values of material velocity in the y-direction are set to zero. That is, the absolute value of a y-component material velocity below YVLMIN is set to zero, exactly. The value of YVLMIN must be a positive number. The default value is 10^{-30}, which is a reasonable number for cm-g-μs problem units. (Only required for two-dimensional problems.)
4	ZVLMIN	z-component of material velocity minimum value. The value of ZVLMIN is the minimum allowable absolute value of z-component material velocity before values of material velocity in the z-direction are set to zero. That is, the absolute value of a z-component material velocity below ZVLMIN is set to zero, exactly. The value of ZVLMIN must be a positive number. The default value is 10^{-30} , which is a reasonable number for cm-g-μs problem units. (Only required for three-dimensional problems.)

Columns →	11	21	31	41	51	61	71 80
	SSSMIN	XVLMIN	YVLMIN	ZVLMIN	DSTMIN	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
5	DSTMIN	Minimum distance. The value of DSTMIN must be set equal to 1% of the distance across a typical boundary zone in problem units. This number is used as a capture tolerance for wall point corners and slidelines and as a default for wall segments. The default value is 10^{-3} *
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*10^{-3} is a reasonable value for a zone size of 10^{-1} in any problem units.

This page intentionally left blank.

Acceleration of Gravity

The GRV input record specifies values of gravity acceleration components for an entire problem. If the GRV input record is omitted, the default values are used. The GRV record may be used at restart time to change the values of gravity acceleration components.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71	80
	GRVX	GRVY	GRVZ	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	GRVX	Acceleration of gravity in the x-direction. A positive value of GRVX results in an acceleration in the positive x-direction, while a negative value of GRVX results in an acceleration in the negative x-direction. The default value of GRVX is 0.0.
2	GRVY	Acceleration of gravity in the y-direction. A positive value of GRVY results in an acceleration in the positive y-direction, while a negative value of GRVY results in an acceleration in the negative y-direction. The default value of GRVY is 0.0. GRVY must be left blank for one-dimensional problems.
3	GRVZ	Acceleration of gravity in the z-direction. A positive value of GRVZ results in an acceleration in the positive z-direction, while a negative value of GRVZ results in an acceleration in the negative z-direction. The default value of GRVZ is 0.0. GRVZ must be left blank for one- and two-dimensional problems.
4-7	--	Fields 4-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Grid Definition

The GRD input record defines a complete grid. At least one grid must be specified. The GRD input record may not be used at restart time. N + 1 grids are required for either N 1D voids or N 2D slidelines.

	min	max
start	1	MAXGRD
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	LG	MSHTYP	NUMILN	NUMJLN	NUMKLN	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	LG	Grid number. The value of LG must be a unique number for each grid. The value of LG must be integral and greater than or equal to 1 and less than or equal to MAXGRD. (See Appendix "Maximums".) If LG is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine PRBINP. (See Appendix "Messages".)
2	MSHTYP	Mesh type. The value of MSHTYP indicates the type of grid defined by this input record. The value of MSHTYP must be integral and less than or equal to 3. The following definitions apply: ≤ 1.0 Lagrange (default) = 2.0 Euler (not available) = 3.0 other (not available) If the field containing MSHTYP is left blank or has a value different from 1.0, then the value of MSHTYP is set equal to 1.0.
3	NUMILN	Number of I lines. The value of NUMILN must be integral and greater than or equal to 2 and less than or equal to MAXGPT. (See Appendix "Maximums".) If NUMILN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine PRBINP. (See Appendix "Messages".)
4	NUMJLN	Number of J lines. The value of NUMJLN must be integral and greater than or equal to 2 and less than or equal to MAXBUF. (See Appendix "Maximums".) If NUMJLN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine PRBINP. (See Appendix "Messages".) NUMJLN must be left blank for one-dimensional grids.
5	NUMKLN	Number of K lines. The value of NUMKLN must be integral and greater than or equal to 2 and less than or equal to MAXPLN. (See Appendix "Maximums".) If NUMKLN is out of this range, a RGEERR messages is written on the print and the message files and the program terminates immediately in subroutine PRBINP. (See Appendix "Messages".) NUMKLN must be left blank for one- and two-dimensional grids.

Columns →	11	21	31	41	51	61	71 80
	LG	MSHTYP	NUMILN	NUMJLN	NUMKLN	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.019 through 7.098 will not appear in this report.

End of PRB Phase

The END input record signifies the end of a block of data for the PRB input phase. It is required whether or not PRB input records are used and must follow the PRB control record if there is no PRB input data.

	min	max
start	1	1
restart	1	1

Columns →	11	21	31	41	51	61	71	80
	--	--	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1-7	--	Fields 1-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

7.1 MATERIAL SPECIFICATION PHASE (MAT)

The material specification phase (MAT) input block may be located in any position in the input deck after the PRB input block and before the final END record. The purpose of the MAT input block is to specify the material models for the problem. One set of MAT records is required at start time for each material in the problem. At restart time, MAT records need be included only if a material parameter is to be changed. In this case all of the parameters on the record where the change is made must be input again. New materials may not be specified at restart time unless dummy materials were specified at start time; that is, certain parts of the mesh were given dummy material property numbers in the start run.

A material model is defined by a unique material property number, MPN. (MPN is the index of the material arrays in the /MATARY/ labeled COMMON blocks.) MPN is always specified in the first field of a record.

The MAT phase input records are divided into the following groups:

Record Identifier	Group Description
11_	model-type specification
12_	equation-of-state parameters
13_	strength parameters
14_	energy release parameters
15_	heat flow parameters
17_	artificial viscosity prameters

All variables on all records in the MAT phase except reference density, RDN, on record type 121 have default values. Thus, it is possible to specify a material by specifying only one input record, the 121 input record with a reference density greater than the tolerance SMLNUM. The resulting material will have no properties other than inertia.

A summary of MAT phase input records and input variables appears in Table 7.1.

NOTE: Pages 7.103 through 7.108 will not appear in this report.

TABLE 7.1

SUMMARY OF MAT PHASE INPUT RECORDS AND INPUT VARIABLES

FIELDS 1-7

TYPE	1	2	3	4	5	6	7
MAT	NSINP	NSTRC	NSDBG	NSPLT	NSPRT		
111	MPN	MEOS					
112	MPN	MYLD	MSHR	MSPL			
113	MPN	MERL					
114	MPN	MCON	MSHC				
115	MPN	MAVS					
121	MPN	RDN					
122	MPN	EOS0	EOS1	EOS2	EOS3	EOS4	
123	MPN	EOS5	EOS6	EOS7	EOS8	EOS9	
132	MPN	YLD0	YLD1	YLD2	YLD3	YLD4	
134	MPN	SHR0	SHR1	SHR2	SHR3	SHR4	
136	MPN	SPL0	SPL1	SPL2	SPL3	SPL4	
141	MPN	BCJ					
142	MPN	ERL0	ERL1	ERL2	ERL3	ERL4	
152	MPN	CON0	CON1	CON2	CON3	CON4	
154	MPN	SHC0	SHC1	SHC2	SHC3	SHC4	
161	MPN	MAT	COH	FRC			
171	MPN	CQV	CLV	CVT			
END							

Material (MAT) Phase Control

The function of the MAT control record is to activate the MAT input phase. The MAT control record must follow an END input record and is required for all start runs. It may be used at restart time to change data.

	min	max
start	1	1
restart	0	1

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NSINP	Input mode switch. The value of NSINP specifies the mode of input to be used in this input phase. The value of NSINP must be integral and less than or equal to 3. The following definitions apply: ≤ 1.0 card input (default) = 2.0 library input = 3.0 keyboard input If the field containing NSINP is left blank, then the mode of input is assumed to be card input. If the value of NSINP is greater than 3.0, the message, INPUT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN.
2	NSTRC	Trace mode switch. The value of NSTRC specifies whether or not the trace option is active. The value of NSTRC must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 trace is not active, off (default) = 2.0 trace is active, on If the field containing NSTRC is left blank, then the mode is assumed to be not active (off). If the value of NSTRC is greater than 2.0, the message, TRACE MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The trace logic, if active (on), will cause the name of the subroutine or logical phase just entered to be printed on both the print and message files. These actions are taken in subroutines SBRENT and PHSENT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

Columns →	11	21	31	41	51	61	71	80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
3	NSDBG	Debug mode switch. The value of NSDBG specifies whether or not the debug option is active. The value of NSDBG must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 debug is not active, off (default) = 2.0 debug is active, on If the field containing NSDBG is left blank, then the debug mode is assumed to be not active (off). If the value of NSDBG is greater than 2.0, the message, DEBUG MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The debug logic, if active (on), will cause the common blocks associated with this input phase to be dumped at the end of each subroutine in the phase and at the end of the logical phase. These actions are taken in subroutines SBREXT and PHSEXT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.
4	NSPLT	Plot mode switch. The value of NSPLT specifies whether or not plots will be produced by this generator phase. The value of NSPLT must be integral and less than or equal to 2.0. The following definitions apply: ≤ 1.0 no plots produced, option off (default) = 2.0 plots produced, option on If the field containing NSPLT is left blank, then no plots will be produced (off). If the value of NSPLT is greater than 2.0, the message, PLOT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine MATGEN.

Columns →	11	21	31	41	51	61	71	80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
5	NSPRT	Print mode switch. The value of NSPRT controls the printing in this generator phase. The value of NSPRT must be integral and less than or equal to 2.0. The following definitions apply: = 1.0 only input records and error messages are printed, option off = 2.0 full printing done, option on (default) If the field containing NSPRT is left blank, full printing is done (option on). If the value of NSPRT is greater than 2.0, the message, PRINT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine MATGEN.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Equation-of-State Model Type

The 111 input record specifies the type of equation-of-state model for material MPN. If the 111 input record is omitted, the default value is used. The 111 input record may be used at restart time to change the equation-of-state model type.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71 80
	MPN	MEOS	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. The value of MPN uniquely identifies a material model. A model consists of an equation of state and strength, explosive, and thermal descriptions. A single value of MPN links together a set of MAT phase input records for one material model. The value of MPN must be integral and must be greater than or equal to 1 and less than or equal to MAXMAT. (See Appendix "Maximums".) If MPN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine MATINP. (See Appendix "Messages".)
2	MEOS	Equation-of-state model type. The value of MEOS uniquely identifies the type of equation-of-state model for material MPN. The equation of state defines a relationship for pressure as a function of relative volume and internal energy density. The value of MEOS must be integral and must be greater than or equal to 1 and less than or equal to MAXEOS. (See Appendix "Maximums".) If MEOS is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine MATINP. (See Appendix "Messages".) The following definitions apply: = 1.0 function of relative volume only (default) = 2.0 function of internal energy density only = 3.0 function of relative volume and internal energy density = 4.0 p-α compaction model (not yet programmed) = 5.0 JWL chemical explosive model = 6.0-10.0 user-supplied models A description of each model is presented in Appendix "Material Models". Coefficients for a particular model are entered on input records 121, 122, 123.

Columns →	11	21	31	41	51	61	71 80
	MPN	MEOS	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Strength Description Model Type

The 112 input record specifies the type of strength model for material MPN. If the 112 input record is omitted, default values are used. The 112 input record may be used at restart time to change the strength model types.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71 80
	MPN	MYLD	MSHR	MSPL	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	MYLD	Yield stress model type. The value of MYLD identifies the type of yield stress model for material MPN. The yield stress defines a relationship for stress deviators as a function of thermodynamic variables and time. The value of MYLD must be integral and must be greater than or equal to 1 and less than or equal to MAXYLD. (See Appendix "Maximums".) If MYLD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine MATINP. (See Appendix "Messages".) The following definitions apply: = 1.0 hydrodynamic (default) = 2.0 constant = 3.0 function of pressure only = 4.0 function of internal energy density only = 5.0 function of distortional energy (strain hardening or softening) = 6.0-10.0 user-supplied models A description of each model is presented in Appendix "Material Models". Coefficients for a particular model are entered on input record 132.

Columns →	11	21	31	41	51	61	71	80
	MPN	MYLD	MSHR	MSPL	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
3	MSHR	Shear modulus model type. The value of MSHR identifies the type of shear modulus model for material MPN. The model defines a relationship for shear modulus as a function of thermodynamic variables and time. The value of MSHR must be integral and must be greater than or equal to 1 and less than or equal to MAXSHR. (See Appendix "Maximums".) If MSHR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine MATINP. (See Appendix "Messages".) The following definitions apply: = 1.0 hydrodynamic (default) = 2.0 constant = 3.0 function of pressure only = 4.0 function of internal energy density only = 5.0 function of distortional energy density only (strain hardening model) = 6.0-10.0 user-supplied models A description of each model is presented in Appendix "Material Models". Coefficients for a particular model are entered on input record 134.
4	MSPL	Spall model type. The value of MSPL identifies the type of spall model for material MPN. The spall model defines a relationship for tensile pressure (mean stress) as a function of thermodynamic variables and time. The value of MSPL must be integral and must be greater than or equal to 1 and less than or equal to MAXSPL. (See Appendix "Maximums".) If MSPL is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine MATINP. (See Appendix "Messages".) The following definitions apply: = 1.0 zero (default) = 2.0 constant* = 3.0 function of relative volume only = 4.0 function of internal energy density only = 5.0 function of distortional energy density only = 6.0-10.0 user-supplied models A description of each model is presented in Appendix "Material Models". Coefficients for a particular model are entered on input record 136.

---

*For solids, the constant is usually zero or negative, while for fluids, it can be equal to a positive vapor pressure.

Columns →	11	21	31	41	51	61	71	80
	MPN	MYLD	MSHR	MSPL	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Energy Release Model Type

The 113 input record specifies the type of energy release model for material MPN. If the 113 input record is omitted, the default value is used. The 113 input record may be used at restart time to change the energy release model type.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71 80
	MPN	MERL	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	MERL	Energy release model type. The value of MERL identifies the type of energy release model for material MPN. The energy release model defines a relationship for release of chemical energy as a function of thermodynamic variables and time. The value of MERL must be integral and must be greater than or equal to 1 and less than or equal to MAXERL. (See Appendix "Maximums".) If MERL is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine MATINP. (See Appendix "Messages".) The following definitions apply:

≤ 1.0	no energy release (default)
= 2.0	Chapman-Jouguet explosive model
= 3.0	no model presently defined
= 4.0	no model presently defined
= 5.0	no model presently defined
= 6.0-10.0	user-supplied models

A description of each model is presented in Appendix "Material Models". Coefficients for a particular model are entered on input records 141 and 142.

Field Number	Input Variable Name	Description of Input Variable
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Heading Flow Model Type

The 114 input record specifies the type of heat flow model for material MPN. If the 114 input record is omitted, default values are used. The 114 input record may be used at restart time to change heat flow model types.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71 80
	MPN	MCON	MSHC	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	MCON	Conduction model type. The value of MCON identifies the type of heat conduction model for material MPN. The heat conduction model defines a relationship for heat conductivity as a function of thermodynamic variables and time. The value of MCON must be integral and must be greater than or equal to 1 and less than or equal to MAXCON. (See Appendix "Maximums".) If MCON is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine MATINP. (See Appendix "Messages".) The following definitions apply:

= 1.0	no heat conduction (default)
= 2.0	constant heat conduction
= 3.0	function of temperature only
= 4.0	no model presently defined
= 5.0	no model presently defined
= 6.0-10.0	user-supplied models

A description of each model is presented in Appendix "Material Models". Coefficients for a particular model are entered on input record 152.

Columns →	11	21	31	41	51	61	71	80
	MPN	MCON	MSHC	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
3	MSHC	Specific heat capacity model type. The value of MSHC identifies the type of specific heat capacity model for material MPN. The specific heat capacity model defines a relationship for specific heat capacity as a function of thermodynamic variables and time. The value of MSHC must be integral and must be greater than or equal to 1 and less than or equal to MAXSHC. (See Appendix "Maximums".) If MSHC is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine MATINP. (See Appendix "Messages".) The following definitions apply: = 1.0 no specific heat capacity (default) = 2.0 constant specific heat capacity = 3.0 function of temperature only = 4.0 no model presently defined = 5.0 no model presently defined = 6.0-10.0 user-supplied models A description of each model is presented in Appendix "Material Models". Coefficients for a particular model are entered on input record 154.
4-7	--	Fields 4-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Artificial Viscosity Model Type

Page 1 of 1

The 115 input record specifies the type of artificial viscosity model for material MPN. If the 115 input record is omitted, the default value is used. The 115 record may be used at restart time to change the artificial viscosity model type.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71	80
	MPN	MAVS	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	MAVS	Artificial viscosity model type. The value of MAVS identifies the type of artificial viscosity model for material MPN. The artificial viscosity model defines a relationship for linear, quadratic, and tensor artificial viscosities. The value of MAVS must be integral and must be greater than or equal to 1 and less than or equal to 5. If MAVS is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine MATINP. (See Appendix "Messages".) The following definitions apply: = 1.0 quadratic artificial viscosity in compression only (default) = 2.0 quadratic artificial viscosity in compression and linear artificial viscosity always = 3.0 quadratic artificial viscosity in compression and linear artificial viscosity in compression = 4.0 quadratic artificial viscosity in compression and linear artificial viscosity in expansion = 5.0 user-supplied model A description of each model is presented in Appendix "Material Models". Coefficients for a particular model are entered on input record 171.
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.116 through 7.120 will not appear in this report.

Reference Density

The 121 input record specifies the reference density for the equation of state for material MPN. The 121 record is absolutely required for each equation-of-state model. The 121 input record may be used at restart time to change the reference density.

	min	max
start	1	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71	80
	MPN	RDN	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	RDN	Reference density. The value of RDN must be a positive number greater than SMLNUM. If RDN is less than SMLNUM a material is assumed not to exist. The value of RDN is often chosen to be that of the initial density. There is no default value.
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Equation-of-State Parameters (#1)

The 122 input record specifies equation-of-state parameters for the equation-of-state model specified on the 111 input record. If the 122 input record is omitted, default values are used. The 122 input record may be used at restart time to change equation-of-state parameters.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71	80
	MPN	EOS0	EOS1	EOS2	EOS3	EOS4	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	EOS0	Equation-of-state parameter 0. (See Appendix "Material Models".) Default value is 0.
3	EOS1	Equation-of-state parameter 1. (See Appendix "Material Models".) Default value is 0.
4	EOS2	Equation-of-state parameter 2. (See Appendix "Material Models".) Default value is 0.
5	EOS3	Equation-of-state parameter 3. (See Appendix "Material Models".) Default value is 0.
6	EOS4	Equation-of-state parameter 4. (See Appendix "Material Models".) Default value is 0.
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Equation-of-State Parameters (#2)

Page 1 of 1

The 123 input record specifies equation-of-state parameters for the equation-of-state model specified on the 111 input record. If the 123 input record is omitted, default values are used. The 123 input record may be used at restart time to change equation-of-state parameters.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71 80
	MPN	EOS5	EOS6	EOS7	EOS8	EOS9	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	EOS5	Equation-of-state parameter 5. (See Appendix "Material Models".) Default value is -1.0.
3	EOS6	Equation-of-state parameter 6. (See Appendix "Material Models".) Default value is 100.
4	EOS7	Equation-of-state parameter 7. (See Appendix "Material Models".) Default value is 0.
5	EOS8	Equation-of-state parameter 8. (See Appendix "Material Models".) Default value is 0.
6	EOS9	Equation-of-state parameter 9. (See Appendix "Material Models".) Default value is 0.
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.124 through 7.131 will not appear in this report.

Yield Stress Parameters

The 132 input record specifies yield stress parameters for the yield stress model specified on the 112 input record. If the 132 input record is omitted, default values are used. The 132 input record may be used at restart time to change yield stress parameters.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71 80
	MPN	YLD0	YLD1	YLD2	YLD3	YLD4	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	YLD0	Yield stress parameter 0. (See Appendix "Material Models".) Default value is 0.
3	YLD1	Yield stress parameter 1. (See Appendix "Material Models".) Default value is 0.
4	YLD2	Yield stress parameter 2. (See Appendix "Material Models".) Default value is 0.
5	YLD3	Yield stress parameter 3. (See Appendix "Material Models".) Default value is 0.
6	YLD4	Yield stress parameter 4. (See Appendix "Material Models".) Default value is 0.
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Shear Modulus Parameters

The 134 input record specifies shear modulus parameters for the shear modulus model specified on the 112 input record. If the 134 input record is omitted, default values are used. The 134 input record may be used at restart time to change shear modulus parameters.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71 80
	MPN	SHR0	SHR1	SHR2	SHR3	SHR4	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	SHR0	Shear modulus parameter 0. (See Appendix "Material Models".) Default value is 0.
3	SHR1	Shear modulus parameter 1. (See Appendix "Material Models".) Default value is 0.
4	SHR2	Shear modulus parameter 2. (See Appendix "Material Models".) Default value is 0.
5	SHR3	Shear modulus parameter 3. (See Appendix "Material Models".) Default value is 0.
6	SHR4	Shear modulus parameter 4. (See Appendix "Material Models".) Default value is 0.
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Spall Parameters

The 136 input record specifies spall parameters for the spall model specified on the 112 input record. If the 136 input record is omitted, default values are used. The 136 input record may be used at restart time to change spall parameters.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71–80
	MPN	SPL0	SPL1	SPL2	SPL3	SPL4	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record
2	SPL0	Spall parameter 0. (See Appendix "Material Models".) Default value is 0.
3	SPL1	Spall parameter 1. (See Appendix "Material Models".) Default value is 0.
4	SPL2	Spall parameter 2. (See Appendix "Material Models".) Default value is 0.
5	SPL3	Spall parameter 3. (See Appendix "Material Models".) Default value is 0.
6	SPL4	Spall parameter 4. (See Appendix "Material Models".) Default value is 0.
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.137 through 7.140 will not appear in this report.

Chapman-Jouguet Explosive

Page 1 of 1

TYPE 141

The 141 input record specifies the Chapman-Jouguet parameter for the Chapman-Jouguet model specified on the 113 input record. If the 141 input record is omitted, default values are used. The 141 input record may be used at restart time to change the Chapman-Jouguet parameter.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71 80
	MPN	BCJ	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	BCJ	Chapman-Jouguet beta. (See Appendix "Material Models".) Default value is 0.
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Energy Release Parameters

Page 1 of 1

The 142 input record specifies energy release parameters for the energy release model specified on the 113 input record. If the 142 input record is omitted, default values are used. The 142 input record may be used at restart time to change energy release parameters.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71	80
	MPN	ERL0	ERL1	ERL2	ERL3	ERL4	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	ERL0	Energy release parameter 0. (See Appendix "Material Models".) Default value is 0.
3	ERL1	Energy release parameter 1. (See Appendix "Material Models".) Default value is 0.
4	ERL2	Energy release parameter 2. (See Appendix "Material Models".) Default value is 0.
5	ERL3	Energy release parameter 3. (See Appendix "Material Models".) Default value is 0.
6	ERL4	Energy release parameter 4. (See Appendix "Material Models".) Default value is 0.
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.144 through 7.151 will not appear in this report.

Heat Conductivity Parameters

Page 1 of 1

The 152 input record specifies heat conductivity parameters for the heat conductivity model specified on the 114 input record. If the 152 input record is omitted, default values are used. The 152 input record may be used at restart time to change heat conductivity parameters.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71 80
	MPN	CONO	CON1	CON2	CON3	CON4	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	CONO	Heat conductivity parameter 0. (See Appendix "Material Models".) Default value is 0.
3	CON1	Heat conductivity parameter 1. (See Appendix "Material Models".) Default value is 0.
4	CON2	Heat conductivity parameter 2. (See Appendix "Material Models".) Default value is 0.
5	CON3	Heat conductivity parameter 3. (See Appendix "Material Models".) Default value is 0.
6	CON4	Heat conductivity parameter 4. (See Appendix "Material Models".) Default value is 0.
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Specific Heat Capacity Parameters

The 154 input record specifies specific heat capacity parameters for the specific heat capacity model specified on the 114 input record. If the 154 input record is omitted, default values are used. The 154 input record may be used at restart time to change specific heat capacity parameters.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71	80
	MPN	SHCO	SHC1	SHC2	SHC3	SHC4	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	SHCO	Specific heat capacity parameter 0. (See Appendix "Material Models".) Default value is 0.
3	SHC1	Specific heat capacity parameter 1. (See Appendix "Material Models".) Default value is 0.
4	SHC2	Specific heat capacity parameter 2. (See Appendix "Material Models".) Default value is 0.
5	SHC3	Specific heat capacity parameter 3. (See Appendix "Material Models".) Default value is 0.
6	SHC4	Specific heat capacity parameter 4. (See Appendix "Material Models".) Default value is 0.
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.155 through 7.160 will not appear in this report.

Surface Properties

The 161 input record specifies the surface properties, cohesion and friction. If the 161 input record is omitted, default values are used. The 161 record may be used at restart time to change the surface properties between materials.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71 80
	MPN	MAT	COH	FRC	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	MAT	Material property number of interacting material. The value of MAT must be equal to the value of MPN of another defined material to which these surface properties correspond.
3	COH	Surface cohesion. The value of COH is the normal cohesive stress which must be overcome to separate the materials identified by MPN and MAT. A positive value of COH is assumed to be the tensile limit. The default value of COH is 0.0.
4	FRC	Surface friction. The value of FRC is the coefficient of friction between materials identified by MPN and MAT. The range of values of FRC is between 0.0 and 1.0. The value of 0.0 means no frictional resistance, while 1.0 means no slip. Values between 0.0 and 1.0 represent the fraction of normal surface force that is frictional resistance. The default value of FRC is 0.0. FRC applies only in two-dimensional problems and must be left blank in one-dimensional problems.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.163 through 7.170 will not appear in this report.

Artificial Viscosity Parameters

Page 1 of 1

TYPE 171

The 171 input record specifies artificial viscosity parameters for the artificial viscosity model specified on the 115 input record. If the 171 input record is omitted, default values are used. The 171 input record may be used at restart time to change artificial viscosity parameters.

	min	max
start	0	MAXMAT
restart	0	MAXMAT

Columns →	11	21	31	41	51	61	71–80
	MPN	CQV	CLV	CTV	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPN	Material property number. See Field Number 1 on TYPE 111 record.
2	CQV	Coefficient of quadratic artificial viscosity. The value of CQV must be a positive number greater than SMLNUM or the default value is used. A typical value of CQV is 2.0 for all materials up to 1 Mbar. When the 171 input record is not specified or the field is left blank, the default value of 2.0 is assumed.
3	CLV	Coefficient of linear artificial viscosity. The value of CLV must be a positive number. Typical values range between 0.0 and 1.0. Default value is 0.0.
4	CTV	Coefficient of tensor viscosity. CTV is applicable only to two-dimensional problems and is ignored for one-dimensional problems.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.173 through 7.198 will not appear in this report.

End of MAT Phase

The END input record signifies the end of a block of data for the MAT input phase. It must follow the last MAT input record.

	min	max
start	1	1
restart	0	1

Columns →	11	21	31	41	51	61	71	80
	--	--	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1-7	--	Fields 1-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

7.2 GRID POINTS SPECIFICATION PHASE (GPT)

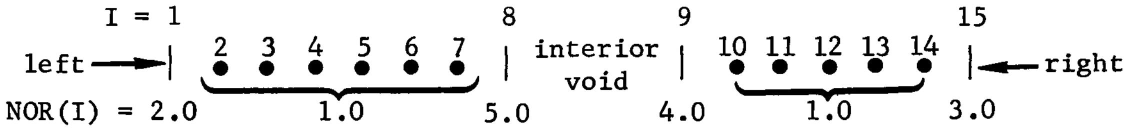
The grid points specification phase (GPT) input block may be located in any position in the input deck after the PRB input block and before the final END record. The purpose of the GPT input block is to specify the location and orientation of grid points and wall points for the problem at start time. The GPT input block may not be used at restart time.

Grid points are specified by "grid" index (LG) and then by grid-point "block" index (L). (Both indexes are local to the GPT phase and are used to locate array elements in the labeled COMMON block /GPTPRM/.) Grids are defined by unique physical boundaries so that grid-point orientation can be determined. Grid-point blocks are defined as convenient groupings of grid points for the purpose of grid-point coordinate generation. From one to MAXBLK grid-point blocks can be specified in from one to MAXGRD grids (see Appendix "Maximums"). Blocks find their way into a particular grid by means of the specification of grid-point block index limits. Block index specification may not overlap two grids.

Grid-point orientation depends on the dimensionality of the PROCESSOR, and is determined as a result of the input recorded on record types 21_. The STEALTH 1D Lagrange processor allows six (6) orientations, as follows:

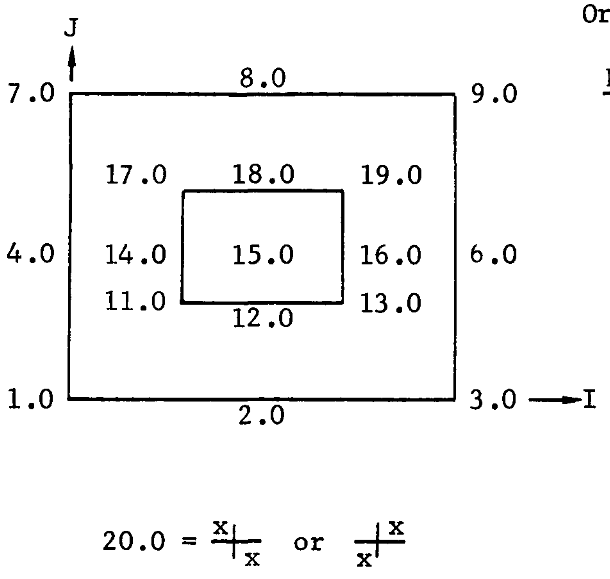
Orientation Value NOR(I)	Orientation Description
1.0	interior
2.0	outside left
3.0	outside right
4.0	inside left
5.0	inside right
6.0	closed void right
7.0	closed void left

One orientation value is contained in each element of the NOR array. The index of the NOR array is the grid-point index, I. A one-dimensional problem is shown below in index space with appropriate orientation values.



To define the orientations, two grids would be required; on input record type 211, LG = 1.0 would include grid points 1 - 8, while LG = 2.0 would include grid points 9 - 15.

The STEALTH 2D Lagrange processor allows twenty (20) orientations. The orientation values for a single grid are shown below in index space.



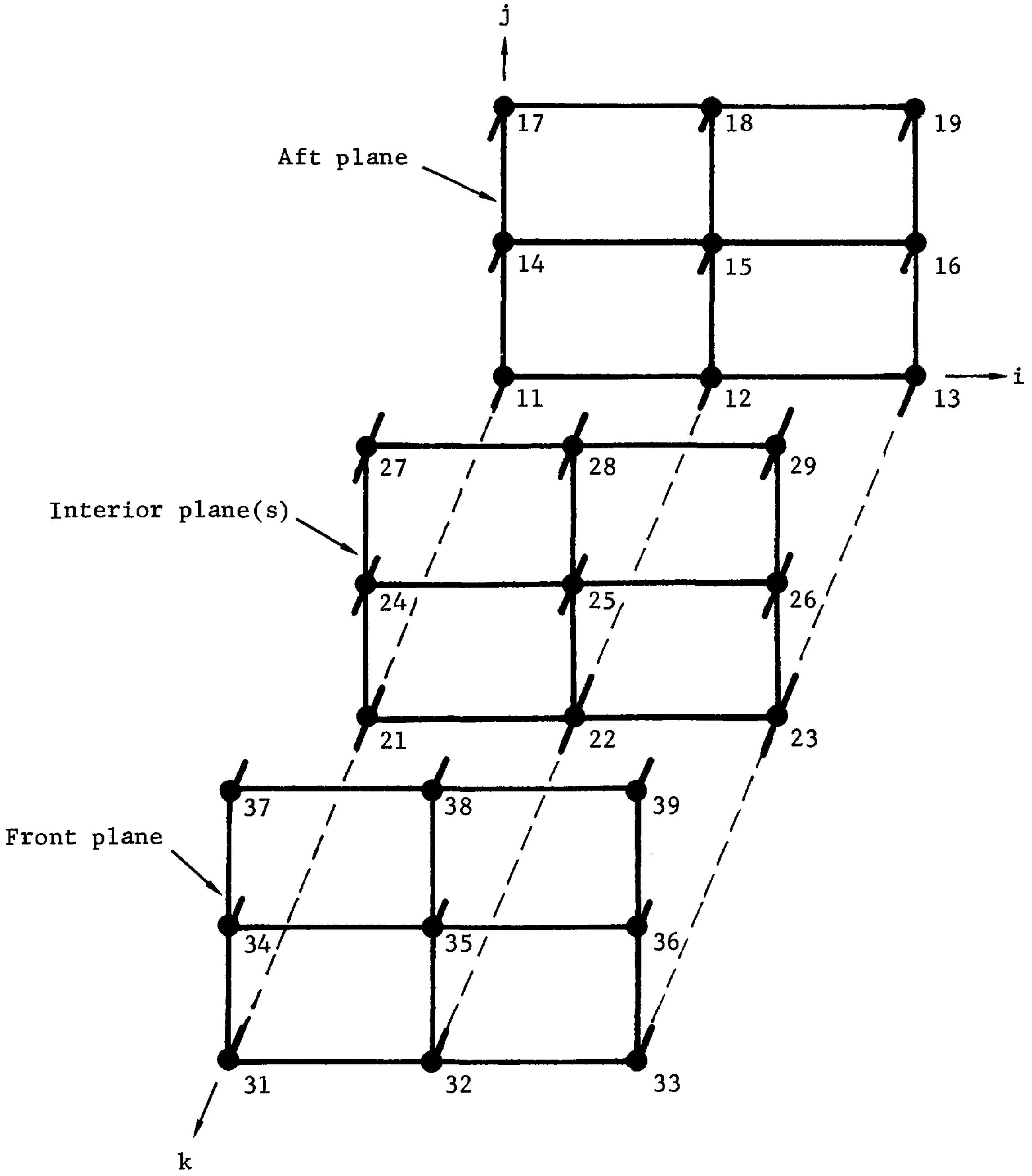
Orientation Value NOR(I,J)	Orientation Description
1.0	outside bottom left corner
2.0	outside bottom
3.0	outside bottom right corner
4.0	outside left
5.0	interior
6.0	outside right
7.0	outside top left corner
8.0	outside top
9.0	outside top right corner
10.0	user-supplied
11.0	inside bottom left notch
12.0	inside bottom (same as 8.0)
13.0	inside bottom right notch
14.0	inside left (same as 6.0)
15.0	nonexistent point
16.0	inside right (same as 4.0)
17.0	inside top left notch
18.0	inside top (same as 2.0)
19.0	inside top right notch
20.0	outside corner-on-corner

Unlike the one-dimensional code, the orientation values are defined similarly for each grid. The inside orientations (11-20) are not presently available.

The STEALTH 3D code has twenty-seven (27) possible outside orientations. The orientation values for a single grid are separated into three groups: (1) aft plane, (2) interior plane(s), and (3) front plane. In each group, there are nine (9) orientations analogous to the nine (9) outside orientation values for the 2D code. The 3D orientation values are listed below by group and are shown on the following page in schematic form.

ORIENTATION VALUE
NOR(I,J,K)

Aft Plane	Interior Plane(s)	Front Plane
11.0 corner	21.0 edge	31.0 corner
12.0 edge	22.0 face	32.0 edge
13.0 corner	23.0 edge	33.0 corner
14.0 edge	24.0 face	34.0 edge
15.0 face	25.0 interior	35.0 face
16.0 edge	26.0 face	36.0 edge
17.0 corner	27.0 edge	37.0 corner
18.0 edge	28.0 face	38.0 edge
19.0 corner	29.0 edge	39.0 corner


j
17
18
19
Aft plane
14
15
16
11
12
13
i
27
28
29
Interior plane(s)
24
25
26
21
22
23
37
38
39
Front plane
34
35
36
31
32
33
k

The GPT phase input records for one- or two-dimensional coordinate input are divided into the following groups:

Record Identifier	Group Description
22_	Block definition
23_	Point-by-point input algorithms
24_	Equal zone input algorithms
25_	Geometric-ratio zone algorithms
26_	Polar and hyperbolic-elliptic zone algorithms
28_	Special algorithms

There are no global input defaults in the GPT input block. Variable defaults do exist but are expressly noted in the text of the variable description. A minimum input for a start run consists of one input record to specify grid definition (orientations) and one input record to specify grid-point coordinates. Changing grid-point coordinates and orientation after a problem has started can be done only by rezoning.

A summary of GPT phase input records and input variables appears in Table 7.2.

7.2.1 One-Dimensional Input Blocks. A user may define the positions of mesh points in a grid by dividing the grid into one or more blocks. A block is a set of grid points which are contiguous in index space (see Figure 7.4). The x-positions of the grid points in a block are generated from information supplied by user input.

A block must be one of the following types:

Equally Spaced Points

A block containing equally spaced grid points implies constant zone size in the block. The user may specify equally spaced points in a block in one of three ways. In all cases, the number of zones and the block's leftmost grid point coordinate value must be specified. One method of specification, which uses the 241 input record, requires the block's rightmost grid point coordinate value; the second method of specification, which uses the 242 input record, requires the block width; and the third method, which uses the 243 input record, requires the width of a zone in the block.

Geometrically Spaced Points

A block containing grid points spaced by a geometric ratio also requires that the number of zones in the block, the block's leftmost grid point coordinate value, and the geometric ratio be specified for all methods of generation. There are four ways to specify geometrically spaced grid points in a block: (1) input record 251 uses the block's rightmost grid point coordinate value; (2) input record 252 uses the width of the block; (3) input record 253 uses the block's leftmost zone width; and (4) input record 254 uses the block's rightmost zone width.

Point-by-Point

The coordinates of each point in a block may be given explicitly.

Special

The user may provide FORTRAN logic in subroutine MYGPT to generate grid points for a block. The subroutine must be programmed so that, for given values of i in a block (variable I), the subroutine returns the x-coordinates for that block (variables XPN). The block number (NBLK) is also a parameter, so that the subroutine may contain logic for more than one block. The user-supplied logic should not alter I or NBLK.

7.2.2 Two-Dimensional Input Blocks. A user may define the positions of mesh points in a grid by dividing the grid into one or more blocks. A block is a set of grid points which are contiguous in index space (see Figure 7.5).* The x- and y-positions of the grid points in a block are

---

*Blocks may overlap one another with the highest block number having highest priority.

generated from information supplied by user input. Only in axial symmetry is there a restriction on the x- and y-values. In 2D axial symmetry, the x-direction is the radial direction and the y-direction is the axial direction.

A block must be one of the following types:

Quadrilateral

A quadrilateral block is one in which the border of the block in the real space forms a convex quadrilateral. The user provides (1) the coordinates of the lower leftmost grid point (lower left in the i-j space of the block); (2) information about the size of the zones in the block (dimensions of the first zone or dimensions of the entire block); and (3) a pair of geometric ratios used to space grid points along the bottom (lowest value j-line) of the block and on the left (lowest value i-line) of the block. These data are provided on a 246 or a 247 input record. If a geometric ratio, r, is provided, then the ratio is used to space grid points such that the distance between grid point 2 and grid point 3 is r times the distance between grid point 1 and grid point 2, the distance between grid point 3 and grid point 4 is r times the distance between grid point 2 and grid point 3, etc.

A 246 or a 247 input record is sufficient to define a rectangular block with i-lines parallel to the y-axis and j-lines parallel to the x-axis. If a more general quadrilateral is desired, a 256 or a 257 input record must augment a 246 or a 247 input record. On the 256 and 257 records, the user may specify (1) angles between the sides of the block; (2) an angle of rotation of the entire block; and (3) information used to space grid points along the rightmost (highest value) i-line. The grid points are generated such that the i- and j-lines are straight line segments in x-y space.

Polar*

A polar block is one in which the grid points on a given i-line lie on the same circle (or radial line) in x-y space, and the grid points on a given j-line lie on the same radial line (or circle) in x-y space. All circles are concentric and all radial lines pass through their center.

The user provides (1) the coordinates of the center; (2) the radius of the inner circle; (3) the angle that the first radial line (bottommost j-line) makes with the positive x-axis; (4) information

---

*A detailed description of the subroutine (PHE2DL) that handles polar grid point generation can be found in Volume 3, "Programmer's Manual", under Appendix "PHE2DL".

about the size of the zones in the block (dimensions of the first zone or dimensions of the entire block); and (5) whether the i-lines or the j-lines are the circles. These data are provided on a 263 input record and either a 261 or a 262 input record. A 261 or a 262 input record is sufficient to define a polar block in which grid points are evenly spaced along i-lines and j-lines. If geometric spacing is desired, ratios must be specified by including a 265 or a 266 input record. The ratios are used to space grid points along circles and radial lines.

Hyperbolic-Elliptic*

A hyperbolic-elliptic block is one in which the grid points on a given i-line lie on the same ellipse (or hyperbola) in x-y space and the grid points on a given j-line lie on the same hyperbola (or ellipse) in x-y space. All ellipses and hyperbolas are concentric, and all hyperbolas share the same foci with the innermost ellipse.

Three input records are needed to specify a hyperbolic-elliptic block. On a 263 input record, the user specifies whether the i-lines or the j-lines are ellipses. On a 261 or a 262 input record, the user provides (1) the coordinates of the center; (2) the length of the semi-minor axis of the inner ellipse; (3) the angle which the asymptote of the first hyperbola makes with the semi-major axis of the ellipses and hyperbolas; and (4) information used to space the semi-minor axes of consecutive ellipses (either the difference between the first two, or between the first and last) and the asymptotes of consecutive hyperbolas (either the angle between the first two, or between the first and last). On a 266 or a 267 input record, the user provides the semi-major axis of the inner ellipse and information used to space the semi-major axes of consecutive ellipses (either the difference between the first two or between the first and last). Geometric ratios used to space the semi-major axes of the ellipses, semi-minor axes of the ellipses, and asymptotes of the hyperbolas may also be given, as may the rotation of the major axis from the positive x-axis.

Special

The user may provide FORTRAN logic in subroutine MYGPT to generate grid points for a block. The subroutine must be programmed so that, for given values of i and j (variables III and JJJ), the subroutine returns the x- and y-coordinates for that point (variables XXX and YYY). The block number (NBLK) is also a parameter so that the subroutine may contain logic for more than one block. The user-supplied logic should not alter III, JJJ, or NBLK.

---

*A detailed description of the subroutine (PHE2DL) that handles hyperbolic-elliptic grid point generation can be found in Volume 3, "Programmer's Manual", under Appendix "PHE".

Grid-point coordinates may also be given explicitly, point by point. Point-by-point coordinates need not be contiguous in index space.

Each block must be given a unique block number from 1 to MAXBLK. (See Appendix "Maximums".) Point-by-point initializations should also be given a unique block number, though they need not form a contiguous set of points. All point-by-point initializations should be associated with the same block number.

If the same point is defined in more than one block, the block with the highest number will be used to define the point. Thus, it is possible, for example, to define a large quadrilateral block, then redefine a few of its points by using point-by-point initializations with a higher block number than the quadrilateral block number. See Figure 7.201.

Although all STEALTH 2D zones are quadrilaterals, it is possible to form a triangular zone by making one point colinear with its two neighbors. This often occurs naturally in hyperbolic-elliptic zoning along the semi-major axis. In general, three-node zones are numerically stiffer than quadrilaterals, so they are not used.

7.2.3 Three-Dimensional Input Blocks. A user may define the positions of mesh points in a grid by dividing the grid into one or more blocks. A block is a set of grid points which are contiguous in index space. The blocks may overlap one another, with the highest block number having the highest priority. The x-, y-, and z-positions of the grid points in a block are generated from information supplied by user input.

At the present time, the only block type available is cubical. The user provides (1) the coordinates of the lower-left-aftmost grid point (aft-lower-left in the i-j-k space of the block); and (2) information about the size of the zones in the block (dimensions of the first zone or dimensions of the entire block). These data are provided on a 248 or a 249 input record.

7.2.4 Wall-Point Specification. Wall points define line segments (known as wall segments) which are kinematic constraints for the grid. Wall point values are provided on the 212 input record.

In one-dimensional runs, single wall points may be used to specify kinematic boundaries on the left and right of the grid. Two or more wall points may be used to define a flume symmmetry boundary or a "thin" option.*

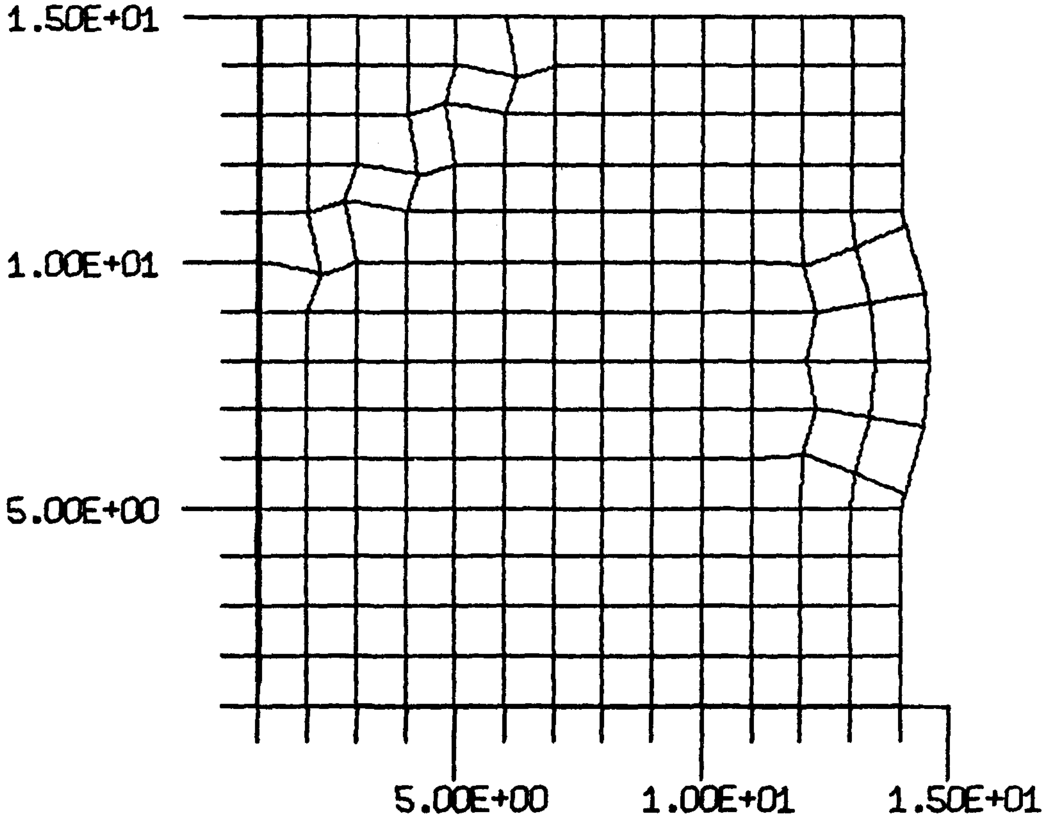
In two-dimensional runs, pairs of wall points may be used to define wall segments. Single wall points are not allowed. Two or more wall points form a sequence of wall points. In axial symmetry, at least two wall points are required to define the axis of symmetry.*

In three-dimensional runs, three wall points define a wall surface. Wall surfaces are only linked to other surfaces if they share two common wall points. (This option is not available.)

---

*These concepts are described in greater detail in Appendix "Boundary Interaction Algorithms".

This page intentionally left blank.



221	BLK	1.0	1.0	14.0	1.0	15.0		
246	QUD	1.0	1.0	1.0	1.0	1.0		
221	BLK	2.0	12.0	14.0	6.0	10.0		
262	POL	2.0	7.0	8.0	5.365	2.231	-21.8	43.6
263	POL	2.0	1.0					
232	PBP	10.0	2.0	10.0	2.25	9.75		
232	PBP	10.0	3.0	11.0	2.75	11.25		
232	PBP	10.0	4.0	12.0	4.25	11.75		
232	PBP	10.0	5.0	13.6	4.75	13.25		
232	PBP	10.0	6.0	14.0	6.25	13.75		

In the above scheme, block number 1 defines a 14×15 regular quadrilateral mesh. Block number 2 then redefines the points $\{(i,j): 12 \leq i \leq 14,\ 6 \leq j \leq 10\}$ to be a polar block. Finally, the points (2,10), (3,11), (4,12), (5,13), and (6,14) are specified explicitly in a point-by-point fashion with block number 10.

Figure 7.201. Example of grid point generation.

TABLE 7.2

SUMMARY OF GPT PHASE INPUT RECORDS AND INPUT VARIABLES

FIELDS 1-7

TYPE	1	2	3	4	5	6	7	
GPT	NSINP	NSTRC	NSDBG	NSPLT	NSPRT			
211	LG	IMIN	JMIN	XMIN	YMIN			
212	LW	XWL	YWL	NWO				
221	L	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT	
231	L	IPSN	XPSN	IPSN	XPSN	IPSN	XPSN	1D
232	L	IPSN	JPSN	XPSN	YPSN			2D
233	L	IPSN	JPSN	KPSN	XPSN	YPSN	ZPSN	3D
241	L	NZON	XLFT	XRHT				1D
242	L	NZON	XLFT	XBLK				1D
243	L	NZON	XLFT	XZON				1D
246	L	XBL	ZONJBL	YBL	ZONIBL	RATJBT	RATILF	2D
247	L	XBL	BLKJBT	YBL	BLKILF	RATJBT	RATILF	2D
248	L	XBL	ZONJBL	YBL	ZONIBL	ZBL	ZONKBL	3D
249	L	XBL	BLKJBT	YBL	BLKILF	ZBL	BLKKBL	3D

TABLE 7.2 (continued)

FIELDS 1-7

TYPE	1	2	3	4	5	6	7	
251	L	NZON	XLFT	XRHT	XRAT			1D
252	L	NZON	XLFT	XBLK	XRAT			1D
253	L	NZON	XLFT	XZONL	XRAT			1D
254	L	NZON	XLFT	XZONR	XRAT			1D
256	L	ANG1	ANG2	ANG3	ZONIBR	RATIRH		2D
257	L	ANG1	ANG2	ANG3	BLKIRH	RATIRH		2D
261	L	XCEN	YCEN	SMLRAD	ZONRAD	SMLANG	ZONANG	2D
262	L	XCEN	YCEN	SMLRAD	BLKRAD	SMLANG	BLKANG	2D
263	L	IJORN						2D
266	L	RATRAD	RATANG	SMLMAJ	ZONMAJ	RATMAJ	ANGMAJ	2D
267	L	RATRAD	RATANG	SMLMAJ	BLKMAJ	RATMAJ	ANGMAJ	2D
271	L	ZTHK						2D
281	L	NZON	XLFT	XRHT				1D
282	L	NZON	XLFT	XBLK				1D
283	L							
END								

This page intentionally left blank.

Grid Point (GPT) Phase Control

The function of the GPT control record is to activate the GPT input phase. The GPT control record must follow an END input record and is required for all start runs. It may not be used at restart time.

	min	max
start	1	1
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NSINP	Input mode switch. The value of NSINP specifies the mode of input to be used in this input phase. The value of NSINP must be integral and less than or equal to 3. The following definitions apply: ≤ 1.0 card input (default) = 2.0 library input = 3.0 keyboard input If the field containing NSINP is left blank, then the mode of input is assumed to be card input. If the value of NSINP is greater than 3.0, the message, INPUT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN.
2	NSTRC	Trace mode switch. The value of NSTRC specifies whether or not the trace option is active. The value of NSTRC must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 trace is not active, off (default) = 2.0 trace is active, on If the field containing NSTRC is left blank, then the mode is assumed to be not active (off). If the value of NSTRC is greater than 2.0, the message, TRACE MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The trace logic, if active (on), will cause the name of the subroutine or logical phase just entered to be printed on both the print and message files. These actions are taken in subroutines SBRENT and PHSENT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

Columns →	11	21	31	41	51	61	71	80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
3	NSDBG	Debug mode switch. The value of NSDBG specifies whether or not the debug option is active. The value of NSDBG must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 debug is not active, off (default) = 2.0 debug is active, on If the field containing NSDBG is left blank, then the debug mode is assumed to be not active (off). If the value of NSDBG is greater than 2.0, the message, DEBUG MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The debug logic, if active (on), will cause the common blocks associated with this input phase to be dumped at the end of each subroutine in the phase and at the end of the logical phase. These actions are taken in subroutines SBREXT and PHSEXT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.
4	NSPLT	Plot mode switch. The value of NSPLT specifies whether or not plots will be produced by this generator phase. The value of NSPLT must be integral and less than or equal to 2.0. The following definitions apply: ≤ 1.0 no plots produced, option off (default) = 2.0 plots produced, option on If the field containing NSPLT is left blank, then no plots will be produced (off). If the value of NSPLT is greater than 2.0, the message, PLOT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GPTGEN.

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
5	NSPRT	Print mode switch. The value of NSPRT controls the printing in this generator phase. The value of NSPRT must be integral and less than or equal to 2.0. The following definitions apply: = 1.0 only input records and error messages are printed, option off = 2.0 full printing done, option on (default) If the field containing NSPRT is left blank, full printing is done (option on). If the value of NSPRT is greater than 2.0, the message, PRINT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GPTGEN.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Grid Origin Definition

The 211 input record defines a grid origin. The 211 input record may not be used at restart time. At least one 211 input record is required for each grid defined by the GRD input record.

	min	max
start	1	MAXGRD
restart	0	0

Columns → 11 21 31 41 51 61 71 80

	LG	IMIN	JMIN	XMIN	YMIN	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	LG	Grid number. The value of LG must be a unique number for each grid. The value of LG must be integral and greater than or equal to 1 and less than or equal to MAXGRD. (See Appendix "Maximums".) If LG is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	IMIN	Leftmost grid point index of this grid. The value of IMIN must be integral and greater than or equal to 1 and less than or equal to MAXGPT - 1. (See Appendix "Maximums".) If IMIN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".) $1 \leq \text{IMIN} \leq \text{MAXGPT} - 1$
3	JMIN	Bottommost grid point index of this grid. The value of JMIN must be integral and greater than or equal to 1 and less than or equal to MAXROW - 1. (See Appendix "Maximums".) If JMIN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".) JMIN must be left blank in one-dimensional problems. $1 \leq \text{JMIN} \leq \text{MAXROW} - 1$
4	XMIN	x-coordinate for the (IMIN,JMIN) grid point in this grid. The value of XMIN can be any number in problem units for non-divergent symmetries. XMIN cannot be a negative number in divergent symmetries.
5	YMIN	y-coordinate for the (IMIN,JMIN) grid point in this grid. The value of YMIN can be any number in problem units. YMIN must be left blank in one-dimensional problems.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Wall Point Definition

The 212 input record defines a wall point. The 212 input record may not be used at restart time.

	min	max
start	0	MAXWPT
restart	0	0

Columns →	11	21	31	41	51	61	71–80
	LW	XWL	YWL	NWO	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	LW	Wall point number. The value of LW must be a unique number for each wall point. The value of LW must be integral and greater than or equal to 1 and less than or equal to MAXWPT. (See Appendix "Maximums".) If LW is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".) The values of LW = MAXWPT - 1 and LW = MAXWPT have special meaning for one-dimensional runs. They are the left and right boundary pistons, respectively. Wall point segments are defined as a set of wall points which must be consecutively numbered in increasing integer value. One-dimensional problems may have only one wall point segment composed of up to MAXWPT - 2 wall points. Two-dimensional problems may have up to MAXWPT/2 segments with a sum total of MAXWPT wall points.
2	XWL	x-coordinate for wall point LW. The value of XWL can be any number in problem units for non-divergent symmetries. XWL can not be a negative number in divergent symmetries.
3	YWL	y-coordinate for wall point LW. The value of YWL can be any number in problem units. YWL must be left blank when specifying one-dimensional boundary pistons.

Columns →	11	21	31	41	51	61	71	80
	LW	XWL	YWL	NWO	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
4	NWO	Wall point orientation number. The value of NWO must be integral and greater than or equal to 1 and less than or equal to 5. The following definitions apply: ≤ 1.0 interior wall point = 2.0 first wall point = 3.0 last wall point = 4.0 wall point on the left for 1D only = 5.0 wall point on the right for 1D only If the field containing NWO is left blank, then NWO is assumed to be equal to 1.0, i.e., an interior wall point. If the value of NWO is greater than 5.0, the message WALL POINT ORIENTATION IMPROPERLY DEFINED is written on the print and the message files and the program terminates immediately in subroutine GPTINP.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.213 through 7.220 will not appear in this report.

Grid Point Block Definition

The 221 input record defines a grid point block for which grid point spacing is described on input records in the GPT input phase. At least one 221 input record is required for each grid defined by the GRD input record for a start run to set up grid points. The 221 input record may not be used at restart time.

	min	max
start	1	MAXBLK
restart	0	0

Columns → 11 21 31 41 51 61 71 80

	L	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	ILFT	Leftmost grid point index for grid point block L. The value of ILFT must be integral and greater than or equal to 1 and less than IRHT. If ILFT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the GPT GENERATOR phase. (See Appendix "Messages".) $1 \le \text{ILFT} < \text{IRHT}$
3	IRHT	Rightmost grid point index for grid point block L. The value of IRHT must be integral and greater than ILFT and less than or equal to MAXGPT. (See Appendix "Maximums".) If IRHT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the GPT GENERATOR phase. (See Appendix "Messages".) $\text{ILFT} < \text{IRHT} \le \text{MAXGPT}$

Columns →	11	21	31	41	51	61	71	80
	L	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
4	JBOT[*]	Bottommost grid point index for grid point block L. The value of JBOT must be integral and greater than or equal to 1 and less than JTOP. If JBOT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the GPT GENERATOR phase. (See Appendix "Messages".) $1 \leq \mathrm{JBOT} < \mathrm{JTOP}$
5	JTOP[*]	Topmost grid point index for grid point block L. The value of JTOP must be integral and greater than JBOT and less than or equal to MAXROW. (See Appendix "Maximums".) If JTOP is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the GPT GENERATOR phase. (See Appendix "Messages".) $\mathrm{JBOT} < \mathrm{JTOP} \leq \mathrm{MAXROW}$
6	KAFT[*]	Aftmost grid point index for grid point block L. The value of KAFT must be integral and greater than or equal to 1 and less than KFRT. If KAFT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the GPT GENERATOR phase. (See Appendix "Messages".) $1 \leq \mathrm{KAFT} < \mathrm{KFRT}$
7	KFRT[*]	Frontmost grid point index for grid point block L. The value of KFRT must be integral and greater than KAFT and less than or equal to MAXPLN. (See Appendix "Maximums".) If KFRT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the GPT GENERATOR phase. (See Appendix "Messages".) $\mathrm{KAFT} < \mathrm{KFRT} \leq \mathrm{MAXPLN}$

NOTE: Pages 7.222 through 7.230 will not appear in this report.

---

[*] JBOT, JTOP, KAFT, and KFRT are not required for one-dimensional problems and KAFT and KFRT are not required for two-dimensional problems. Input values in these fields when not required will result in the FLDCHK message being written on the print and the message files and the program being terminated at the end of the GENERATOR phase group. (See Appendix "Messages".)

Block Point-by-Point Zoning

Page 1 of 1

The 231 input record may be used to specify point-by-point grid point input specification for block number L. The 231 input record may not be used at restart time.

	min	max
start	0	MAXGPT
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	IPSN	XPSN	IPSN	XPSN	IPSN	XPSN
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 221 record.
2,4,6	IPSN	Grid point index for the grid point whose x-position is specified in the next field. The value of IPSN must be integral and greater than or equal to 1 and less than or equal to MAXGPT. (See Appendix "Maximums".) If IPSN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3,5,7	XPSN	x-coordinate for the grid point index specified in the previous field. Its value can be any number in problem units. Values of the XPSN must increase for increasing IPSN; that is, $XPSN(IPSN-1) < XPSN(IPSN) < XPSN(IPSN+1) < \cdots$

Point-by-Point Zoning

2D only

TYPE
232

Page 1 of 1

The 232 input record may be used to specify point-by-point grid point input. The 232 input record may not be used at restart time.

	min	max
start	0	MAXPBP
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	IPSN	JPSN	XPSN	YPSN	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies the set of all point-by-point initializations. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".) L should have the same value on all 232 input records.
2	IPSN	I grid point index for the grid point whose x and y position is specified on this input record. The value of IPSN must be integral and greater than or equal to 1 and less than or equal to MAXGPT. (See Appendix "Maximums".) If IPSN is out of this range a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3	JPSN	J grid point index for the grid point whose x and y position is specified on this input record. The value of JPSN must be integral and greater than or equal to 1 and less than or equal to MAXBUF. (See Appendix "Maximums".) If JPSN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
4	XPSN	x-coordinate for the (I,J) grid point specified on this input record. Its value can be any number in problem units for nondivergent symmetries. XPSN cannot be a negative number in divergent symmetry.
5	YPSN	y-coordinate for the (I,J) grid point specified on this input record. Its value can be any number in problem units.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Point-by-Point Zoning

Page 1 of 2

The 233 input record may be used to specify point-by-point grid point input. The 233 input record may not be used at restart time.

	min	max
start	0	MAXPBP
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	L	IPSN	JPSN	KPSN	XPSN	YPSN	ZPSN	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies the set of all point-by-point initializations. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".) L should have the same value on all 233 input records.
2	IPSN	I grid point index for the grid point whose x, y, and z position is specified on this input record. The value of IPSN must be integral and greater than or equal to 1 and less than or equal to MAXGPT. (See Appendix "Maximums".) If IPSN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3	JPSN	J grid point index for the grid point whose x, y, and z position is specified on this input record. The value of JPSN must be integral and greater than or equal to 1 and less than or equal to MAXROW. (See Appendix "Maximums".) If JPSN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
4	KPSN	K grid point index for the grid point whose x, y, and z position is specified on this input record. The value of KPSN must be integral and greater than or equal to 1 and less than or equal to MAXPLN. (See Appendix "Maximums".) If KPSN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)

Columns →	11	21	31	41	51	61	71 80
	L	IPSN	JPSN	KPSN	XPSN	YPSN	ZPSN
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
5	XPSN	x-coordinate for the (I,J,K) grid point specified on this input record. Its value can be any number in problem units.
6	YPSN	y-coordinate for the (I,J,K) grid point specified on this input record. Its value can be any number in problem units.
7	ZPSN	z-coordinate for the (I,J,K) grid point specified on this input record. Its value can be any number in problem units.

NOTE: Pages 7.234 through 7.240 will not appear in this report.

Equal-Space Zoning #1

Page 1 of 1

The 241 input record may be used to specify equally spaced grid points for block number L. The 241 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	L	NZON	XLFT	XRHT	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 221 record.
2	NZON	Number of zones in this block, NZON ≡ IRHT - ILFT. The value of NZON must be integral and greater than or equal to 1 and less than or equal to MAXZON. (See Appendix "Maximums".) If NZON is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3	XLFT	x-coordinate of the leftmost grid point in this block. The value of XLFT can be any number less than XRHT in problem units but must be non-negative when NSSYM = 2, 3, or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
4	XRHT	x-coordinate of the rightmost grid point in this block. The value of XRHT can be any number greater than XLFT in problem units but must be non-negative when NSSYM = 2, 3, or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Equal-Space Zoning #2

The 242 input record may be used to specify equally spaced grid points for block number L. The 242 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	NZON	XLFT	XBLK	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 221 record.
2	NZON	Number of zones in this block, NZON ≡ IRHT - ILFT. The value of NZON must be integral and greater than or equal to 1 and less than or equal to MAXZON. (See Appendix "Maximums".) If NZON is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3	XLFT	x-coordinate of the leftmost grid point in this block. The value of XLFT can be any number less than XRHT* in problem units but must be non-negative when NSSYM = 2, 3, or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
4	XBLK	Width of the block. The value of XBLK must be a positive number in problem units.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*XRHT ≡ XLFT + XBLK

Equal-Space Zoning #3

Page 1 of 1

The 243 input record may be used to specify equally spaced grid points for block number L. The 243 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	L	NZON	XLFT	XZON	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 221 record.
2	NZON	Number of zones in this block, $NZON \equiv IRHT - ILFT$. The value of NZON must be integral and greater than or equal to 1 and less than or equal to MAXZON. (See Appendix "Maximums".) If NZON is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3	XLFT	x-coordinate of the leftmost grid point in this block. The value of XLFT can be any number less than XRHT* in problem units but must be non-negative when $NSSYM = 2, 3,$ or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
4	XZON	Width of each zone in this block. The value of XZON must be a positive number in problem units.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.244 through 7.245 will not appear in this report.

---

*$XRHT \equiv XLFT + NZON * XZON$

Quadrilateral Zoning #1

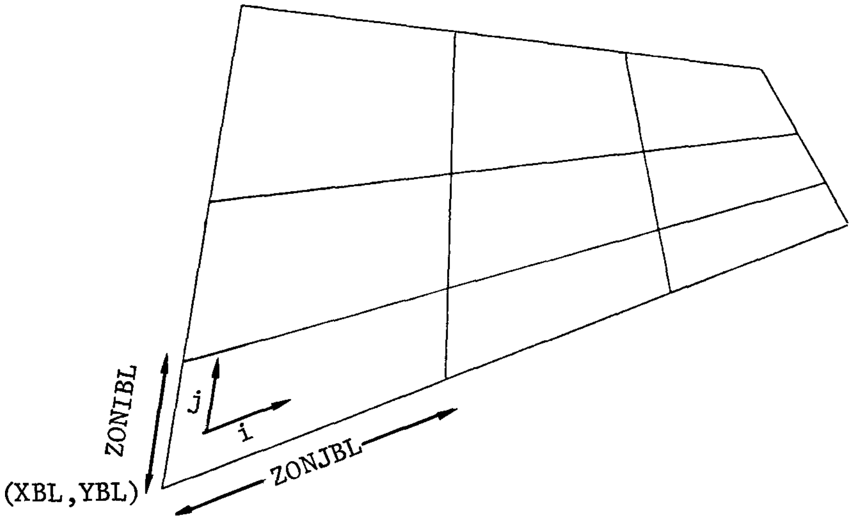
Page 1 of 2

The 246 record may be used alone or in conjunction with a 256 or 257 record to specify quadrilateral zoning for block number L. A 246 record alone is sufficient to specify a block of rectangular zones with sides parallel to the x and y axes.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	XBL	ZONJBL	YBL	ZONIBL	RATJBT	RATILF
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable



Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	XBL	x-coordinate of lower-leftmost grid point (in i-j space) in this block.
3	ZONJBL	Length along bottom j-line of the lower-leftmost zone (in i-j space) in the block (see figure). The value of ZONJBL must be a positive number in problem units.
4	YBL	y-coordinate of the lower-leftmost grid point (in i-j space) in this block.

Columns →	11	21	31	41	51	61	71 80
	L	XBL	ZONJBL	YBL	ZONIBL	RATJBT	RATILF
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
5	ZONIBL	Length along left i-line of the lower-leftmost zone (in i-j space) in the block (see figure). The value of ZONIBL must be a positive number in problem units.
6	RATJBT	Geometric ratio. The value of RATJBT is used to space grid points along j-lines. The value of RATJBT must be greater than or equal to 0.5 and less than or equal to 1.5, or the message GEOMETRIC RATIO IMPROPERLY DEFINED is written on the print and the message files and the program terminates immediately in subroutine GPTINP. If this field is left blank, a ratio of 1.0 is assumed.
7	RATILF	Geometric ratio. The value of RATILF is used to space grid points along the leftmost i-line (in i-j space). The value of RATILF must be greater than or equal to 0.5 and less than or equal to 1.5 or the message GEOMETRIC RATIO IMPROPERLY DEFINED is written on the print and the message files and the program terminates immediately in subroutine GPTINP. If this field is left blank, a ratio of 1.0 is assumed.

This page intentionally left blank.

Quadrilateral Zoning #2

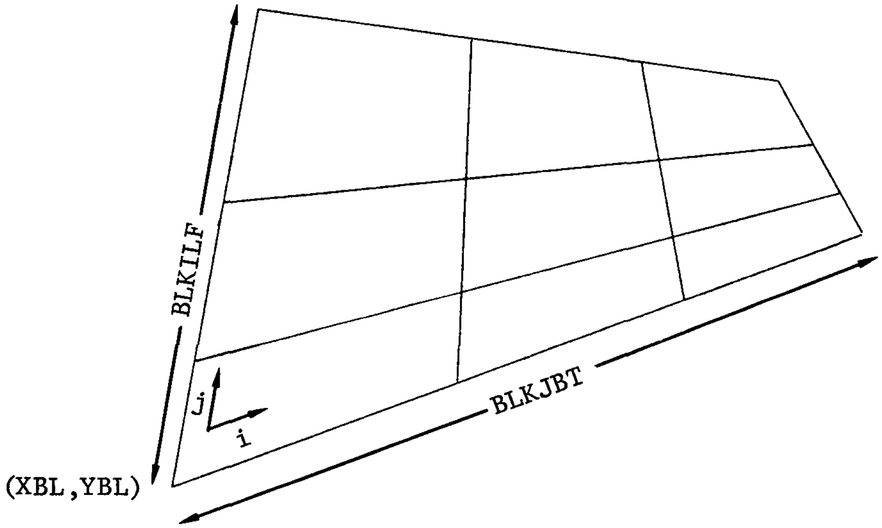
Page 1 of 2

The 247 record may be used alone or in conjunction with a 256 or 257 record, to specify quadrilateral zoning for block number L. A 247 record alone is sufficient to specify a block of rectangular zones with sides parallel to the x and y axes.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	XBL	BLKJBT	YBL	BLKILF	RATJBT	RATILF
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable



1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	XBL	x-coordinate of the lower-leftmost grid point (in i-j space) in this block.
3	BLKJBT	Length of the entire block along the bottommost j-line (in i-j space) (see figure). The value of BLKJBT must be a positive number in problem units.
4	YBL	y-coordinate of the lower-leftmost grid point (in i-j space) in this block.

Columns →	11	21	31	41	51	61	71 80
	L	YBL	BLKJBT	YBL	BLKILF	RATJBT	RATILF
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
5	BLKILF	Length of the entire block along leftmost i-line (in i-j space) (see figure). The value of BLKILF must be a positive number in problem units.
6	RATJBT	Geometric ratio. The value of RATJBT is used to space grid points along j-lines. The value of RATJBT must be greater than or equal to 0.5 and less than or equal to 2.0, or the message GEOMETRIC RATIO IMPROPERLY DEFINED is written on the print and the message files and the program terminates immediately in subroutine GPTINP. If this field is left blank, a ratio of 1.0 is assumed.
7	RATILF	Geometric ratio. The value of RATILF is used to space grid points along the leftmost i-line (in i-j space). The value of RATILF must be greater than or equal to 0.5 and less than or equal to 2.0 or the message GEOMETRIC RATIO IMPROPERLY DEFINED is written on the print and the message files and the program terminates immediately in subroutine GPTINP. If this field is left blank, a ratio of 2.0 is assumed.

This page intentionally left blank.

Cubical Zoning #1

3D only

TYPE
248

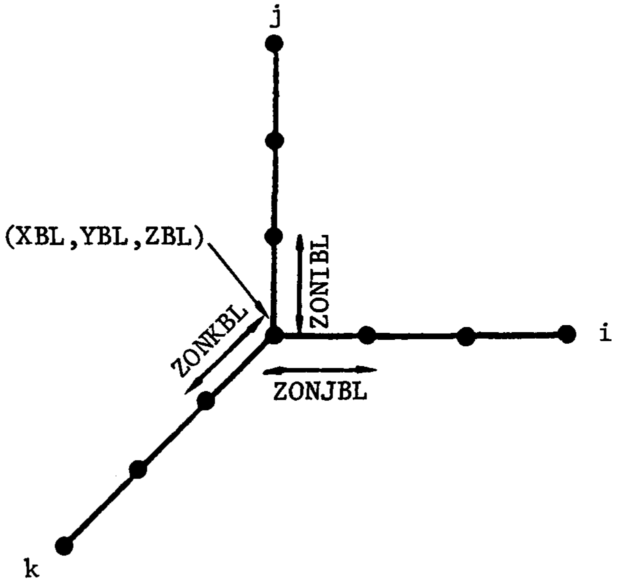
Page 1 of 2

The 248 input record may be used to specify cubical zoning for block number L. The 248 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	L	XBL	ZONJBL	YBL	ZONIBL	ZBL	ZONKBL	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable



Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	XBL	x-coordinate of lower-left-aftmost grid point (in i-j-k space) in this block.
3	ZONJBL	Length along bottom j-line of the lower-left-aftmost zone (in i-j-k space) in the block (see figure). The value of ZONJBL must be a positive number in problem units.
4	YBL	y-coordinate of the lower-left-aftmost grid point (in i-j-k space) in this block.

Columns →	11	21	31	41	51	61	71 80
	L	XBL	ZONJBL	YBL	ZONIBL	ZBL	ZONKBL
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
5	ZONIBL	Length along left i-line of the lower-left-aftmost zone (in i-j-k space) in the block (see figure). The value of ZONIBL must be a positive number in problem units.
6	ZBL	z-coordinate of lower-left-aftmost grid point (in i-j-k space) in this block.
7	ZONKBL	Length along lower-left k-line of the lower-left-aftmost zone (in i-j-k space) in the block (see figure). The value of ZONKBL must be a positive number in problem units.

This page intentionally left blank.

Cubical Zoning #2

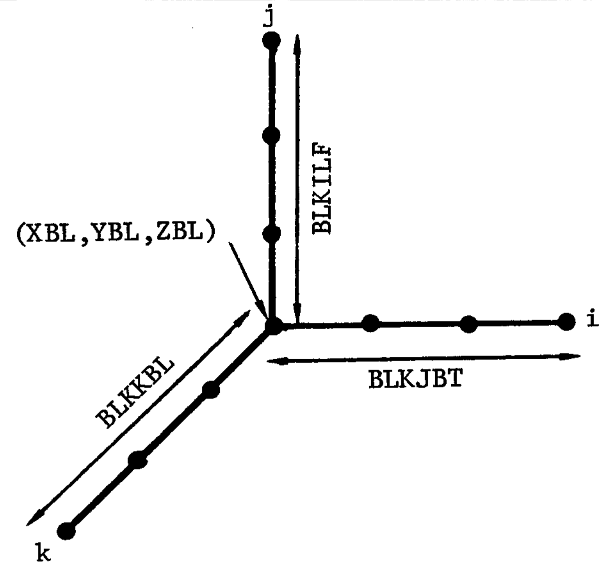
Page 1 of 2

The 249 input record may be used to specify cubical zoning for block number L. The 249 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	XBL	BLKJBT	YBL	BLKILF	ZBL	BLKKBL
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable



1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	XBL	x-coordinate of the lower-left-aftmost grid point (in i-j-k space) in this block.
3	BLKJBT	Length of the entire block along the bottommost j-line (in i-j-k space) (see figure). The value of BLKJBT must be a positive number in problem units.
4	YBL	y-coordinate of the lower-left-aftmost grid point (in i-j-k space) in this block.

Columns →	11	21	31	41	51	61	71 80
	L	XBL	BLKJBT	YBL	BLKILF	ZBL	BLKKBL
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
5	BLKILF	Length of the entire block along the leftmost i-line (in i-j-k space) (see figure). The value of BLKILF must be a positive number in problem units.
6	ZBL	z-coordinate of the lower-left-aftmost grid point (in i-j-k space) in this block.
7	BLKKBL	Length of the entire block along the bottom-leftmost k-line (in i-j-k space) (see figure). The value of BLKKBL must be a positive number in problem units.

NOTE: Page 7.250 will not appear in this report.

Geometric-Ratio Space Zoning #1

Page 1 of 1

The 251 input record may be used to specify geometrically spaced grid points for block number L. The 251 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	L	NZON	XLFT	XRHT	XRAT	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 221 record.
2	NZON	Number of zones in this block, NZON ≡ IRHT - ILFT. The value of NZON must be integral and greater than or equal to 1 and less than or equal to MAXZON. (See Appendix "Maximums".) If NZON is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3	XLFT	x-coordinate of the leftmost grid point in this block. The value of XLFT can be any number less than XRHT in problem units but must be non-negative when NSSYM = 2, 3, or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
4	XRHT	x-coordinate of the rightmost grid point in this block. The value of XRHT can be any number greater than XLFT in problem units but must be non-negative when NSSYM = 2, 3, or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
5	XRAT	Geometric ratio. The value of XRAT is used to space grid points from XLFT to XRHT. The value of XRAT must be greater than or equal to 0.5 and less than or equal to 2.0 or the message, GEOMETRIC RATIO IMPROPERLY DEFINED. is written on the print and the message files and the program terminates immediately in subroutine GPTINP.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Geometric-Ratio Space Zoning #2

1D only

TYPE 252

Page 1 of 1

The 252 input record may be used to specify geometrically spaced grid points for block number L. The 252 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	NZON	XLFT	XBLK	XRAT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 221 record.
2	NZON	Number of zones in this block, NZON ≡ IRHT - ILFT. The value of NZON must be integral and greater than or equal to 1 and less than or equal to MAXZON. (See Appendix "Maximums".) If NZON is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3	XLFT	x-coordinate of the leftmost grid point in this block. The value of XLFT can be any number less than XRHT[*] in problem units but must be non-negative when NSSYM = 2, 3, or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
4	XBLK	Width of the block. The value of XBLK must be a positive number in problem units.
5	XRAT	Geometric ratio. The value of XRAT is used to space grid points from XLFT to XRHT.[*] The value of XRAT must be greater than or equal to 0.5 and less than or equal to 2.0 or the message, GEOMETRIC RATIO IMPROPERLY DEFINED. is written on the print and the message files and the program terminates immediately in subroutine GPTINP.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] XRHT ≡ XLFT + XBLK

Geometric-Ratio Space Zoning #3

Page 1 of 1

The 253 input record may be used to specify geometrically spaced grid points for block number L. The 253 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	L	NZON	XLFT	XZONL	XRAT	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 221 record.
2	NZON	Number of zones in this block, NZON ≡ IRHT - ILFT. The value of NZON must be integral and greater than or equal to 1 and less than or equal to MAXZON. (See Appendix "Maximums".) If NZON is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3	XLFT	x-coordinate of the leftmost grid point in this block. The value of XLFT can be any number less than XRHT[*] in problem units but must be non-negative when NSSYM = 2, 3, or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
4	XZONL	Width of the leftmost zone. The value of XZONL must be a positive number in problem units.
5	XRAT	Geometric ratio. The value of XRAT is used to space grid points from XLFT to XRHT.[*] The value of XRAT must be greater than or equal to 0.5 and less than or equal to 2.0 or the message, GEOMETRIC RATIO IMPROPERLY DEFINED. is written on the print and the message files and the program terminates immediately in subroutine GPTINP.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] XRHT ≡ XLFT + XZONL *(XRAT**NZON - 1.0) / (XRAT - 1.0)

Geometric-Ratio Space Zoning #4

1D only

TYPE 254

Page 1 of 1

The 254 input record may be used to specify geometrically spaced grid points for block number L. The 254 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	NZON	XLFT	XZONR	XRAT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 221 record.
2	NZON	Number of zones in this block, NZON ≡ IRHT - ILFT. The value of NZON must be integral and greater than or equal to 1 and less than or equal to MAXZON. (See Appendix "Maximums".) If NZON is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3	XLFT	x-coordinate of the leftmost grid point in this block. The value of XLFT can be any number less than XRHT* in problem units but mus be non-negative when NSSYM = 2, 3, or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
4	XZONR	Width of the rightmost zone. The value of XZONR must be a positive number in problem units.
5	XRAT	Geometric ratio. The value of XRAT is used to space grid points from XLFT to XRHT.* The value of XRAT must be greater than or equal to 0.5 and less than or equal to 2.0 or the message, GEOMETRIC RATIO IMPROPERLY DEFINED. is written on the print and the message files and the program terminates immediately in subroutine GPTINP.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] XRHT ≡ XLFT + XZONR *((1.0 / XRAT)**NZON - 1.0) / ((1.0 / XRAT) - 1.0)

This page intentionally left blank.

Quadrilateral Zoning -- Additional Specifications

2D only

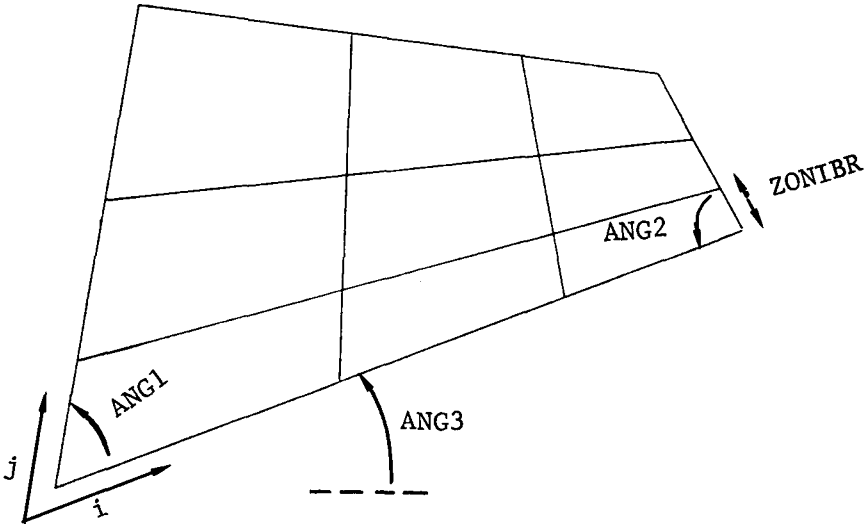
TYPE 256

Page 1 of 2

The 256 input record may be used in conjunction with a 246 or a 247 input record to specify quadrilateral zoning for block number L.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	L	ANG1	ANG2	ANG3	ZONIBR	RATIRH	--	
Fields →	1	2	3	4	5	6	7	



Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	ANG1	Angle (expressed in degrees) between the bottommost j-line (in i-j space) and the leftmost i-line (see figure). The value of ANG1 must be greater than 0.0 and less than 180.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP. If this field is left blank, a right angle (90^o) is assumed.

Columns → 11 21 31 41 51 61 71 80

L	ANG1	ANG2	ANG3	ZONIBR	RATIRH	--
1	2	3	4	5	6	7

Fields →

Field Number	Input Variable Name	Description of Input Variable
3	ANG2	Angle (expressed in degrees) between the bottommost j-line and the rightmost i-line (in i-j space) (see figure). The value of ANG2 must be greater than 0.0 and less than 180.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP. If this field is left blank, a right angle (90°) is assumed.
4	ANG3	Angle (expressed in degrees) measured counterclockwise from the x-axis to the bottommost j-line (in i-j space) (see figure). The value of ANG3 must be greater than -360.0 and less than 360.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP. If this field is left blank, an angle of 0° is assumed.
5	ZONIBR	Length along the rightmost i-line of the lower rightmost zone (in i-j space) in the block (see figure). The value of ZONIBR must be a positive number in problem units. If this field is left blank, ZONIBR will be assumed to be the same as ZONIBL (as specified on a 246 input record or implied on a 247 input record).
6	RATIRH	Geometric ratio. The value of RATIRH is used to space grid points along the rightmost i-line (in i-j space). The grid points on the left i-line will be connected to those on the right i-line with straight lines. The value of RATIRH must be greater than or equal to 0.5 and less than or equal to 1.5 or the message GEOMETRIC RATIO IMPROPERLY DEFINED is written on the print and the message files and the program terminates at the end of subroutine GPTINP. If this field is left blank, RATIRH will be set to the value of RATILF (as specified on a 246 or 247 input record).
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

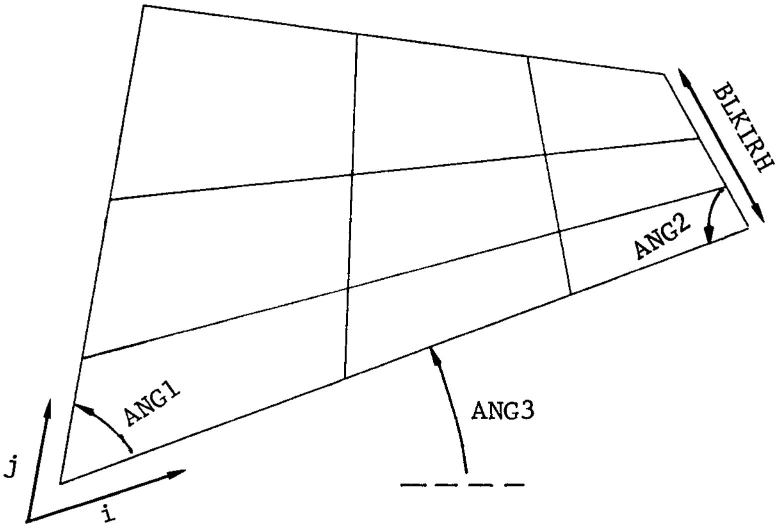
Page 1 of 2

The 257 input record may be used in conjunction with a 246 or a 247 input record to specify quadrilateral zoning for block number L.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	ANG1	ANG2	ANG3	BLKIRH	RATIRH	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable



1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	ANG1	Angle (expressed in degrees) between the bottommost j-line and the leftmost i-line (in i-j space) (see figure). The value of ANG1 must be greater than 0.0 and less than 180.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP. If this field is left blank, a right angle (90°) is assumed.

Columns →	11	21	31	41	51	61	71 80
	L	ANG1	ANG2	ANG3	BLKIRH	RATIRH	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
3	ANG2	Angle (expressed in degrees) between the bottommost j-line and the rightmost i-line (in i-j space) (see figure). The value of ANG2 must be greater than 0.0 and less than 180.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP. If this field is left blank, a right angle (90°) is assumed.
4	ANG3	Angle (expressed in degrees) measured counterclockwise from the x-axis to the bottommost j-line (in i-j space) (see figure). The value of ANG3 must be greater than -360.0 and less than 360.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP. If this field is left blank, an angle of 0° is assumed.
5	BLKIRH	Length of the entire block along the rightmost i-line (in i-j space) (see figure). The value of BLKIRH must be a positive number in problem units. If this field is left blank, BLKIRH will be assumed to be the same as BLKILF (as specified on a 247 record or implied on a 246 record).
6	RATIRH	Geometric ratio. The value of RATIRH is used to space grid points along the rightmost i-line (in i-j space). The grid points on the left i-line will be connected to those on the right i-line with straight lines. The value of RATIRH must be greater than or equal to 0.5 and less than or equal to 1.5 or the message GEOMETRIC RATIO IMPROPERLY DEFINED is written on the print and the message files and the program terminates at the end of subroutine GPTINP. If this field is left blank, RATIRH will be set to the value of RATILF (as specified on a 246 or 247 input record).
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.258 through 7.260 will not appear in this report.

Polar or Hyperbolic-Elliptic Zoning #1

Page 1 of 2

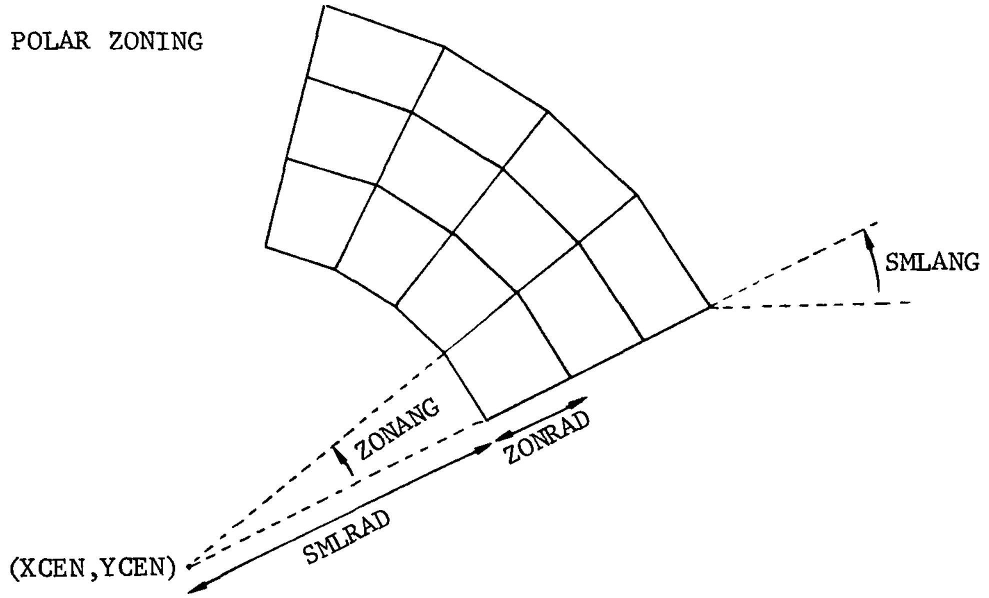
The 261 input record must be used with a 263 input record to specify i-j orientations and with a 266 or a 267 input record to specify polar or hyperbolic-elliptic zoning for block number L. A 261 input record alone is sufficient to specify a polar block with equal zoning, but a 266 or a 267 input record must be included for a hyperbolic-elliptic block or a polar block with geometric zoning.

	min	max
start	0	MAXBLK
restart	0	0

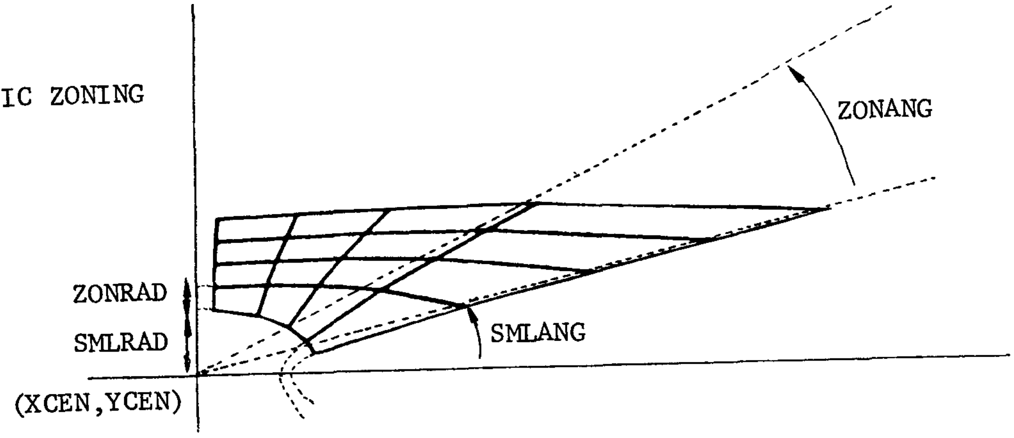
Columns →	11	21	31	41	51	61	71	80
	L	XCEN	YCEN	SMLRAD	ZONRAD	SMLANG	ZONANG	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable

POLAR ZONING



HYPERBOLIC-ELLIPTIC ZONING



Columns →	11	21	31	41	51	61	71 80
	L	XCEN	YCEN	SMLRAD	ZONRAD	SMLANG	ZONANG
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	XCEN	x-coordinate of the center of the circles (polar) or ellipses and hyperbolas, expressed in problem units.
3	YCEN	y-coordinate of the center of the circles (polar) or ellipses and hyperbolas, expressed in problem units.
4	SMLRAD	For polar zoning, SMLRAD is the radius of the inner circle. SMLRAD must be a positive number expressed in problem units. For hyperbolic-elliptic zoning, SMLRAD is the length of the semi-minor axis of the smallest ellipse. It may be 0.0.
5	ZONRAD	For polar zoning, ZONRAD is the distance along a radius from the innermost circle to the next circle (i.e., the width of the first zone) (see figure). For hyperbolic-elliptic zoning, ZONRAD is the difference in length between the semi-minor axis of the smallest ellipse and the semi-minor axis of the next smallest ellipse. ZONRAD should be a positive number expressed in problem units.
6	SMLANG	SMLANG is the angle (expressed in degrees) measured counter-clockwise from the x-axis to the first radial line (polar zoning), or from the major axis to the asymptote of the first hyperbola (hyperbolic-elliptic zoning). The value of SMLANG must be greater than or equal to -360.0 and less than or equal to 360.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP.
7	ZONANG	ZONANG is the angle (expressed in degrees) formed between the first and second radial lines (polar zoning), or the first and second set of asymptotes (hyperbolic-elliptic zoning). The value of ZONANG must be greater than 0.0 and less than or equal to 360.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP.

This page intentionally left blank.

Polar or Hyperbolic-Elliptic Zoning #2

Page 1 of 2

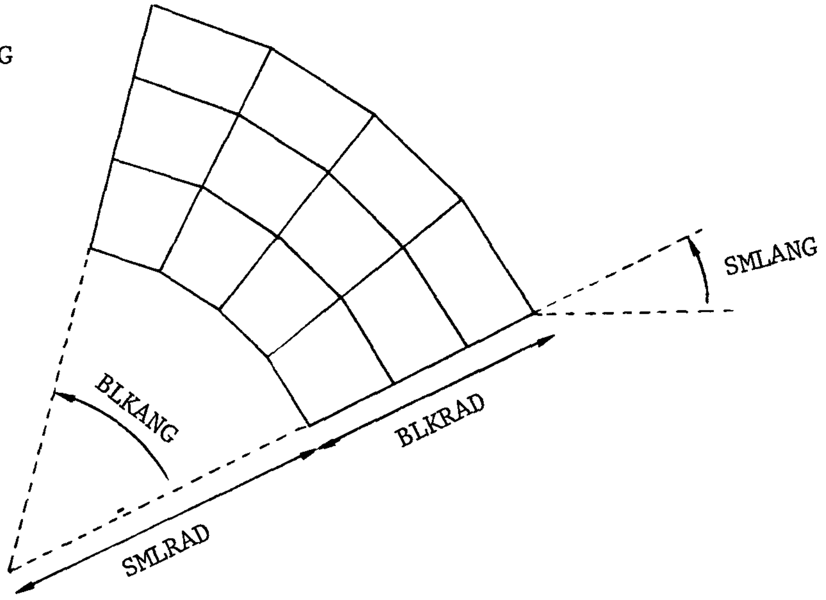
The 262 input record must be used with a 263 input record to specify i-j orientations and may be used with a 266 or a 267 input record to specify polar or hyperbolic-elliptic zoning for block number L. A 262 input record alone is sufficient to specify a polar block with equal zoning, but a 266 or a 267 input record must be included for hyperbolic-elliptic zoning or for polar zoning with geometric spacing of zones.

	min	max
start	0	MAXBLK
restart	0	0

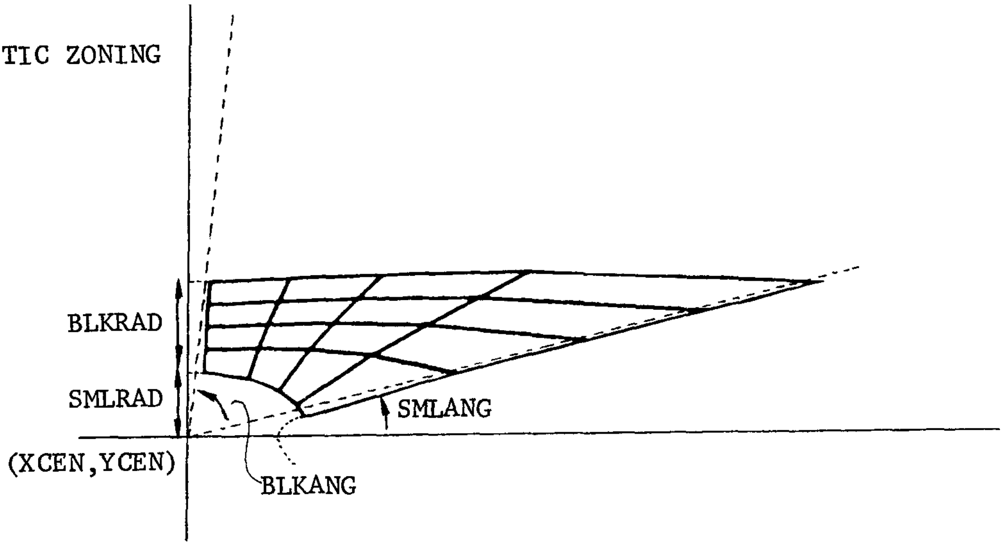
Columns →	11	21	31	41	51	61	71 80
	L	XCEN	YCEN	SMLRAD	BLKRAD	SMLANG	BLKANG
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable

POLAR ZONING



HYPERBOLIC-ELLIPTIC ZONING



Rev. 1
1 DEC 76

Columns →	11	21	31	41	51	61	71 80
	L	XCEN	YCEN	SMLRAD	BLKRAD	SMLANG	BLKANG
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	XCEN	x-coordinate of the center of the circles (polar) or ellipses and hyperbolas, expressed in problem units.
3	YCEN	y-coordinate of the center of the circles (polar) or ellipses and hyperbolas, expressed in problem units.
4	SMLRAD	For polar zoning, SMLRAD is the radius of the inner circle. SMLRAD must be a positive number expressed in problem units. For hyperbolic-elliptic zoning, SMLRAD is the length of the semi-minor axis of the smallest ellipse. It may be 0.0.
5	BLKRAD	For polar zoning, BLKRAD is the distance along a radius from the innermost to the outermost radius; i.e., the "length" of the entire block. For hyperbolic-elliptic zoning, BLKRAD is the difference in length between the semi-minor axes of the smallest and largest ellipses. BLKRAD should be a positive number expressed in problem units.
6	SMLANG	SMLANG is the angle (expressed in degrees) measured counterclockwise from the x-axis to the first radial line (polar zoning), or from the major axis to the asymptote of the first hyperbola (hyperbolic-elliptic zoning). The value of SMLANG must be greater than or equal to -360.0 and less than or equal to 360.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP.
7	BLKANG	BLKANG is the angle (expressed in degrees) formed between the outermost radial lines (polar zoning) or the asymptotes of the first and last hyperbolas (hyperbolic-elliptic zoning). The value of BLKANG must be greater than 0.0 and less than 360.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP.

This page intentionally left blank.

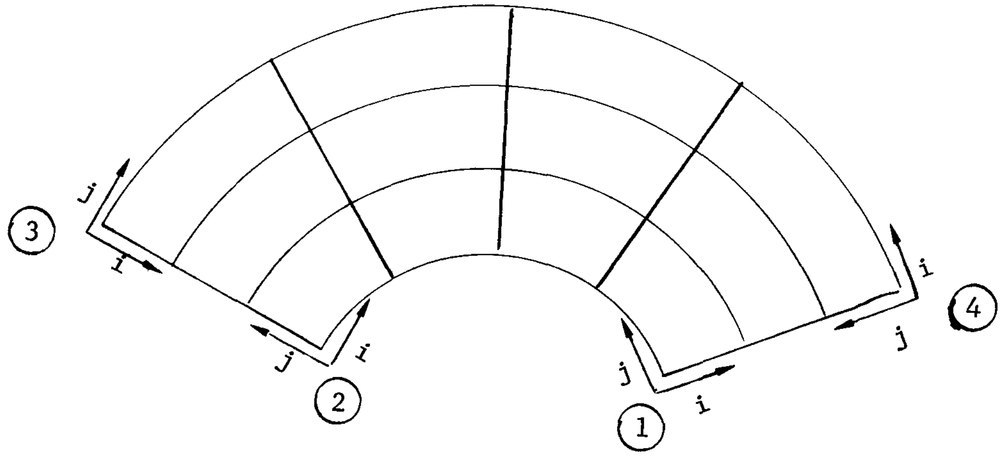
Polar or Hyperbolic-Elliptic Zoning -- i-j Space Orientation

Page 1 of 2

A 263 input record defines the i-j space orientation of a polar or hyperbolic-elliptic zone specified with the 261-262 and 266-267 input records. There must be exactly one 263 input record for each polar or hyperbolic-elliptic block.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	IJORN	--	--	--	--	--
Fields →	1	2	3	4	5	6	7



Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)

Columns →	11	21	31	41	51	61	71 80
	L	IJORN	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
2	IJORN	i-j space orientation type. The value of IJORN defines the orientation in i-j space of polar or hyperbolic-elliptic block number L. The value of IJORN must be integral and have a value greater than or equal to 1.0 and less than or equal to 4.0. The following definitions apply: = 1.0 circles (polar) or ellipses (hyperbolic-elliptic) are i-lines, and radial lines (polar) or hyperbolas (hyperbolic-elliptic) are j-lines. i increases with increasing radius and j increases with increasing angle (see figure). = 2.0 circles (polar) or ellipses (hyperbolic-elliptic) are j-lines, and radial lines (polar) or ellipses (hyperbolic-elliptic) are i-lines. i increases with decreasing angle and j increases with increasing radius (see figure). = 3.0 circles (polar) or ellipses (hyperbolic-elliptic) are i-lines, and radial lines (polar) or hyperbolas (hyperbolic-elliptic) are j-lines. i increases with decreasing radius and j increases with decreasing angle (see figure). = 4.0 circles (polar) or ellipses (hyperbolic-elliptic) are j-lines, and radial lines (polar) or hyperbolas (hyperbolic-elliptic) are i-lines. i increases with increasing angle and j increases with decreasing radius (see figure).
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.264 through 7.265 will not appear in this report.

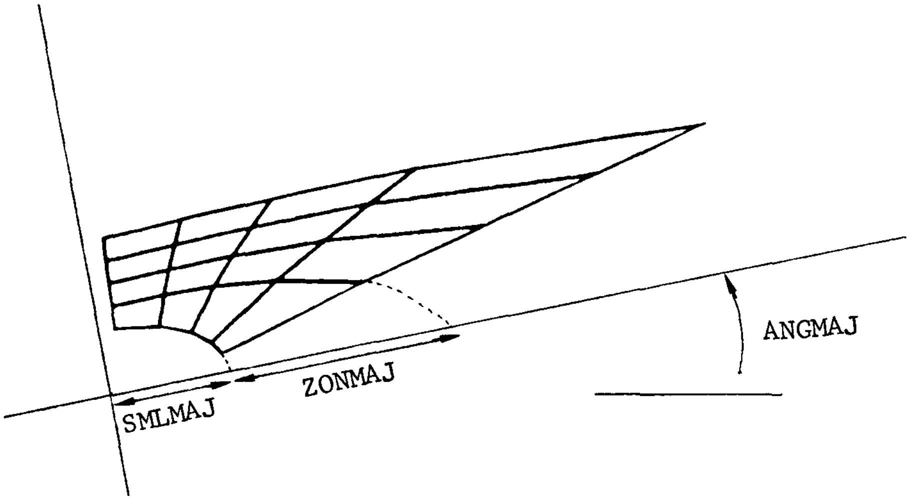
Page 1 of 2

The 266 input record may be used in conjunction with a 261 or a 262 input record to specify polar or hyperbolic-elliptic zoning.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	RATRAD	RATANG	SMLMAJ	ZONMAJ	RATMAJ	ANGMAJ
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable



1 L Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)

2 RATRAD Geometric ratio. The value of RATRAD is used to space circles (polar zoning) or semi-minor axes (hyperbolic-elliptic zoning). The value of RATRAD must be greater than or equal to 0.5 and less than or equal to 1.5 or the message

GEOMETRIC RATIO
IMPROPERLY DEFINED

is written on the print and the message files and the program terminates at the end of subroutine GPTINP.

Columns →	11	21	31	41	51	61	71	80
	L	RATRAD	RATANG	SMLMAJ	ZONMAJ	RATMAJ	ANGMAJ	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
3	RATANG	Geometric ratio. The value of RATANG is used to space radii (polar zoning) or asymptotes (hyperbolic-elliptic zoning). The value of RATANG must be greater than or equal to 0.5 and less than or equal to 1.5 or the message GEOMETRIC RATIO IMPROPERLY DEFINED is written on the print and on the message files and the program terminates at the end of subroutine GPTINP.
4	SMLMAJ	For hyperbolic-elliptic zoning, SMLMAJ is the length of the semi-major axis of the smallest ellipse. The value of SMLMAJ must be a positive number in problem units. Leave this field blank for polar zoning.
5	ZONMAJ	For hyperbolic-elliptic zoning, ZONMAJ is the difference in length between the semi-major axes of the smallest and next-smallest ellipses. The value of ZONMAJ must be a positive number in problem units. Leave this field blank for polar zoning.
6	RATMAJ	Geometric ratio. The value of RATMAJ is used to space the semi-major axes in hyperbolic-elliptic zoning. The value of RATMAJ must be greater than or equal to 0.5 and less than or equal to 1.5 or the message GEOMETRIC RATIO IMPROPERLY DEFINED is written on the print and on the message files and the program terminates at the end of subroutine GPTINP. If this field is left blank, a ratio of 1.0 is assumed. Leave this field blank for polar zoning.
7	ANGMAJ	For hyperbolic-elliptic zoning, ANGMAJ is the angle (expressed in degrees) measured counterclockwise from the x-axis to the line containing the major axes of the ellipses. The value of ANGMAJ must be greater than or equal to -360.0 and less than or equal to 360.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP. Leave this field blank for polar zoning.

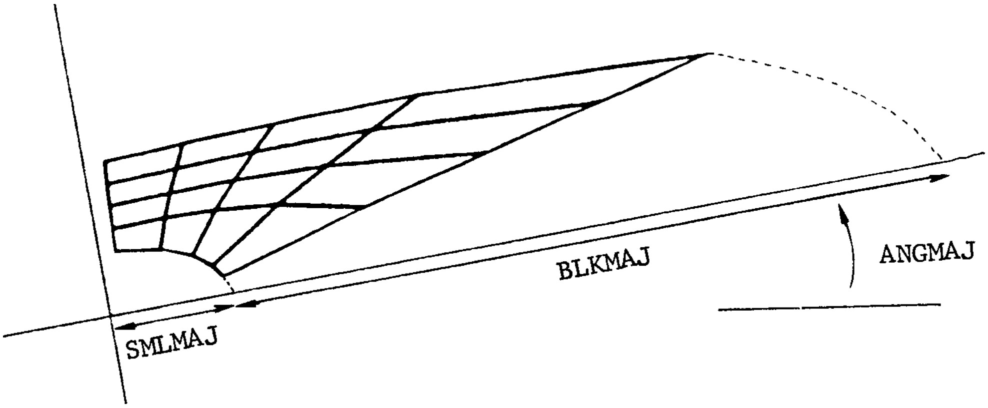
This page intentionally left blank.

Polar or Hyperbolic-Elliptic Zoning -- Additional Specifications

The 267 input record may be used in conjunction with a 261 or a 262 input record to specify polar or hyperbolic-elliptic zoning.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	RATRAD	RATANG	SMLMAJ	BLKMAJ	RATMAJ	ANGMAJ
Fields →	1	2	3	4	5	6	7



Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	RATRAD	Geometric ratio. The value of RATRAD is used to space circles (polar zoning) or semi-minor axes (hyperbolic-elliptic zoning). The value of RATRAD must be greater than or equal to 0.5 and less than or equal to 1.5 or the message GEOMETRIC RATIO IMPROPERLY DEFINED is written on the print and the message files and the program terminates at the end of subroutine GPTINP. If this field is left blank, a ratio of 1.0 is assumed.

Columns →	11	21	31	41	51	61	71 80
	L	RATRAD	RATANG	SMLMAJ	BLKMAJ	RATMAJ	ANGMAJ
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
3	RATANG	Geometric ratio. The value of RATANG is used to space radii (polar zoning) or asymptotes (hyperbolic-elliptic zoning). The value of RATANG must be greater than or equal to 0.5 and less than or equal to 1.5 or the message GEOMETRIC RATIO IMPROPERLY DEFINED is written on the print and on the message files and the program terminates at the end of subroutine GPTINP.
4	SMLMAJ	For hyperbolic-elliptic zoning, SMLMAJ is the length of the semi-major axis of the smallest ellipse. The value of SMLMAJ must be a positive number in problem units. Leave this field blank for polar zoning.
5	BLKMAJ	For hyperbolic-elliptic zoning, BLKMAJ is the difference in length between the semi-major axes of the smallest and largest ellipses. The value of BLKMAJ must be a positive number in problem units. Leave this field blank for polar zoning.
6	RATMAJ	Geometric ratio. The value of RATMAJ is used to space the semi-major axes in hyperbolic-elliptic zoning. The value of RATMAJ must be greater than or equal to 0.5 and less than or equal to 1.5 or the message GEOMETRIC RATIO IMPROPERLY DEFINED is written on the print and on the message files and the program terminates at the end of subroutine GPTINP. If this field is left blank, a ratio of 1.0 is assumed. Leave this field blank for polar zoning.
7	ANGMAJ	For hyperbolic-elliptic zoning, ANGMAJ is the angle (expressed in degrees) measured counterclockwise from the x-axis to the line containing the major axes of the ellipses. The value of ANGMAJ must be greater than or equal to -360.0 and less than or equal to 360.0 or a message is written on the print and the message files and the program terminates at the end of subroutine GPTINP. Leave this field blank for polar zoning.

NOTE: Pages 7.268 through 7.270 will not appear in this report.

Plane-Stress Thickness Specification

Page 1 of 1

The 271 input record may be used to specify the plane-stress (z-direction) thickness for a grid point input block. This input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	ZTHK	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2	ZTHK	Plane-stress (z-direction) thickness. The value of ZTHK is the initial thickness of grid point block L for translational plane stress geometry. The default value of ZTHK is 0.0.
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.272 through 7.280 will not appear in this report.

Special Zoning #1

Page 1 of 1

The 281 input record may be used to specify special parameters for block number L. The 281 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	NZON	XLFT	XRHT	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 221 record.
2	NZON	Number of zones in this block, NZON ≡ IRHT - ILFT. The value of NZON must be integral and greater than or equal to 1 and less than or equal to MAXZON. (See Appendix "Maximums".) If NZON is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3	XLFT	x-coordinate of the leftmost grid point in this block. The value of XLFT can be any number less than XRHT in problem units but must be non-negative when NSSYM = 2, 3, or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
4	XRHT	x-coordinate of the rightmost grid point in this block. The value of XRHT can be any number greater than XLFT in problem units but must be non-negative when NSSYM = 2, 3, or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Special Zoning #2

1D only

TYPE 282

Page 1 of 1

The 282 input record may be used to specify special parameters for block number L. The 282 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	L	NZON	XLFT	XBLK	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 221 record.
2	NZON	Number of zones in this block, NZON ≡ IRHT - ILFT. The value of NZON must be integral and greater than or equal to 1 and less than or equal to MAXZON. (See Appendix "Maximums".) If NZON is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
3	XLFT	x-coordinate of the leftmost grid point in this block. The value of XLFT can be any number less than XRHT* in problem units but must be non-negative when NSSYM = 2, 3, or 5. (The value of NSSYM is specified in input block PRB on the SYM input record.)
4	XBLK	Width of the block. The value of XBLK must be a positive number in problem units.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*XRHT ≡ XLFT + XBLK

Special 2D Zoning

Page 1 of 1

The 283 input record is used to activate special subroutine MYGPT for block number L. The 283 input record may not be used at restart time.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 221. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine GPTINP. (See Appendix "Messages".)
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.284 through 7.298 will not appear in this report.

End of GPT Phase

Page 1 of 1

The END input record signifies the end of a block of data for the GPT input phase. It must follow the last GPT input record.

	min	max
start	1	1
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	--	--	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1-7	--	Fields 1-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

7.3 ZONE SPECIFICATION PHASE (ZON)

The zone specification phase (ZON) input block may be located in any position in the input deck after the PRB input block and before the final END record. The purpose of the ZON input block is to specify initial physics values for problem time zero, rezone initial-value-alter algorithms for each subsequent cycle, and two-dimensional row and/or column restart alters. Only rezoner and 2D row/column alter data may be changed at restart time.

Initial-value blocks* are specified on input record types 31_ by grid-point index limits. (The block number L is local to phase ZON and is used to locate array elements in the labeled COMMON block /ZONPRM/.) Up to MAXBLK initial-value blocks may be specified to identify variations in initial values (see Appendix "Maximums").

Initial values are divided into the following groups:

Record Identifier	Group Description
32_	Initial Scalars
33_	Initial Vectors
34_	Initial Tensors

Initial vectors and tensors have global defaults of zero (0.0) but initial scalars must always be specified.

A minimum input deck for a start run consists of one input record to specify an initial value block of the entire grid and one set of initial scalar input records which specify the material properties model of the block and the initial relative volume. Changing zone values after a problem has started can only be done by rezoning.

---

*Blocks may overlap one another with the highest block number having highest priority.

7.3.1 Automatic Rezoning. The STEALTH codes contain a rezoning capability which can perform calculations with a Lagrangian, an Eulerian, or a hybrid mesh. The capabilities of the rezoner give STEALTH an ALE-like (Arbitrary Lagrangian Eulerian) character which has proven to be very useful on both hydrodynamic and large distortion solid mechanics problems.

The basic philosophy of the rezoner is to gently and continuously alter the positions of grid points into more favorable locations. This usually implies a more regularly spaced mesh for increased computational efficiency and accuracy. The rezoner prevents zones from turning inside out. Thus, the tickle rezoner eliminates the need for major mesh alteration in order to continue a calculation.

The rezoner is designed to operate automatically and continuously in time, and on a point-by-point basis in space. Within this structure, there are many ways to use the rezoner. At one extreme, a single point may be rezoned periodically, say every 10 to 50 cycles, to prevent a specific zone from turning inside out. At the other extreme, it is possible to rezone each point every cycle to effectively achieve an Eulerian calculation.

The standard algorithm for choosing when to rezone is staggered in time, with each grid point rezoned once every four cycles for the 1D code, once every ten cycles for the 2D code, and once every thirty cycles for the 3D code. Two standard algorithms are available for moving a point in 1D. Eight algorithms are available in the 2D code, and four for the 3D code. In all three codes, there are two standard algorithms for rezoning thermodynamic variables. The first conserves mass and internal energy and the second conserves stress. Finally, velocity may be rezoned to conserve momentum or kinetic energy. In spite of the flexibility in the rezoner, many applications will require special logic to achieve the precise rezoning required for a particular problem. Special slots are therefore available in all parts of the rezoner for user-supplied models.

The rezoner is divided into eight subroutines which STEALTH executes in the following sequence: RZNPRO, RZNOLD, RZNPSN, RZNINT, RZNTRV, RZNVEL, RZNMOM, and RZNNEW. The two most important routines are RZNPSN and RZNINT, which must be executed for every point which is rezoned. RZNOLD and RZNNEW are data tranfer routines and will not be discussed furhter. Subroutine RZNTRV evaluates the zonal volumes after a point has been rezoned.

RZNPRO is the scheduling routine for the rezoner. It determines whether or not a point is a rezone point and, if so, whether or not the point will be rezoned during the current cycle. If a point is to be rezoned, then the other rezone subroutines are called by RZNPRO.

RZNPSN contains the position algorithms for moving grid points. The algorithms for each code are:

1D	2D	3D
(1) mean	(1) mean	(1) mean
(2) Eulerian	(2) parallelogram	(2) x-mean
	(3) x-mean	(3) y-mean
	(4) y-mean	(4) z-mean
	(5) top-bottom	
	(6) left-right	
	(7) bottom left-top right	
	(8) bottom right-top left	

The mean algorithm defines the ideal grid point location as the mean position of all the nearest neighbors to a point. The parallelogram algorithm assumes that the ideal location corresponds to the point which keeps the surrounding zones as close to parallelograms as possible. The x-mean algorithm finds the mean value of the x-coordinates of all nearest neighbors, but leaves the other coordinates of the rezone point unchanged. Similarly, the y-mean and z-mean algorithms find the mean value of the y-coordinate and z-coordinate, respectively, of all nearest neighbors, but leaves the other coordinates of the rezone point unchanged. The last four 2D algorithms select two neighboring points, and define the ideal location as the bisector of the line segment between the points. The terms left-right, top-bottom, etc., refer to the neighboring points in the index space for numbering grid points. The 1D Eulerian rezone puts points back to original coordinates.

A point will usually not be moved all the way to the ideal location. A damping factor between zero (for no correction) and one (for full correction) may be selected with each of the RZNPSN options to control the degree of rezoning. Different points can have different damping factors.

After a point is moved, RZNINT will recompute the interior or thermodynamic variables for the zones surrounding the rezone point. One standard option uses conservation of internal energy and mass to find new values of the density and pressure. The second standard option is to conserve stress during the rezone. Mass and internal energy are not conserved in the latter option, which is most useful for rezoning points on a free surface. Applying the first option to points on a free surface usually produces an instability.

RZNVEL will evaluate the local velocity gradient and compute a new velocity for the rezone point at its new location. Use of this routine is optional.

RZNMOM will recompute the velocities of selected nearest neighbors of the rezone point in order to conserve momentum or kinetic energy before and after the rezone. Use of this routine is also optional.

7.3.2 Restart Alter. There are situations in which the automatic rezoner does not provide enough flexibility to untangle zones or move points far enough apart to allow for an increased stable time step. In these cases, it is useful to have a restart alter capability in which it is possible to add or remove grid points at restart time.

A limited capability which allows rows and columns to be dropped is available in STEALTH 2D. The option is activated by using input record types 388 and/or 389. When the drop row/column option is used, it automatically renumbers the index space and repartitions the current physics to preserve mass and momentum.

A summary of ZON phase input records and input variables appears in Table 7.3.

This page intentionally left blank.

NOTE: Pages 7.307 through 7.308 will not appear in this report.

TABLE 7.3

SUMMARY OF ZON PHASE INPUT RECORDS AND INPUT VARIABLES

FIELDS 1-7

TYPE	1	2	3	4	5	6	7	
ZON	NSINP	NSTRC	NSDBG	NSPLT	NSPRT			
311	L	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT	
321	L	MPNBLK						
322	L	RLVBLK	ZIEBLK	TMPBLK	ZHEBLK			
331	L	XVLBLK	YVLBLK	ZVLBLK				
341	L	TXXBLK	TYYBLK	TZZBLK	TXYBLK	TXZBLK	TYZBLK	
381	L	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT	
382	L	RZNDPG	MRZPSN	MRZINT	MRZVEL	MRZMOM		
388	LTYP	ILNNUM	ILNNUM	ILNNUM	ILNNUM	ILNNUM	ILNNUM	2D
389	LTYP	JLNNUM	JLNNUM	JLNNUM	JLNNUM	JLNNUM	JLNNUM	2D
END								

Zone (ZON) Phase Control

The function of the ZON control record is to activate the ZON input phase. The ZON control record must follow an END input record and is required for all start runs. It may be used at restart time for rezone specification only.

	min	max
start	1	1
restart	0	1

Columns →	11	21	31	41	51	61	71	80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable

1 NSINP

Input mode switch. The value of NSINP specifies the mode of input to be used in this input phase. The value of NSINP must be integral and less than or equal to 3. The following definitions apply:

≤ 1.0	card input (default)
= 2.0	library input
= 3.0	keyboard input

If the field containing NSINP is left blank, then the mode of input is assumed to be card input. If the value of NSINP is greater than 3.0, the message,

```
INPUT MODE SWITCH
IMPROPERLY DEFINED.
```

is written on the print and the message files, and the program terminates immediately in subroutine GENGEN.

2 NSTRC

Trace mode switch. The value of NSTRC specifies whether or not the trace option is active. The value of NSTRC must be integral and less than or equal to 2. The following definitions apply:

≤ 1.0	trace is not active, off (default)
= 2.0	trace is active, on

If the field containing NSTRC is left blank, then the mode is assumed to be not active (off). If the value of NSTRC is greater than 2.0, the message,

```
TRACE MODE SWITCH
IMPROPERLY DEFINED.
```

is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The trace logic, if active (on), will cause the name of the subroutine or logical phase just entered to be printed on both the print and message files. These actions are taken in subroutines SBRENT and PHSENT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
3	NSDBG	Debug mode switch. The value of NSDBG specifies whether or not the debug option is active. The value of NSDBG must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 debug is not active, off (default) = 2.0 debug is active, on If the field containing NSDBG is left blank, then the debug mode is assumed to be not active (off). If the value of NSDBG is greater than 2.0, the message, DEBUG MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The debug logic, if active (on), will cause the common blocks associated with this input phase to be dumped at the end of each subroutine in the phase and at the end of the logical phase. These actions are taken in subroutines SBREXT and PHSEXT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.
4	NSPLT	Plot mode switch. The value of NSPLT specifies whether or not plots will be produced by this generator phase. The value of NSPLT must be integral and less than or equal to 2.0. The following definitions apply: ≤ 1.0 no plots produced, option off (default) = 2.0 plots produced, option on If the field containing NSPLT is left blank, then no plots will be produced (off). If the value of NSPLT is greater than 2.0, the message, PLOT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine ZONGEN.

Columns →	11	21	31	41	51	61	71	80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
5	NSPRT	Print mode switch. The value of NSPRT controls the printing in this generator phase. The value of NSPRT must be integral and less than or equal to 2.0. The following definitions apply: = 1.0 only input records and error messages are printed, option off = 2.0 full printing done, option on (default) If the field containing NSPRT is left blank, full printing is done (option on). If the value of NSPRT is greater than 2.0, the message, PRINT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine ZONGEN.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

The 311 input record defines an initial values block for which initial values are described on input records in the ZON input phase. At least one 311 input record is required for each grid defined by the GRD input record for a start run to set up initial values. The 311 input record may not be used at restart time.

	min	max
start	1	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 311. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXBLK. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine ZONINP. (See Appendix "Messages".)
2	ILFT	Leftmost grid point index for initial value block L. The value of ILFT must be integral and greater than or equal to 1 and less than IRHT. If ILFT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) $1 \le \text{ILFT} < \text{IRHT}$
3	IRHT	Rightmost grid point index for initial value block L. The value of IRHT must be integral and greater than ILFT and less than or equal to MAXGPT. (See Appendix "Maximums".) If IRHT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) $\text{ILFT} < \text{IRHT} \le \text{MAXGPT}$

Columns →	11	21	31	41	51	61	71 80
	L	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	JBOT*	Bottommost grid point index for initial value block L. The value of JBOT must be integral and greater than or equal to 1 and less than JTOP. If JBOT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) $1 \le \text{JBOT} < \text{JTOP}$
5	JTOP*	Topmost grid point index for initial value block L. The value of JTOP must be integral and greater than JBOT and less than or equal to MAXROW. (See Appendix "Maximums".) If JTOP is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) $\text{JBOT} < \text{JTOP} \le \text{MAXROW}$
6	KAFT*	Aftmost grid point index for initial value block L. The value of KAFT must be integral and greater than or equal to 1 and less than KFRT. If KAFT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) $1 \le \text{KAFT} < \text{KFRT}$
7	KFRT*	Frontmost grid point index for initial value block L. The value of KFRT must be integral and greater than KAFT and less than or equal to MAXPLN. (See Appendix "Maximums".) If KFRT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) $\text{KAFT} < \text{KFRT} \le \text{MAXPLN}$

NOTE: Pages 7.312 through 7.320 will not appear in this report.

---

*JBOT, JTOP, KAFT, and KFRT are not required for one-dimensional problems and KAFT and KFRT are not required for two-dimensional problems. Input values in these fields when not required will result in the FLDCHK message being written on the print and the message files and the program being terminated at the end of the GENERATOR phase group. (See Appendix "Messages".)

Material Model Specification

Page 1 of 1

The 321 input record specifies the material property number for zones in block number L. At least one 321 input record is required for all start runs. It may not be used at restart time.

	min	max
start	1	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	L	MPNBLK	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 311 record.
2	MPNBLK	Material property number.* The value of MPNBLK uniquely identifies a material model. A model consists of an equation of state and strength, explosive, and thermal descriptions. The value of MPNBLK must be integral and must be greater than or equal to 1 and less than or equal to MAXMAT. (See Appendix "Maximums".) If MPNBLK is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine ZONINP. (See Appendix "Messages".)
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*The value of MPNBLK must be one of the MPN values defined in the MAT input phase.

Initial Scalars Specification

The 322 input record specifies the initial relative volume, internal energy density, temperature, and heat energy density for zones in block number L. At least one 322 input record is required for all start runs. It may not be used at restart time.

	min	max
start	1	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	L	RLVBLK	ZIEBLK	TMPBLK	ZHEBLK	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 311 record.
2	RLVBLK	Initial relative volume. RLVBLK is related to the reference density defined for the material model specified on the 321 input record for this block. The value of RLVBLK must be a positive number greater than SMLNUM or the message, INITIAL RELATIVE VOLUME OF BLOCK ii MUST BE A NONZERO POSITIVE NUMBER ITS VALUE IS RLVBLK = eeeeeeeeeee is written on the print and the message files and the program terminates immediately in subroutine ZONINP.
3	ZIEBLK	Initial internal energy density.
4	TMPBLK	Initial temperature.
5	ZHEBLK	Initial heat energy density.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.323 through 7.330 will not appear in this report.

Initial Velocity Specification

The 331 input record specifies the initial velocity for zones in block number L. The 331 input record may not be used at restart time. If the 331 input record is omitted, the initial velocity is assumed to be the default value.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	L	XVLBLK	YVLBLK	ZVLBLK	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 311 record.
2	XVLBLK	Initial x-velocity. The value of XVLBLK can be any number in problem units. The default value is zero.
3	YVLBLK	Initial y-velocity. The value of YVLBLK can be any number in problem units. The default value is zero. (Only needed for two-dimensional problems.)
4	ZVLBLK	Initial z-velocity. The value of ZVLBLK can be any number in problem units. The default value is zero. (Only needed for three-dimensional problems.)
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.333 through 7.340 will not appear in this report.

Initial Total Stress Tensor Specification

Page 1 of 1

TYPE 341

The 341 input record specifies the initial total stress tensor for zones in block number L. The 341 input record may not be used at restart time. If the 341 input record is omitted, the initial total stresses are assumed to be the default values.

	min	max
start	0	MAXBLK
restart	0	0

Columns →	11	21	31	41	51	61	71–80
	L	TXXBLK	TYYBLK	TZZBLK	TXYBLK	TYZBLK	TXZBLK
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on TYPE 311 record.
2	TXXBLK	Initial xx-total stress. The value of TXXBLK can be any number in problem units. The default value is zero.
3	TYYBLK	Initial yy-total stress. The value of TYYBLK can be any number in problem units. The default value is zero.
4	TZZBLK	Initial zz-total stress. The value of TZZBLK can be any number in problem units. The default value is zero.
5	TXYBLK	Initial xy-shear stress. The value of TXYBLK can be any number in problem units. The default value is zero. This field will be ignored in one-dimensional problems.
6	TYZBLK	Initial yz-total stress. The value of TYZBLK can be any number in problem units. The default value is zero. This field will be ignored in one- and two-dimensional problems.
7	TXZBLK	Initial xz-shear stress. The value of TXZBLK can be any number in problem units. The default value is zero. This field will be ignored in one- and two-dimensional problems.

This page intentionally left blank.

NOTE: Pages 7.343 through 7.380 will not appear in this report.

Rezone Values Block Specification

The 381 input record defines a rezone values block for which rezone values are described on the 382 input record. At least one 381 input record is required to specify a block of rezone values. The 381 input record may be used at start and restart times.

	min	max
start	0	MAXRZN
restart	0	MAXRZN

Columns →	11	21	31	41	51	61	71	80
	L	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. The value of L uniquely identifies a block of grid points defined by the grid point limits specified on record type 381. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXRZN. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine ZONINP. (See Appendix "Messages".)
2	ILFT	Leftmost grid point index for rezone values block L. The value of ILFT must be integral and greater than or equal to 1 and less than or equal to IRHT. If ILFT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) $1 \le$ ILFT $\le$ IRHT
3	IRHT	Rightmost grid point index for rezone values block L. The value of IRHT must be integral and greater than or equal to ILFT and less than or equal to MAXGPT. (See Appendix "Maximums".) If IRHT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) ILFT $\le$ IRHT $\le$ MAXGPT
4	JBOT*	Bottommost grid point index for rezone values block L. The value of JBOT must be integral and greater than or equal to 1 and less than or equal to JTOP. If JBOT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) $1 \le$ JBOT $\le$ JTOP

---

* JBOT, JTOP, KAFT, and KFRT are not required for one-dimensional problems and KAFT and KFRT are not required for two-dimensional problems. Input values in these fields when not required will result in the FLDCHK message being written on the print and the message files and the program being terminated at the end of the GENERATOR phase group. (See Appendix "Messages".)

Columns →	11	21	31	41	51	61	71	80
	L	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
5	JTOP*	Topmost grid point index for rezone values block L. The value of JTOP must be integral and greater than or equal to JBOT and less than or equal to MAXROW. (See Appendix "Maximums".) If JTOP is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) $JBOT \le JTOP \le MAXROW$
6	KAFT*	Aftmost grid point index for rezone values block L. The value of KAFT must be integral and greater than or equal to 1 and less than or equal to KFRT. If KAFT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) $1 \le KAFT \le KFRT$
7	KFRT*	Frontmost grid point index for rezone values block L. The value of KFRT must be integral and greater than or equal to KAFT and less than or equal to MAXPLN. (See Appendix "Maximums".) If KFRT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the ZON GENERATOR phase. (See Appendix "Messages".) $KAFT \le KFRT \le MAXPLN$

---

*JBOT, JTOP, KAFT, and KFRT are not required for one-dimensional problems and KAFT and KFRT are not required for two-dimensional problems. Input values in these fields when not required will result in the FLDCHK message being written on the print and the message files and the program being terminated at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Rezone Model Parameters

The 382 input record specifies the rezone model parameters for the grid points and zones in block number L. One 382 input record is required for every block defined by a 381 input record. The 382 input record may be used at start or restart time.

	min	max
start	0	MAXRZN
restart	0	MAXRZN

Columns →	11	21	31	41	51	61	71	80
	L	RZNDPG	MRZPSN	MRZINT	MRZVEL	MRZMOM	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Block number. See Field Number 1 on input record 381.
2	RZNDPG	Damping factor. The value of RZNDPG is limited to the range 0.0 - 1.0. If the damping factor is out of this range, an error message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. The damping factor controls the amount of position rezoning that is done. That is, depending on the position model (see field 3), new positions, $\vec{R}_{NEW}$, are related to old positions, $\vec{R}_{OLD}$, and model positions, $\vec{R}_{MDL}$, as follows: $\vec{R}_{NEW} = f \cdot \vec{R}_{MDL} + (1.0 - f) \cdot \vec{R}_{OLD}$ where f is the damping factor. Notice that when $f = 0.0$, no rezone occurs and when $f = 1.0$, $\vec{R}_{NEW} = \vec{R}_{MDL}$.
3	MRZPSN	Position rezone model type. The position model type value must be integral and must be greater than or equal to 1 and less than or equal to 9. If MRZPSN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine ZONINP. (See Appendix "Messages".) The allowed values of MRZPSN have the following meanings: For one-dimensional calculations, the new grid point position is determined from the following algorithms: = 1.0 mean of its two neighbors = 2.0 cycle zero position (Euler rezone)* = 3.0 - 9.0 user-supplied algorithm

---

*When the Euler rezone is used, the effective value of RZNDPG is 1.0 (i.e., maximum rezone). In effect, the value in field 2 is ignored.

Columns →	11	21	31	41	51	61	71 80
	L	RZNDPG	MRZPSN	MRZINT	MRZVEL	MRZMOM	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable

For two-dimensional calculations, the new grid point position is determined from the following algorithms:

= 1.0 mean (uses 8 surrounding points)
= 2.0 parallelogram (uses 8 surrounding points)
= 3.0 x-component mean (uses 8 surrounding points)
= 4.0 y-component mean (uses 8 surrounding points)
= 5.0 I-line mean for left, interior and right points only; J-line mean for top and bottom points only
= 6.0 J-line mean for interior points only
= 7.0 bottom left-top right mean for interior points only
= 8.0 bottom right-top left mean for interior points only
= 9.0 user-supplied algorithm

The mean algorithm defines the rezoned grid point location as the mean position of all the nearest neighbors to the point. The parallelogram algorithms assume the new (rezoned) location corresponds to the point which keeps the surrounding zones as close to parallelograms as possible. The x-mean algorithm finds the mean value of the x-coordinates of all nearest neighbors, but leaves the y-coordinate of the rezone point unchanged. Similarly, the y-mean algorithm finds the mean value of the y-coordinate of all nearest neighbors, but leaves the x-coordinate of the rezone point unchanges. The last four algorithms select two neighboring points, and define the rezone location as the bisector of the line segment between the points. The terms left-right, top-bottom, etc., refer to the neighboring points in the i-j index space for numbering grid points. A point will usually not be moved all the way to the ideal location. A damping factor (defined in field 2 of this input record) between zero (for no correction) and one (for full correction) may be selected with each of the eight standard options to control the degree of rezoning.

For three-dimensional calculations, the new grid point position is determined from the following algorithms:

= 1.0 mean (uses 26 surrounding points)
= 2.0 x-component mean (uses 26 surrounding points)
= 3.0 y-component mean (uses 26 surrounding points)
= 4.0 z-component mean (uses 26 surrounding points)
= 5.0 - 9.0 user-supplied algorithm

Columns →	11	21	31	41	51	61	71 80
	L	RZNDPG	MRZPSN	MRZINT	MRZVEL	MRZMOM	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	MRZINT	Interior rezone model type. The interior rezone model type value must be integral and must be greater than or equal to 1 and less than or equal to 9. If MRZINT is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine ZONINP. (See Appendix "Messages".) The allowed values of MRZINT have the following meanings: = 1.0 conservation of mass and internal energy = 2.0 conservation of stress (for free boundaries) = 3.0 - 9.0 user-supplied algorithm After a point is moved, the interior or thermodynamic variables must be rezoned by one of the above options. The first standard option uses conservation of internal energy and mass to find new values of the density and pressure. The second standard option, which is most useful for rezoning points on a free surface, conserves stress during the rezone. Mass and internal energy are not conserved in the latter option. Applying the first option to points on a free surface usually produces an instability.
5	MRZVEL	Velocity rezone model type. The velocity rezone model type value must be integral and must be greater than or equal to 0 and less than or equal to 9. If MRZVEL is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine ZONINP. (See Appendix "Messages".) The allowed values of MRZVEL have the following meanings: = 0.0 no rezoning of the velocity of the rezone point = 1.0 velocity is rezoned according to local velocity gradient = 2.0 - 9.0 user-supplied algorithm
6	MRZMOM	Momentum rezone model type. The momentum rezone model type value must be integral and must be greater than or equal to 0 and less than or equal to 9. If MRZMOM is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine ZONINP. (See Appendix "Messages".) The allowed values of MRZMOM have the following meanings: = 0.0 no rezoning of the velocity of neighboring points = 1.0 neighboring velocities are altered to conserve momentum = 2.0 neighboring velocities are altered to conserve kinetic energy = 3.0 - 9.0 user-supplied algorithm

Columns →	11	21	31	41	51	61	71	80
	L	RZNDPG	MRZPSN	MRZINT	MRZVEL	MRZMOM	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.383 through 7.387 will not appear in this report.

Column Alter

The 388 input record specifies columns which will be added or dropped. The 388 input record may only be used at restart time when the restart model is NSSOR = 3 on the SOR input record type.

	min	max
start	0	0
restart	0	MAXLNS*

Columns →	11	21	31	41	51	61	71 80
	LTYP	ILNNUM	ILNNUM	ILNNUM	ILNNUM	ILNNUM	ILNNUM
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	LTYP	Type of column alter. The value of LTYP specifies whether columns are to be added or dropped. The value of LTYP must be integral and must be greater than or equal to 1 and less than or equal to 2. If LTYP is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine ZONINP. (See Appendix "Messages".) The allowed values of LTYP have the following meanings: = 1.0 add a column (not available) = 2.0 drop a column
2-7	ILNNUM	Column number. The value of ILNNUM is the i-line (column) number which is to be altered. A value of ILNNUM less than or equal to zero or greater than MAXGPT will be ignored. (See Appendix "Maximums".) All of the column numbers on this input record will be added or dropped according to the value of LTYP.

---

*MAXLNS ≡ MAXGPT - 1. (See Appendix "Maximums".)

Row Alter

The 389 input record specifies rows which will be added or dropped. The 389 input record may only be used at restart time when the restart model is NSSOR = 3 on the SOR input record type.

	min	max
start	0	0
restart	0	MAXROW*

Columns →	11	21	31	41	51	61	71 80
	LTYP	JLNNUM	JLNNUM	JLNNUM	JLNNUM	JLNNUM	JLNNUM
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	LTYP	Type of row alter. The value of LTYP specifies whether rows are to be added or dropped. The value of LTYP must be integral and must be greater than or equal to 1 and less than or equal to 2. If LTYP is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine ZONINP. (See Appendix "Messages".) The allowed values of LTYP have the following meanings: = 1.0 add a row (not available) = 2.0 drop a row
2-7	JLNNUM	Row number. The value of JLNNUM is the j-line (row) number which is to be altered. A value of JLNNUM less than or equal to zero or greater than MAXROW will be ignored. (See Appendix "Maximums".) All of the row numbers on this input record will be added or dropped according to the value of LTYP.

---

*See Appendix "Maximums".

This page intentionally left blank.

NOTE: Pages 7.391 through 7.398 will not appear in this report.

End of ZON Phase

The END input record signifies the end of a block of data for the ZON input phase. It must follow the last ZON input record.

	min	max
start	1	1
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	--	--	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1-7	--	Fields 1-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

7.4 BOUNDARY CONDITIONS SPECIFICATIONS PHASE (BDY)

The boundary specifications phase (BDY) input block may be located in any position in the input deck after the PRB input block and before the final END record. The purpose of the BDY input block is to specify time-dependent boundary conditions for the physics equations in the PROCESSOR. Boundary conditions may be changed at restart time.

Boundary conditions must be specified for grid points as well as for wall points. Usually, only boundary grid points require explicit boundary conditions, but there are circumstances in which an interior grid point requires a boundary condition. All wall points require boundary conditions.

Boundary conditions are specified point-by-point in one-dimensional problems and by line segment (two points in space) in two-dimensional problems. Only the points which require boundary values (momentum or thermal) need be specified. Specification of the type of boundary point is done by grid-point index on input record groups 41_ and 42_ .

Boundary conditions fall into two distinct categories: momentum and thermal. These categories may be further classified as directional (vector) or non-directional (non-vector). Directional boundary conditions are centered at a point (i.e., a boundary grid point), while non-directional boundary conditions are centered between grid points. For momentum boundary conditions, velocity, displacement, acceleration, and force are the typical directional boundary conditions; pressure is a non-directional boundary condition. For thermal boundary conditions, heat flux is directional and temperature is non-directional.

Grid and wall point boundary conditions require both momentum and thermal specifications. However, when a directional quantity is used to specify a momentum condition, then a non-directional quantity may not be used at that point, and vice versa. Similar remarks apply to thermal boundary conditions.

All boundary conditions require boundary data. These data may come by prescription or from an interaction calculation. Prescribed data are usually in the form of a history or a constant. Interactive conditions require the proper "interaction" algorithm.*

Input specifications in the BDY GENERATOR phase are grouped into categories which reflect the concepts described above. The 411 and 412 input records assign momentum and thermal boundary properties to each boundary point (denoted by its index space location). The 411 input record defines the boundary point (or segment) and the 412 input record defines the properties. The properties are composed of the momentum boundary number (NBM), the thermal boundary number (NBT), the boundary value number (NBV), and a material model specification (MPN). There are eight types of boundary conditions each for momentum and thermal boundary conditions. They are summarized below.

NBM	Momentum Boundary Condition
1.0	interior
2.0	pressure history
3.0	free (pressure = 0)
4.0	velocity history
5.0	fixed (velocity = 0)
6.0	wall interaction (rigid) (user-supplied in 3D code)
7.0	grid interaction (not available in 3D code)
8.0	user-supplied special

---

*See Appendix "Boundary Interaction Algorithms".

NBT	Thermal Boundary Condition
1.0	interior
2.0	temperature history
3.0	isothermal (temperature = 0)
4.0	heat flow history*
5.0	adiabatic (heat flow = 0)
6.0	wall interaction (adiabatic)*
7.0	grid interaction*
8.0	user-supplied special

For certain boundary conditions, no more data need be specified than that contained on input records 411 and 412. For example, a free, adiabatic boundary requires no more input. However, if boundary history data are necessary for either the momentum or the thermal type of boundary condition, then a 422 and/or a 423 input record corresponding to the momentum and thermal boundary conditions, respectively, must be specified to identify which history data are to be used. The momentum boundary data number (MBD) and/or the thermal boundary data number (TBD) are set equal to the correct history data model number. The 422 and 423 input records connect a specific boundary condition on the 411 and 412 input records to a particular model that has been specified on input records 431-469.

History data are input through input records 431-469 as shown below.

Record Identifier	Group Description	
43_	Pressure conditions	momentum values
44_	Velocity conditions	
45_	Temperature conditions	thermal values
46_	Heat flow conditions	

---

*Not presently available in 2D and 3D codes.

Non-directional momentum data are specified on input records 431-439. For example, pressure history data are provided on records 431 and 432.* Directional momentum data are specified on records 441-449;* x-velocity on the 441 and 442 records, and y-velocity on the 443-444 records. Non-directional thermal data are specified on input records 451-459; temperature history data appear on the 451-452 input records. Directional thermal data are specified on records 461-469; x-heat flux on records 461-462 and y-heat flux on records 463-464.

If a wall interaction momentum condition has been specified for a particular boundary grid point, then the boundary specifications for the wall are required. Wall boundary conditions are specified on input records 481-489.

Minimum input is simply the BDY and END control records when all the boundaries are free and adiabatic. At restart time, BDY records may only be used if a prescribed boundary type or function is to be changed. In this case, all of the prameters on the affected record must be specified again. Interactive boundaries may not be changed at restart time through standard input. New boundaries may not be specified at restart time.

A summary of BDY phase input records and input variables appears in Table 7.4.

NOTE: Pages 7.405 through 7.408 will not appear in this report.

---

*When the range of the pressure or velocity history data for a grid point has been exceeded, the boundary condition for that point becomes "free".

TABLE 7.4

SUMMARY OF BDY PHASE INPUT RECORDS AND INPUT VARIABLES

FIELDS 1-7

TYPE	1	2	3	4	5	6	7	
BDY	NSINP	NSTRC	NSDBG	NSPLT	NSPRT			
411	LS	IBBGN	JBBGN	IBEND	JBEND			2D
412	LS	MPNBSG	NBMBSG	NBTBSG	NBVBSG			2D/3D
413	LP	IBLFT	IBRHT	JBBOT	JBTOP	KBAFT	KBFRT	3D
421	I	NBM	NBT	NBV				1D
422	NBV	MMBD						
423	NBV	MTBD						
431	MMBD	PRHFNC	PRHS	PRHE				
432	MMBD	PRH1	PRH2	PRH3	PRH4			
441	MMBD	XVLFNC	XVLS	XVLE				
442	MMBD	XVL1	XVL2	XVL3	XVL4			
443	MMBD	YVLFNC	YVLS	YVLE				
444	MMBD	YVL1	YVL2	YVL3	YVL4			
445	MMBD	ZVLFNC	ZVLS	ZVLE				
446	MMBD	ZVL1	ZVL2	ZVL3	ZVL4			

TABLE 7.4 (continued)

FIELDS 1-7

TYPE	1	2	3	4	5	6	7	
451	MTBD	TMPFNC	TMPS	TMPE				
452	MTBD	TMP1	TMP2	TMP3	TMP4			
461	MTBD	XHFFNC	XHFS	XHFE				
462	MTBD	XHF1	XHF2	XHF3	XHF4			
463	MTBD	YHFFNC	YHFS	YHFE				
464	MTBD	YHF1	YHF2	YHF3	YHF4			
465	MTBD	ZHFFNC	ZHFS	ZHFE				
466	MTBD	ZHF1	ZHF2	ZHF3	ZHF4			
481	LS	LWBGN	LWEND					1D/2D
482	LS	MPNWSG	NBMWSG	NBTWSG	NBVWSG	DWLWSG		1D/2D
483	NMW	NTW	NVW	MWL				1D
484	NMW	NTW	NVW	MWL				1D
END								

Boundary (BDY) Phase Control

The function of the BDY control record is to activate the BDY input phase. The BDY control record must follow an END input record and is required for all start runs. It may be used at restart time to change data.

	min	max
start	1	1
restart	0	1

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable

1 NSINP

Input mode switch. The value of NSINP specifies the mode of input to be used in this input phase. The value of NSINP must be integral and less than or equal to 3. The following definitions apply:

≤ 1.0	card input (default)
= 2.0	library input
= 3.0	keyboard input

If the field containing NSINP is left blank, then the mode of input is assumed to be card input. If the value of NSINP is greater than 3.0, the message,

```
INPUT MODE SWITCH
IMPROPERLY DEFINED.
```

is written on the print and the message files, and the program terminates immediately in subroutine GENGEN.

2 NSTRC

Trace mode switch. The value of NSTRC specifies whether or not the trace option is active. The value of NSTRC must be integral and less than or equal to 2. The following definitions apply:

≤ 1.0	trace is not active, off (default)
= 2.0	trace is active, on

If the field containing NSTRC is left blank, then the mode is assumed to be not active (off). If the value of NSTRC is greater than 2.0, the message,

```
TRACE MODE SWITCH
IMPROPERLY DEFINED.
```

is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The trace logic, if active (on), will cause the name of the subroutine or logical phase just entered to be printed on both the print and message files. These actions are taken in subroutines SBRENT and PHSENT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

Columns →	11	21	31	41	51	61	71	80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
3	NSDBG	Debug mode switch. The value of NSDBG specifies whether or not the debug option is active. The value of NSDBG must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 debug is not active, off (default) = 2.0 debug is active, on If the field containing NSDBG is left blank, then the debug mode is assumed to be not active (off). If the value of NSDBG is greater than 2.0, the message, DEBUG MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The debug logic, if active (on), will cause the common blocks associated with this input phase to be dumped at the end of each subroutine in the phase and at the end of the logical phase. These actions are taken in subroutines SBREXT and PHSEXT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.
4	NSPLT	Plot mode switch. The value of NSPLT specifies whether or not plots will be produced by this generator phase. The value of NSPLT must be integral and less than or equal to 2.0. The following definitions apply: ≤ 1.0 no plots produced, option off (default) = 2.0 plots produced, option on If the field containing NSPLT is left blank, then no plots will be produced (off). If the value of NSPLT is greater than 2.0, the message, PLOT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine BDYGEN.

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
5	NSPRT	Print mode switch. The value of NSPRT controls the printing in this generator phase. The value of NSPRT must be integral and less than or equal to 2.0. The following definitions apply: = 1.0 only input records and error messages are printed, option off = 2.0 full printing done, option on (default) If the field containing NSPRT is left blank, full printing is done (option on). If the value of NSPRT is greater than 2.0, the message, PRINT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine BDYGEN.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Boundary Point Segment Definition

Page 1 of 2

The 411 input record defines a sequence of contiguous boundary points for which unique boundary properties are described on input record 412. A boundary point segment may be composed of one or more boundary points. Undefined boundary points are assumed to be mechanically free and thermally adiabatic.

	min	max
start	0	MAXSEG
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	LS	IBBGN	JBBGN	IBEND	JBEND	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	LS	Segment number. The value of LS uniquely identifies a sequence of boundary points defined by the grid point limits specified on record type 411. The value of LS must be integral and greater than or equal to 1 and less than or equal to MAXSEG. (See Appendix "Maximums".) If LS is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) If the segment is composed of only one point, then IBBGN = IBEND and JBBGN = JBEND. In one-dimensional problems, JBBGN and JBEND are ignored. In two-dimensional problems, the boundary point limits for a given grid must be defined counterclockwise in a right-handed i,j space and must not cross that grid's corner in i,j space.*
2	IBBGN	I index of first boundary point in a sequence of boundary points. The value of IBBGN must be integral and greater than or equal to 1 and less than or equal to MAXGPT. (See Appendix "Maximums".) If IBBGN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
3	JBBGN	J index of first boundary point in a sequence of boundary points. The value of JBBGN must be integral and greater than or equal to 1 and less than or equal to MAXBUF. (See Appendix "Maximums".) If JBBGN is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)

---

*In summary, boundary segments for each grid must be defined in a counterclockwise sense with respect to that grid and no single boundary segment may "turn" a corner in i,j space.

Columns →	11	21	31	41	51	61	71	80
	LS	IBBGN	JBBGN	IBEND	JBEND	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
4	IBEND	I index of last boundary point in a sequence of boundary points. The value of IBEND must be integral and greater than or equal to 1 and less than or equal to MAXGPT. (See Appendix "Maximums".) If IBEND is out of this range, a RGEERR message is written on the print and the message files and the program terminates in subroutine BDYINP. (See Appendix "Messages".)
5	JBEND	J index of last boundary point in a sequence of boundary points. The value of JBEND must be integral and greater than or equal to 1 and less than or equal to MAXBUF. (See Appendix "Maximums".) If JBEND is out of this range, a RGEERR message is written on the print and the message files and the program terminates in subroutine BDYINP. (See Appendix "Messages".)
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Boundary Segment Description

The 412 input record describes the properties of a contiguous sequence of boundary segments defined on the 411 input record. Grid points not defined on the 411 input record are assumed to be mechanically free and thermally adiabatic.

	min	max
start	0	MAXSEG
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	LS	MPNBSG	NBMBSG	NBTBSG	NBVBSG	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	LS	Segment number. The value of LS uniquely identifies a sequence of boundary points defined by the grid point limits specified on record type 411. The value of LS must be integral and greater than or equal to 1 and less than or equal to MAXSEG. (See Appendix "Maximums".) If LS is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) If the segment is composed of only one point, then IBBGN = IBEND and JBBGN = JBEND. In two-dimensional problems, the boundary point limits must be defined counterclockwise in a right-handed i,j space and must not cross a grid corner in i,j space.
2	MPNBSG	Material property number for this segment. The value of MPNBSG uniquely identifies a material model. A model consists of an equation of state and strength, explosive, and thermal descriptions; however, only the mechanical and thermal surface properties will be used. The value of MPNBSG must be integral and must be greater than or equal to 1 and less than or equal to MAXMAT. (See Appendix "Maximums".) If MPNBSG is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) **Not currently used.**

Columns →	11	21	31	41	51	61	71 80
	LS	MPNBSG	NBMBSG	NBTBSG	NBVBSG	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
3	NBMBSG	Momentum boundary number for this segment. The value of NBMBSG identifies the momentum boundary condition type. The value of NBMBSG must be integral and greater than or equal to 1 and less than or equal to 8. If NBMBSG is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 1.0 interior = 2.0 pressure history* = 3.0 free, p = 0.0 (default when input record not used) = 4.0 velocity history* = 5.0 fixed (rigid) = 6.0 wall interaction = 7.0 grid interaction = 8.0 special
4	NBTBSG	Thermal boundary number for this segment. The value of NBTBSG identifies the thermal boundary condition type. The value of NBTBSG must be integral and greater than or equal to 1 and less than or equal to 8. If NBTBSG is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 1.0 interior = 2.0 temperature history** = 3.0 isothermal, T = 0.0 = 4.0 heat flux history** = 5.0 adiabatic (default when input record not used and for non-thermal runs) = 6.0 wall interaction = 7.0 grid interaction = 8.0 special

---

*When a pressure history boundary point in a particular cycle is outside of the range of the function defined on the 431 input record, it automatically becomes a free point for that cycle. When a velocity history point is outside of its range as defined on the 441 input record, it is permanently changed to a free point for all time.

**When a temperature history boundary point in a particular cycle is outside of the range of the function defined on the 451 input record, it automatically becomes an isothermal point where T = 0 for that cycle. When a heat flux history point is outside of its range as defined on the 461 input record, it is permanently changed to an isothermal point where T = 0 for all time.

Columns →	11	21	31	41	51	61	71	80
	LS	MPNBSG	NBMBSG	NBTBSG	NBVBSG	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
5	NBVBSG	Index of boundary array. The value of NBVBSG specifies the index location of boundary history model data for a grid point which has a history specification; or it specifies the greater wall point number of the wall point segment that it is touching or near, for a grid point which interacts with wall points; or it specifies the closest i value of the interacting row in the other grid for a grid point which interacts with grid points in another grid.* When the grid point is not a history, wall-interacting, or grid-interacting boundary point, leave NBVBSG blank. The value of NBVBSG must be integral and greater than or equal to 0 and less than or equal to MAXBDY. (See Appendix "Maximums".) If NBVBSG is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*If the boundary points specified on the associated 411 input record have been designated to be wall or grid interacting (i.e., NBMBSG = 6 or 7, respectively) and NBVBSG is left blank, then the value of NBVBSG will be computed automatically using a minimum distance algorithm.

Boundary Plane Definition

3D only

TYPE 413

Page 1 of 2

The 413 input record defines a boundary plane for which unique boundary properties are described on input record 412. Undefined boundary planes are assumed to be mechanically free and thermally adiabatic.

	min	max
start	0	MAXSEG
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	LP	IBLFT	IBRHT	JBBOT	JBTOP	KBAFT	KBFRT	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	LP	Plane number. The value of LP uniquely identifies a boundary plane defined by the limits on input record 413. The value of LP must be integral and greater than or equal to 1 and less than or equal to MAXSEG. (See Appendix "Maximums".) If LP is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) In three-dimensional problems, the boundary plane limits are defined in terms of a right-handed i,j,k space and must not cross a grid edge in i,j,k space.
2	IBLFT	Leftmost i-index of the boundary plane. The value of IBLFT must be integral and greater than or equal to 1 and less than or equal to MAXGPT. (See Appendix "Maximums".) If IBLFT is out of this range, a RGEERR message is written on the print and the message files and the program terminates in subroutine BDYINP. (See Appendix "Messages".)
3	IBRHT	Rightmost i-index of the boundary plane. The value of IBRHT must be integral and greater than or equal to 1 and less than or equal to MAXGPT. (See Appendix "Maximums".) If IBRHT is out of this range, a RGEERR message is written on the print and the message files and the program terminates in subroutine BDYINP. (See Appendix "Messages".)
4	JBBOT	Bottommost j-index of the boundary plane. The value of JBBOT must be integral and greater than or equal to 1 and less than or equal to MAXROW. (See Appendix "Maximums".) If JBBOT is out of this range, a RGEERR message is written on the print and the message files and the program terminates in subroutine BDYINP. (See Appendix "Messages".)
5	JBTOP	Topmost j-index of the boundary plane. The value of JBTOP must be integral and greater than or equal to 1 and less than or equal to MAXROW. (See Appendix "Maximums".) If JBTOP is out of this range, a RGEERR message is written on the print and the message files and the program terminates in subroutine BDYINP. (See Appendix "Messages".)

Page 2 of 2

Columns →	11	21	31	41	51	61	71 80
	LP	IBLFT	IBRHT	JBBOT	JBTOP	KBAFT	KBFRT
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
6	KBAFT	Aftmost k-index of the boundary plane. The value of KBAFT must be integral and greater than or equal to 1 and less than or equal to MAXBUF. (See Appendix "Maximums".) If KBAFT is out of this range, a RGEERR message is written on the print and the message files and the program terminates in subroutine BDYINP. (See Appendix "Messages".)
7	KBFRT	Frontmost k-index of the boundary plane. The value of KBFRT must be integral and greater than or equal to 1 and less than or equal to MAXBUF. (See Appendix "Maximums".) If KBFRT is out of this range, a RGEERR message is written on the print and the message files and the program terminates in subroutine BDYINP. (See Appendix "Messages".)

This page intentionally left blank.

Boundary Interaction Description

The 414 input record specifies the type of interaction algorithms which are to act on the boundary segment LS, defined on the 411 and 412 input records.

	min	max
start	0	MAXSEG
restart	0	0

Columns →	11	21	31	41	51	61	71	80
	LS	NSW	NSS	DGDGSG	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	LS	Segment number. The value of LS uniquely identifies a sequence of boundary points defined by the grid point limits specified on record type 411. The value of LS must be integral and greater than or equal to 1 and less than or equal to MAXSEG. (See Appendix "Maximums".) If LS is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) If the segment is composed of only one point, then IBBGN = IBEND and JBBGN = JBEND. In two-dimensional problems, the boundary point limits must be defined counterclockwise in a right-handed i,j space and must not cross a grid corner in i,j space.
2	NSW	Wall interaction type switch. The value of NSW specifies the type of wall interaction logic to be used. There are three types: = 0.0, rigid wall with infinite mass (default) = 1.0, shell finite element = 2.0, rigid body with finite mass and moment of inertia If NSW is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
3	NSS	Grid interaction type switch. The value of NSS specifies the type of grid interaction logic to be used. There are four types: = 0.0, free slip (frictionless and cohesionless) = 1.0, tied sliding (infinite friction and cohesion) = 2.0, frictional sliding and finite cohesion* = 3.0, drag sliding and finite cohesion* If NSS is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)

---

*Model requires user-created special logic.

Columns →	11	21	31	41	51	61	71 80
	LS	NSW	NSS	DGDGSG	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	DGDGSG	Capture distance for a grid point segment. For a grid interaction boundary segment, the value of DGDGSG specifies the distance from an interaction within which the grid point will be "capatured" by the interacting grid-point segment. The default value for DGDGSG, when the field is left blank, is DSTMIN (see MIN input record). DGDGSG may not be zero.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.415 through 7.420 will not appear in this report.

Boundary Location

Page 1 of 2

Each 421 input record specifies the boundary conditions for a particular boundary point. A 421 input record is required for each boundary point in a grid. There are no default values and the 421 input record may be used at restart time to change boundary conditions.

	min	max
start	2	MAXGPT
restart	0	MAXGPT

Columns →	11	21	31	41	51	61	71	80
	I	NBM	NBT	NBV	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	I	Index of grid point. The value of I specifies a grid point index location that requires boundary conditions to be specified. The value of I must be integral and greater than or equal to 1 and less than or equal to MAXGPT. (See Appendix "Maximums".) If I is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	NBM	Momentum boundary number. The value of NBM identifies the momentum boundary condition type. The value of NBM must be integral and greater than or equal to 1 and less than or equal to 8. If NBM is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 1.0 interior = 2.0 pressure history* = 3.0 free, p = 0.0 = 4.0 velocity history* = 5.0 fixed (rigid) = 6.0 wall interaction = 7.0 grid interaction = 8.0 special

---

*When a pressure history boundary point in a particular cycle is outside of the range of the function defined on the 431 input record, it automatically becomes a free point for that cycle. When a velocity history point is outside of its range as defined on the 441 input record, it is permanently changed to a free point for all time.

Columns →	11	21	31	41	51	61	71 80
	I	NBM	NBT	NBV	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
3	NBT	Thermal boundary number. The value of NBT identifies the thermal boundary condition type. The value of NBT must be integral and greater than or equal to 1 and less than or equal to 8. If NBT is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply:

= 1.0	interior
= 2.0	temperature history*
= 3.0	isothermal, T = 0.0
= 4.0	heat flux history*
= 5.0	adiabatic (default for non-thermal runs)**
= 6.0	wall interaction
= 7.0	grid interaction
= 8.0	special

Field Number	Input Variable Name	Description of Input Variable
4	NBV	Index of boundary array. The value of NBV specifies the index location of boundary history model data for a grid point in the boundary values array. When no history data is required, leave NBV blank. The value of NBV must be integral and greater than or equal to 0 and less than or equal to MAXBDY. (See Appendix "Maximums".) If NBV is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*When a temperature history boundary point in a particular cycle is outside of the range of the function defined on the 451 input record, it automatically becomes an isothermal point where T = 0 for that cycle. When a heat flux history point is outside of its range as defined on the 461 input record, it is permanently changed to an isothermal point where T = 0 for all time.

**Refers only to use of STEALTH files which do not have thermal capability.

This page intentionally left blank.

A 422 input record is required for each boundary point whose momentum boundary is a specified time history input. It is used in conjunction with the 421, 483, and 484 input records in 1D, the 412 and 482 input records in 2D, and the 412 input record in 3D.*

	min	max
start	0	MAXBDY
restart	0	MAXBDY

Columns →	11	21	31	41	51	61	71 80
	NBV	MMBD	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NBV	Index of boundary array. The value of NBV specifies the index location of boundary history model data for a grid point in the boundary values array. The value of NBV must be integral and greater than or equal to 0 and less than or equal to MAXBDY. (See Appendix "Maximums".) If NBV is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	MMBD	Momentum boundary model number. The value of MMBD defines the array location of the function coefficients, model, and range defined on input records 431, 432, 441 thru 446. The value of MMBD must be integral and greater than or equal to 1 and less than or equal to MAXMBD. (See Appendix "Maximums".) If MMBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*This input record is only required when either boundary points or wall points are assigned history data. Wall interacting boundary points which interact with fixed-in-space rigid walls do not need an associated 422 input record. Do not use this input record when mechanical history data are not required.

Thermal Boundary History Model

The 423 input record is required for each boundary point whose thermal boundary is a specified time history input. It is used in conjunction with the 421, 483, and 484 input records in 1D, the 412 and 482 input records in 2D, and the 412 input record in 3D.*

	min	max
start	0	MAXBDY
restart	0	MAXBDY

Columns →	11	21	31	41	51	61	71	80
	NBV	MTBD	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	NBV	Index of boundary array. The value of NBV specifies the index location of boundary history model data for a grid point in the boundary values array. The value of NBV must be integral and greater than or equal to 0 and less than or equal to MAXBDY. (See Appendix "Maximums".) If NBV is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	MTBD	Thermal boundary model number. The value of MTBD defines the array location of the function coefficients, model, and range defined on input records 451, 452, 461 thru 466. The value of MTBD must be integral and greater than or equal to 1 and less than or equal to MAXTBD. (See Appendix "Maximums".) If MTBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*This input record is only required when either boundary points or wall points are assigned history data. Wall interacting boundary points which interact with an adiabatic wall do not need an associated 423 input record. Do not use this input record when thermal history data are not required.

This page intentionally left blank.

NOTE: Pages 7.425 through 7.430 will not appear in this report.

Pressure History Function and Range

A 431 input record is required to specify a function type and a range for a pressure boundary.

	min	max
start	0	MAXMBD
restart	0	MAXMBD

Columns →	11	21	31	41	51	61	71	80
	MMBD	PRHFNC	PRHS	PRHE	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MMBD	Momentum boundary model number. The value of MMBD defines the array location of the function coefficients, model, and range defined on input records 431, 432, 441 thru 446. The value of MMBD must be integral and greater than or equal to 1 and less than or equal to MAXMBD. (See Appendix "Maximums".) If MMBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	PRHFNC	Function type for pressure history modeling. The value of PRHFNC specifies the type of function of time. The value of PRHFNC must be integral and greater than 1 and less than or equal to 10. If PRHFNC is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 1.0 polynomial = 2.0 rational = 3.0 exponential #1 = 4.0 exponential #2 = 5.0 exponential #3 = 6.0 trigonometric #1 = 7.0 trigonometric #2 = 8.0 (none) = 9.0 user-supplied = 10.0 user-supplied See Appendix "Functions" for a description of the available function types.
3	PRHS	Start of time range for pressure function. The value of PRHS is a positive number. The value of problem time must be greater than or equal to PRHS and less than PRHE for the function to be activated.

Columns →	11	21	31	41	51	61	71 80
	MMBD	PRHFNC	PRHS	PRHE	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	PRHE	End of time range for pressure function. The value of PRHE is a positive number. The value of problem time must be greater than or equal to PRHS and less than PRHE for the function to be activated.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Pressure History Coefficients

Page 1 of 1

The 432 input record is required to specify function coefficients for a pressure boundary.

	min	max
start	0	MAXMBD
restart	0	MAXMBD

Columns →	11	21	31	41	51	61	71 80
	MMBD	PRH1	PRH2	PRH3	PRH4	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MMBD	Momentum boundary model number. The value of MMBD defines the array location of the function coefficients, model, and range defined on input records 431, 432, 441 thru 446. The value of MMBD must be integral and greater than or equal to 1 and less than or equal to MAXMBD. (See Appendix "Maximums".) If MMBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	PRH1	Pressure coefficient number 1. Default value is 0.
3	PRH2	Pressure coefficient number 2. Default value is 0.
4	PRH3	Pressure coefficient number 3. Default value is 0.
5	PRH4	Pressure coefficient number 4. Default value is 0.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.433 through 7.440 will not appear in this report.

x-Velocity History Function and Range

A 441 input record is required to specify a function type and a range for an x-velocity boundary.

	min	max
start	0	MAXMBD
restart	0	MAXMBD

Columns →	11	21	31	41	51	61	71	80
	MMBD	XVLFNC	XVLS	XVLE	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MMBD	Momentum boundary model number. The value of MMBD defines the array location of the function coefficients, model, and range defined on input records 431, 432, 441 thru 446. The value of MMBD must be integral and greater than or equal to 1 and less than or equal to MAXMBD. (See Appendix "Maximums".) If MMBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	XVLFNC	Function type for x-velocity history modeling. The value of XVLFNC specifies the type of function of time. The value of XVLFNC must be integral and greater than or equal to 1 and less than or equal to 10. If XVLFNC is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 1.0 polynomial = 2.0 rational = 3.0 exponential #1 = 4.0 exponential #2 = 5.0 exponential #3 = 6.0 trigonometric #1 = 7.0 trigonometric #2 = 8.0 (none) = 9.0 user-supplied = 10.0 user-supplied See Appendix "Functions" for a description of available function types.
3	XVLS	Start of time range of x-velocity function. The value of XVLS is a positive number. The value of problem time must be greater than or equal to XVLS and less than XVLE for the function to be activated.

Columns →	11	21	31	41	51	61	71 80
	MMBD	XVLFNC	XVLS	XVLE	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	XVLE	End of time range of x-velocity function. The value of XVLE is a positive number. The value of problem time must be greater than or equal to XVLS and less than XVLE for the function to be activated.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

x-Velocity History Coefficients

The 442 input record is required to specify function coefficients for an x-velocity boundary.

	min	max
start	0	MAXMBD
restart	0	MAXMBD

Columns →	11	21	31	41	51	61	71 80
	MMBD	XVL1	XVL2	XVL3	XVL4	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MMBD	Momentum boundary model number. The value of MMBD defines the array location of the function coefficients, model, and range defined on input records 431, 432, 441 thru 446. The value of MMBD must be integral and greater than or equal to 1 and less than or equal to MAXMBD. (See Appendix "Maximums".) If MMBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	XVL1	x-velocity coefficient number 1. Default value is 0.
3	XVL2	x-velocity coefficient number 2. Default value is 0.
4	XVL3	x-velocity coefficient number 3. Default value is 0.
5	XVL4	x-velocity coefficient number 4. Default value is 0.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

y-Velocity History Function and Range

A 443 input record is required to specify a function type and a range for a y-velocity boundary.

	min	max
start	0	MAXMBD
restart	0	MAXMBD

Columns →	11	21	31	41	51	61	71 80
	MMBD	YVLFNC	YVLS	YVLE	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MMBD	Momentum boundary model number. The value of MMBD defines the array location of the function coefficients, model, and range defined on input records 431, 432, 441 thru 446. The value of MMBD must be integral and greater than or equal to 1 and less than or equal to MAXMBD. (See Appendix "Maximums".) If MMBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	YVLFNC	Function type for y-velocity history modeling. The value of YVLFNC specifies the type of function of time. The value of YVLFNC must be integral and greater than or equal to 1 and less than or equal to 10. If YVLFNC is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 1.0 polynomial = 2.0 rational = 3.0 exponential #1 = 4.0 exponential #2 = 5.0 exponential #3 = 6.0 trigonometric #1 = 7.0 trigonometric #2 = 8.0 (none) = 9.0 user-supplied = 10.0 user-supplied See Appendix "Functions" for a description of available function types.
3	YVLS	Start of time range of y-velocity function. The value of YVLS is a positive number. The value of problem time must be greater than or equal to YVLS and less than YVLE for the function to be activated.

Columns →	11	21	31	41	51	61	71 80
	MMBD	YVLFNC	YVLS	YVLE	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	YVLE	End of time range of y-velocity function. The value of YVLE is a positive number. The value of problem time must be greater than or equal to YVLS and less than YVLE for the function to be activated.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

y-Velocity History Coefficients

The 444 input record is required to specify function coefficients for a y-velocity boundary.

	min	max
start	0	MAXMBD
restart	0	MAXMBD

Columns →	11	21	31	41	51	61	71 80
	MMBD	YVL1	YVL2	YVL3	YVL4	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MMBD	Momentum boundary model number. The value of MMBD defines the array location of the function coefficients, model, and range defined on input records 431, 432, 441 thru 446. The value of MMBD must be integral and greater than or equal to 1 and less than or equal to MAXMBD. (See Appendix "Maximums".) If MMBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	YVL1	y-velocity coefficient number 1. Default value is 0.
3	YVL2	y-velocity coefficient number 2. Default value is 0.
4	YVL3	y-velocity coefficient number 3. Default value is 0.
5	YVL4	y-velocity coefficient number 4. Default value is 0.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

z-Velocity History Function and Range

A 445 input record is required to specify a function type and a range for a z-velocity boundary.

	min	max
start	0	MAXMBD
restart	0	MAXMBD

Columns →	11	21	31	41	51	61	71 80
	MMBD	ZVLFNC	ZVLS	ZVLE	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MMBD	Momentum boundary model number. The value of MMBD defines the array location of the function coefficients, model, and range defined on input records 431, 432, 441 thru 446. The value of MMBD must be integral and greater than or equal to 1 and less than or equal to MAXMBD. (See Appendix "Maximums".) If MMBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	ZVLFNC	Function type for z-velocity history modeling. The value of ZVLFNC specifies the type of function of time. The value of ZVLFNC must be integral and greater than or equal to 1 and less than or equal to 10. If ZVLFNC is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 1.0 polynomial = 2.0 rational = 3.0 exponential #1 = 4.0 exponential #2 = 5.0 exponential #3 = 6.0 trigonometric #1 = 7.0 trigonometric #2 = 8.0 (none) = 9.0 user-supplied = 10.0 user-supplied See Appendix "Functions" for a description of available function types.
3	ZVLS	Start of time range of z-velocity function. The value of ZVLS is a positive number. The value of problem time must be greater than or equal to ZVLS and less than ZVLE for the function to be activated.

Columns →	11	21	31	41	51	61	71 80
	MMBD	ZVLFNC	ZVLS	ZVLE	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	ZVLE	End of time range of z-velocity function. The value of ZVLE is a positive number. The value of problem time must be greater than or equal to ZVLS and less than ZVLE for the function to be activated.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

z-Velocity History Coefficients

The 446 input record is required to specify function coefficients for a z-velocity boundary.

	min	max
start	0	MAXMBD
restart	0	MAXMBD

Columns →	11	21	31	41	51	61	71	80
	MMBD	ZVL1	ZVL2	ZVL3	ZVL4	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MMBD	Momentum boundary model number. The value of MMBD defines the array location of the function coefficients, model, and range defined on input records 431, 432, 441 thru 446. The value of MMBD must be integral and greater than or equal to 1 and less than or equal to MAXMBD. (See Appendix "Maximums".) If MMBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	ZVL1	z-velocity coefficient number 1. Default value is 0.
3	ZVL2	z-velocity coefficient number 2. Default value is 0.
4	ZVL3	z-velocity coefficient number 3. Default value is 0.
5	ZVL4	z-velocity coefficient number 4. Default value is 0.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.447 through 7.450 will not appear in this report.

Temperature History Function and Range

A 451 input record is required to specify a function type and a range for a temperature boundary.

	min	max
start	0	MAXTBD
restart	0	MAXTBD

Columns → 11 21 31 41 51 61 71 80

	MTBD	TMPFNC	TMPS	TMPE	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MTBD	Thermal boundary model number. The value of MTBD defines the array location of the function coefficients, model, and range defined on input records 451, 452, 461 thru 466. The value of MTBD must be integral and greater than or equal to 1 and less than or equal to MAXTBD. (See Appendix "Maximums".) If MTBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	TMPFNC	Function type for temperature history modeling. The value of TMPFNC specifies the type of function of time. The value of TMPFNC must be integral and greater than or equal to 1 and less than or equal to 10. If TMPFNC is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 1.0 polynomial = 2.0 rational = 3.0 exponential #1 = 4.0 exponential #2 = 5.0 exponential #3 = 6.0 trigonometric #1 = 7.0 trigonometric #2 = 8.0 (none) = 9.0 user-supplied = 10.0 user-supplied See Appendix "Functions" for a description of the available function types.
3	TMPS	Start of time range for temperature function. The value of TMPS is a positive number. The value of problem time must be greater than or equal to TMPS and less than TMPE for the function to be activated.

Columns →	11	21	31	41	51	61	71 80
	MTBD	TMPFNC	TMPS	TMPE	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	TMPE	End of time range for temperature function. The value of TMPE is a positive number. The value of problem time must be greater than or equal to TMPE and less than TMPS for the function to be activated.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Temperature History Coefficients

The 452 input record is required to specify function coefficients for a temperature boundary.

	min	max
start	0	MAXTBD
restart	0	MAXTBD

Columns →	11	21	31	41	51	61	71	80
	MTBD	TMP1	TMP2	TMP3	TMP4	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MTBD	Thermal boundary model number. The value of MTBD defines the array location of the function coefficients, model, and range defined on input records 451, 452, 461 thru 466. The value of MTBD must be integral and greater than or equal to 1 and less than or equal to MAXTBD. (See Appendix "Maximums".) If MTBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	TMP1	Temperature coefficient number 1. Default value is 0.
3	TMP2	Temperature coefficient number 2. Default value is 0.
4	TMP3	Temperature coefficient number 3. Default value is 0.
5	TMP4	Temperature coefficient number 4. Default value is 0.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.453 through 7.460 will not appear in this report.

x-Heat Flux History Function and Range

The 461 input record is required to specify a function type and a range for an x-heat flux boundary.

	min	max
start	0	MAXTBD
restart	0	MAXTBD

Columns →	11	21	31	41	51	61	71 80
	MTBD	XHFFNC	XHFS	XHFE	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MTBD	Thermal boundary model number. The value of MTBD defines the array location of the function coefficients, model, and range defined on input records 451, 452, 461 thru 466. The value of MTBD must be integral and greater than or equal to 1 and less than or equal to MAXTBD. (See Appendix "Maximums".) If MTBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	XHFFNC	Function type for x-heat flux history modeling. The value of XHFFNC specifies the type of function of time. The value of XHFFNC must be integral and greater than or equal to 1 and less than or equal to 10. If XHFFNC is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 1.0 polynomial = 2.0 rational = 3.0 exponential #1 = 4.0 exponential #2 = 5.0 exponential #3 = 6.0 trigonometric #1 = 7.0 trigonometric #2 = 8.0 (none) = 9.0 user-supplied = 10.0 user-supplied See Appendix "Functions" for a description of the available function types.
3	XHFS	Start of time range of x-heat-flux function. The value of XHFS is a positive number. The value of problem time must be greater than or equal to XHFS and less than XHFE for the function to be activated.

Columns →	11	21	31	41	51	61	71	80
	MTBD	XHFFNC	XHFS	XHFE	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
4	XHFE	End of time range for x-heat flux function. The value of XHFE is a positive number. The value of problem time must be greater than or equal to XHFS and less than XHFE for the function to be activated.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

x-Heat Flux History Coefficients

The 462 input record is required to specify function coefficients for an x-heat flux boundary.

	min	max
start	0	MAXTBD
restart	0	MAXTBD

Columns →	11	21	31	41	51	61	71 80
	MTBD	XHF1	XHF2	XHF3	XHF4	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MTBD	Thermal boundary model number. The value of MTBD defines the array location of the function coefficients, model, and range defined on input records 451, 452, 461 thru 466. The value of MTBD must be integral and greater than or equal to 1 and less than or equal to MAXTBD. (See Appendix "Maximums".) If MTBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	XHF1	x-heat flux coefficient number 1. Default value is 0.
3	XHF2	x-heat flux coefficient number 2. Default value is 0.
4	XHF3	x-heat flux coefficient number 3. Default value is 0.
5	XHF4	x-heat flux coefficient number 4. Default value is 0.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

y-Heat Flux History Function and Range

The 463 input record is required to specify a function type and a range for a y-heat flux boundary.

	min	max
start	0	MAXTBD
restart	0	MAXTBD

Columns →	11	21	31	41	51	61	71 80
	MTBD	YHFFNC	YHFS	YHFE	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MTBD	Thermal boundary model number. The value of MTBD defines the array location of the function coefficients, model, and range defined on input records 451, 452, 461 thru 466. The value of MTBD must be integral and greater than or equal to 1 and less than or equal to MAXTBD. (See Appendix "Maximums".) If MTBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	YHFFNC	Function type for y-heat flux history modeling. The value of YHFFNC specifies the type of function of time. The value of YHFFNC must be integral and greater than or equal to 1 and less than or equal to 10. If YHFFNC is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 1.0 polynomial = 2.0 rational = 3.0 exponential #1 = 4.0 exponential #2 = 5.0 exponential #3 = 6.0 trigonometric #1 = 7.0 trigonometric #2 = 8.0 (none) = 9.0 user-supplied = 10.0 user-supplied See Appendix "Functions" for a description of the available function types.
3	YHFS	Start of time range of y-heat flux function. The value of YHFS is a positive number. The value of problem time must be greater than or equal to YHFS and less than YHFE for the function to be activated.

Columns →	11	21	31	41	51	61	71	80
	MTBD	YHFFNC	YHFS	YHFE	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
4	YHFE	End of time range for y-heat flux function. The value of YHFE is a positive number. The value of problem time must be greater than or equal to YHFS and less than YHFE for the function to be activated.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

y-Heat Flux History Coefficients

The 464 input record is required to specify function coefficients for a y-heat flux boundary.

	min	max
start	0	MAXTBD
restart	0	MAXTBD

Columns →	11	21	31	41	51	61	71 80
	MTBD	YHF1	YHF2	YHF3	YHF4	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MTBD	Thermal boundary model number. The value of MTBD defines the array location of the function coefficients, model, and range defined on input records 451, 452, 461 thru 466. The value of MTBD must be integral and greater than or equal to 1 and less than or equal to MAXTBD. (See Appendix "Maximums".) If MTBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	YHF1	y-heat flux coefficient number 1. Default value is 0.
3	YHF2	y-heat flux coefficient number 2. Default value is 0.
4	YHF3	y-heat flux coefficient number 3. Default value is 0.
5	YHF4	y-heat flux coefficient number 4. Default value is 0.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

z-Heat Flux History Function and Range

The 465 input record is required to specify a function type and a range for a z-heat flux boundary.

	min	max
start	0	MAXTBD
restart	0	MAXTBD

Columns →	11	21	31	41	51	61	71–80
	MTBD	ZHFFNC	ZHFS	ZHFE	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MTBD	Thermal boundary model number. The value of MTBD defines the array location of the function coefficients, model, and range defined on input records 451, 452, 461 thru 466. The value of MTBD must be integral and greater than or equal to 1 and less than or equal to MAXTBD. (See Appendix "Maximums".) If MTBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
2	ZHFFNC	Function type for z-heat flux history modeling. The value of ZHFFNC specifies the type of function of time. The value of ZHFFNC must be integral and greater than or equal to 1 and less than or equal to 10. If ZHFFNC is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 1.0 polynomial = 2.0 rational = 3.0 exponential #1 = 4.0 exponential #2 = 5.0 exponential #3 = 6.0 trigonometric #1 = 7.0 trigonometric #2 = 8.0 (none) = 9.0 user-supplied =10.0 user-supplied See Appendix "Functions" for a description of the available function types.
3	ZHFS	Start of time range of z-heat flux function. The value of ZHFS is a positive number. The value of problem time must be greater than or equal to ZHFS and less than ZHFE for the function to be activated.

Columns →	11	21	31	41	51	61	71	80
	MTBD	ZHFFNC	ZHFS	ZHFE	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
4	YHFE	End of time range for z-heat flux function. The value of ZHFE is a positive number. The value of problem time must be greater than or equal to ZHFS and less than ZHFE for the function to be activated.
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

z-Heat Flux History Coefficients

Page 1 of 1

The 466 input record is required to specify function coefficients for a z-heat flux boundary.

	min	max
start	0	MAXTBD
restart	0	MAXTBD

Columns →	11	21	31	41	51	61	71
	MTBD	ZHF1	ZHF2	ZHF3	ZHF4	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MTBD	Thermal boundary model number. The value of MTBD defines the array location of the function coefficients, model, and range defined on input records 451, 452, 461 thru 466. The value of MTBD must be integral and greater than or equal to 1 and less than or equal to MAXTBD. (See Appendix "Maximums".) If MTBD is out of this range, a RGEERR message is written on the print and the message files and the program terminates immdeiately in subroutine BDYINP. (See Appendix "Messages".)
2	ZHF1	z-heat flux coefficient number 1. Default value is 0.
3	ZHF2	z-heat flux coefficient number 2. Default value is 0.
4	ZHF3	z-heat flux coefficient number 3. Default value is 0.
5	ZHF4	z-heat flux coefficient number 4. Default value is 0.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.467 through 7.480 will not appear in this report.

Wall Point Sequence Definition

Page 1 of 1

TYPE
481

The 481 input record defines a sequence of contiguous wall points for which unique boundary properties are described on input record 482.

	min	max
start	0	MAXSEG
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	LS	LWBGN	LWEND	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	LS	Sequence number. The value of LS uniquely identifies a sequence of wall points defined by the wall point limits specified on record type 481. The value of LS must be integral and greater than or equal to 1 and less than or equal to MAXSEG. (See Appendix "Maximums".) If LS is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. See Appendix "Messages".) A sequence may be composed of only one point, i.e., LWBGN ≤ LWEND.
2	LWBGN	L index of first wall point in a sequence of wall points. The value of LWBGN must be integral and greater than or equal to 1 and less than or equal to MAXWPT. (See Appendix "Maximums".) If LWBGN is out of this range, a RGEERR message is written on the print and the message files and the program terminates in subroutine BDYINP. (See Appendix "Messages".)
3	LWEND	L index of last wall point in a sequence of wall points. The value of LWEND must be integral and greater than or equal to 1 and less than or equal to MAXWPT. (See Appendix "Maximums".) If LWEND is out of this range, a RGEERR message is written on the print and the message files and the program terminates in subroutine BDYINP. (See Appendix "Messages".)
4-7	--	Fields 4-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Wall Point Sequence Properties

The 482 input record describes the properties of a contiguous sequence of wall point segments defined on the 481 input record. The 482 input record may not be used at restart time.

	min	max
start	0	MAXSEG
restart	0	0

Columns →	11	21	31	41	51	61	71 80
	LS	MPNWSG	NBMWSG	NBTWSG	NBVWSG	DWLWSG	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	LS	Sequence number. The value of LS uniquely identifies a sequence of wall points defined by the wall point limits specified on record type 481. The value of LS must be integral and greater than or equal to 1 and less than or equal to MAXSEG. (See Appendix "Maximums".) If LS is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) A sequence may be composed of only one point, i.e., IWBGN ≤ IBEND.
2	MPNWSG	Material property number for this sequence. The value of MPNWSG uniquely identifies a material model. A model consists of an equation of state and strength, explosive, and thermal descriptions; however, only the mechanical and thermal surface properties will be used. The value of MPNWSG must be integral and must be greater than or equal to 1 and less than or equal to MAXMAT. (See Appendix "Maximums".) If MPNWSG is out of this range, a RGEERR message is written on the print and the message files and the program terminates in subroutine BDYINP. (See Appendix "Messages".) **Not currently used.**
3	NBMWSG	Momentum boundary number for this sequence. The value of NBMWSG identifies the momentum boundary condition type. The value of NBMWSG must be integral and greater than or equal to 4 and less than or equal to 5 or equal to 8. If NBMWSG is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 4.0 velocity history* = 5.0 fixed (rigid) = 8.0 special

---

*When a velocity history wall point is outside of its range as defined on the 441 input record, it is permanently changed to a fixed wall point for all time.

Columns →	11	21	31	41	51	61	71 80
	LS	MPNWSG	NBMWSG	NBTWSG	NBVWSG	DWLWSG	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	NBTWSG	Thermal boundary number for this sequence. The value of NBTWSG identifies the thermal boundary condition type. The value of NBTWSG must be integral and greater than or equal to 4 and less than or equal to 5 or equal to 8. If NBTWSG is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 4.0 heat flux history[*] = 5.0 adiabatic = 8.0 special
5	NBVWSG	Index of boundary array.[**] The value of NBVWSG specifies the index location of boundary history model data for a wall point in the boundary values array. When no history data are required, leave NBVWSG blank. The value of NBVWSG must be integral and greater than or equal to 0 and less than or equal to MAXBDY. (See Appendix "Maximums".) If NBVWSG is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
6	DWLWSG	Capture distance to the wall sequence. The value of DWLWSG should be set to a value greater than zero but less than half of a typical zone size representing a perpendicular capture distance (in problem units) from the wall segment to a wall interactiong boundary grid point. When an appropriate boundary grid point comes within this capture distance of a wall segment, it is placed on the wall segment at the point of perpendicular projection. The default value is DSTMIN. (See the MIN input record.)
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] When a heat flux history wall point is outside of its range as defined on the 461 input record, it is permanently changed to an adiabatic wall point for all time.

[**] Relates to history data through the 422 and 423 input records.

This page intentionally left blank.

Left Wall Point Boundary

Page 1 of 2

A 483 input record is used to specify the boundary conditions for a left wall point. There are no default values and the 483 input record may be used at restart time to change boundary conditions. The data on this record are stored in boundary array location MAXWPT-1.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71 – 80
	NMW	NTW	NVW	MWL	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NMW	Momentum boundary number. The value of NMW identifies the momentum boundary condition type. The value of NMW must be integral and greater than or equal to 4 and less than or equal to 5 or equal to 8. If NMW is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 4.0 velocity history* = 5.0 fixed (rigid) = 8.0 special
2	NTW	Thermal boundary number. The value of NTW identifies the thermal boundary condition type. The value of NTW must be integral and greater than or equal to 4 and less than or equal to 5 or equal to 8. If NTW is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 4.0 heat flux history** = 5.0 adiabatic = 8.0 special

---

*When a velocity history wall point is outside of its range as defined on the 441 input record, it is permanently changed to a fixed wall point for all time.

**When a heat flux history wall point is outside of its range as defined on the 461 input record, it is permanently changed to an adiabatic wall point for all time.

Columns →	11	21	31	41	51	61	71 80
	NMW	NTW	NVW	MWL	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
3	NVW	Index of boundary array. The value of NVW specifies the index location of boundary history model data for a grid point in the boundary values array. When no history data are required, leave NVW blank. The value of NVW must be integral and greater than or equal to 0 and less than or equal to MAXBDY. (See Appendix "Maximums".) If NVW is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
4	MWL	Material property number for this wall point. The value of MWL uniquely identifies a material model. A model consists of an equation of state and strength, explosive, and thermal descriptions; however, only the mechanical and thermal surface properties will be used. The value of MWL must be integral and must be greater than or equal to 1 and less than or equal to MAXMAT. (See Appendix "Maximums".) If MWL is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Right Wall Point Boundary

Page 1 of 2

A 484 input record is used to specify the boundary conditions for a right wall point. There are no default values and the 484 input record may be used at restart time to change boundary conditions. The data on this record are stored in boundary array location MAXWPT.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71 80
	NMW	NTW	NVW	MWL	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NMW	Momentum boundary number. The value of NMW identifies the momentum boundary condition type. The value of NMW must be integral and greater than or equal to 4 and less than or equal to 5 or equal to 8. If NMW is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 4.0 velocity history* = 5.0 fixed (rigid) = 8.0 special
2	NTW	Thermal boundary number. The value of NTW identifies the thermal boundary condition type. The value of NTW must be integral and greater than or equal to 4 and less than or equal to 5 or equal to 8. If NTW is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".) The following definitions apply: = 4.0 heat flux history** = 5.0 adiabatic = 8.0 special

---

*When a velocity history wall point is outside of its range as defined on the 441 input record, it is permanently changed to a fixed wall point for all time.

**When a heat flux history wall point is outside of its range as defined on the 461 input record, it is permanently changed to an adiabatic wall point for all time.

Columns →	11	21	31	41	51	61	71 80
	NMW	NTW	NVW	MWL	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
3	NVW	Index of boundary array. The value of NVW specifies the index location of boundary history model data for a grid point in the boundary values array. When no history data are required, leave NVW blank. The value of NVW must be integral and greater than or equal to 0 and less than or equal to MAXBDY. (See Appendix "Maximums".) If NVW is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
4	MWL	Material property number for this wall point. The value of MWL uniquely identifies a material model. A model consists of an equation of state and strength, explosive, and thermal descriptions; however, only the mechanical and thermal surface properties will be used. The value of MWL must be integral and must be greater than or equal to 1 and less than or equal to MAXMAT. (See Appendix "Maximums".) If MWL is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine BDYINP. (See Appendix "Messages".)
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.485 through 7.498 will not appear in this report.

The END input record signifies the end of a block of data for the BDY input phase. It must follow the last BDY input record.

	min	max
start	1	1
restart	0	1

Columns →	11	21	31	41	51	61	71 80
	--	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1-7	--	Fields 1-7 must be left blank or the FLDCHK message is written on the print the the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

7.5 TIME SPECIFICATION PHASE (TIM)

The time specification phase (TIM) input block may be located in any position in the input deck after the PRB input block and before the final END record. The purpose of the TIM input block is to specify time step and problem time related information. TIM phase information may be changed at restart time.

Only the 513 and 514 input records have default values. All other TIM phase input records are required for start runs and at least the 521 input record is also required at restart time.

The input for the TIM phase is usually calculated as follows:

1. For a <u>start run</u>, the initial time step DLTSOR is taken to be one-tenth (0.1) of the maximum stable time step based on initial conditions for the entire grid. The one-tenth multiplier is used to minimize the lack of velocity centering in the first cycle (see Section 1.2.2), and to "smooth" out discontinuous boundary values. The growth factor DLTGRF allows the time step to grow to its stable value based on Eq.(1.58). For a <u>restart run</u>, the best value of DLTSOR is the stable time step based on the last cycle. This value for DLTSOR should be used unless the mesh has been rezoned or has been given new input data that affects the time step.

2. The minimum time step DLTMIN should be chosen to be 0.99 of the initial time step. Its value can be increased or decreased at restart time to better control the economics of the problem. However, it can never be greater than or equal to DLTSOR or the problem will terminate immediately.

3. The maximum time step, DLTMAX, is usually input to be a large number (e.g., $10^3 \times$ maximum stable time step). However, if a constant time step is required that is less than the maximum stable time step, it is input to be the constant value.

4. The time step safety factor, DLTSFR, should be chosen to provide more conservatism to the sound speed calculation and the zone minimum distance calculation. In general, a value of 0.95 may be used if the sound speed and minimum distances formulas are already conservative. In a small strain elastic problem where the sound speed is constant and the zones do not change shape, DLTSFR = 0.99 may be used. For problems where an uncertainty exists, a value of 0.67 should be used.

5. TIMMAX is chosen from physics considerations, while MAXCYC is based on economic considerations. Cost is proportional to the number of grid points in a mesh multiplied by the number of cycles (time steps). For a particular problem, the number of grid points is usually fixed so that cost is directly proportional to the number of cycles. A typical calculation of cost proceeds as follows:

$$C = K \times N$$

where

C = cost

K = cost per point-cycle

N = (number of grid points) × (number of cycles)

$= p \times n$.

Thus,

$$C = K \times p \times n.$$

For 100 grid points and K = \$.0001/point-cycle, the formula becomes

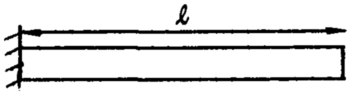
$$C = 10^{-2}n \text{ or } \$1.00 \text{ per 100 cycles.}$$

If a maximum of \$10.00 is to be spent whether or not the problem reaches the TIMMAX limit, then MAXCYC should be set equal to 1000 cycles.

To input the relaxation frequency, ω_0, on the 514 input record requires that the fundamental frequency response of a system be calculated. There are two ways of estimating the fundamental frequency response of a system.

For simple planar geometries, the first three of the four formulas given on Page 7.514 can be used. The characteristic length or fundamental wave length is primarily a function of the imposed boundary conditions. Consider a solid* bar of length ℓ with the following boundary conditions:

(a) One end fixed

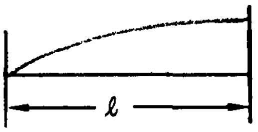


(b) Both ends fixed

(c) Both ends free

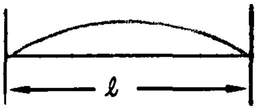
The fundamental mode shapes for cases (a), (b), and (c) are as follows:

(a)



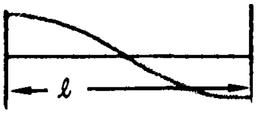
→ characteristic length = 4ℓ

(b)



→ characteristic length = 2ℓ

(c)



→ characteristic length = 2ℓ

---

* For thin-walled cylinders in axisymmetric geometries, the radial breathing mode is 2π times greater than the axial mode.

For more complicated geometries and boundary conditions, problems should first be run for a number of cycles with no damping ($\omega_0 = 0$) to establish the fundamental frequency (or period) of the mesh. Then, the fourth formula on Page 7.154 may be used to get ω_0.

A summary of TIM phase input records and input variables appears in Table 7.5.

NOTE: Pages 7.505 through 7.508 will not appear in this report.

TABLE 7.5

SUMMARY OF TIM PHASE INPUT RECORDS AND INPUT VARIABLES

FIELDS 1-7

TYPE	1	2	3	4	5	6	7
TIM	NSINP	NSTRC	NSDBG	NSPLT	NSPRT		
511	DLTSOR						
512	DLTMIN	DLTMAX					
513	DLTGRF	DLTSFR					
514	RLXFRQ						
521	TIMMAX	MAXCYC					
END							

Time (TIM) Phase Control

The function of the TIM control record is to activate the TIM input phase. The TIM control record must follow an END input record and is required for all start runs. It may be used at restart time to change data.

	min	max
start	1	1
restart	1	1

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NSINP	Input mode switch. The value of NSINP specifies the mode of input to be used in this input phase. The value of NSINP must be integral and less than or equal to 3. The following definitions apply: ≤ 1.0 card input (default) = 2.0 library input = 3.0 keyboard input If the field containing NSINP is left blank, then the mode of input is assumed to be card input. If the value of NSINP is greater than 3.0, the message, INPUT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN.
2	NSTRC	Trace mode switch. The value of NSTRC specifies whether or not the trace option is active. The value of NSTRC must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 trace is not active, off (default) = 2.0 trace is active, on If the field containing NSTRC is left blank, then the mode is assumed to be not active (off). If the value of NSTRC is greater than 2.0, the message, TRACE MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The trace logic, if active (on), will cause the name of the subroutine or logical phase just entered to be printed on both the print and message files. These actions are taken in subroutines SBRENT and PHSENT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable

3 NSDBG

Debug mode switch. The value of NSDBG specifies whether or not the debug option is active. The value of NSDBG must be integral and less than or equal to 2. The following definitions apply:

≤ 1.0	debug is not active, off (default)
= 2.0	debug is active, on

If the field containing NSDBG is left blank, then the debug mode is assumed to be not active (off). If the value of NSDBG is greater than 2.0, the message,

DEBUG MODE SWITCH
IMPROPERLY DEFINED.

is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The debug logic, if active (on), will cause the common blocks associated with this input phase to be dumped at the end of each subroutine in the phase and at the end of the logical phase. These actions are taken in subroutines SBREXT and PHSEXT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

4 NSPLT

Plot mode switch. The value of NSPLT specifies whether or not plots will be produced by this generator phase. The value of NSPLT must be integral and less than or equal to 2.0. The following definitions apply:

≤ 1.0	no plots produced, option off (default)
= 2.0	plots produced, option on

If the field containing NSPLT is left blank, then no plots will be produced (off). If the value of NSPLT is greater than 2.0, the message,

PLOT MODE SWITCH
IMPROPERLY DEFINED.

is written on the print and the message files, and the program terminates immediately in subroutine TIMGEN.

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
5	NSPRT	Print mode switch. The value of NSPRT controls the printing in this generator phase. The value of NSPRT must be integral and less than or equal to 2.0. The following definitions apply: = 1.0 only input records and error messages are printed, option off = 2.0 full printing done, option on (default) If the field containing NSPRT is left blank, full printing is done (option on). If the value of NSPRT is greater than 2.0, the message, PRINT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine TIMGEN.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Start or Restart Time Step

The 511 input record specifies the initial time step for a run. The 511 input record is required in all start runs and is optional in a restart run.

	min	max
start	1	1
restart	0	1

Columns →	11	21	31	41	51	61	71 80
	DLTSOR	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	DLTSOR	Start or restart time step. The value of DLTSOR must be a positive number greater than the "zero tolerance", SMLNUM, greater than or equal to the minimum time step, DLTMIN, and smaller than or equal to the maximum time step, DLTMAX, or the messages,

```
START OR RESTART TIME STEP, DLTSOR,
MUST BE GREATER THAN OR EQUAL TO
ZERO TOLERANCE, SMLNUM
DLTSOR = eeeeeeeeeeee
SMLNUM = eeeeeeeeeeee

START OR RESTART TIME STEP, DLTSOR,
MUST BE GREATER THAN OR EQUAL TO
MINIMUM TIME STEP, DLTMIN
DLTSOR = eeeeeeeeeeee
DLTMIN = eeeeeeeeeeee

START OR RESTART TIME STEP, DLTSOR
MUST BE SMALLER THAN OR EQUAL TO
MAXIMUM TIME STEP, DLTMAX
DLTSOR = eeeeeeeeeeee
DLTMIN = eeeeeeeeeeee
```

are written on the print and the message files and the program terminates at the end of the GENERATOR phase group.

Field Number	Input Variable Name	Description of Input Variable
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Time Step Limits

Page 1 of 1

The 512 input record specifies time step limits for a run. The 512 input record is required in all start runs and is optional in a restart run.

	min	max
start	1	1
restart	0	1

Columns →	11	21	31	41	51	61	71	80
	DLTMIN	DLTMAX	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	DLTMIN	Minimum time step. The problem time steps, DLTO (Δt^n) and DLTH ($\Delta t^{n+\frac{1}{2}}$), may be equal to but never be smaller than DLTMIN. The value of DLTMIN must be a positive number greater than the "zero tolerance", SMLNUM, or the message, MINIMUM TIME STEP, DLTMIN, MUST BE GREATER THAN OR EQUAL TO ZERO TOLERANCE, SMLNUM DLTMIN = eeeeeeeeeeee SMLNUM = eeeeeeeeeeee is written on the print and the message files and the program terminates at the end of the GENERATOR phase group.
2	DLTMAX	Maximum time step. The problem time steps, DLTO (Δt^n) and DLTH ($\Delta t^{n+\frac{1}{2}}$), may be equal to but never be greater than DLTMAX. The value of DLTMAX must be a positive number greater than or equal to DLTMIN, or the message, MAXIMUM TIME STEP, DLTMAX, MUST BE GREATER THAN OR EQUAL TO MINIMUM TIME STEP, DLTMIN DLTMAX = eeeeeeeeeeee DLTMIN = eeeeeeeeeeee is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. If dynamic relaxation is being used in this problem, DLTMAX will be compared with 1/RLXFRQ to be sure that DLTMAX ≥ 1/RLXFRQ. If this is not true, DLTMAX will be set equal to 1/RLXFRQ.
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Time Step Factors

The 513 input record specifies time step factors for a run. If the 513 input record is omitted, default values are used. Default for DLTGRF is 1.2, while default for DLTSFR is 2/3.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71 80
	DLTGRF	DLTSFR	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	DLTGRF	Time step growth factor. Problem time steps, DLTO (Δt^n) and DLTH ($\Delta t^{n+\frac{1}{2}}$), are limited to grow only as fast as the DLTGRF value allows. The value of DLTGRF must be a positive number between 1.0 (no growth) and 1.2 (20% growth). If the field containing DLTGRF is left blank or a value is used that is less than 1.0, then DLTGRF is assumed to be equal to 1.2. If the value of DLTGRF is greater than 1.2, the message,

```
TIME STEP GROWTH FACTOR, DLTGRF,
MUST BE GREATER THAN OR EQUAL TO
ZERO TOLERANCE, SMLNUM, AND
MUST BE SMALLER THAN OR EQUAL TO
20 PERCENT GROWTH (1.2)
DLTGRF = eeeeeeeeeeee
SMLNUM = eeeeeeeeeeee
```

is written on the print and the message files and the program terminates at the end of the GENERATOR phase group.

Field Number	Input Variable Name	Description of Input Variable
2	DLTSFR	Time step safety factor. The calculated stable time step is multiplied by DLTSFR. The value of DLTSFR must be a positive number greater than or equal to the "zero tolerance", SMLNUM, and less than or equal to 1.0. If the field containing DLTSFR is left blank or a value is used that is less than the "zero tolerance", SMLNUM, then DLTSFR is assumed to be two-thirds (2/3).* If the value of DLTSFR is greater than 1.0, the message,

```
TIME STEP SAFETY FACTOR, DLTSFR,
MUST BE GREATER THAN OR EQUAL TO
ZERO TOLERANCE, SMLNUM, AND
MUST BE SMALLER THAN OR EQUAL TO
UNITY (1.0)
DLTSFR = eeeeeeeeeeee
SMLNUM = eeeeeeeeeeee
```

is written on the print and the message files and the program terminates at the end of the GENERATOR phase group.

---

*For elastic small strain problems, DLTSFR should use values closer to 1.0. Depending on problem specific initial and boundary conditions, values between 0.9 and 0.99 are recommended.

Columns →	11	21	31	41	51	61	71 80
	DLTGRF	DLTSFR	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Relaxation Frequency

Page 1 of 1

The 514 input record specifies the relaxation frequency to be used in static dynamic relaxation* problems. If the 514 input record is omitted, the stress wave dynamic default value of 0.0 is used.

	min	max
start	0	1
restart	0	1

Columns → 11 21 31 41 51 61 71 80

	RLXFRQ	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	RLXFRQ	Relaxation frequency. The value of RLXFRQ specifies the relaxation frequency to be used when a problem uses dynamic relaxation. The value of RLXFRQ must be a positive number or zero. When nonzero, it is estimated from one of the following plane strain formulas for the lowest fundamental frequency, ω_o. (See Page 7.503.) $\omega_o \cong \sqrt{\frac{\text{stiffness modulus}}{\text{mass}}}\,(2\pi)$ $\omega_o \cong \sqrt{\frac{\text{appropriate modulus}}{\text{reference density}}}\left(\frac{2\pi}{\text{characteristic length}}\right)$ $\omega_o \cong \left(\frac{\text{appropriate wave speed}}{\text{fundamental wave length}}\right)2\pi$ $\omega_o \cong \frac{2\pi}{\text{fundamental period}}$ The value of RLXFRQ (ω_o) will override DLTMAX (Δt_{max}) if $\omega_o > \frac{1}{\Delta t_{max}}$. The override will result in Δt_{max} set to a value of $1/\omega_o$.
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Pages 7.515 through 7.520 will not appear in this report.

---

*See DTS input record.

Problem Temporal Limits

The 521 input record specifies the time and cycle limits of the problem. One and only one record is required in every start and restart run.

	min	max
start	1	1
restart	1	1

Columns →	11	21	31	41	51	61	71	80
	TIMMAX	MAXCYC	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	TIMMAX	Problem time limit. The value of TIMMAX specifies the maximum problem time to which the calculation will be allowed to proceed. When problem time, TIMN (t^{n+1}), is equal to or greater than TIMMAX, the problem terminates. The value of TIMMAX must be a positive number in problem units greater than the start or restart time.
2	MAXCYC	Problem cycle limit. The value of MAXCYC specifies the maximum cycle to which the calculation will be allowed to proceed. When the cycle counter, NCCYC (n+1), is equal to or greater than MAXCYC, the problem terminates. The value of MAXCYC must be integral and greater than the start or restart number.
3-7	--	Fields 3-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.523 through 7.598 will not appear in this report.

End of TIM Phase

The END input record signifies the end of a block of data for the TIM input phase. It must follow the last TIM input record.

	min	max
start	1	1
restart	1	1

Columns →	11	21	31	41	51	61	71	80
	--	--	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1-7	--	Fields 1-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

7.6 EDIT SPECIFICATION PHASE (EDT)

The edit specification phase (EDT) input block may be located in any position in the input deck after the PRB input block and before the final END record. The purpose of the EDT input block is to specify output edits. EDT phase information may be changed at restart time.

EDT phase data are divided into the following groups:

Record Identifier	Group Description
61_	Output mode type
62_	Print output parameters
63_	Regional summary output parameters
64_	Restart output parameters
65_	Archive output parameters
66_	Debug, trace, and storage output parameters
67_	Plot output parameters

The six edit output modes correspond to the following files and output media:

Edit Mode	File Name*	Output Medium
Print	NFPRT,NFMSG**	Printer
Regional summary	NFPRT,NFMSG	Printer
Restart	NFRSO	Tape
Archive	NFARV	Tape
Debug, Trace	NFPRT,NFMSG	Printer
Storage	NFSTG	Printer
Plot	NFPLT	Mass storage or tape

---

*See Appendix "Files".

**Full edits are automatically written to file NFPRT, while the user controls edits to file NFMSG. The user may eliminate edits to file NFPRT altogether (see 624 input record).

Rev. 1
15 NOV 77

Each output mode can offer several forms of output, including user-supplied forms. For example, in print mode it is possible to get "complete" edits which print all zone and grid-point data or "short" edits which print only selected variables. Complete edits are usually a minimum of six pages per edit, while short edits can be as short as one page. (See Appendix "Output".)

Whether or not edits are specified, a certain number of edits will be written automatically on the output files. These edits need not be specified through input records. The automatic edits are:

Edit Mode	Cycles at which Automatic Edits Occur
Print	0, 1, last, restart zero, restart first
Regional summary	1, last, restart first
Restart	Last
Archive	None
Debug, Trace, Storage	None
Plot	Time history edits at last cycle for time history plots

The files containing restart, archive, and plot data must be saved in order to be used. Restart data are read by STEALTH 1D and 2D and archive data are read by ADAPRO. Plot output is read by GRADIS.

A summary of EDT phase input records and input variables appears in Table 7.6.

NOTE: Pages 7.603 through 7.608 will not appear in this report.

TABLE 7.6

SUMMARY OF EDT PHASE INPUT RECORDS AND INPUT VARIABLES

FIELDS 1-7

TYPE	1	2	3	4	5	6	7
EDT	NSINP	NSTRC	NSDBG	NSPLT	NSPRT		
611	MPRT						
612	MRSY						
613	MRST						
614	MARV						
615	MSTG						
616	MPLT						
617	MPET						
618	MTRC						
619	MDBG						
621	L	PRTBGN	PRTRGE	PRTINC			
622	MINIPR	MAXIPR	MINJPR	MAXJPR	MINKPR	MAXKPR	
623	IDPRT	IDPRT	IDPRT	IDPRT	IDPRT	IDPRT	IDPRT
624	MOPT						
625	L	CBCBGN	CBCRGE	CBCINC			
631	L	RSYBGN	RSYRGE	RSYINC			
632	LREG	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT

ADP

TABLE 7.6 (continued)

FIELDS 1-7

TYPE	1	2	3	4	5	6	7	
641	L	RSTBGN	RSTRGE	RSTINC				
651	L	ARVBGN	ARVRGE	ARVINC				
652	MINIAR	MAXIAR	MINJAR	MAXJAR	MINKAR	MAXKAR		
653	IDARV	IDARV	IDARV	IDARV	IDARV	IDARV	IDARV	
654	MARLIM	MINARC	MAXARC	ARCMIN	ARCMAX			ADP
661	L	STGBGN	STGRGE	STGINC				
662	L	TRCBGN	TRCRGE	TRCINC				
663	L	DBGBGN	DBGRGE	DBGINC				
671	L	PLTBGN	PLTRGE	PLTINC				
672	NPLT	IDPLT	IDORD	IDABC	IDLOC	TODLOC		1D
674	NPLT	IDPLT	IDORD	IDABC	IDLOC	TODLOC	IDROW	2D
675	NPLT	IDPLT	IDORD		IDLOC	TODLOC		2D
677	NPLT	PETBGN	PETRGE	PETINC				ADP
END								

This page intentionally left blank.

Edit (EDT) Phase Control

The function of the EDT control record is to activate the EDT input phase. The EDT control record must follow an END input record and is required for all start runs. It may be used at restart time to change data.

	min	max
start	1	1
restart	1	1

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NSINP	Input mode switch. The value of NSINP specifies the mode of input to be used in this input phase. The value of NSINP must be integral and less than or equal to 3. The following definitions apply: ≤ 1.0 card input (default) = 2.0 library input = 3.0 keyboard input If the field containing NSINP is left blank, then the mode of input is assumed to be card input. If the value of NSINP is greater than 3.0, the message, INPUT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN.
2	NSTRC	Trace mode switch. The value of NSTRC specifies whether or not the trace option is active. The value of NSTRC must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 trace is not active, off (default) = 2.0 trace is active, on If the field containing NSTRC is left blank, then the mode is assumed to be not active (off). If the value of NSTRC is greater than 2.0, the message, TRACE MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The trace logic, if active (on), will cause the name of the subroutine or logical phase just entered to be printed on both the print and message files. These actions are taken in subroutines SBRENT and PHSENT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

Columns →	11	21	31	41	51	61	71 80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable

3 NSDBG

Debug mode switch. The value of NSDBG specifies whether or not the debug option is active. The value of NSDBG must be integral and less than or equal to 2. The following definitions apply:

≤ 1.0	debug is not active, off (default)
$= 2.0$	debug is active, on

If the field containing NSDBG is left blank, then the debug mode is assumed to be not active (off). If the value of NSDBG is greater than 2.0, the message,

DEBUG MODE SWITCH
IMPROPERLY DEFINED.

is written on the print and the message files, and the program terminates immediately in subroutine GENGEN. The debug logic, if active (on), will cause the common blocks associated with this input phase to be dumped at the end of each subroutine in the phase and at the end of the logical phase. These actions are taken in subroutines SBREXT and PHSEXT. USE OF THIS OPTION WILL RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

4 NSPLT

Plot mode switch. The value of NSPLT specifies whether or not plots will be produced by this generator phase. The value of NSPLT must be integral and less than or equal to 2.0. The following definitions apply:

≤ 1.0	no plots produced, option off (default)
$= 2.0$	plots produced, option on

If the field containing NSPLT is left blank, then no plots will be produced (off). If the value of NSPLT is greater than 2.0, the message,

PLOT MODE SWITCH
IMPROPERLY DEFINED.

is written on the print and the message files, and the program terminates immediately in subroutine EDTGEN.

Columns →	11	21	31	41	51	61	71	80
	NSINP	NSTRC	NSDBG	NSPLT	NSPRT	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
5	NSPRT	Print mode switch. The value of NSPRT controls the printing in this generator phase. The value of NSPRT must be integral and less than or equal to 2.0. The following definitions apply: = 1.0 only input records and error messages are printed, option off = 2.0 full printing done, option on (default) If the field containing NSPRT is left blank, full printing is done (option on). If the value of NSPRT is greater than 2.0, the message, PRINT MODE SWITCH IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates immediately in subroutine EDTGEN.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Print Edit Mode

Page 1 of 1

The 611 input record specifies the type of print edits, time or cycle, required. If the 611 input record is omitted, print edits* by time will be put on print file, NFPRT. (See Appendix "Files".) The 611 input record may be used at restart time to re-specify print edit mode.

	min	max
start	0	1
restart	0	1

Columns → 11 21 31 41 51 61 71 80

	MPRT	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPRT	Print edit mode. The value of MPRT specifies the mode of print edits to be used. The value of MPRT must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 print edits by time (default) = 2.0 print edits by cycle If the field containing MPRT is left blank, then the mode of print edits is assumed to be edits by time. If the value of MPRT is greater than 2.0, the RGEERR message is written on the print and the message files and the program terminates in subroutine EDTINP. (See Appendix "Messages".)
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group.

---

*The start or restart cycle, as well as the first and last cycles calculated, are automatically put on the print file, NFPRT. (See Appendix "Files".) Additional print edits are specified on the 621 input record.

Regional Summary Edit Mode

Page 1 of 1

The 612 input record specifies the type of regional summary edits, time or cycle, required. If the 612 input record is omitted, regional summary edits* by time will be put on print file, NFPRT. (See Appendix "Files".) The 612 input record may be used at restart time to re-specify regional summary edit mode.

	min	max
start	0	1
restart	0	1

Columns → 11 21 31 41 51 61 71 80

	MRSY	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MRSY	Regional summary edit mode. The value of MRSY specifies the mode of regional summary edits to be used. The value of MRSY must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 regional summary edits by time (default) = 2.0 regional summary edits by cycle If the field containing MRSY is left blank, then the mode of regional summary edits is assumed to be edits by time. If the value of MRSY is greater than 2.0, the RGEERR message is written on the print and the message files and the program terminates in subroutine EDTINP. (See Appendix "Messages".)
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] The start or restart cycle, as well as the first and last cycles calculated, are automatically put on the print file, NFPRT. (See Appendix "Files".) Additional regional summary edits are specified on the 631 input record.

Restart Edit Mode

Page 1 of 1

The 613 input record specifies the type of restart edits, time or cycle, required. If the 613 input record is omitted, restart edits* by time will be put on restart file, NFRST. (See Appendix "Files".) The 613 input record may be used at restart time to re-specify restart edit mode.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71–80
	MRST	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MRST	Restart edit mode. The value of MRST specifies the mode of restart edits to be used. The value of MRST must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 restart edits by time (default) = 2.0 restart edits by cycle If the field containing MRST is left blank, then the mode of restart edits is assumed to be edits by time. If the value of MRST is greater than 2.0, the RGEERR message is written on the print and the message files and the program terminates in subroutine EDTINP. (See Appendix "Messages".)
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*The last cycle calculated is automatically put on the file, NFRST. (See Appendix "Files".) Additional restart edits are specified on the 641 input record.

Archive Edit Mode

Page 1 of 1

The 614 input record specifies the type of archive edits, time or cycle, required. If the 614 input record is omitted, archive edits* by time will be put on archive output file, NFARO. (See Appendix "Files".) The 614 input record may be used at restart time to re-specify archive edit mode.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71 80
	MARV	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MARV	Archive edit mode. The value of MARV specifies the mode of archive edits to be used. The value of MARV must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 archive edits by time (default) = 2.0 archive edits by cycle If the field containing MARV is left blank, then the mode of archive edits is assumed to be edits by time. If the value of MARV is greater than 2.0, the RGEERR message is written on the print and the message files and the program terminates in subroutine EDTINP. (See Appendix "Messages".)
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] There are no default archive edits. All archive edits are specified on the 651 input record and are written on file NFARV. (See Appendix "Files".)

Storage Edit Mode

The 615 input record specifies the type of storage edits, time or cycle, required. If the 615 input record is omitted, storage edits* by time will be put on storage files, NFSTG. (See Appendix "Files".) The 615 input record may be used at restart time to re-specify storage edit mode.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71	80
	MSTG	--	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MSTG	Storage edit mode. The value of MSTG specifies the mode of storage edits to be used. The value of MSTG must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 storage edits by time (default) = 2.0 storage edits by cycle If the field containing MSTG is left blank, then the mode of storage edits is assumed to be edits by time. If the value of MSTG is greater than 2.0, the RGEERR message is written on the print and the message files and the program terminates in subroutine EDTINP. (See Appendix "Messages".)
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*There are no default storage edits. All storage edits are specified on the 661 input record and are written on file NFSTG. (See Appendix "Files".)

Plot History Edit Mode

The 616 input record specifies the type of plot history edits, time or cycle, required. If the 616 input record is omitted, plot history edits* by time will be put on plot file NFPLT. (See Appendix "Files".) The 616 input record may be used at restart time to re-specify plot edit mode.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71 80
	MPLT	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MPLT	Plot edit mode. The value of MPLT specifies the mode of plot history edits to be used. The value of MPLT must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 plot history edits by time (default) = 2.0 plot history edits by cycle If the field containing MPLT is left blank, then the mode of plot history edits is assumed to be edits by time. If the value of MPLT is greater than 2.0, the RGEERR message is written on the print and the message files and the program terminates in subroutine EDTINP. (See Appendix "Messages".)
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*There is no default plot edit sampling rate(s). All plot edit sampling rates are specified on the 671 input record. The edit data, according to the specified sampling rate, are written on file NFPLT. (See Appendix "Files".) Actual history plots to be derived from these data are specified on the 672 and 674 input records.

Multiple Plot Edit Mode

Page 1 of 1

The 617 input record specifies the type of multiple plot edits, time or cycle, required. If the 617 input record is omitted, multiple plot edits will be assumed to be by time. The 617 input record only applies to data specified on 677 input records.

	min	max
start	0	1
restart	N/A	N/A

Columns →	11	21	31	41	51	61	71	80
	MPET	--	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MPET	Multiple plot edit mode. The value of MPET specifies the mode of multiple plot edits to be used. The value of MPET must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 multiple plot edits by time (default) = 2.0 multiple plot edits by cycle If the field containing MPET is left blank, then the mode of multiple plot edits is assumed to be edits by time. If the value of MPET is greater than 2.0, a RGEERR message is written on the print and the message files and the program terminates in subroutine EDTINP. (See Appendix "Messages".)
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

Trace Edit Mode

The 618 input record specifies the type of trace edits, time or cycle, required. If the 618 input record is omitted, trace edits* by time will be put on trace files, NFTRC. (See Appendix "Files".) The 618 input record may be used at restart time to re-specify trace edit mode.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71	80
	MTRC	--	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MTRC	Trace edit mode. The value of MTRC specifies the mode of trace edits to be used. The value of MTRC must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 trace edits by time (default) $= 2.0$ trace edits by cycle If the field containing MTRC is left blank, then the mode of trace edits is assumed to be edits by time. If the value of MTRC is greater than 2.0, the RGEERR message is written on the print and the message files and the program terminates in subroutine EDTINP. (See Appendix "Messages".)
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*There are no default trace edits. All trace edits are specified on the 662 input record and are written on files NFPRT and NFMSG. (See Appendix "Files".)

Debug Edit Mode

Page 1 of 1

TYPE 619

The 619 input record specifies the type of debug edits, time or cycle, required. If the 619 input record is omitted, debug edits* by time will be put on debug files, NFDBG. (See Appendix "Files".) The 619 input record may be used at restart time to re-specify debug edit mode.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71	80
	MDBG	--	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MDBG	Debug edit mode. The value of MDBG specifies the mode of debug edits to be used. The value of MDBG must be integral and less than or equal to 2. The following definitions apply: ≤ 1.0 debug edits by time (default) = 2.0 debug edits by cycle If the field containing MDBG is left blank, then the mode of debug edits is assumed to be edits by time. If the value of MDBG is greater than 2.0, the RGEERR message is written on the print and the message files and the program terminates in subroutine EDTINP. (See Appendix "Messages".)
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*There are no default debug edits. All debug edits are specified on the 663 input record and are written on files NFPRT and NFMSG. (See Appendix "Files".)

This page intentionally left blank.

Print Edit Specification

The 621 input record identifies a unique set of print edits.

	min	max
start	0	MAXEDT
restart	0	MAXEDT

Columns →	11	21	31	41	51	61	71 80
	L	PRTBGN	PRTRGE	PRTINC	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Print edit index. The value of L uniquely identifies the data on this input record. The value of L must be integral and less than or equal to MAXEDT. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
2	PRTBGN	Beginning of print edits.[*] The value of PRTBGN gives a start time or start cycle (depending on MPRT[**]) from which the print edits on this record are computed. The value of PRTBGN must be greater than or equal to zero.[***]
3	PRTRGE	Range of print edits.[*] The value of PRTRGE gives the time range or cycle range (depending on MPRT[**]) from which the print edits on this record are computed. The value of PRTRGE must be greater than or equal to zero.[***]
4	PRTINC	Increment of print edits.[*] The value of PRTINC gives the time increments or cycle increments (depending on MPRT[**]) from which the print edits on this record are computed. The value of PRTINC must be a positive number less than or equal to PRTRGE.[***]
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] Edits occur at PRTBGN + i × PRTINC where i goes from 0 to n (n = PRTRGE/PRTINC). Thus, the first print edit occurs at PRTBGN while the last print edit occurs at (PRTBGN + PRTRGE). Intermediate print edits are PRTINC apart.

[**] See 611 input record.

[***] To specify one edit only, specify its time (or cycle) in field 2; leave fields 3 and 4 blank.

Message File Grid Point[*] Print Limits

Page 1 of 2

	min	max
start	0	1
restart	0	1

The 622 input record defines the grid point, row, and plane print limits for grid point and zone variables printed on the message file. If the 622 input record is omitted, there will be no grid point[*] variables printed on the message file. When the 622 input record is used, MINIPR $\le$ MAXIPR, MINJPR $\le$ MAXJPR, and MINKPR $\le$ MAXKPR.[**] The 622 input record may be used at restart time.

Columns →	11	21	31	41	51	61	71 80
	MINIPR	MAXIPR	MINJPR	MAXJPR	MINKPR	MAXKPR	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MINIPR	Minimum grid point number (i-line) to be printed on file NFMSG. (See Appendix "Files".) The value of MINIPR must be integral and greater than or equal to 1 and less than or equal to MAXGPT. (See Appendix "Maximums".) If MINIPR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) 1 $\le$ MINIPR $\le$ MAXGPT
2	MAXIPR	Maximum grid point number (i-line) to be printed on file NFMSG. (See Appendix "Files".) The value of MAXIPR must be integral and greater than or equal to 1 and less than or equal to MAXGPT. (See Appendix "Maximums".) If MAXIPR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) MINIPR $\le$ MAXIPR $\le$ MAXGPT
3	MINJPR	Minimum row number (j-line) to be printed on file NFMSG. (See Appendix "Files".) The value of MINJPR must be integral and greater than or equal to 1 and less than or equal to MAXROW. (See Appendix "Maximums".) If MINJPR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) This field must be left blank for 1D runs or a FLDCHK message will be written on the print and the message files and the program will terminate at the end of the GENERATOR phase group. (See Appendix "Messages".) 1 $\le$ MINJPR $\le$ MAXROW

---

[*] Or zone.

[**] If MINIPR > MAXIPR, MINJPR > MAXJPR, or MINKPR > MAXKPR, a LIMERR message is written on the print and the message files and the program terminates at the end of the EDT GENERATOR phase. (See Appendix "Messages".)

Columns →	11	21	31	41	51	61	71	80
	MINIPR	MAXIPR	MINJPR	MAXJPR	MINKPR	MAXKPR	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
4	MAXJPR	Maximum row number (j-line) to be printed on file NFMSG. (See Appendix "Files".) The value of MAXJPR must be integral and greater than or equal to 1 and less than or equal to MAXROW. (See Appendix "Maximums".) If MAXJPR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) This field must be left blank for 1D runs or a FLDCHK message will be written on the print and the message files and the program will terminate at the end of the GENERATOR phase group. (See Appendix "Messages".) MINJPR ≤ MAXJPR ≤ MAXROW
5	MINKPR	Minimum plane number (k-line) to be printed on file NFMSG. (See Appendix "Files".) The value of MINKPR must be integral and greater than or equal to 1 and less than or equal to MAXPLN. (See Appendix "Maximums".) If MINKPR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) This field must be left blank for 1D and 2D runs or a FLDCHK message will be written on the print and the message files and the program will terminate at the end of the GENERATOR phase group. (See Appendix "Messages".) 1 ≤ MINKPR ≤ MAXPLN
6	MAXKPR	Maximum plane number (k-line) to be printed on file NFMSG. (See Appendix "Files".) The value of MAXKPR must be integral and greater than or equal to 1 and less than or equal to MAXPLN. (See Appendix "Maximums".) If MAXKPR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) This field must be left blank for 1D and 2D runs or a FLDCHK message will be written on the print and the message files and the program will terminate at the end of the GENERATOR phase group. (See Appendix "Messages".) MINKPR ≤ MAXKPR ≤ MAXPLN
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Message File Grid Point* Variables

Page 1 of 1

	min	max
start	0	MAXVAR
restart	0	MAXVAR

Each 623 input record defines a grid point variable to be printed on the message file. Grid point number (GPT), material property number (MPN), and material state indicator (IND) are automatically printed when a 622 input record is used. All other variables each require specification on a 623 input record. The 623 input record may be used at restart time.

Columns →	11	21	31	41	51	61	71 80
	IDPRT	IDPRT	IDPRT	IDPRT	IDPRT	IDPRT	IDPRT
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1-7	IDPRT	Print variable identifiers. Each value of IDPRT corresponds to a grid point or zone variable identifier. (See Appendix "Identifiers".) Up to seven identifiers may be specified with each 623 input record and blank fields will be ignored. If the total number of variables requested by all 623 input records exceeds MAXVAR (see Appendix "Maximums"), a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) The value of IDPRT must be integral, greater than or equal to 1, and less than or equal to MAXVAR. If IDPRT is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)

---

*Or zone.

Output Mode

The 624 input record specifies the files on which STEALTH print and message edits are written. If the 624 input record is omitted, message edits will be written on file NFMSG and only one-line, cycle-by-cycle edits will be written on file NFPRT. (See Appendix "Files".) The 624 input record may be used at restart time to re-specify the output mode.

	min	max
start	0	1
restart	0	1

Columns → 11 21 31 41 51 61 71 80

	MOPT	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MOPT	Mode of output. The value of MOPT determines on which files STEALTH print edits will be printed. The following definitions apply: = 1.0 full NFMSG output on file NFMSG; full NFPRT output on file NFPRT. = 2.0 full NFMSG output on file NFMSG; only one-line, cycle-by-cycle output on NFPRT (default). = 3.0 full NFMSG output on files NFMSG and NFPRT. If the value of MOPT is less than 1.0 or greater than 3.0, the RGEERR message is written on the print and the message files and the program terminates in subroutine EDTINP. (See Appendix "Messages".)
2-7	--	Fields 2-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

One-Line, Cycle-by-Cycle Summary Edit Specification

The 625 input record identifies a unique set of one-line, cycle-by-cycle summary edit input records. If no 625 input records are included, every cycle will produce a one-line, cycle-by-cycle summary edit.

	min	max
start	0	MAXEDT
restart	0	MAXEDT

Columns →	11	21	31	41	51	61	71 80
	L	CBCBGN	CBCRGE	CBCINC	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	One-line, cycle-by-cycle edit index. The value of L uniquely identifies the data on this input record. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXEDT. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
2	CBCBGN	Beginning of one-line, cycle-by-cycle edits.* The value of CBCBGN gives a start cycle** from which the one-line, cycle-by-cycle edits on this record are computed. The value of CBCBGN must be greater than or equal to zero.***
3	CBCRGE	Range of one-line, cycle-by-cycle edits.* The value of CBCRGE gives the cycle** range from which the one-line, cycle-by-cycle edits on this record are computed. The value of CBCRGE must be greater than or equal to zero.***
4	CBCINC	Increment of one-line, cycle-by-cycle edits.* The value of CBCINC gives the cycle** increments from which the one-line, cycle-by-cycle edits on this record are computed. The value of CBCINC must be a positive number less than or equal to CBCRGE.***
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*Edits occur at CBCBGN + i × CBCINC where i goes from 0 to n (n = CBCRGE/CBCINC). Thus, the first one-line, cycle-by-cycle edit occurs at CBCBGN, while the last one-line, cycle-by-cycle edit occurs at (CBCBGN + CBCRGE). Intermediate one-line, cycle-by-cycle edits are CBCINC apart.

**Time specification is not allowed.

***To specify one edit only, specify its cycle in field 2; leave fields 3 and 4 blank.

This page intentionally left blank.

NOTE: Pages 7.627 through 7.630 will not appear in this report.

Regional Summary Edit Specification

The 631 input record identifies a unique set of regional summary edits.

	min	max
start	0	MAXEDT
restart	0	MAXEDT

Columns →	11	21	31	41	51	61	71 80
	L	RSYBGN	RSYRGE	RSYINC	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Regional summary edit index. The value of L uniquely identifies the data on this input record. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXEDT. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
2	RSYBGN	Beginning of regional summary edits.* The value of RSYBGN gives a start time or start cycle (depending on MRSY**) from which the regional summary edits on this record are computed. The value of RSYBGN must be greater than or equal to zero.***
3	RSYRGE	Range of regional summary edits.* The value of RSYRGE gives the time range or cycle range (depending on MRSY**) from which the regional summary edits on this record are computed. The value of RSYRGE must be greater than or equal to zero.***
4	RSYINC	Increment of regional summary edits.* The value of RSYINC gives the time increments or cycle increments (depending on MRSY**) from which the regional summary edits on this record are computed. The value of RSYINC must be a positive number less than or equal to RSYRGE.***
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

*Edits occur at RSYBGN + i × RSYINC where i goes from 0 to n (n = RSYRGE/RSYINC). Thus, the first regional summary edit occurs at RSYBGN while the last regional summary edit occurs at (RSYBGN + RSYRGE). Intermediate regional summary edits are RSYINC apart.

**See 612 input record.

***To specify one edit only, specify its time (or cycle) in field 2; leave fields 3 and 4 blank.

Regional Summary Region Definition

Page 1 of 2

The 632 input record defines a regional summary region. The 632 input record may be used at restart time.

	min	max
start	0	MAXREG-1
restart	0	MAXREG-1

Columns →	11	21	31	41	51	61	71 80
	LREG	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	LREG	Region number. The value of LREG uniquely identifies a region of grid points defined by the grid point limits specified on record type 632. The value of LREG must be integral and greater than or equal to 1 and less than or equal to MAXREG - 1. (See Appendix "Maximums".) If LREG is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine ZONINP. (See Appendix "Messages".)
2	ILFT	Leftmost grid point index for regional summary region LREG. The value of ILFT must be integral and greater than or equal to 1 and less than IRHT. If ILFT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the EDT GENERATOR phase. (See Appendix "Messages".) $1 \le ILFT < IRHT$
3	IRHT	Rightmost grid point index for regional summary region LREG. IRHT must be integral and greater than ILFT and less than or equal to MAXGPT. (See Appendix "Maximums".) If IRHT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the EDT GENERATOR phase. (See Appendix "Messages".) $ILFT < IRHT \le MAXGPT$

Columns →	11	21	31	41	51	61	71	80
	LREG	ILFT	IRHT	JBOT	JTOP	KAFT	KFRT	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
4	JBOT[*]	Bottommost grid point index for regional summary region LREG. The value of JBOT must be integral and greater than or equal to 1 and less than JTOP. If JBOT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the EDT GENERATOR phase. (See Appendix "Messages".) $1 \leq \text{JBOT} < \text{JTOP}$
5	JTOP[*]	Topmost grid point index for regional summary region LREG. The value of JTOP must be integral and greater than JBOT and less than or equal to MAXROW. (See Appendix "Maximums".) If JTOP is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the EDT GENERATOR phase. (See Appendix "Messages".) $\text{JBOT} < \text{JTOP} \leq \text{MAXROW}$
6	KAFT[*]	Aftmost grid point index for regional summary region LREG. The value of KAFT must be integral and greater than or equal to 1 and less than KFRT. If KAFT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the EDT GENERATOR phase. (See Appendix "Messages".) $1 \leq \text{KAFT} < \text{KFRT}$
7	KFRT[*]	Frontmost grid point index for regional summary region LREG. The value of KFRT must be integral and greater than KAFT and less than or equal to MAXPLN. (See Appendix "Maximums".) If KFRT is out of this range, a LIMERR message is written on the print and the message files and the program terminates at the end of the EDT GENERATOR phase. (See Appendix "Messages".) $\text{KAFT} < \text{KFRT} \leq \text{MAXPLN}$

NOTE: Pages 7.633 through 7.639 will not appear in this report.

---

[*] JBOT, JTOP, KAFT, and KFRT are not required for one-dimensional problems and KAFT and KFRT are not required for two-dimensional problems. Input values in these fields when not required will result in the FLDCHK message being written on the print and the message files and the program being terminated at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Restart Edit Specification

The 641 input record identifies a unique set of restart edits.

	min	max
start	0	MAXEDT
restart	0	MAXEDT

Columns →	11	21	31	41	51	61	71	80
	L	RSTBGN	RSTRGE	RSTINC	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Restart edit index. The value of L uniquely identifies the data on this input record. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXEDT. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
2	RSTBGN	Beginning of restart edits.[*] The value of RSTBGN gives a start time or start cycle (depending on MRST[**]) from which the restart edits on this record are computed. The value of RSTBGN must be greater than or equal to zero.[***]
3	RSTRGE	Range of restart edits.[*] The value of RSTRGE gives the time range or cycle range (depending on MRST[**]) from which the restart edits on this record are computed. The value of RSTRGE must be greater than or equal to zero.[***]
4	RSTINC	Increment of restart edits.[*] The value of RSTINC gives the time increments or cycle increments (depending on MRST[**]) from which the restart edits on this record are computed. The value of RSTINC must be a positive number less than or equal to RSTRGE.[***]
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] Edits occur at RSTBGN + i × RSTINC where i goes from 0 to n (n = RSTRGE/RSTINC). Thus, the first restart edit occurs at RSTBGN while the last restart edit occurs at (RSTBGN + RSTRGE). Intermediate restart edits are RSTINC apart.

[**] See 613 input record.

[***] To specify one edit only, specify its time (or cycle) in field 2; leave fields 3 and 4 blank.

This page intentionally left blank.

NOTE: Pages 7.643 through 7.650 will not appear in this report.

Archive Edit Specification

The 651 input record identifies a unique set of archive edits.

	min	max
start	0	MAXEDT
restart	0	MAXEDT

Columns →	11	21	31	41	51	61	71 80
	L	ARVBGN	ARVRGE	ARVINC	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Archive edit index. The value of L uniquely identifies the data on this input record. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXEDT. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
2	ARVBGN	Beginning of archive edits.[*] The value of ARVBGN gives a start time or start cycle (depending on MARV[**]) from which the archive edits on this record are computed. The value of ARVBGN must be greater than or equal to zero.[***]
3	ARVRGE	Range of archive edits.[*] The value of ARVRGE gives the time range or cycle range (depending on MARV[**]) from which the archive edits on this record are computed. The value of ARVRGE must be greater than or equal to zero.[***]
4	ARVINC	Increment of archive edits.[*] The value of ARVINC gives the time increments or cycle increments (depending on MARV[**]) from which the archive edits on this record are computed. The value of ARVINC must be a positive number less than or equal to ARVRGE.[***]
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] Edits occur at ARVBGN + i × ARVINC where i goes from 0 to n (n = ARVRGE/ARVINC). Thus, the first archive edit occurs at ARVBGN while the last archive edit occurs at (ARVBGN + ARVRGE). Intermediate archive edits are ARVINC apart.

[**] See 614 input record.

[***] To specify one edit only, specify its time (or cycle) in field 2; leave fields 3 and 4 blank.

Archive File Grid Point* Edit Limits

Page 1 of 2

The 652 input record defines the grid point, row, and plane edit limits for grid point and zone variables saved on the archive file. If the 652 input record is omitted, the archive file will not be written. When the 652 input record is used, MINIAR ≤ MAXIAR, MINJAR ≤ MAXJAR, and MINKAR ≤ MAXKAR.** The 652 input record may be used at restart time.

	min	max
start	0	1
restart	0	1

Columns →	11	21	31	41	51	61	71 80
	MINIAR	MAXIAR	MINJAR	MAXJAR	MINKAR	MAXKAR	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	MINIAR	Minimum grid point number (i-line) to be saved on file NFARV. (See Appendix "Files".) The value of MINIAR must be integral, greater than or equal to 1, and less than or equal to MAXGPT. (See Appendix "Maximums".) If MINIAR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) 1 ≤ MINIAR ≤ MAXGPT
2	MAXIAR	Maximum grid point number (i-line) to be saved on file NFARV. (See Appendix "Files".) The value of MAXIAR must be integral, greater than or equal to 1, and less than or equal to MAXGPT. (See Appendix "Maximums".) If MAXIAR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) MINIAR ≤ MAXIAR ≤ MAXGPT
3	MINJAR	Minimum row number (j-line) to be saved on file NFARV. (See Appendix "Files".) The value of MINJAR must be integral, greater than or equal to 1, and less than or equal to MAXROW. (See Appendix "Maximums".) If MINJAR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) This field must be left blank for 1D runs or a FLDCHK message will be written on the print and the message files and the program will terminate at the end of the GENERATOR phase group. (See Appendix "Messages".) 1 ≤ MINJAR ≤ MAXROW

---

*Or Zone.

**If MINIPR > MAXIPR, MINJAR > MAXJAR, or MINKAR > MAXKAR, a LIMERR message is written on the print and the message files and the program terminates at the end of the EDT generator phase. (See Appendix "Messages".)

Columns →	11	21	31	41	51	61	71 80
	MINIAR	MAXIAR	MINJAR	MAXJAR	MINKAR	MAXKAR	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	MAXJAR	Maximum row number (j-line) to be saved on file NFARV. (See Appendix "Files".) The value of MAXJAR must be integral, greater than or equal to 1, and less than or equal to MAXROW. (See Appendix "Maximums".) If MAXJAR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) This field must be left blank for 1D runs or the FLDCHK message will be written on the print and the message files and the program will terminate at the end of the GENERATOR phase group. (See Appendix "Messages".) MINJAR ≤ MAXJAR ≤ MAXROW
5	MINKAR	Minimum plane number (k-line) to be saved on file NFARV. (See Appendix "Files".) The value of MINKAR must be integral, greater than or equal to 1, and less than or equal to MAXPLN. (See Appendix "Maximums".) If MINKAR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) This field must be left blank for 1D and 2D runs or a FLDCHK message will be written on the print and the message files and the program will terminate at the end of the GENERATOR phase group. (See Appendix "Messages".) 1 ≤ MINKAR ≤ MAXPLN
6	MAXKAR	Maximum plane number (k-line) to be saved on file NFARV. (See Appendix "Files".) The value of MAXKAR must be integral, greater than or equal to 1, and less than or equal to MAXPLN. (See Appendix "Maximums".) If MAXKAR is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) This field must be left blank for 1D and 2D runs or a FLDCHK message will be written on the print and the message files and the program will terminate at the end of the GENERATOR phase group. (See Appendix "Messages".) MINKAR ≤ MAXKAR ≤ MAXPLN
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

Archive File Grid Point* Variables

TYPE 653

Page 1 of 1

Each 653 input record defines a set of grid point and zone variables to be saved on the archive data file. Variables may be requested in any order (up to 7 per input record) and blank fields will be ignored. If no variables are requested, a set of default variables will be saved.

	min	max
start	0	MAXVAR
restart	0	MAXVAR

Columns →	11	21	31	41	51	61	71 80
	IDARV	IDARV	IDARV	IDARV	IDARV	IDARV	IDARV
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1-7	IDARV	Archive data identifiers. Each value of IDARV corresponds to a grid point or zone variable identifier. (See Appendix "Identifiers".) Up to seven identifiers may be specified with each 653 input record and blank fields will be ignored. If the total number of variables requested by all 653 input records exceeds MAXVAR (see Appendix "Maximums"), a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) If no variables are requested, a set of default variables will be saved. (See Appendix "Output".) The value of IDARV must be integral, greater than or equal to 1, and less than or equal to MAXVAR. If IDARV is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)

---

*Or zone.

Archive Processor Limits

Page 1 of 2

The 654 input record specifies the range of archive data to be processed during an ADAPRO run. This range can be supplied in terms of either a minimum and a maximum time or a minimum and a maximum cycle. If the 654 input record is omitted, every archive data record up to and including the largest time or cycle for which there is an edit request will be processed.

	min	max
start	1	1
restart	N/A	N/A

Columns →	11	21	31	41	51	61	71	80
	MARLIM	MINARC	MAXARC	ARCMIN	ARCMAX	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	MARLIM	Archive data limit mode. The value of MARLIM specifies the mode in which the archive data limits are expressed. The following definitions apply: = 1.0 archive data limits by time = 2.0 archive data limits by cycle If the value of MARLIM is 1.0, the archive data limits must be supplied in the fields containing ARCMIN and ARCMAX. If the value of MARLIM is 2.0, the archive data limits must be supplied in the fields containing MINARC and MAXARC. If the value of MARLIM is either less than 1.0 or greater than 2.0, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
2	MINARC	Minimum cycle to be processed by ADAPRO. The value of MINARC must be integral, greater than or equal to 1, and less than or equal to MAXARC. If MINARC is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
3	MAXARC	Maximum cycle to be processed by ADAPRO. The value of MAXARC must be integral and greater than or equal to MINARC. If MAXARC is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
4	ARCMIN	Minimum time to be processed by ADAPRO. The value of ARCMIN must be greater than or equal to 0 and less than or equal to ARCMAX. If the value of ARCMIN is out of this range, an error message is written on the print and the message files and the program terminates immediately in subroutine EDTINP.

Columns →	11	21	31	41	51	61	71	80
	MARLIM	MINARC	MAXARC	ARCMIN	ARCMAX	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
5	ARCMAX	Maximum time to be processed by ADAPRO. If the value of ARCMAX is less than ARCMIN, an error message is written on the print and the message files and the program terminates immediately in subroutine EDTINP.
6-7	--	Fields 6-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

NOTE: Pages 7.655 through 7.660 will not appear in this report.

Storage Edit Specification

The 661 input record identifies a unique set of storage edits.

	min	max
start	0	MAXEDT
restart	0	MAXEDT

Columns →	11	21	31	41	51	61	71	80
	L	STGBGN	STGRGE	STGINC	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Storage edit index. The value of L uniquely identifies the data on this input record. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXEDT. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
2	STGBGN	Beginning of storage edits.[*] The value of STGBGN gives a start time or start cycle (depending on MSTG[**]) from which the storage edits on this record are computed. The value of STGBGN must be greater than or equal to zero.[***]
3	STGRGE	Range of storage edits.[*] The value of STGRGE gives the time range or cycle range (depending on MSTG[**]) from which the storage edits on this record are computed. The value of STGRGE must be greater than or equal to zero.[***]
4	STGINC	Increment of storage edits.[*] The value of STGINC gives the time increments or cycle increments (depending on MSTG[**]) from which the storage edits on this record are computed. The value of STGINC must be a positive number less than or equal to STGRGE.[***]
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] Edits occur at STGBGN + i × STGINC where i goes from 0 to n (n = STGRGE/STGINC). Thus, the first storage edit occurs at STGBGN while the last storage edit occurs at (STGBGN + STGRGE). Intermediate storage edits are STGINC apart.

[**] See 615 input record.

[***] To specify one edit only, specify its time (or cycle) in field 2; leave fields 3 and 4 blank.

Trace Edit Specification

The 662 input record identifies a unique set of trace edits. USE OF THIS OPTION MAY RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

	min	max
start	0	MAXEDT
restart	0	MAXEDT

Columns →	11	21	31	41	51	61	71 80
	L	TRCBGN	TRCRGE	TRCINC	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	L	Trace edit index. The value of L uniquely identifies the data on this input record. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXEDT. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
2	TRCBGN	Beginning of trace edits.[*] The value of TRCBGN gives a start time or start cycle (depending on MTRC[**]) from which the trace edits on this record are computed. The value of TRCBGN must be greater than or equal to zero.[***]
3	TRCRGE	Range of trace edits.[*] The value of TRCRGE gives the time range or cycle range (depending on MTRC[**]) from which the trace edits on this record are computed. The value of TRCRGE must be greater than or equal to zero.[***]
4	TRCINC	Increment of trace edits.[*] The value of TRCINC gives the time increments or cycle increments (depending on MTRC[**]) from which the trace edits on this record are computed. The value of TRCINC must be a positive number less than or equal to TRCRGE.[***]
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] Edits occur at TRCBGN + i × TRCINC where i goes from 0 to n (n = TRCRGE/TRCINC). Thus, the first trace edit occurs at TRCBGN while the last trace edit occurs at (TRCBGN + TRCRGE). Intermediate trace edits are TRCINC apart.

[**] See 618 input record.

[***] To specify one edit only, specify its time (or cycle) in field 2; leave fields 3 and 4 blank.

Debug Edit Specification

Page 1 of 1

The 663 input record identifies a unique set of debug edits. USE OF THIS OPTION MAY RESULT IN AN ENORMOUS AMOUNT OF PRINTED OUTPUT. PLEASE USE WITH CAUTION.

	min	max
start	0	MAXEDT
restart	0	MAXEDT

Columns →	11	21	31	41	51	61	71	80
	L	DBGBGN	DBGRGE	DBGINC	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Debug edit index. The value of L uniquely identifies the data on this input record. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXEDT. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
2	DBGBGN	Beginning of debug edits.[*] The value of DBGBGN gives a start time or start cycle (depending on MDBG[**]) from which the debug edits on this record are computed. The value of DBGBGN must be greater than or equal to zero.[***]
3	DBGRGE	Range of debug edits.[*] The value of DBGRGE gives the time range or cycle range (depending on MDBG[**]) from which the debug edits on this record are computed. The value of DBGRGE must be greater than or equal to zero.[***]
4	DBGINC	Increment of debug edits.[*] The value of DBGINC gives the time increments or cycle increments (depending on MDBG[**]) from which the debug edits on this record are computed. The value of DBGINC must be a positive number less than or equal to DBGRGE.[***]
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] Edits occur at DBGBGN + i × DBGINC where i goes from 0 to n (n = DBGRGE/DBGINC). Thus, the first debug edit occurs at DBGBGN while the last debug edit occurs at (DBGBGN + DBGRGE). Intermediate debug edits are DBGINC apart.

[**] See 619 input record.

[***] To specify one edit only, specify its time (or cycle) in field 2; leave fields 3 and 4 blank.

This page intentionally left blank.

NOTE: Pages 7.665 through 7.670 will not appear in this report.

Plot History Edit Specification

Page 1 of 1

The 671 input record identifies a unique set of plot history edits.

	min	max
start	0	MAXEDT
restart	0	MAXEDT

Columns →	11	21	31	41	51	61	71	80
	L	PLTBGN	PLTRGE	PLTINC	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1	L	Plot history edit index. The value of L uniquely identifies the data on this input record. The value of L must be integral and greater than or equal to 1 and less than or equal to MAXEDT. (See Appendix "Maximums".) If L is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".)
2	PLTBGN	Beginning of plot history edits.[*] The value of PLTBGN gives a start time or start cycle (depending on MPLT[**]) from which the plot history edits on this record are computed. The value of PLTBGN must be greater than or equal to zero.[***]
3	PLTRGE	Range of plot history edits.[*] The value of PLTRGE gives the time range or cycle range (depending on MPLT[**]) from which the plot history edits on this record are computed. The value of PLTRGE must be greater than or equal to zero.[***]
4	PLTINC	Increment of plot history edits.[*] The value of PLTINC gives the time increments or cycle increments (depending on MPLT[**]) from which the plot history edits on this record are computed. The value of PLTINC must be a positive number less than or equal to PLTRGE.[***]
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] Edits occur at $\mathrm{PLTBGN} + i \times \mathrm{PLTINC}$ where i goes from 0 to n ($n = \mathrm{PLTRGE}/\mathrm{PLTINC}$). Thus, the first plot history edit occurs at PLTBGN while the last plot history edit occurs at (PLTBGN + PLTRGE). Intermediate plot history edits are PLTINC apart.

[**] See 616 input record.

[***] To specify one edit only, specify its time (or cycle) in field 2; leave fields 3 and 4 blank.

Plot Definition

Page 1 of 2

A 672 input record is required to specify a 1D plot. Each 672 input record defines a unique time history, snapshot, or mesh plot. Plots may be defined at start or restart time.

	min	max
start	0	MAXPLT
restart	0	MAXPLT

Columns →	11	21	31	41	51	61	71 80
	NPLT	IDPLT	IDORD	IDABC	IDLOC	TODLOC	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NPLT	Plot number. The value of NPLT defines the array location of the plot parameters in this record. The value of NPLT must be integral and greater than or equal to 1 and less than or equal to MAXPLT. (See Appendix "Maximums".) If NPLT is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) Plot numbers do not have to be consecutive.
2	IDPLT	Plot type. The value of IDPLT specifies the type of plot specified on this record. The value of IDPLT must be integral and greater than or equal to one and less than or equal to 3. The following definitions apply: = 1.0 time history* (sampling rate defined on 671 input record) = 2.0 snapshot = 3.0 mesh If the field containing IDPLT is left blank, then the plot is assumed not to exist. If the value of IDPLT is greater than 3.0, the message PLOT TYPE IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates at the end of the GENERATOR phase group.
3	IDORD	Ordinate identifier. The value of IDORD identifies the variable to be plotted on the ordinate of a time history or a snapshot plot. A list of identifier values appears in Appendix "Identifiers". The value of IDORD must be integral and must correspond to a legitimate variable or the message ORDINATE IDENTIFIER IMPROPERLY DEFINED VALUE = eeeeeeeeeeee is written on the print and the message files, and the value of IDPLT is set equal to zero so that no plot will be made. Leave this field blank for a mesh plot.

---

*Time does not have to appear on either axis.

Columns →	11	21	31	41	51	61	71 80
	NPLT	IDPLT	IDORD	IDABC	IDLOC	TODLOC	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	IDABC	Abscissa identifier. The value of IDABC identifies the variable to be plotted on the abscissa of a time history or a snapshot plot. A list of identifier values appears in Appendix "Identifiers". The value of IDABC must be integral and must correspond to a legitimate variable or the message ABSCISSA IDENTIFIER IMPROPERLY DEFINED VALUE = eeeeeeeeeeee is written on the print and the message files, and the value of IDPLT is set equal to zero so that no plot will be made. Leave this field blank for a mesh plot.
5	IDLOC	Zone or grid point index for a moving (Lagrange) time history plot or cycle number for a snapshot or mesh plot. If IDPLT = 1.0, the value of IDLOC is the zone or grid-point index where the time history is to be made. If IDPLT = 2.0 or 3.0, the value of IDLOC is the cycle number at which the snapshot or mesh plot is to be made. The value of IDLOC must be integral and greater than or equal to 1.0 and less than or equal to NCGPT (for zone or grid-point specification) or less than or equal to NCCYC (for cycle specification). If IDLOC is less than 1.0, the zone or grid point index or cycle number will be calculated using the TODLOC specification.
6	TODLOC	Position for a fixed (Euler) time history plot or time for a snapshot or mesh plot. If IDPLT = 1.0, the value of TODLOC is the fixed position (in problem units) where the Eulerian time history is to be made. If IDPLT = 2.0 or 3.0, the value of TODLOC is the time (in problem units) at which the snapshot or mesh plot is to be made. The value of TODLOC is used only when IDLOC is left blank.
7	--	Field 7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

NOTE: Page 7.673 will not appear in this report.

Plot Definition

A 674 input record is required to specify a 2D or 3D function plot. Each 674 input record defines a unique time history or snapshot plot. Plots may be defined at start or restart time.

	min	max
start	0	MAXPLT
restart	0	MAXPLT

Columns →	11	21	31	41	51	61	71 80
	NPLT	IDPLT	IDORD	IDABC	IDLOC	TODLOC	IDROW
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NPLT	Plot number. The value of NPLT defines the array location of the plot parameters on this record. The value of NPLT must be integral and greater than or equal to 1 and less than or equal to MAXPLT. (See Appendix "Maximums".) If NPLT is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) Plot numbers do not have to be consecutive.
2	IDPLT	Plot type. The value of IDPLT specifies the type of plot specified on this record. The value of IDPLT must be integral and have the value of 1.0 or 2.0. The following definitions apply: = 1.0 time history* (sampling rate defined on 671 input record) = 2.0 snapshot If the value of IDPLT is not 1.0 or 2.0, the message, PLOT TYPE IMPROPERLY DEFINED. is written on the print and the message files, and the program terminates at the end of the GENERATOR phase group.
3	IDORD	Ordinate identifier. The value of IDORD identifies the variable to be plotted on the ordinate of a time history or a snapshot plot. A list of identifier values appears in Appendix "Identifiers". The value of IDORD must be integral and must correspond to a legitimate variable or the message, ORDINATE IDENTIFIER IMPROPERLY DEFINED VALUE = <u>eeeeeeeeeee</u> is written on the print and the message files, and the value of IDPLT is set equal to zero so that no plot will be made.

---

*Time does not have to appear on either axis.

Columns →	11	21	31	41	51	61	71 80
	NPLT	IDPLT	IDORD	IDABC	IDLOC	TODLOC	IDROW
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	IDABC	Abscissa identifier. The value of IDABC identifies the variable to be plotted on the abscissa of a time history plot. A list of identifier values appears in Appendix "Identifiers". The value of IDABC must be integral and must correspond to a legitimate variable or the message, ABSCISSA IDENTIFIER IMPROPERLY DEFINED VALUE = eeeeeeeeeeee is written on the print and the message files, and the value of IDPLT is set equal to zero so that no plot will be made. Leave this field blank for a snapshot plot.
5	IDLOC	Zone or grid point index for a moving (Lagrange) time history plot or cycle number for a snapshot plot. If IDPLT = 1.0, the value of IDLOC is the six-digit number IIIJJJ, where III is the column number (i-index), and JJJ is the row number (j-index) of the zone or grid point where the time history is to be made for a 2D plot, or the value of IDLOC is the six-digit number IIJJKK, where II is the column number (i-index), JJ is the row number (j-index), and KK is the plane number (k-index) of the zone or grid point where the time history is to be made for a 3D plot. If IDPLT = 2.0, the value of IDLOC is the cycle number at which the snapshot plot is to be made. When IDPLT = 1.0, the value of IDLOC must be such that $1 \le i \le$ NCGPT, $1 \le j \le$ NCROW, and $1 \le k \le$ NCPLN (for zone or grid-point specification). When IDPLT = 2.0 and IDLOC is less than 1.0, the cycle number will be calculated using TODLOC specification.
6	TODLOC	Time for a snapshot plot. If IDPLT = 2.0 and IDLOC is left blank, the value of TOTLOC is the time (in problem units) at which the snapshot plot is to be made. This field has no meaning for a time history plot.

Columns →	11	21	31	41	51	61	71 80
	NPLT	IDPLT	IDORD	IDABC	IDLOC	TODLOC	IDROW
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
7	IDROW	Index space line number. For 2D, this is the row (j-index) or column (i-index) for which a snapshot will be made. The value of IDROW should be a six-digit number of the form IIIJJJ. If a snapshot of a row is to be made, JJJ should be the row number, III should be zero, and 1 ≤ JJJ ≤ NCROW. Is a snapshot of a column is to be made, III should be the column number, JJJ should be zero, and 1 ≤ III ≤ NCGPT. For 3D, this is the plane (k-index) and the row (j-index) or column (i-index) for which a snapshot will be made. The value of IDROW will be a six-digit number of the form IIJJKK, where one of the two indices (II or JJ) should be non-zero to uniquely specify the column or row that the 3D snapshot is to be made. KK must always be non-zero and 1 ≤ KK ≤ NCPLN. Leave this field blank for a time history plot.

Plot Definition

Page 1 of 2

A 675 input record is required to specify a 2D or 3D grid-type plot. Each 675 record defines a unique mesh, contour, vector (velocity), tensor (stress), or isometric contour plot.

	min	max
start	0	MAXPLT
restart	0	MAXPLT

Columns →	11	21	31	41	51	61	71 80
	NPLT	IDPLT	IDORD	--	IDLOC	TODLOC	IDPLN
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NPLT	Plot number. The value of NPLT defines the array location of the plot parameters in this record. The value of NPLT must be integral and greater than or equal to 1 and less than or equal to MAXPLT. (See Appendix "Maximums".) If NPLT is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) Plot numbers do not have to be consecutive.
2	IDPLT	Plot type. The value of IDPLT specifies the type of plot specified on this record. The value of IDPLT must be integral and have a value greater than or equal to 3.0 and less than or equal to 8.0. The following definitions apply: = 3.0 mesh plot = 4.0 contour plot = 5.0 vector plot (velocity) = 6.0 tensor plot (stress) = 7.0 isometric contour = 8.0 solid plot (3D only) If the value of IDPLT is not one of the above, a message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group.
3	IDORD	Ordinate identifier. For contour or isometric contour plots, the value of IDORD specifies the variable to be contoured.* A list of variable identifiers appears in Appendix "Identifiers". The value of IDORD must be integral and must correspond to a legitimate variable or the message, ORDINATE IDENTIFIER IMPROPERLY DEFINED VALUE = eeeeeeeeeee is written on the print and the message files, and the value of IDPLT is set to zero so that no plot will be made. Leave this field blank for a mesh, vector, or tensor plot.

---

*For isometric contour plots, the value of IDORD specifies the value to be displayed as a "z"-value above the grid.

Columns →	11	21	31	41	51	61	71 80
	NPLT	IDPLT	IDORD	--	IDLOC	TODLOC	IDPLN
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
4	--	Field 4 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)
5	IDLOC	Cycle number. The value of IDLOC is the cycle number at which the plot is to be made. It must be integral and less than or equal to MAXCYC. If the value of IDLOC is 0.0, the cycle number will be calculated using the TODLOC specification.
6	TODLOC	Time. If IDLOC is 0.0, TODLOC is the time at which the plot is to be made.
7	IDPLN	Plane in which the contour, tensor, vector, or isometric contour plot is to be made (3D only). IDPLN is a six-digit number of the form IIJJKK where one of the indices (II, JJ, or KK) gives the plane of the plot. Trailing zeros must be specified.

NOTE: Page 7.676 will not appear in this report.

Multiple Plot Edit Specification

A 677 input record specifies a set of multiple plot edits for a plot defined by a 672, a 674, or a 675 input record. Multiple plot edits can be specified for any plot type except time histories and column snapshots. Since each plot edit results in the generation of a complete plot, the 677 input record can be used to generate plot movies.

Page 1 of 1

	min	max
start	0	MAXPLT
restart	N/A	N/A

Columns → 11 21 31 41 51 61 71 80

	NPLT	PETBGN	PETRGE	PETINC	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1	NPLT	Plot number. The value of NPLT identifies the plot for which the specified multiple plot edits are to apply. The value of NPLT must be integral, greater than or equal to 1, and less than or equal to MAXPLT. (See Appendix "Maximums".) If NPLT is out of this range, a RGEERR message is written on the print and the message files and the program terminates immediately in subroutine EDTINP. (See Appendix "Messages".) The corresponding plot can be of any type except time history or column snapshot. If multiple plot edits are supplied for a time history plot or for a column snapshot, a TYPERR message is written on the print and the message files and the program terminates immediately in subroutine EDTCHK. (See Appendix "Messages".)
2	PETBGN	Beginning of multiple plot edits.[*] The value of PETBGN gives a start time or start cycle (depending on MPET[**]) from which the multiple plot edits for plot number NPLT are computed. The value of PETBGN must be greater than or equal to zero.[***]
3	PETRGE	Range of multiple plot edits.[*] The value of PETRGE gives the time range or cycle range (depending on MPET[**]) from which the multiple plot edits for plot number NPLT are computed. The value of PETRGE must be greater than or equal to zero.[***]
4	PETINC	Increment of plot edits. The value of PETINC gives the time increments or cycle increments (depending on MPET[**]) from which the multiple plot edits for plot number NPLT are computed. The value of PETINC must be a positive number less than or equal to PETRGE.[***]
5-7	--	Fields 5-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

---

[*] Edits occur at $\mathrm{PETBGN} + i \times \mathrm{PETINC}$ where i goes from 0 to n ($n = \mathrm{PETRGE}/\mathrm{PETINC}$). Thus, the first plot edit occurs at PETBGN while the last plot edit occurs at (PETBGN + PETRGE). Intermediate plot edits are PETINC apart.

[**] See 617 input record.

[***] To specify one edit only, specify its time (or cycle) in field 2; leave fields 3 and 4 blank.

This page intentionally left blank.

NOTE: Pages 7.679 through 7.698 will not appear in this report.

End of EDT Phase

Page 1 of 1

The END input record signifies the end of a block of data for the EDT input phase. It must follow the last EDT input record.

	min	max
start	1	1
restart	0	1

Columns →	11	21	31	41	51	61	71 – 80
	--	--	--	--	--	--	--
Fields →	1	2	3	4	5	6	7

Field Number	Input Variable Name	Description of Input Variable
1-7	--	Fields 1-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

7.7 END OF INPUT DATA DECK (END)

The last input record in every data deck, start or restart, must be an END record. This END record must follow another END record, which is the end-of-data record of the last input block in the data deck.

This page intentionally left blank.

NOTE: Pages 7.703 through 7.798 will not appear in this report.

End of Input Data Deck

This END input record signifies the end of all blocks of data in the input data deck. It must follow the last END input record of the last input data block.

	min	max
start	1	1
restart	1	1

Columns →	11	21	31	41	51	61	71	80
	--	--	--	--	--	--	--	
Fields →	1	2	3	4	5	6	7	

Field Number	Input Variable Name	Description of Input Variable
1-7	--	Fields 1-7 must be left blank or the FLDCHK message is written on the print and the message files and the program terminates at the end of the GENERATOR phase group. (See Appendix "Messages".)

This page intentionally left blank.

APPENDIX

BOUNDARY INTERACTION ALGORITHMS (BIA)

I. INTRODUCTION

Two types of boundary interaction algorithms are available in STEALTH. The simpler is the wall point interaction logic, while the more complex is the grid interaction logic. The former allows boundary grid points to interact with impenetrable and inflexible (rigid) surfaces, while the latter allows the boundary surfaces of two grids to interact with each other. For example, the response of an object which is represented by a finite-difference grid frequently requires that boundary grid points of that grid interact with external or internal obstacles. These obstacles can be represented by deformable bodies as represented by other grids or by kinematic boundaries defined by wall point segments. Since grid and kinematic boundaries in two- and three-dimensional problems can have both an arbitrary shape and an arbitrary velocity, a general technique is required which allows a string of boundary grid points to attach onto, move around, and then (possibly) detach from grid and wall surfaces which are also defined by strings of points. Even when these wall or grid interaction segments are assumed to be perfectly smooth and straight, programming the geometric aspects of the logic is nontrivial. In most cases, the physics of interaction is conceptually straightforward, but as the degrees of geometric freedom increase, the topology of interactions becomes quite complex. Two-dimensional cases are significantly more difficult than one-dimensional interactions, and three-dimensional interaction scenarios are extremely complex and usually are very costly.

This Appendix is divided into two sections -- the first deals with the wall point interaction logic (subroutine NBVCNT), while the second concentrates on grid interaction logic (subroutines NBVCNT and BDYGRD). Within each of these sections of the Appendix, attention will be focused on the peculiarities associated with 1D, 2D, and 3D versions of the logic.

II. ONE-DIMENSIONAL WALL POINT LOGIC

A. INTRODUCTION

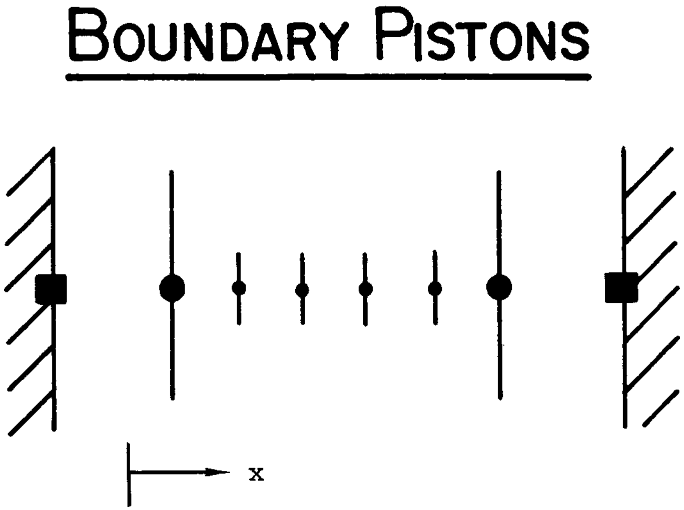
In STEALTH 1D, wall points may be used for two purposes. The first purpose is to define the location of impenetrable boundary pistons on the left and on the right of the entire mesh. The second purpose is to define flume and thin boundary geometries.

B. PISTONS

Only one wall point is required to locate a boundary piston. When a piston exists, the wall point number of a boundary piston must always be equal to MAXWPT - 1 (see Appendix "Maximums") for the left-side piston and must be equal to MAXWPT for the right-side piston. Figure BIA.1 displays left- and right-side wall point boundaries. These impenetrable boundaries can be stationary or moving. Wall interacting boundary grid points are free points until they come in contact (interact) with the wall point constraint. When a boundary grid point interacts with a rigid boundary piston, it takes on the velocity of the piston (wall point constraint). A capture distance, DWL, defined by the user, determines how close a boundary grid point (left or right) must be to be captured by the piston.

C. FLUMES

Two flume options are available in the one-dimensional code. The flume options are (1) planar flume (Figure BIA.2), which allows the user to define a variable area, circular cross section, pipe flow geometry, and (2) cylindrical flume (Figure BIA.3), which simulates cylindrically divergent radial flow between flat plates of variable vertical separations, respectively, as a function of the one-dimensional coordinate.



■ = wall point

● = boundary point

• = interior point

Figure BIA.1. Left and right side wall point boundaries.

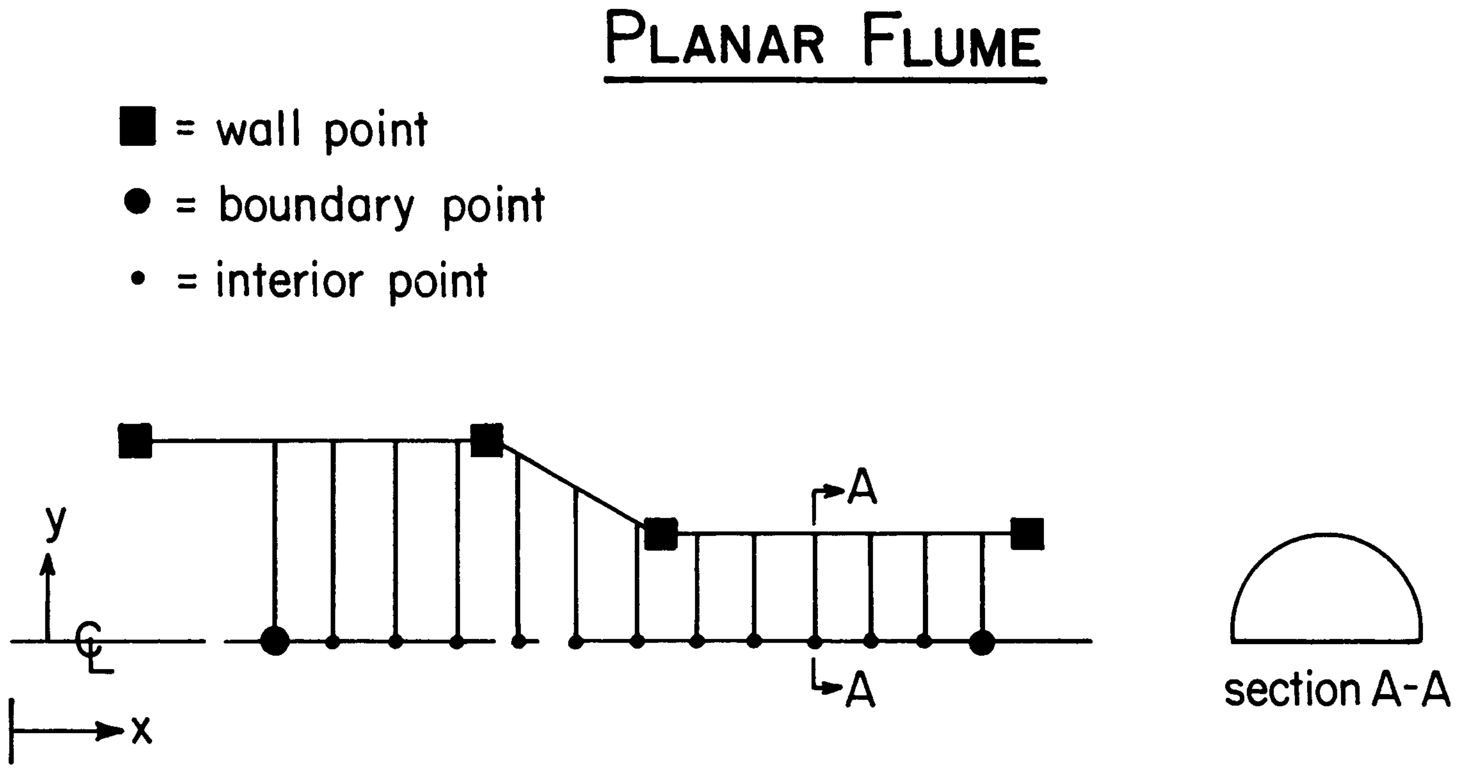


Figure BIA.2. Planar flume geometry.

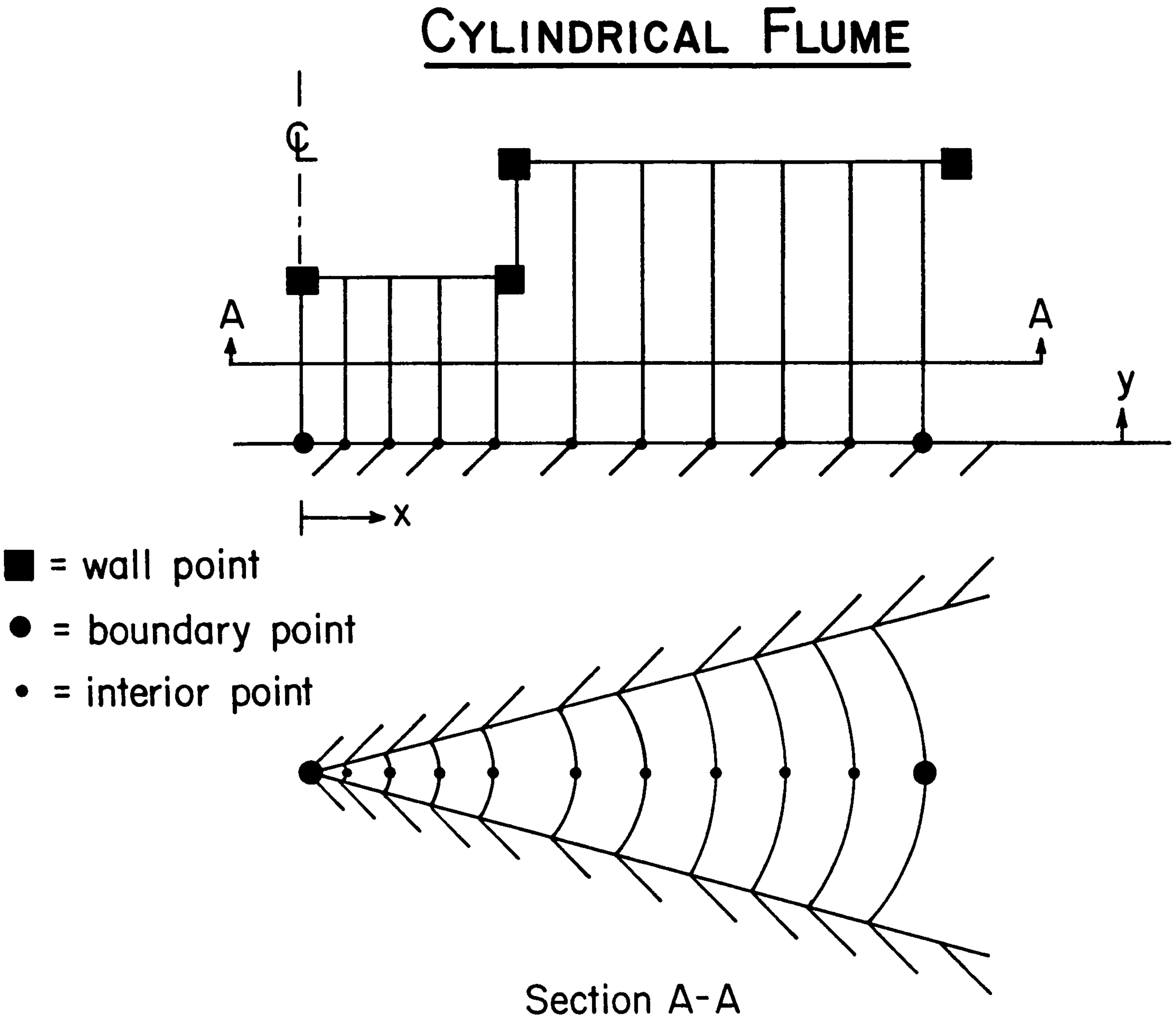


Figure BIA.3. Cylindrical flume geometry.

D. THIN GEOMETRIES

The two thin options are available. They include thin rod (Figure BIA.4) and thin plate (Figure BIA.5) capabilities. For the thin boundary geometries, the wall points define the rod radius and plate thickness, respectively, as functions of the one-dimensional coordinate.

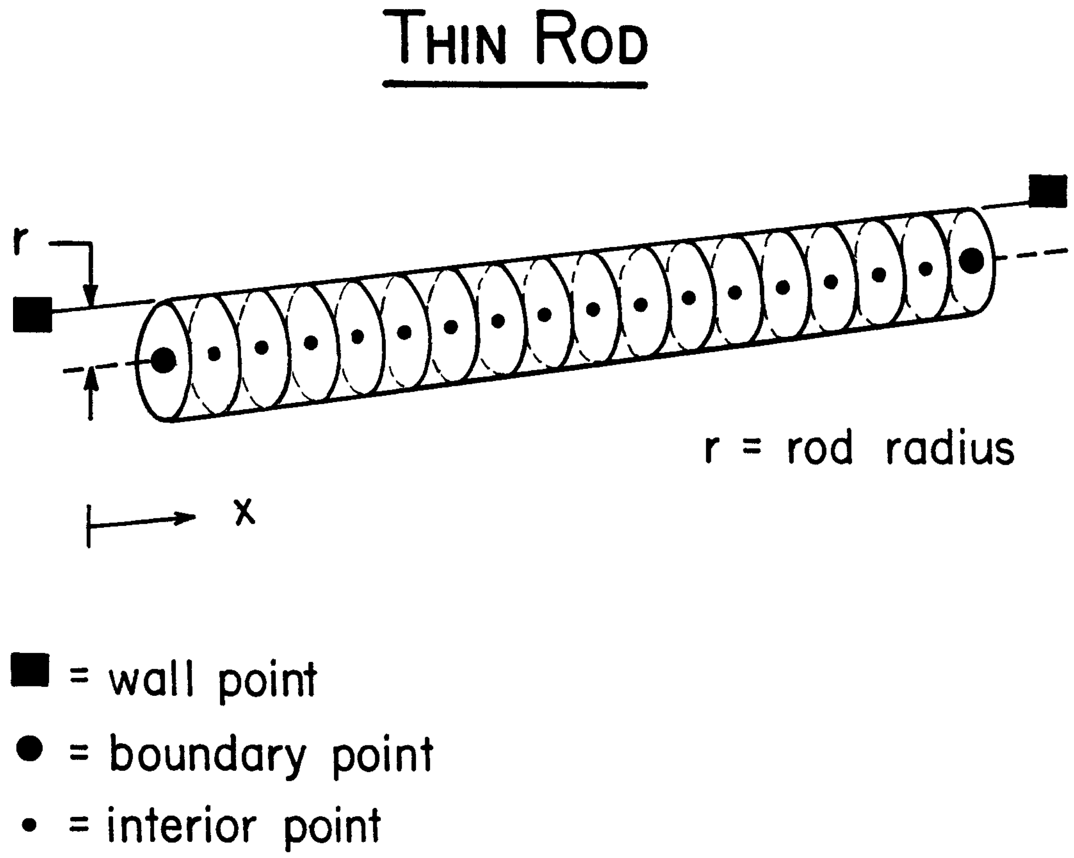


Figure BIA.4. Thin rod geometry.

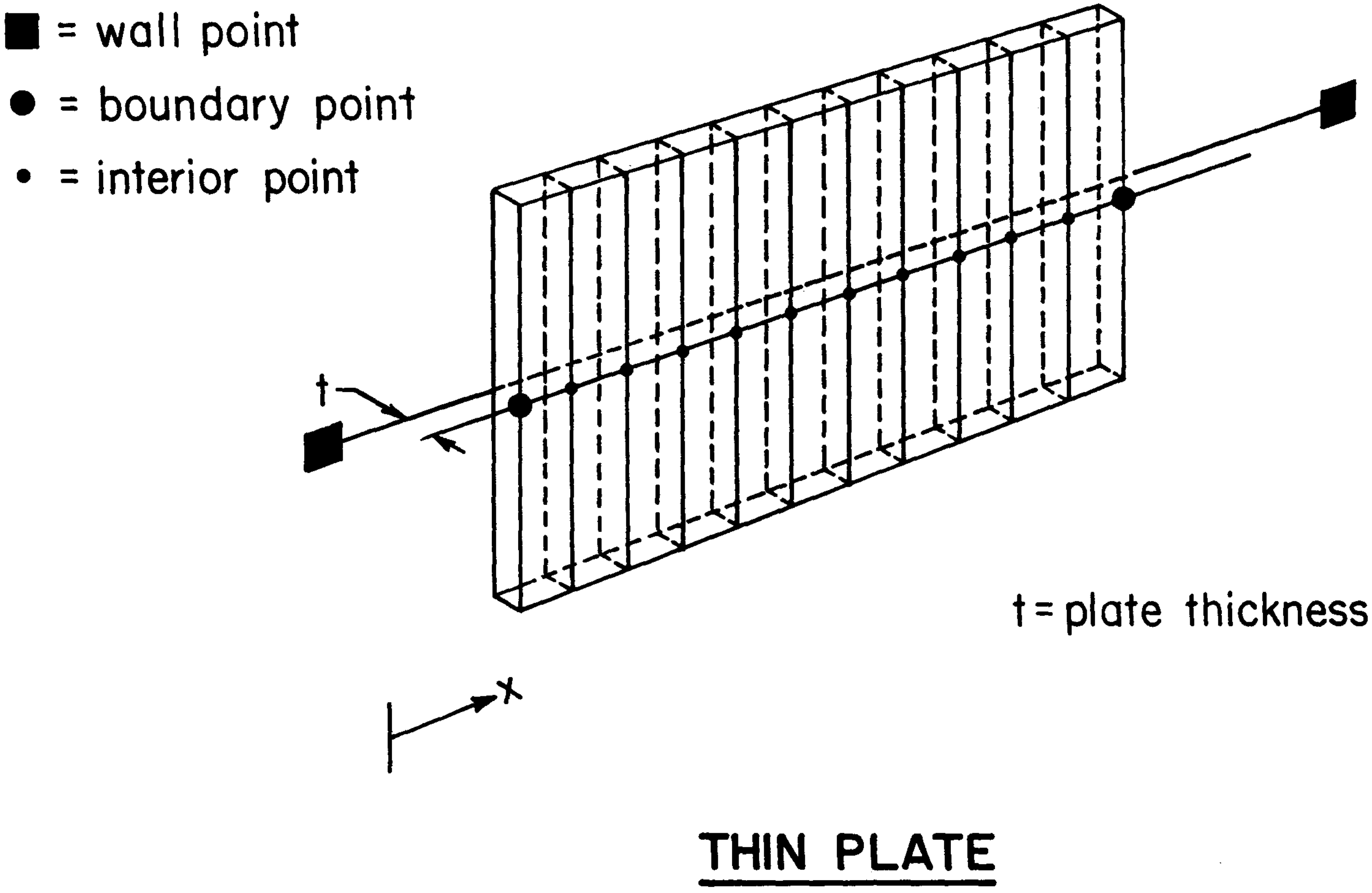


Figure BIA.5. Thin plate geometry.

III. TWO-DIMENSIONAL WALL POINT LOGIC

A. INTRODUCTION

In STEALTH 2D, wall points are used to describe the outline of rigid obstacles, planes of symmetry, and the axis of symmetry in axisymmetric geometry.* Wall points are connected by straight line segments and a minimum of two wall points can be used to define a kinematic constraint. Wall point strings (a constraint defined by two or more contiguous wall points, i.e., one or more wall segments) have directed length (first and last points) and free and impenetrable sides. Each string of wall points is a self-contained unit defining a specific object or constraint. Strings cannot interact with other strings; they only interact with grids.

The STEALTH 2D approach to the interaction between boundary grid points and wall segments is based on the concept of a capture distance. Boundary grid points within a perpendicular capture distance of a closest wall segment are placed at the intersection of the wall segment and the perpendicular line from the boundary grid point to the wall segment. Boundary grid points outside the capture distance are free as long as the point has not penetrated through the wall segment into an impenetrable region. If it has entered an impenetrable region, it is placed on an appropriate wall segment, independent of capture distance.

The capture distance is a simple numerical parameter designed primarily for cohesionless interaction. Typically, the distance must be small relative to a characteristic zone dimension in order to have the least influence on a calculation, but large enough to prevent a boundary grid point from jumping on and off a wall segment every other cycle as a result of computational noise. In practice, a very small value for the capture distance, typically a hundredth to a thousandth of a characteristic zone dimension, is adequate.

---

*The seismic version of STEALTH 2D uses wall points to define the outline of rigid body and shell finite-element models in addition to the standard roller boundary application.

It is possible, however, to use the capture distance to simulate strong cohesion. When using wall points to define a plane or axis of symmetry or a roller boundary, infinite cohesion is required and the capture distance should be set to a value which is one-fourth to one-third times a characteristic zone dimension. Values of capture distance in between the cohesionless and infinite cohesion extremes may be used to approximate some forms of finite bonding.

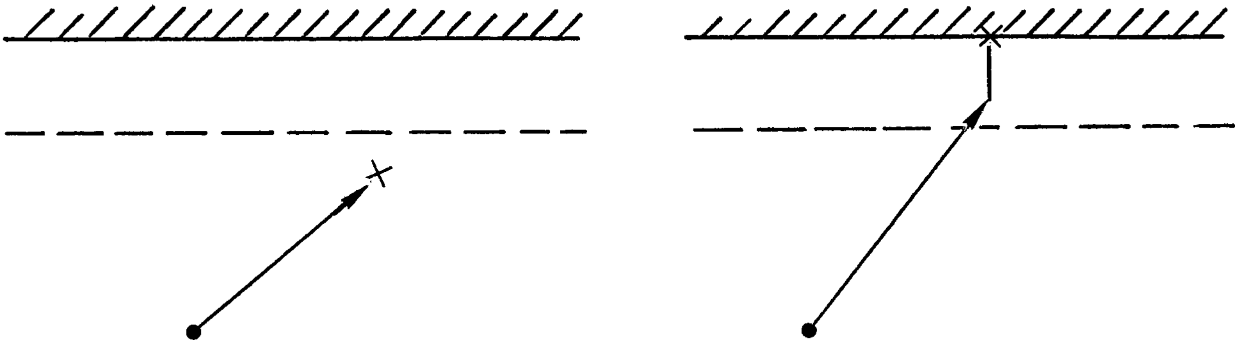
Boundary grid points which can interact with wall segments are called wall interaction boundary grid points. These wall interaction points have a special logic for computing the kinematic variables of acceleration, velocity, and position. The sequence of steps is:

(1) Compute new acceleration, velocity, and position of a wall interaction point, assuming it is free. These new values are temporary trial values, and are computed even if a point is initially on a wall segment.

(2) If the trial location is within a capture distance of any wall segment, or if the trial location is in an impenetrable region, place the point exactly on the appropriate wall segment. New velocity and acceleration are then back-calculated from the new position to maintain consistency.

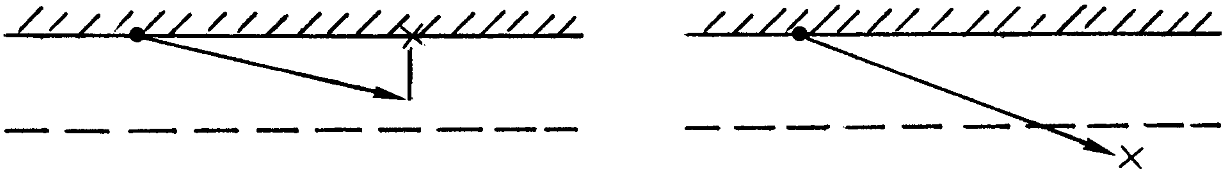
(3) If the trial location is not within a capture distance of a segment or is not within an impenetrable region, the point is free and the trial parameters become the new acceleration, velocity, and location.

Some simple cases are illustrated in Figure BIA.6. The tail and head of the arrow are the old and trial locations, respectively. The dashed line is the limit of the capture region, and an x marks the final location of the wall interaction point. The impenetrable region is the space on the side of the wall segment containing parallel slash marks.



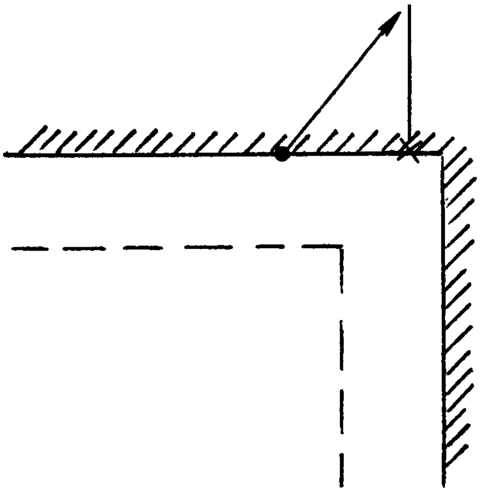
Point remains free.

Point is captured.



Point remains captured.

Point detaches from wall.



Point remains captured (into forbidden region).

Figure BIA.6. Some simple wall interaction cases.

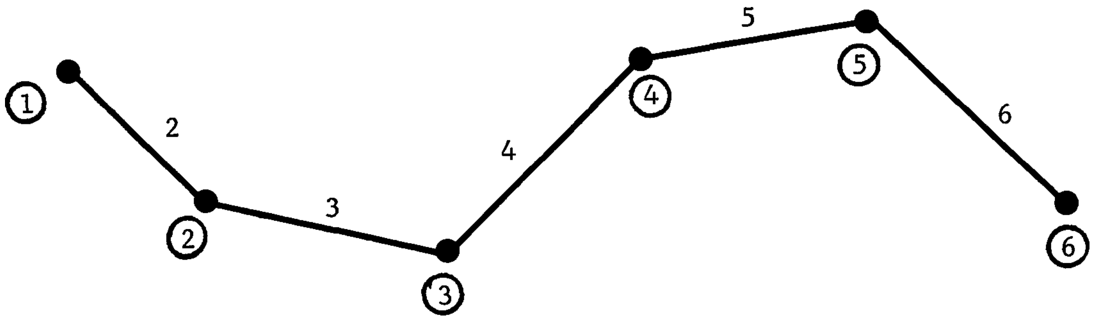
B. GEOMETRIC PATHOLOGY

The boundary grid point, wall point interaction logic in STEALTH 2D has been designed to account for most of the pathological cases of interaction. The discussion which follows describes the fundamental notions of the logic, details of the critical decision-making process, and gives examples of certain pathological cases.

The fundamental notions of the interaction logic are:

(1) First, the position of a boundary grid point (I,J) which has been specified through input to be wall-interacting is updated as if it were a free point. That is, an acceleration is computed from conservation of momentum assuming that the boundary is stress-free. The computed acceleration is integrated to get velocity and then the velocity is integrated to yield the updated position. The updated coordinates of the boundary grid point are given by (X3,Y3).

(2) Next, the wall segment number (L) nearest (or touching) the boundary grid point is determined. If the last cycle (N) was cycle zero $(N = 0)$ of the calculation, then the wall point logic assumes that, through input, the user has properly specified a value of L which identifies where the search should begin for the wall segment closest to boundary grid point (I,J). If the last cycle was not cycle zero $(N > 0)$, then STEALTH 2D logic is used to determine the nearest wall segment number (i.e., the value of L). The wall segment number is always the larger of the two wall point numbers that define the wall segment (see Figure BIA.7); its value, L, is stored in the NBV array in COMMON block /GPTARY/, Grid PoinT ArRaY, at index location (I,J). If the boundary grid point position is coincident with a wall point position, then the NBV number takes on the value of the coincident wall point number.



Wall segment numbers are not circled.

Wall point numbers are circled.

Figure BIA.7. String of wall points (sequence of wall segments).

Rev. 0
15 NOV 77

(3) After the nearest (or in contact) wall segment number is determined, the coordinates of its end points (wall points) are extracted from COMMON block /BDYARY/, BounDarY ArRaY, using the indexes L and L-1 to determine the array locations of appropriate values. The lesser wall point number (L-1) identifies the lower end of the wall segment, while the greater wall point number (L) identifies the upper end. The coordinates of the lower end are (X1,Y1), while those of the upper end are (X2,Y2) (see Figure BIA.8. If one stands on the lower wall point looking toward the upper end of the wall segment, the region on the right is the impenetrable (rigid) region (see Figure BIA.9), while the region on the left is the region in which the grid may exist free from capture. The left and right convention is consistent with the fact that wall point input data must be defined counterclockwise around a grid. Wall segments also have physical properties in addition to geometric properties. They have a capture tolerance, called DWL, which defines the distance from a wall segment that a grid point must exceed in order to remain free, and they have a material property number, MWL, which identifies the storage location of friction and cohesion coefficients.

Specific details of the interaction logic are presented below.

After computing the free acceleration and velocity of the boundary grid point, the coordinates (X3,Y3) of the boundary grid point are projected toward the closest wall segment by dropping a perpendicular line through the boundary grid point onto a line coincident with the wall segment. The coordinates of the intersection (XI,YI) are computed whether or not this intersection falls within the line segment defined by (X1,Y1), (X2,Y2). There are four interesting cases associated with the location of the intersection of the projection: Case a – the intersection could be off the lower or (X1,Y1) end (see Figure BIA.10a); Caseb – the intersection could be off the upper or (X2,Y2) end (see Figure BIA.10b); Case c – the intersection could be on the line segment (X1,Y1), (X2,Y2) and be coincident with the trial position

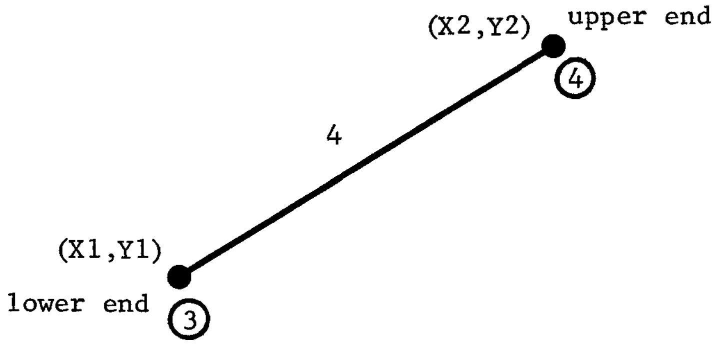


Figure BIA.8. Wall segment end point conventions.

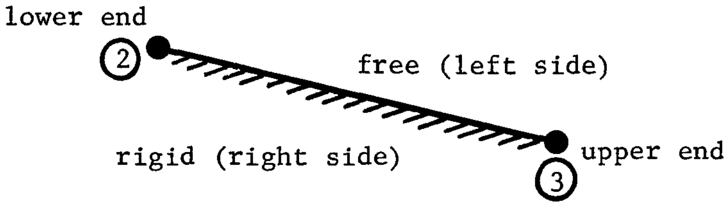
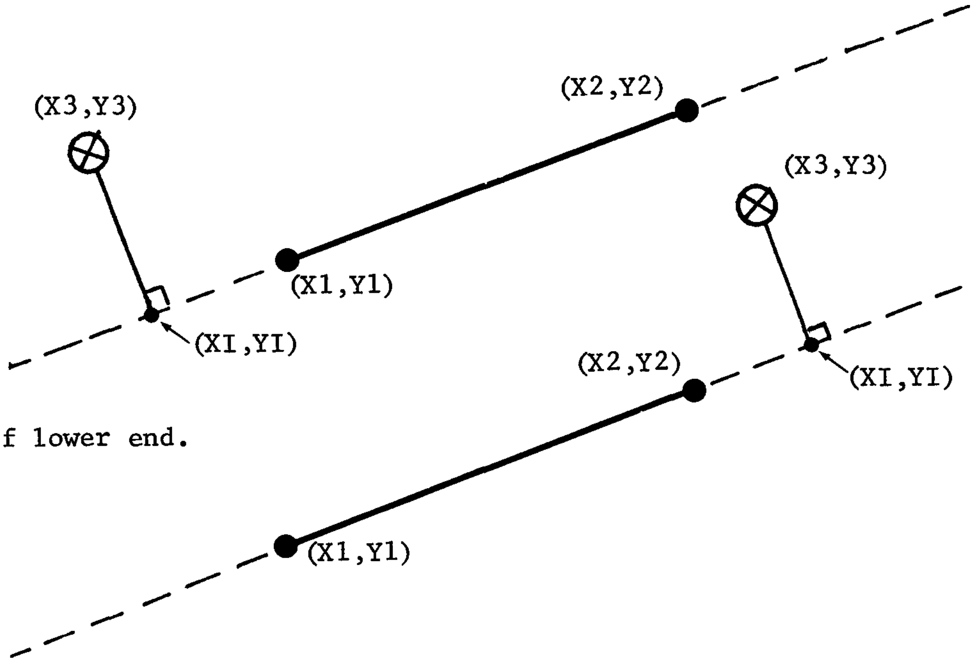
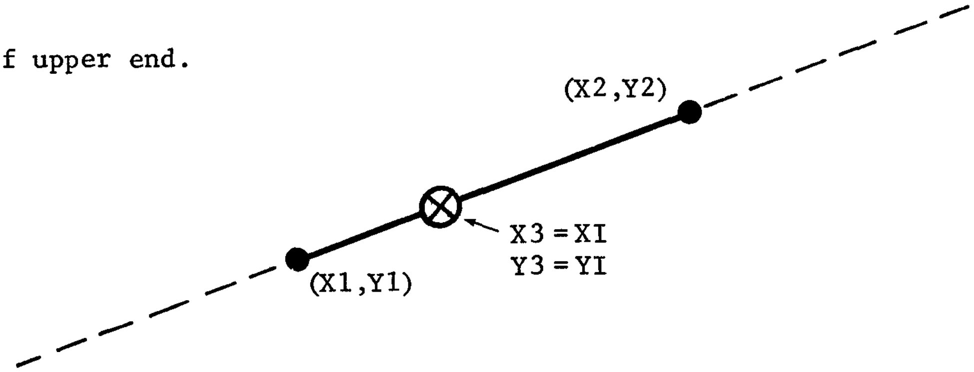


Figure BIA.9. Wall segment rigidity convention.

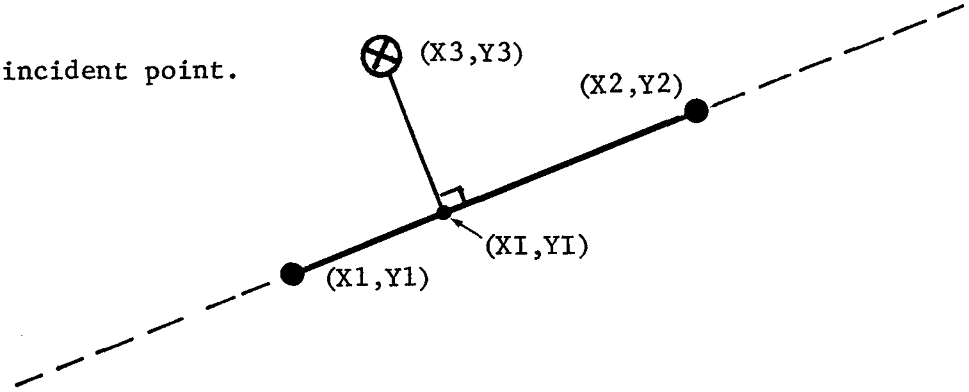


a. Off lower end.

b. Off upper end.



c. Coincident point.



d. Intersection on line segment.

Figure BIA.10. Four intersection cases. (Trial position (X3,Y3) could be on either side of wall segment.)

(X3,Y3) (see Figure BIA.10c); Case d — the intersection could be on the line segment (X1,Y1), (X2,Y2) but not be coincident with the trial position (X3,Y3) (see Figure BIA.10d).

Case c is a trivial case, since the trial position (X3,Y3) is the correct captured position of the boundary grid point on the wall segment. No adjustment need be made. Cases a and b, in which the intersection is off one of the ends of the wall segment, require a search of neighboring wall segments to determine if the grid point is now closer to any other wall segment. The discussion of the Case a and b search will be deferred until Case d is described.

Case d, in which the perpendicular projection of (X3,Y3) falls on segment (X1,Y1), (X2,Y2) implies that the point (X3,Y3) is in the "shadow" of the wall segment defined by (X1,Y1), (X2,Y2). The shadow of the wall segment is defined as that region between the perpendicular lines passing through the end points of the wall point segments (see Figure BIA.11). The shadow is divided into negative and positive regions. The negative region is defined as the impenetrable side of the wall segment. The positive region is the area in which the grid may exist.

After it has been determined that the point is within the shadow of the wall segment, the distance, DST, from (X3,Y3) to its intersection point (XI,YI) is computed (see Figure BIA.12). This distance is compared to the user-specified capture distance of the wall segment, DSTWSG (DSTWSG is the local name for DWL). If the distance is smaller than the capture distance, the point is considered captured by the wall point segment (see Figure BIA.13a). The grid point coordinates are changed to intersection coordinates (XI,YI). Grid point velocity and acceleration are then back-calculated and the wall interaction calculation and search are complete.

If the distance from point (X3,Y3) to its intersection point (XI,YI) is greater than the capture distance (see Figure BIA.13b), then a test is made to see whether the grid point is in the negative or positive shadow of the

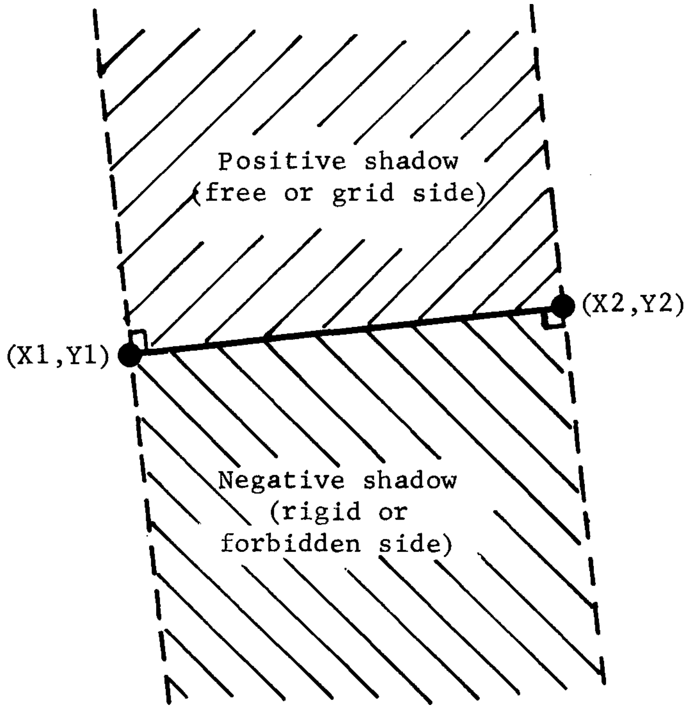


Figure BIA.11. Shadow conventions.

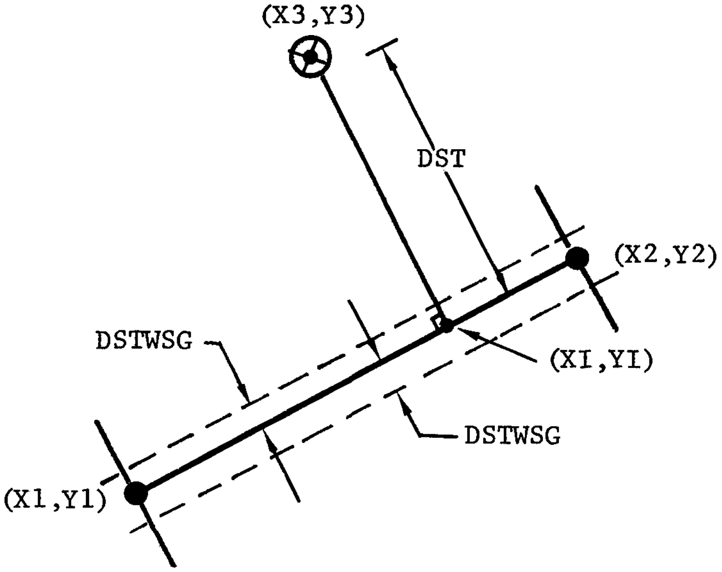
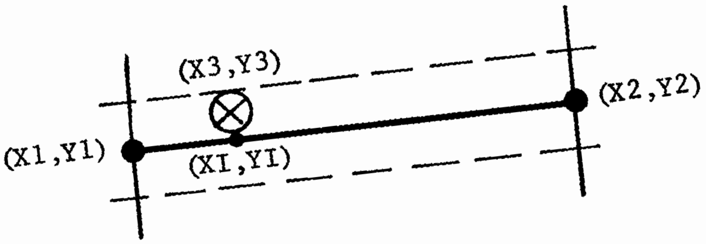
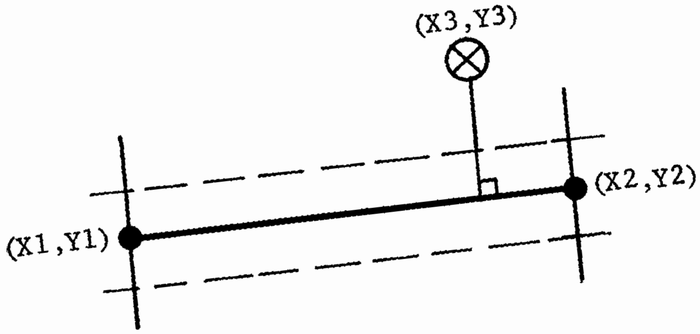


Figure BIA.12. Capture distance definitions.

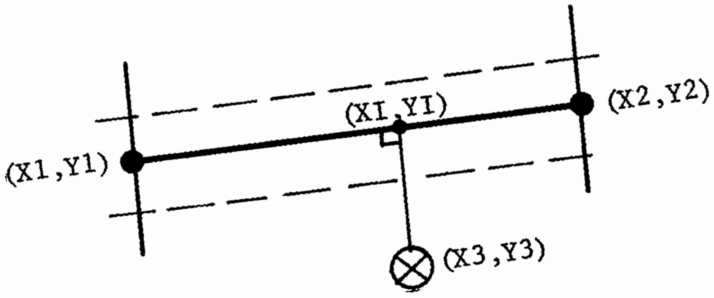
Rev. 0
15 NOV 77



Case a. DST < DSTWSG (captured in either shadow).



Case b. DST > DSTWSG (not captured if in positive shadow).

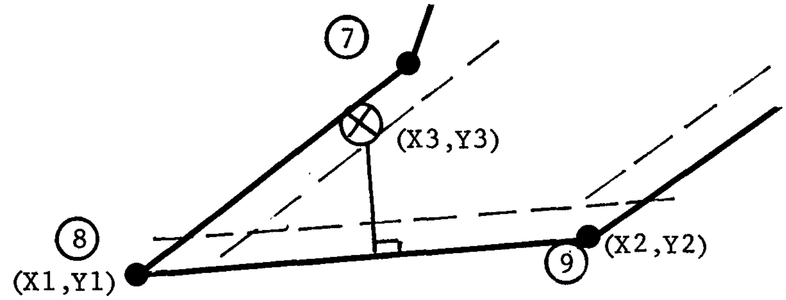


Case c. DST > DSTWSG (captured if in negative shadow).

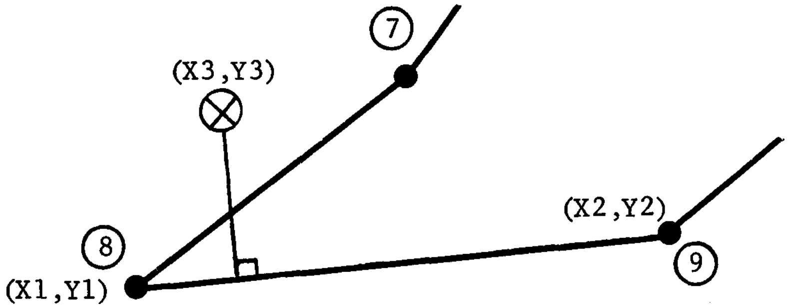
Figure BIA.13. Capture scenarios.

wall segment. If point (X3,Y3) is in the negative shadow (see Figure BIA.13c), then the grid point again takes the intersection point coordinates as its captured position. Velocity and acceleration are again back-calculated, completing the search. If the point is within the positive shadow, additional tests are performed to determine whether the boundary grid point is in contact with a different wall segment. This scenario involves testing the wall segments above and below the current wall segment to see if the pathological cases shown in Figures BIA.14a and BIA.14b exist. If one does exist, the the boundary grid point will be captured by the appropriate wall segment. If neither case exists, the point is declared free, and its previously computed position, velocity, and acceleration are permanently stored along with the value of the closest wall segment.

In the cases in which the boundary grid point is not in the shadow region (that is, the point is located off end 1 or off end 2), a search of neighboring wall segments is performed starting with the appropriate lower or upper segment. The test logic is identical to the logic previously described except that a few pathological cases exist in which the search for a new wall segment will indicate that the boundary grid point is somewhere between two wall segments but not in the shadow of either. This condition is determined when the search direction reverses once. These pathological cases are shown in Figures BIA.15a, BIA.15b, BIA.15c, and BIA.15d. The shaded area represents a region of ambiguity in the search logic. To determine the final location of the boundary point, it is necessary to differentiate the first two cases from the remaining two. This is accomplished by computing the positive shadow angle formed by the neighboring wall segments. If the positive shadow angle is greater than π radians, the grid point remains free. If the positive shadow angle is less than π radians, then the grid point is captured at the vertex of the angle (the common wall point) between the wall point segments. The specific test to separate the cases uses an area algorithm in which the sign of the area of the triangle formed by three consecutive wall points determines if the angle is less than or greater than π.

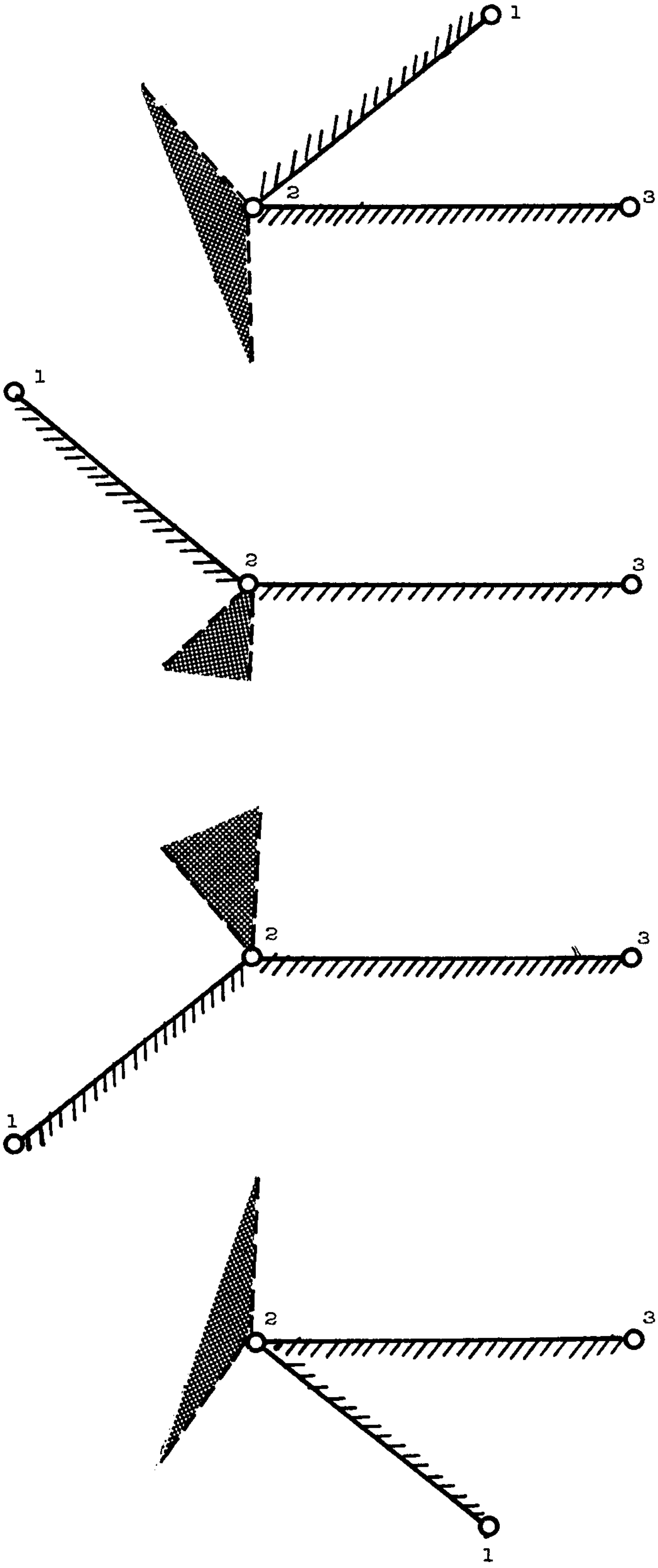


Case a. Point (X3,Y3) was declared free by wall segment 9, but is within the capture distance of the segment "below" segment 9. (An analogous case can also exist for the segment "above" segment 9.)



Case b. Point (X3,Y3) was declared free by wall segment 9, but is in the negative shadow of the segment "below" segment 9. (An analogous case can also exist for the segment "above" segment 9.)

Figure BIA.14. Pathological cases associated with free points.



a. Angle 2 less than π

b. Angle 2 less than π

c. Angle 2 greater than π

d. Angle 2 greater than π

Figure BIA.15. Pathological cases of neighbor search.

Rev. 0
15 NOV 77

In all cases, when a point is considered captured, a test is made to see how close the intersection point (XI,YI) is to each of the end points, (X1,Y1), (X2,Y2) of the capturing wall segment. If the intersection point is within a capture distance for corner points, DSTMIN, then the point is put on the appropriate end point exactly, and the NBV value is set equal to that wall point number.

C. RIGID BODY INTERACTION

Wall points may also be used to define the geometry of an interactive rigid body. This interaction capability is currently available only in the seismic version of STEALTH 2D. The discussion below is for information only.

This BIA type is similar to rigid walls in that it also uses wall points to define a rigid interaction surface. However, this sequence has to be closed in order to geometrically define the perimeter of the rigid body. The rigid body is also different in that it can respond to mesh reaction forces on its perimeter applied through the center of mass. To accomplish this, the rigid body is assigned a mass and moment of inertia through input. The location of the center of mass must also be specified. This is done by specifying one of the wall points in the sequence that also defines the rigid body perimeter as the center of mass.

Initial translational and rotational velocities can be provided for the rigid body but the motion of the rigid body is governed by a combination of the previous velocity and the exterior forces along the rigid body perimeter. External forces are computed from the stresses in the zones in contact with the rigid body perimeter. Whenever two adjacent BIA grid points are in contact with the rigid body, a STEALTH contour integral is performed to find the interaction force that acts at the BIA grid point in question. Only the inward normal (to the perimeter) force component is applied to the rigid body, i.e., no friction and no cohesion are allowed to act. In addition, each normal force component is used to compute a torque acting about the center of mass. The net force and torque on the rigid body is just the vector sum of the forces and torques from all of the contributing BIA points. The net force results in a translational motion that is identical for every wall point defining the rigid body including the center of mass location. The net torque results in an additional motion for each wall point in terms of a rotation about the center of mass.

D. SHELL FINITE-ELEMENT INTERACTION

Another application of wall points (again, available only in the seismic version of STEALTH 2D) involves the interactive coupling of an explicit finite-element shell program.

In contrast to the cases of the rigid wall or rigid body interaction, the wall points defining the finite-element structure are not rigid, but are allowed to move relative to each other as defined by the calculated flexibility of the finite-element model. By convention, there is a one-to-one correspondence between wall points and finite-element nodes. The wall point motions (node motions) are governed by internal and external forces. The internal forces arise from constitutive relations describing the finite-element material response characteristics. The external forces arise from STEALTH BIA points in contact with wall segments (element surfaces). As in the rigid body case, if two adjacent BIA grid points are in contact with a wall segment (finite-element surface), a STEALTH contour integration is performed for the BIA grid point considered. The resultant normal force (normal to the element) is transformed into an effective pressure. This effective pressure is then decomposed into forces and moments acting on the node points defining the element which is in contact with the STEALTH BIA grid points. The force and moment determination is made for all elements in contact with interacting BIA points. In addition, the finite-element nodal masses are modified to include mass contributed by the interacting STEALTH BIA grid points. At the present time, the finite-element structure can only interact with the top row of a STEALTH grid.

IV. THREE-DIMENSIONAL WALL POINT LOGIC

(This logic has not yet been implemented in STEALTH 3D.)

V. ONE-DIMENSIONAL GRID INTERACTION LOGIC

One-dimensional grid interaction logic is quite simple compared to its two- and three-dimensional counterparts. This is due in part to the fact that the topological problems associated with sliding (relative motion of two surfaces along their common interface) is not physically possible. In one-dimensional grid interaction, only void opening and closing is possible, i.e., interaction occurs only from motions normal to the interaction surfaces which are always parallel to each other. The physics governing this interaction is described in Section 4.2.3.

VI. TWO-DIMENSIONAL GRID INTERACTION LOGIC

Two-dimensional grid interaction contains the most involved logic of the various BIA types. In two-dmensional grid interaction, two contiguous STEALTH 2D grids interact by simultaneously imposing forces on one another. At present, the interaction line or slideline in STEALTH 2D can only be between adjacent rows (j-lines) at grid boundaries. This limitation is due primarily to STEALTH's extended core data buffering scheme. A STEALTH 2D mesh can be made up of up to 25 grids, each of which can interact with its immediate neighboring grids via the contiguous j-line interaction, i.e., grid #1 can interact with grid #2; grid #2 can interact with grids #1 and #3, etc.

Two extremes of the slideline algorithm have been developed and tested -- these are free sliding and tied sliding. Free sliding is frictionless-cohesionless sliding; that is, frictionless during contact and unable to maintain contact when surface tensions exist. When the grids are not in contact, a void develops between the grids and the BIA grid points are governed by stress-free boundary conditions. Void opening and closure make use of a capture distance algorithm which was discussed in a previous section of this Appendix. Tied sliding is a condition of infinite friction and infinite cohesion between the BIA grid points of both grids. Relative motion between BIA grid points of the two grids is inhibited so that these points effectively act as non-boundary (interior) grid points. The primary advantage of tied sliding is that it allows discontinuous changes in mesh discretization in the interior of the physical model.

Computation of the boundary forces in grid interaction is more involved than in the other BIA types because the coupling is simultaneous. The other BIA types use a "weaker" coupling concept called "master-slave". In grid interaction coupling, the stress tensor in each zone along both sides of the slideline of two interacting grids is rotated to a coordinate system with axes that are tangent and normal to the slideline at that particular location. Boundary interaction forces are computed by multiplying the components of the rotated stress tensor with the fractional zone length that is within a minimum contact distance of the other grid. Fractional masses along with forces are computed for each side of the slideline. The forces are then converted back to stresses and the stresses are rotated back into the original frame of reference. These values are used as stress boundary conditions for each of the grids. The fractional masses of the material on the other side of the slideline are added to the mass of the grid point being calculated for use in the computation of acceleration from the motion equations. The motion equations for slideline points are written in the tangent-normal coordinate frame. Free-sliding and tied-sliding motions are computed differently. In tied-sliding, the grid point motion is computed as if the point is an interior point, using the full STEALTH 2D surface integral, stress tensor, and mass. In free-sliding, the motion in the normal direction is also computed in this fashion, but the tangential motion is computed as if the other grid does not exist. This means that there are no inertia and stress contributions from the other grid in the tangential direction.

For each computational cycle, the free motion of the slideline points of each grid are computed. In STEALTH 2D, the lower-numbered (lower) grid becomes the position adjustment kinematic constraint for the lowest row of grid points in the next higher-numbered (upper) grid. After the motion is computed, the slideline points of the upper grid undergo contact discrimination logic and motion modification to reflect the presence of the lower grid.

The capture algorithm for grid interaction implemented in STEALTH 2D performs three tasks. First, the algorithm determines which interaction segment a boundary point can interact with (usually, this segment is the segment that is closest to the grid point). An interaction segment is defined by two consecutive grid points along a row (j-line). The second task is to determine if the boundary grid point in question is in contact with the interaction segment. If the point is not in contact, no action is taken. However, if the point is in contact, the last task of the capture algorithm is to modify the motion of the grid point to reflect the presence of the interaction segment. This modification logic is the same logic used for roller boundaries. (See "Two-Dimensional Wall Point Logic" discussed in Section III of this Appendix.)

VII. THREE-DIMENSIONAL GRID INTERACTION LOGIC

(This logic has not yet been implemented in STEALTH 3D.)

APPENDIX

FILES (FLS)

FORTRAN File Name	FORTRAN Logical Unit Number	File Description
NFCRD	5	card input
NFLIB	3	library input
NFKBD	4	on-line keyboard input
NFPRT	20	print output
NFSCP	1	scope output
NFSTG	7	storage output
NFMSG	6	message output
NFPLT	8	plot output
NFARI	17	archive input-records
NFARO	9	archive output-records
NFRSI	10	restart input-records
NFRSO	11	restart output-records
NFGPT	12	intermediate (binary) GPTGEN phase
NFZON	13	intermediate (binary) ZONGEN phase
NFBDY	14	intermediate (binary) BDYGEN phase
NFCMN	16	intermediate (binary) commmon block dump
NFIO1	12	scratch I/O number 1
NFIO2	13	scratch I/O number 2
NFIO3	14	scratch I/O number 3
NFIO4	15	scratch I/O number 4
NFIO5	17	scratch I/O number 5
NFIO6	0	scratch I/O number 6
NFIO7	0	scratch I/O number 7
NFIO8	0	scratch I/O number 8
NFIO9	0	scratch I/O number 9

This page intentionally left blank.

APPENDIX

FUNCTIONS (FNC)

PRIMARY FUNCTIONS

Polynomial (function type 1)

$$y = a_1 + a_2 x + a_3 x^2 + a_4 x^3$$

Rational (function type 2)

$$y = \frac{a_1 + a_2 x}{1 + a_3 x + a_4 x^2}$$

Exponential #1 (function type 3)

$$y = (a_1 + a_2 x + a_3 x^2) e^{-a_4 x}$$

Exponential #2 (function type 4)

$$y = a_1 + a_2 e^{(a_3 x^2 + a_4 x)}$$

Exponential #3 (function type 5)

$$y = a_1 e^{(a_2 e^{a_3 x})} + a_4$$

Trigonometric #1 (function type 6)

$$y = a_1 \left[1 - \cos(a_2 \pi x)\right] + a_3 \left[1 + \sin(a_4 \pi x)\right]$$

Trigonometric #2 (function type 7)

$$y = a_1 \sin(a_2 \pi x) + a_3 \cos(a_4 \pi x)$$

DERIVATIVES OF FUNCTIONS

Polynomial (function type 1)

$$y' = a_2 + 2a_3x + 3a_4x^2$$

Rational (function type 2)

$$y' = \frac{(a_1 + a_2x)(a_3 + 2a_4x)}{(1 + a_3x + a_4x^2)^2} \left(\frac{a_2}{1 + a_3x + a_4x^2} \right)$$

Exponential #1 (function type 3)

$$y' = \left[(a_2 - a_1a_4) + (2a_3 - a_2a_4)x - a_3a_4x^2\right]e^{-a_4x}$$

Exponential #2 (function type 4)

$$y' = a_2e^{(a_3x^2 + a_4x)} (a_4 + 2a_3x)$$

Exponential #3 (function type 5)

$$y' = a_1a_2a_3e^{a_3x} e^{(a_2e^{a_3x})}$$

Trigonometric #1 (function type 6)

$$y' = a_1a_2\pi \sin(a_2\pi x) + a_3a_4\pi \cos(a_4\pi x)$$

Trigonometric #2 (function type 7)

$$y' = a_1a_2\pi \cos(a_2\pi x) - a_3a_4\pi \sin(a_4\pi x)$$

APPENDIX

GLOSSARY (GLS)

anisotropic material

Material state described by physical properties which are arbitrarily directional. A material that has physical properties that depend on material coordinates.

boundary conditions

The state and location of physical boundaries as a function of time. Values of the primary dependent variables (including position) of the equations of change at all boundary locations for the duration of a calculated event.

cell

Smallest spatial domain with unique information defined by surrounding mesh points, nodes, or grid points. Identical to the concept of a zone, but usually refers to the Eulerian frame of reference.

column

The name associated with the vertical coordinate in index space. Sometimes referred to as an "I-line".

computational noise

Zone-to-zone oscillations of stress or velocity that do not grow in time, that have a frequency related to natural (fundamental) grid frequencies, and that do not lead to anomalous energies.

conservation equations

Basic conservation laws of physics in mathematical form; equations of change; mathematical statements of the principles of continuity, Newton's laws, and the laws of thermodynamics.

constitutive equations

All the equations that make up a material model; equations that describe the response characteristics of a material.

continuum

A physical space (fixed or moving) with defined boundaries in which mass, momentum, and energy densities are associated with large enough groups of molecules so that individual molecules do not dominate response characteristics of that domain. Regions of space in which this condition is not met are modeled as voids, i.e., regions containing no matter.

coordinates

Component values of position in terms of a defined coordinate system. Independent space variables; position vectors.

coupling

The logic required when two grids interact.

cycle

Computational time increment or time step.

deviatoric tensor

Stress or strain tensor formed by subtracting one-third of the tensor's trace from the diagonal components of the tensor itself.

dezone

When lines in a mesh are dropped to increase the distance between the nodes.

dilatational component

Stress or strain components proportional to their respective tensor traces. Also is sometimes used to refer to volume expansion.

dynamic

When the rate of change of material velocity is not zero. When material accelerates or decelerates.

effective (or equivalent) plastic strain

A scalar strain invariant used as a measure of plastic work hardening defined by

$$\epsilon^p_{eff} = \int \sqrt{\frac{2}{3} d\epsilon^p_{ij} \, d\epsilon^p_{ij}}$$

where ϵ^p_{ij} is the plastic strain tensor.

effective (or equivalent) stress

A scalar stress invariant defined by

$$\sigma_{eff} = \sqrt{\frac{3}{2} s_{ij} \, s_{ij}}$$

where s_{ij} is the stress deviator tensor.

effective (or equivalent) strain

A scalar strain invariant given by

$$\epsilon_{eff} = \sqrt{\frac{2}{3} \epsilon_{ij} \, \epsilon_{ij}}$$

where ϵ_{ij} is the strain tensor.

This page intentionally left blank.

entropy

Energy unavailable to do work. A measure of the cost of energy to produce usable work.

equation of state

The relationship between thermodynamic properties; usually only relates to scalars (e.g., hydrostatic mechanical states).

Eulerian grid (or mesh)

A computational network of fixed-in-space mesh points usually called nodes.

explicit

Variables directly dependent on time. Time is an independent variable.

finite-difference method

A method of approximating differential equations in a continuum described by a finite number of mesh points, nodes, or grid points.

flow rule

The rule describing the process (usually plastic flow) by which a material relaxes from a failed non-equilibrium state to an equilibrium yield surface.

frame of reference

The view that an observer has when watching an event. Lagrangian and Eulerian refer to moving and fixed frames of reference, respectively.

grid

The network of computational points that define a physical space in a Lagrangian frame of reference.

grid-point generation

The act of setting up the coordinate values associated with grid points.

grid points

Spatial locations that identify physical as well as zone boundaries. Usually refers to a Lagrange grid. Same as mesh points and nodes.

Grüneisen parameter

A multiplicative (equation-of-state) thermal constant for the internal energy density term of the pressure function.

history

Dependence on time.

implicit

Variables are an indirect function of time. Time is not an independent variable.

index space

Computational space which is made up of columns and rows.

initial conditions

The state of a mesh interior prior to an event. Values of the primary dependent variables at the instant an event begins.

instability

Stress or velocity oscillations that grow in time and that do not conserve energy.

isotropic material

Material state described by physical properties which are not directional. A material that has physical properties which are not directional. A material that has physical properties that are the same in all directions.

Lagrangian grid (or mesh)

A computational network of moving grid points in which the grid points are tied to the material they describe.

masterline

The column of grid points in a Lagrange grid upon which other columns of grid points (known as slave points) depend.

material model

Relationships between properties of a material that describe material response states. Constitutive relations.

mesh

The network of computational points that defines a physical space. Same as a grid.

mesh-point generation

The act of setting up the coordinate values associated with mesh points.

mesh points

Spatial locations that identify physical as well as zone or cell boundaries. Locations where vector quantities such as position, velocity, and acceleration are defined. Same as grid points and nodes.

natural symmetry

When gradients of all dependent variables are zero with respect to a coordinate direction, that direction is said to exhibit a natural symmetry.

nodes

Spatial locations that identify physical as well as zone or cell boundaries. Usually refers to an Eulerian grid. Same as grid points and mesh points.

orthotropic anisotropy

Anisotropic material in which material properties may be resolved into three orthogonal coordinates.

physical space

The real space.

plastic work

A measure of plastic work hardening per unit volume defined by

$$W^p = \int \sigma_{eff} \, d\epsilon^p_{eff}$$

where σ_{eff} is the equivalent (effective) stress and ϵ^p_{eff} is the equivalent (effective) plastic strain.

Prandtl-Reuss flow rule

An elastic-plastic stress-strain formula which relates the increments of plastic strain and the current deviatoric stress state. This flow rule assumes the von Mises yield criterion.

profile

Dependence on space; a spatial snapshot of a variable at a particular time.

remesh

When mesh points in a Lagrange mesh are reordered in order to untangle a zone.

rezone

After a remesh, the scalars, vectors, and tensors must be redistributed from the old to the new mesh. The redistribution of these quantities is called a rezone.

row

The name associated with the horizontal coordinate in index space. Sometimes referred to a a "J-line".

slave points

Boundary points of a Lagrange grid which are subject to velocity constraints. Usually refers to interactions with a masterline boundary from another Lagrange grid. Slave points on a column make up the slideline.

slideline

The column of grid points in a Lagrange grid which is composed of grid points which are slaved (tied) to another column of grid points (known as the masterline) by means of a velocity (piston) boundary condition. Slidelines are composed of slave points.

spall

A type of dynamic failure or exfoliation associated with a tension greater than the local fracture strength.

static

All variables that cause motion are in balance, i.e., there are no motions.

steady state

When the rate of change of velocity is periodic or constant.

stress equilibrium

All components of stress are in balance.

thermal equilibrium

There are no temperature imbalances.

time step

The time difference between two consecutive cycles in a calculation.

tracer particles

Massless particles imbedded in an Eulerian flow used to locate material interfaces, etc.

transients

Motion in which the rate of change of a physical variable is explicitly dependent on time as the independent variable.

yield criterion

The relationship between stress invariants describing failure processes.

APPENDIX
HYDRODYNAMIC VERSIONS (HYD)

I. INTRODUCTION

This Appendix describes special, streamlined versions of STEALTH which are applicable only to hydrodynamic calculations. These versions, called the hydro (HYD) versions, are subsets of STEALTH and were initially developed for large, two-dimensional fluid-structure interaction (FSI) calculations. The motivations for the development of the two-dimensional version were economy and size. The cost of the FSI calculations was reduced by 30% to 50% with the two-dimensional hydro version. The sizes of the hydro versions are also much smaller than the sizes of STEALTH -- an important consideration when central memory space is limited and when separate codes for the fluid and the structure must be coupled and must reside in core simultaneously.

The hydro versions have been maintained as subset codes ever since their successful application to two-dimensional FSI calculations (Reference HYD.1). Other special-purpose derivatives of the hydrodynamic versions include the 1D piping code (Reference HYD.2), and the 1D, 2D, and 3D codes for calculations of asymmetric loads on pressure vessel internals (Reference HYD.3).

The hydro versions retain the same equations of motion and the same nonlinear capabilities as the basic STEALTH codes; the major change is that the stress tensor has been simplified for hydrodynamics. Assuming an inviscid fluid, the components of the STEALTH stress tensor reduce to:

$$\sigma_{xx} = \sigma_{yy} = \sigma_{zz} = -(p+q) \ ,$$

and

$$\sigma_{xy} = \sigma_{yz} = \sigma_{xz} = 0 \ ,$$

where σ is the stress tensor, p the pressure, and q the artificial viscosity. The hydro versions store and use the quantities p and q, rather than the complete stress tensor.

The explicit hydro versions have three basic limitations when compared to STEALTH: (1) there is no thermal response capability, (2) there is no two-dimensional slideline capability, and (3) the dump overlay, with the capability of printing the contents of selected COMMON blocks, has been removed. The hydro versions retain all other STEALTH capabilities.

Changing from a full STEALTH code to a hydro version is almost transparent to the user. No new input data are required and the input files for STEALTH and hydro are usually identical. The exceptions are that the hydro version will not accept STEALTH input record types which define thermal material properties, thermal boundary conditions, or material properties for solids. These input records are normally not required for hydrodynamic simulations, so the STEALTH and hydro input files are usually identical. The computational results with STEALTH and hydro will also be identical.

II. CREATION OF THE HYDRO VERSIONS

The hydro versions are automatically created from STEALTH with three simple steps: (1) eliminate unnecessary variables, (2) streamline subroutine ZONMDL, and (3) eliminate coding for thermal response, slidelines, and the dump routines.

A. ELIMINATE VARIABLES

Since it is very time-consuming to generate individual updates for removing specific variables from a code as large as STEALTH, a special SNOBOL program was written which automatically generated most of the required updates. These updates are now a standard part of the STEALTH master file from which the STEALTH HYD hydro files are spawned. The following variables and arrays have been removed from STEALTH's COMMON blocks:

from /CMNPTR/	LTBDAS, LTBDAE
from /MATARY/	MAYLD, AYLD0, AYLD1, AYLD2, AYLD3, AYLD4, MASHR, ASHR0, ASHR1, ASHR2, ASHR3, ASHR4, MAERL, AERL0, AERL1, AERL2, AERL3, AERL4, ABCJ, MACON, ACON0, ACON1, ACON2, ACON3, ACON4, MASHC, ASHC0, ASHC1, ASHC2, ASHC3, ASHC4, ACOH, AFRC
from /GPTARY/	ZPN, ZVL, ZAC, XHF, YHF, ZHF, NBT
from /ZONARY/	ZDE, ZHE, TMP, CON, SHC, TXX, TYY, TZZ, TXY, SXX, SYY, SZZ, YLD, SHR, IGN, BFS, ACT

from /MBDARY/	MAZVL, BAZVLS, BAZVLE, BAZVL1, BAZVL2, BAZVL3, BAZVL4
from /TBDARY/	All arrays deleted
from /BDYARY/	ZWL, NWT, PRHBDY, TYYBDY, TXYBDY, TZZBDY, ZMSBDY, QDABDY, TRVBDY, TXXTOP, TYYTOP, TXYTOP, TZZTOP, ZMSTOP, QDATOP, TRVTOP
from /RSYVAL/	ARDE, ARHE, TDE, THE
from /ZONPRM/	TMPBLK, ZHEBLK, ZVLBLK, TXXBLK, TYYBLK, TZZBLK, TXYBLK, TXZBLK, TYZBLK
from /BDYPRM/	NBTBSG, NBTWSG

The thermal variables have not been removed from COMMON blocks /ZONVAR/ and /GPTVAR/ because these variables are too few to have a substantial impact on storage requirements. Appendix CVN of Volume 3 of the STEALTH manuals (Reference HYD.4) provides definitions for FORTRAN variables.

B. STREAMLINE ZONMDL

The material modeling within general-purpose STEALTH and the hydro versions is performed in subroutine ZONMDL. In general, a complex material model can increase the running time of STEALTH by up to a factor of two. Conversely, a simple fluid model can decrease the code running time significantly. Therefore, subroutine ZONMDL was streamlined for hydrodynamics in the hydro versions.

Subroutine ZONMDL computes the thermodynamic state and state of stress for each zone in a mesh. The input data to subroutine ZONMDL are the new values of relative volume, V^{n+1}, and artificial viscosity, $q^{n+\frac{1}{2}}$, plus the old (previous cycle) values of relative volume, V^n, pressure, p^n, and internal energy density per reference volume, u^n, for a zone. The streamlined version of ZONMDL solves the energy equation, $du = -(p+q)dV$, for the new values of pressure and internal energy density in a two-step iteration. The details are:

(i) Guess a new value of the internal energy, $\tilde{u}^{n+1}$, with the old value for pressure, p^n:

$$\tilde{u}^{n+1} = u^n - (p^n + q^{n+\frac{1}{2}})(V^{n+1} - V^n) .$$

(ii) Find a preliminary value for pressure, $\tilde{p}^{n+1}$, from the equation of state:

$$\tilde{p}^{n+1} = f(\tilde{u}^{n+1}, V^{n+1}) ,$$

where the function f represents the equation of state.

(iii) Apply a spall limit: if $\tilde{p}^{n+1} < p_{spl}$, set $\tilde{p}^{n+1} = p_{spl}$. The spall pressure can be a function of u and V.

(iv) Compute the average pressure, $p^{n+\frac{1}{2}}$

$$p^{n+\frac{1}{2}} = \frac{1}{2}(\tilde{p}^{n+1} + p^n) .$$

(v) Improve the computation of the new internal energy density, u^{n+1}, using the average pressure:

$$u^{n+1} = u^n - (p^{n+\frac{1}{2}} + q^{n+\frac{1}{2}})(V^{n+1} - V^n) .$$

(vi) Compute the new pressure from the equation of state:

$$p^{n+1} = f(u^{n+1}, V^{n+1}) .$$

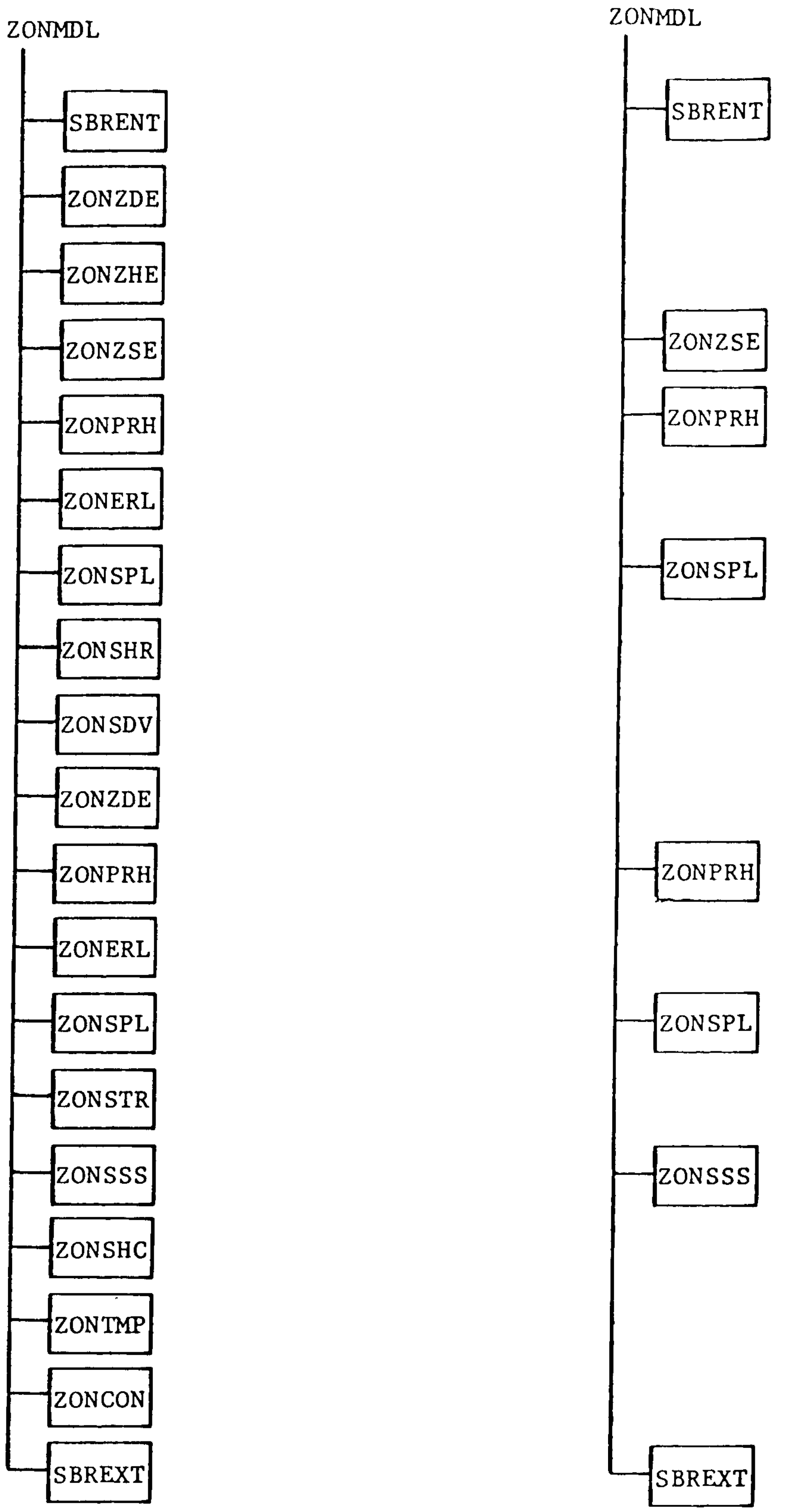
(vii) Apply the spall limit again, if necessary.

(viii) Compute a new sound speed for this zone.

The full STEALTH codes follow a similar sequence, but must also compute the elastic-plastic state of stress and the thermal state of each zone. These extra operations involve calls to ten additional subroutines, which have been eliminated from the hydro versions. The flow chart in Figure HYD.1 summarizes the material model subroutines which have been eliminated.

C. ELIMINATE CODING

Subroutines and blocks of coding for thermal response, slidelines, and the dump subroutines have been removed from the hydro versions. A few specialized subroutines, such as ZONTHN for a thin-plate option, were also removed. Table HYD.1 lists all the subroutines which have been eliminated in the hydro versions.



General-purpose STEALTH

Hydro versions

Figure HYD.1. Subroutine calls from ZONMDL for general-purpose STEALTH and for the hydro versions.

TABLE HYD.1. STEALTH SUBROUTINES DELETED FROM THE HYDRO VERSIONS

Reduce ZONMDL for Fluids

ZONZDE	
ZONZHE	
ZONERL	MYERL
ZONSHR	MYSHR
ZONSDV	MYSDV
ZONSTR	
ZONTMP	MYTMP
ZONCON	MYCON
ZONSHC	MYSHC
ZONYLD	MYYLD

Eliminate Dump Capability

OVL30

OVLDMP

DMPBDY

DMPCMN

DMPEDT

DMPGPT

DMPMAT

DMPPRB

DMPPRO

DMPTIM

DMPZON

Eliminate Thermal Capability

GPTTMP

GPTXHF

GPTYHF

Eliminate Slideline Capability

GPTGRD

BDYGRD

GETBDY

Eliminate Thin Plate Capability

ZONTHN

Eliminate Tensor Rotation

TNSROT

III. SIMPLE CALCULATIONS WITH THE HYDRO VERSIONS

Shifting from the general-purpose STEALTH codes to the hydro versions is almost transparent to a user. The input file will usually be identical for hydrodynamic calculations, with the exception of the elimination of a few input record types and a few output variables.

The hydro version will not accept the following input record types:

MAT input:	113, 114, 132, 134, 141, 142, 152, 154, 161
ZON input:	341
BDY input:	423, 451, 452, 461, 462, 463, 464

Other hydro input record types have fields for non-hydro variables or parameters. These fields may be left blank because the hydro version does not read these data fields. For example, fields 2 and 3 of the 112 input record may be left blank because these fields specify yield and shear models. (The 112 input record must be included to specify a spall model in field 4.)

Many variables have been eliminated from the hydro versions. The remaining variables have the same identifier numbers as the general-purpose codes. These identifiers are necessary for specifying output edits and plots. Table HYD.2 lists the hydro version variable identifiers for the reader's convenience.

TABLE HYD.2 HYDRO VERSION IDENTIFIERS

1	2	3	4	5	6	7	8	9	10
TIM	TIE			TKE	TEG	TXM	TYM	TXK	TYK
11	12	13	14	15	16	17	18	19	20
XPN	XVL	XAC	YPN	YVL	YAC				
21	22	23	24	25	26	27	28	29	30
GXK	GYK								
31	32	33	34	35	36	37	38	39	40
NOR	NBM		NBV		MPN	IND			
41	42	43	44	45	46	47	48	49	50
DLL	RLV	COM	QDA	VSR	DNS	ZMS	TRV		
51	52	53	54	55	56	57	58	59	60
ZIE			ZSE	ZKE					
61	62	63	64	65	66	67	68	69	70
			PRH	AVS	SSP				
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100
EX1	EX2	EX3	EX4	EX5	EX6				

IV. ADDITIONAL CHANGES FOR THE HYDRO VERSIONS

Below are described some additional changes which are too specialized to be included in the distribution form of the hydro versions, but which may be desirable for certain types of calculations. All of these changes are optional, and they can be implemented easily. These changes will cause minor numerical differences between the solution from a general-purpose STEALTH calculation and the corresponding hydro calculation.

A. A SPECIALIZED ZONMDL SUBROUTINE

The solution procedure in subroutine ZONMDL to calculate the thermodynamic state in a fluid zone is applicable to an arbitrary equation of state, such as a table look-up for a mixed phase fluid. For these general equations of state, no significant refinements to ZONMDL are possible. However, it is frequently possible to collapse the ZONMDL solution procedure for an analytic equation of state, with a corresponding saving in computation time.

Consider the case of hydrodynamic calculations with liquid water, and assume that compressibility effects are negligible. Then, a typical equation of state and spall model are:

$$p = p_o + K(1/V - 1) \; ,$$

and

$$p > p_{spl} \; ,$$

where the bulk modulus, K, the spall pressure, p_{spl}, and the reference pressure, p_o, are constant. The quantities p and V are pressure and relative volume, respectively.

Figure HYD.2 presents a special version of ZONMDL for this equation of state and spall model. The two-step iteration has been eliminated because pressure can be calculated directly from the relative volume, independent of the internal energy. A moment's reflection will show that a similar approach is valid for any equation of state which is independent of internal energy.

The two-step iteration can also be eliminated for equations of state with a simple energy dependence. For example, the equation of state for an ideal gas is:

$$p = (\gamma - 1)u/V \ ,$$

where γ is the isentropic exponent. Substituting into the energy equation to eliminate pressure,

$$\frac{du}{dV} = -(p + q) \ ,$$

or

$$\frac{du}{dV} = - \left[(\gamma - 1)u/V + q\right] \ .$$

Integration of this first-order equation determines u as a function of V:

$$u^{n+1} = \left(\frac{V^{n+1}}{V^n}\right)^{-(\gamma-1)} \left\{- \frac{q^{n+\frac{1}{2}}V^n}{\gamma} \left[\left(\frac{V^{n+1}}{V^n}\right)^{\gamma} - 1\right] + u^n\right\} ,$$

where the quantities u^n and V^n are the old (previous cycle) values of internal energy density and relative volume in a zone. A two-step iteration is no longer required because the internal energy density can be calculated directly from the value of the relative volume and the pressure can then be calculated from the equation of state.

```
        SUBROUTINE ZONMDL
C
C           PURPOSE -
C                   (*) CALCULATE INTERNAL ENERGY AND
C                       PRESSURE IN A FLUID ZONE
C
C           ADD COMMON /PRBVAR/ HERE
*CALL PRBVAR
C
C           ADD COMMON /MATVAR/ HERE
*CALL MATVAR
C
C           ADD COMMON /ZONVAR/ HERE
*CALL ZONVAR
C
C           LOCAL STORAGE FOR SUBROUTINE NAME
        DATA NSBLFT,NSBRHT/3HZON,3HMDL/
C           DEFINE HYDRODYNAMIC AND SPALL INDICATORS
        DATA NAMHYD,NAMSPL/3HHYD,3HSPL/
C
C           SAVE NAME OF CALLING SUBROUTINE
*CALL ENTSBR
C
C           CALCULATE PRESSURE AT TIME N+1
        VAR     = 1.0 /RLVN - 1.0
        PRHN    = EOS1 + EOS2 * VAR
C
C           PRESSURE MUST BE GREATER THAN THE SPALL LIMIT
        PRHN    = AMAX1(PRHN,SPL0)
C
C           DEFINE ZONE INDICATORS
C           ZERO ARTIFICIAL VISCOSITY IN ZONE SPALLED
        INDN    = NAMHYD
        IF(PRHN.NE.SPL0 ) GO TO 10
        AVSH    = 0.0
        INDN    = NAMSPL
C
C           CALCULATE ENERGY AT TIME N+1
     10 PRHH    = 0.5 * (PRHN + PRHO)
        ZIEN    = ZIEO - (PRHH + AVSH) * DLRLVH
C
C           CALCULATE SOUND SPEED SQUARED AT TIME N+1
        SSSN    = AMAX1((EOS2 / RDN),SSSMIN)
C
C           TEST FOR AN ERROR EXIT
*CALL EXTSBR
C
C           END OF SUBROUTINE ZONMDL
        RETURN
        END
```

Figure HYD.2. Special version of ZONMDL for calculations with liquid water.

B. INITIALIZING PRESSURE AT CYCLE ZERO

The general-purpose STEALTH codes have a set-up cycle, called cycle zero, which defines the initial conditions in a mesh. These initial conditions include the position and velocity of all grid points and the density, internal energy, and (usually) pressure for all zones. The total stress is generally not set to a physical value at cycle zero because the total stress may depend on strain rates, which are unknown during the set-up cycle. Since the motion equations are formulated in terms of the total stress and the total stresses are initialized to zero, there is no acceleration between cycle zero and cycle one.

Hydro versions of STEALTH are designed to be identical to the general-purpose STEALTH codes and hence no acceleration will occur between cycle zero and cycle one. However, the hydro versions do not have total stress arrays, so the only way to have no initial acceleration is to initialize the pressure in all zones to zero. This approach has been implemented in the distributed hydro versions.

It is sometimes more convenient to initialize the zone pressures to their cycle one values. The zone pressure can easily be computed with the equation of state from the input values for relative volume and internal energy density. This initialization of pressure removes a potential inconsistency between pressure boundary conditions which can start at time t = 0. The pressure should be initialized in subroutine GENCHK, just before the statement "400 CONTINUE". For example, the logic needed to initialize pressure in the two-dimensional hydro version is:

```
          ZIEN   = ZIE(I,JT)
          CALL MATPRM
          SSS(I,JT) = SSSMIN
          CALL ZONPRH
          PRH(I,JT) = PRHN
          CALL ZONSSS
          SSS(I,JT) = SSSN
      400 CONTINUE
```

The equivalent logic to initialize pressure in the one-dimensional hydro version is:

```
          ZIEN   = ZIE(I)
          MPNO   = MPN(I)
          CALL MATPRM
          SSS(I) = SSSMIN
          CALL ZONPRH
          PRH(I) = PRHN
          CALL ZONSSS
          SSS(I) = SSSN
          GO TO 500
      400 CONTINUE
```

C. REPLACING THE DIRECTIONAL STRAIN RATE (DSRH) WITH THE VOLUME STRAIN RATE (VSRH)

It may be desirable to replace the directional strain rate, DSRH, with the volume strain rate, VSRH, for certain hydrodynamic calculations. The directional strain rate is the component of the strain rate tensor in the direction of a zone-averaged acceleration vector. The volume strain rate is the rate of change of zone volume per unit volume, $\dot{V}/V$, where V is the relative volume. The directional strain rate is currently used to compute artificial viscosity and a stable time step for both the hydro versions and the full STEALTH codes.

Historically, artificial viscosity and a stable time step were computed with the volume strain rate until a pathological case was discovered. The calculation of a spherically imploding and rebounding shock is unstable with a viscosity based on volume strain rate, but stable with a viscosity based on directional strain rate. Hence the shift from VSRH to DSRH to compute artificial viscosity. Unfortunately, the approach based on directional strain rate has a drawback. The directional strain rate is based on a sensitive quantity, the direction of an acceleration vector. Therefore, DSRH varies much more rapidly than the volume strain rate. The variation in the value of DSRH produces a more rapidly varying time step. The sensitivity of DSRH can also destroy symmetry in two-dimensional calculations, because of small variations in the artificial viscosity. Both of these features are undesirable, and most two-dimensional hydrodynamic calculations are performed with a viscosity and time step based on the volume strain rate.

The substitution of VSRH for DSRH is best performed in subroutine ZONDLL. The value of DSRH is compued between statement numbers 80 and 90. The user should replace the following statement,

```
DSRH = EXXH*COSANG**2 + EYHH*SINANG**2 + 2.0 *EXYH*SINCOS
```

with the statement,

```
DSRH = VSRH
```

V. TYPICAL INPUT DECKS

A. THE SHOCK TUBE CALCULATION

A shock tube calculation is an excellent test of the capabilities of the hydro versions because an analytic solution is available and because the calculation has shock waves and expansion waves, the two basic types of waves in unsteady fluid mechanics.

A typical shock tube is a long, constant-diameter pipe which is separated by a diaphragm into a high pressure gas reservoir and a low pressure driven section. At time t = 0, the diaphragm is instantaneously removed. A shock wave propagates into the low pressure driven section, while a rarefaction or expansion propagates into the high pressure reservoir. The strength of the shock and expansion are determined by the criteria that pressure and velocity must be continuous across the contact surface separating the reservoir gas from the driven section gas. If the gas in the shock tube is ideal, with a constant ratio of specific heats, then a simple analytic formula relates the pressure ratio across the shock to the initial pressure ratio across the diaphragm.

Article C in Volume 2 of the STEALTH manuals (Reference HYD.4) presents an extensive discussion of the shock tube problem. The article contains a brief description of shock tube theory and computational results for initial pressure ratios of 2:1 and 10:1 across the diaphragm.

Appendix A in Article C contains listings of the input streams for one-dimensional and two-dimensional STEALTH calculations of a shock tube problem. These input streams can be used with the appropriate hydro versions, provided that plot numbers 7, 8, 9, and 13 on type 672 input records are removed from the one-dimensional input stream. These input records request plots of total stress, a variable which is not available in any hydro version. The two-dimensional input stream does not require any changes for the hydro version.

B. RIGID CYLINDER IMPACTS ON A POOL OF WATER

Rigid cylinder impact calculations have been performed with the two-dimensional hydro version in a plane strain geometry. Figure HYD.3 presents a schematic diagram for the calculations, and Figure HYD.4 shows the initial mesh plot for the calculations. The existence of a plane of symmetry has been used to reduce the size of the computational mesh.

The rigid cylinder is initially a small distance above a large stagnant pool of water. The cylinder is defined by 35 closely spaced wall points which are connected by straight line segments. Each cylinder wall point moves downward with a constant velocity of 7.3 m/s (7.3 X 10 cm/μs) during the calculation.

The walls of the pool are rigid and fixed with free slip in the tangential direction.

The water is modeled with a linear equation of state with constant bulk modulus, K:

$$p = K(\rho/\rho^{o} - 1) ,$$

with

$$K = 2.2 \times 10^{9}\ \mathrm{Pa}(0.022\ \mathrm{Mbar}) ,$$

where p is the pressure, ρ the density, and ρ^{o} a reference density, chosen here to be the ambient density of water. A simple water tension model, which specified that $p \geq -1.01 \times 10^{5}$ Pa (-1.0 atm), was assumed for the calculations.

As shown in Figure HYD.4, the cylinder diameter is 0.2096 m (20.96 cm). Beneath the cylinder, the zones are square with 0.45-cm sides. The cylinder wall segments are 0.51 cm long on the lower portion of the cylinder, so both the fluid grid and cylinder wall maintain the

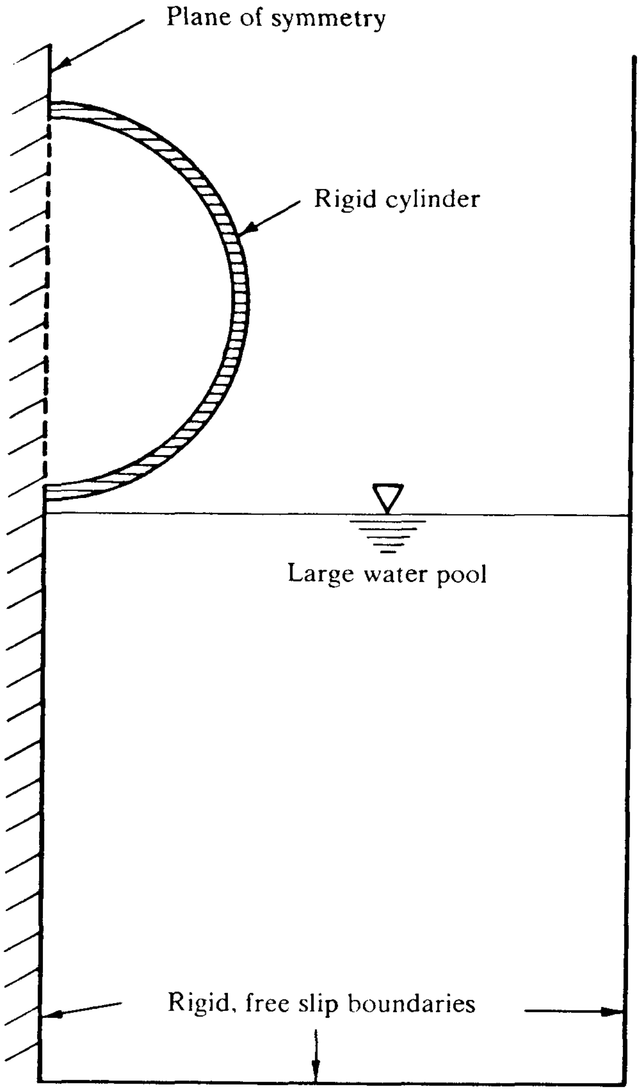


Figure HYD.3. Schematic diagram for the rigid cylinder impact calculations.

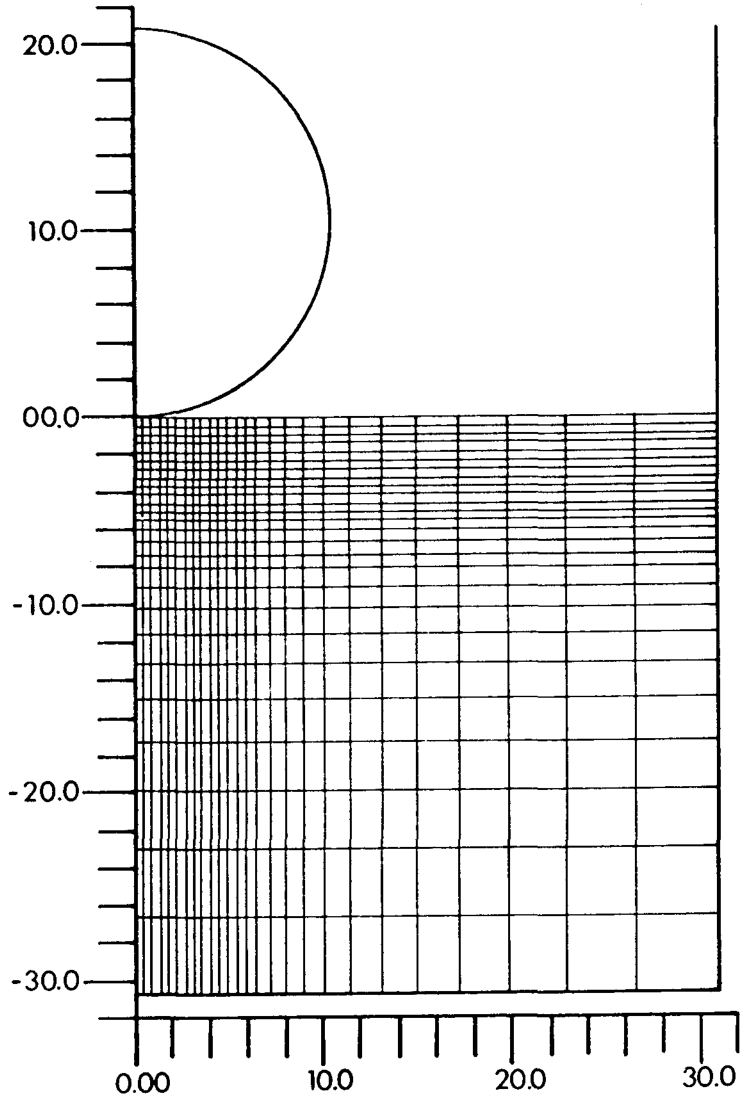


Figure HYD.4. Initial mesh for the rigid cylinder impact calculations. Distance is in centimeters.

same spatial resolution. A grid point on the top row of the fluid grid acts as a free surface point until it impacts a cylinder wall segment. After impact, the grid point moves along the wall segments with free slip. If the grid-point velocity becomes high enough, the point can detach from the cylinder wall and revert to a free surface point. Further details of the rigid cylinder impact calculations and a comparison of the calculations to experimental data are presented in Reference HYD.1.

REFERENCES

HYD.1 Michael B. Gross et al., "Fluid-Structure Interaction Calculations for Cylinders Impacting a Water Pool", Paper 78PVP-59, presented at Joint ASME/CSME Pressure Vessels and Piping Conference, Montreal, Canada, June 25-30, 1978.

HYD.2 Lynn M. Cohen, "STEALTH, A Lagrange Explicit Finite-Difference Code for Solids, Structural, and Thermohydraulic Analysis, Volume 6: Piping Version", EPRI NP-260, Electric Power Research Institute, Palo Alto, California. Prepared by Science Applications, Inc., San Leandro, California under EPRI Contract RP-307 CCM-4. (To be published.)

HYD.3 G. E. Santee, Jr. et al., "LOCA Hydroloads Calculations with Multidimensional Nonlinear Fluid/Structure Interaction". Volume 1: "STEALTH 1D Single-Phase Fluid Studies". Volume 2: "STEALTH 2D/WHAMS 2D Single-Phase Fluid, Elastic Structure Studies", EPRI NP-1401, Electric Power Research Institute, Palo Alto, California, April 1980. Prepared by Intermountain Technologies Inc., Idaho Falls, Idaho and Science Applications, Inc., San Leandro, California, under EPRI Contract RP-1065. (Volume 2 to be published.)

HYD.4 Ronald Hofmann, "STEALTH, A Lagrange Explicit Finite-Difference Code for Solids, Structural, and Thermohydraulic Analysis", EPRI NP-260, Vols. 1-3, Electric Power Research Institute, Palo Alto, California, August 1976. Prepared by Science Applications, Inc., San Leandro, California under EPRI Contract RP-307 CCM-4.

APPENDIX

IDENTIFIERS (IDS)*

1	2	3	4	5	6	7	8	9	10
TIM	TIE	TDE	THE	TKE	TEG	TXM	TYM	TXK	TYK
11	12	13	14	15	16	17	18	19	20
XPN	XVL	XAC	YPN	YVL	YAC	ZPN	ZVL	ZAC	DST
21	22	23	24	25	26	27	28	29	30
GXK	GYK	GZK	XHF	YHF	ZHF				
31	32	33	34	35	36	37	38	39	40
NOR	NBM	NBT	NBV	ACT	MPN	IND			
41	42	43	44	45	46	47	48	49	50
DLL	RLV	COM	QDA	VSR	DNS	ZMS	TRV		
51	52	53	54	55	56	57	58	59	60
ZIE	ZDE	ZHE	ZSE	ZKE					
61	62	63	64	65	66	67	68	69	70
TMP	CON	SHC	PRH	AVS	SSP	BFS	IGN		
71	72	73	74	75	76	77	78	79	80
TXX	TYY	TZZ	TXY	TYZ	TXZ				
81	82	83	84	85	86	87	88	89	90
SXX	SYY	SZZ	SXY	SYZ	SZX	YLD	SHR		
91	92	93	94	95	96	97	98	99	100
EX1	EX2	EX3	EX4	EX5	EX6				

---

*The identifiers are index (address) values for the arrays IDPTR (variable pointer) and IDATT (variable attribute) found in subroutine INIPTR. Variables 1-10 are global variables, while the rest are either grid-point or zone-related. Variable definitions may be found in Appendix "Conventions" of Volume 3, "Programmer's Manual".

Rev. 3
30 SEP 80

This page intentionally left blank.

APPENDIX

MATERIAL MODELS (MAT)

There are several independent categories of information which must be specified to form the complete mechanical-thermal response model for a material. They are:

1. Thermodynamic model, $p = p(u,V)$
2. Strength model, $\underline{\underline{s}} = s(u,V)$
3. Energy release model, $\dot{u} = u(t)$
4. Heat flow model, $\dot{h} = h(u,V)$
5. Artificial viscosity, $q = q\left(\frac{\dot{V}}{V}\right)$

The minimum set of models must be chosen to satisfy boundary and initial conditions. The functions, p, s, u, and h may take on any convenient form -- analytic or tabular.

On the following pages, standard (i.e., already programmed) models for each modeling category are described according to the model-type value specified. Standard models use the function capability wherever possible.

Special (i.e., user-supplied) models are programmed into subroutines specifically set aside for special programming. The names of these user-supplied subroutines are always five (5) characters as opposed to normal subroutine names which are composed of six (6) characters. The names of special subroutines are formed by joining the prefix MY to a root of an appropriate model identifier while the equivalent standard subroutine uses the root ZON as a prefix. The following user-supplied subroutines are available for material modeling:

Standard Subroutine	User-supplied Subroutine	Description
ZONSDV	MYSDV	stress deviators
ZONYLD	MYYLD	yield stress
ZONSHR	MYSHR	shear modulus
ZONSPL	MYSPL	spall strength
ZONTMP	MYTMP	temperature
ZONCON	MYCON	conductivity
ZONSHC	MYSHC	specific heat capacity
ZONPRH	MYPRH	pressure equation of state
ZONERL	MYERL	energy release
ZONSSS	MYSSS	sound speed squared

Any combination of standard and/or user-supplied subroutines may be used to achieve a particular set of material-response characteristics.

The calling sequence of the material modeling subroutines may be changed by re-programming subroutine ZONMDL (zone model). However, care must be taken that certain state variables in each zone be updated. These variables are summarized below.

Variable Description	Symbol	FORTRAN Array Name	Standard Model Subroutine Name	User-supplied Model Subroutine Name
Internal energy density	u	ZIE	ZONMDL	ZONMDL
Pressure	p	PRH	ZONPRH	MYPRH
Normal xx, yy, zz stresses	$\sigma_{xx}, \sigma_{yy},$	TXX,TYY,	ZONSTR	ZONSTR
	σ_{zz}	TZZ	ZONSTR	ZONSTR
Shear xy, yz, xz stresses	$\sigma_{xy}, \sigma_{yz},$	TXY,TYZ,	ZONSTR	ZONSTR
	σ_{xz}	TXZ	ZONSTR	ZONSTR
Specific heat capacity	C_V	SHC	ZONSHC	MYSHC
Temperature	T	TMP	ZONTMP	MYTMP
Conductivity	k	CON	ZONCON	MYCON
Sound speed squared	c^2	SSS	ZONSSS	MYSSS

The two-phase water equation of state for "Standard Problem #1" is an example of a user-supplied model. It is presented at the end of this Appendix. Other special material models may be developed after becoming familiar with the functions of the ZON phase PROCESSOR. The chart below lists the subroutines in the ZON phase of the PROCESSOR.

ZON
<u>Phase Scheduler</u>
ZONPRO*

ZON Phase PROCESSOR STEALTH 1D <u>One Dimension</u>	ZON Phase PROCESSOR STEALTH 2D <u>Two Dimensions</u>	ZON Phase PROCESSOR STEALTH 3D <u>Three Dimensions</u>
ZONOLD	ZONOLD	ZONOLD
ZONTHN	ZONTHN	
ZONSTN	ZONSTN	ZONSTN
MYSTN*	MYSTN*	MYSTN*
ZONTRV	ZONTRV	ZONTRV
ZONAVS*	ZONAVS*	ZONAVS*
MYAVS*	MYAVS*	MYAVS*
ZONMDL*	ZONMDL*	ZONMDL*
ZONNEW	ZONNEW	ZONNEW

Subroutine ZONPRO schedules the subroutines in the ZON phase PROCESSOR. The logic may be summarized as follows:

ZONOLD transfers last cycle's zone data from arrays in in COMMON /ZONARY/ to local variables in COMMON /ZONVAR/ .

---

*Same subroutine used for 1D, 2D, and 3D processors.

ZONTHN	for thin options only. If used, all other ZON phase subroutines are ignored and upon completion of ZONTHN, control is transferred to ZONNEW.
ZONSTN	calculates components of strain from symmetry considerations. The mean strain (i.e., the change in relative volume or compression) is also computed. Calls ZONTRV.
ZONTRV	calculates the true volume, area, and other geometry-related characteristics of a zone from symmetry considerations.
ZONAVS	calculates the components of scalar artificial viscosity from a standard model or from a user-supplied model programmed into MYAVS.
ZONMDL	contains the logic for the standard iterative constitutive model.
ZONNEW	transfers just-calculated zone data from local variables in COMMON /ZONVAR/ into array storage in COMMON /ZONARY/ .

ZONOLD and ZONNEW depend on the contents of the /ZON___/ COMMON blocks and, therefore, cannot be changed unless many other subroutines are also changed. ZONMDL may be completely replaced or changed selectively. In the latter case, changes may be made to ZONMDL logic or to the subroutines which ZONMDL calls. Below is a list of all the subroutines called directly or indirectly by subroutine ZONMDL.

Energy Density Subroutines	Material Property Subroutines
ZONZSE[*]	ZONSTR[*]
ZONZDE[*]	ZONSDV
ZONZHE	
	ZONSHR[*]
	MYSHR[*]
	ZONYLD[*]
	MYYLD[*]
	ZONSHC[*]
	MYSHC[*]
	ZONTMP[*]
	MYTMP[*]
	ZONCON[*]
	MYCON[*]
	ZONPRH[*]
	MYPRH[*]
	ZONERL[*]
	MYERL[*]
	ZONSPL[*]
	MYSPL[*]
	ZONSSS[*]
	MYSSS[*]

Most of these subroutines (specifically those under the heading "Material Property Subroutines") have already been described. The remaining subroutines (ZONZSE, ZONZDE, and ZONZHE) are used to calculate components of the internal energy density. ZONZSE is the source term; ZONZDE is the distortional strain energy; and ZONZHE provides the heat added to a zone.

---

[*] Same subroutine used for 1D, 2D, and 3D processors.

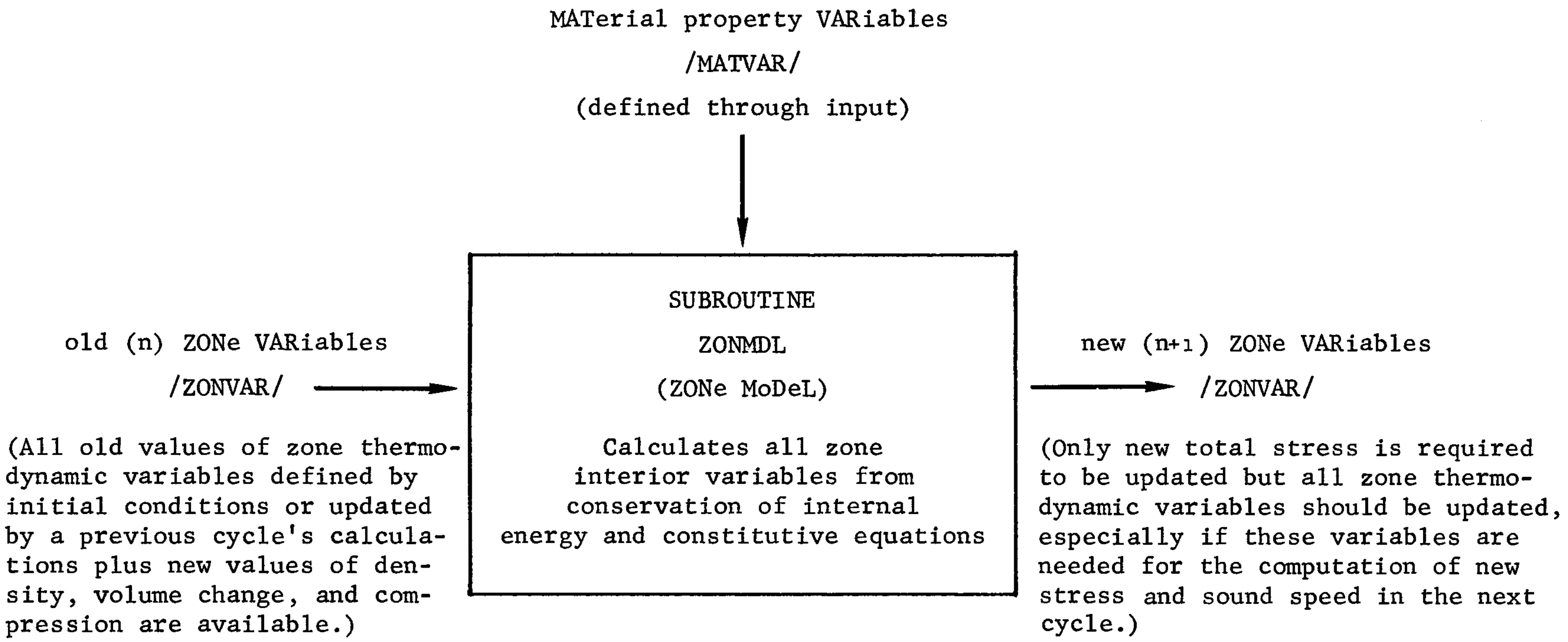
The subroutine ZONSTR, at the top of the material property column, is a bit different from the remaining property subroutines. It computes total stress components from the sum of pressure, artificial viscosity, and deviatoric stress components. ZONSTR, as well as ZONZSE, ZONZDE, and ZONZHE, use geometry-dependent formulas.

A listing of subroutine ZONMDL is shown below and on the next page.

```
C
C          CALCULATE CHANGE IN DISTORTIONAL ENERGY DENSITY AT TIME N+1/2
C          FROM STRESS DEVIATORS AT TIME N
      SXXN   = SXXO
      SYYN   = SYYO
      SZZN   = SZZO
      SXYN   = SXYO
      CALL ZONZDE
C
C          CALCULATE CHANGE IN HEAT ENERGY DENSITY AT TIME N+1/2
C          FROM HEAT FLUXES AT TIME N+1/2
C          CALCULATED FROM TEMPERATURES AT TIME N
      CALL ZONZHE
C
C          CALCULATE SOURCE ENERGY DENSITY TO BE DEPOSITED AT TIME N
      CALL ZONZSE
C
C          CALCULATE CHANGE IN INTERNAL ENERGY DENSITY AT TIME N+1/2
C          FROM PRESSURE AT TIME N, ARTIFICIAL VISCOSITY AT TIME N+1/2,
C          CHANGE OF RELATIVE VOLUME AT TIME N+1/2 AND CHANGES IN
C          ENERGY DENSITY AS DEFINED ABOVE
      ZIEN   = ZIEO - (PRHO + AVSH) * DLRLVH + DLZDEH + DLZHEH + ZSEO
C
C          CALCULATE PRESSURE AT TIME N+1
      CALL ZONPRH
C
C          CALCULATE ENERGY RELEASE PRESSURE CONTRIBUTION AT TIME N+1
      CALL ZONERL
C
C          CALCULATE SPALL STRESS AT TIME N+1
      CALL ZONSPL
C
C          CALCULATE PRESSURE AT TIME N+1/2
      PRHH   = (PRHN + PRHO) / 2.0
```

```
C
C           CALCULATE SHEAR MODULUS AT TIME N+1
      CALL ZONSHR
C
C           CALCULATE STRESS DEVIATORS AT TIME N+1
      CALL ZONSDV
C
C           CALCULATE CHANGE IN DISTORTIONAL ENERGY DENSITY AT TIME N+1/2
C           FROM STRESS DEVIATORS AT TIME N+1
      CALL ZONZDE
C
C           CALCULATE CHANGE IN INTERNAL ENERGY DENSITY AT TIME N+1/2
C           FROM PRESSURE AT TIME N+1/2, ARTIFICIAL VISC. AT TIME N+1/2,
C           CHANGE OF RELATIVE VOLUME AT TIME N+1/2 AND CHANGES IN
C           ENERGY DENSITIES AT TIME N+1/2
      ZIEN   = ZIEO - (PRHH + AVSH) * DLRLVH + DLZDEH + DLZHEH + ZSEO
C
C           CALCULATE PRESSURE AT TIME N+1
      CALL ZONPRH
C
C           CALCULATE ENERGY RELEASE PRESSURE CONTRIBUTION AT TIME N+1
      CALL ZONERL
C
C           CALCULATE SPALL STRESS AT TIME N+1
      CALL ZONSPL
C
C           CALCULATE TOTAL STRESS AT TIME N+1
      CALL ZONSTR
C
C           CALCULATE SOUND SPEED SQUARED AT TIME N+1
      CALL ZONSSS
C
C           CALCULATE TEMPERATURE AT TIME N+1
      CALL ZONTMP
C
C           CALCULATE CONDUCTIVITY AT TIME N+1
      CALL ZONCON
C
C           CALCULATE SPECIFIC HEAT CAPACITY AT TIME N+1
      CALL ZONSHC
```

Figure MAT.1 presents a schematic view of the interaction between COMMON blocks and subroutine ZONMDL, while Figure MAT.2 displays the relationship between the ZON PROCESSOR and subroutine ZONMDL. Table MAT.1 describes all the subroutines in the ZON PROCESSOR phase.



MATerial property VARiables
/MATVAR/
(defined through input)

old (n) ZONe VARiables
/ZONVAR/

(All old values of zone thermodynamic variables defined by initial conditions or updated by a previous cycle's calculations plus new values of density, volume change, and compression are available.)

SUBROUTINE
ZONMDL
(ZONe MoDeL)

Calculates all zone interior variables from conservation of internal energy and constitutive equations

new (n+1) ZONe VARiables
/ZONVAR/

(Only new total stress is required to be updated but all zone thermodynamic variables should be updated, especially if these variables are needed for the computation of new stress and sound speed in the next cycle.)

Figure 1. Conceptual flowchart of Subroutine ZONMDL.

Scheduler

ZONPRO

Main line
Subroutines

ZONOLD*
ZONTHN*
ZONSTN* (MYSTN)
ZONTRV*
ZONAVS (MYAVS)
ZONMDL → Standard Constitutive Model
ZONNEW*

Standard
Constitutive
Model

ZONZDE*
ZONZHE*
ZONZSE
ZONSTR
ZONSDV*
ZONSHR (MYSHR)
ZONYLD (MYYLD)
ZONSHC (MYSHC)
ZONTMP (MYTMP)
ZONCON (MYCON)
ZONPRH (MYPRH)
ZONERL (MYERL)
ZONSPL (MYSPL)
ZONSSS (MYSSS)

---

*Subroutine contains different programming in all three processors.

Figure 2. STEALTH Zone Processor.

TABLE MAT.1. DESCRIPTION OF ZON PHASE SUBROUTINES

- ZONPRO..........scheduler
  - ZONOLD.......transfers old zone variables from arrays
  - ZONTHN.......calculates thin symmetry zone variables
  - ZONSTN.......calculates complete strain tensor including volume change
    - MYSTN.....user-supplied strain tensor and volume change
  - ZONTRV.......calculates zone true volume
  - ZONAVS.......calculates scalar artificial viscosity
    - MYAVS.....user-supplied scalar artificial viscosity
  - ZONMDL.......schedules or calculates zone property values from thermodynamics
    - ZONZDE....calculates distortional energy density
    - ZONZHE....calculates heat transfer energy density
    - ZONZSE....calculates source energy density
    - ZONSTR....calculates stress tensor
    - ZONSDV....calculates stress deviators
    - ZONSHR....calculates shear modulus
      - MYSHR..user-supplied shear modulus
    - ZONYLD....calculates yield stress
      - MYYLD..user-supplied yield stress
    - ZONSHC....calculates specific heat capacity
      - MYSHC..user-supplied specific heat capacity
    - ZONTMP....calculates temperature
      - MYTMP..user-supplied temperature
    - ZONCON....calculates heat conductivity
      - MYCON..user-supplied heat conductivity
    - ZONPRH....calculates pressure
      - MYPRH..user-supplied pressure
    - ZONERL....calculates energy release pressure fraction
      - MYERL..user-supplied energy release pressure fraction
    - ZONSPL....calculates spall stress and pressure adjustment
      - MYSPL..user-supplied spall stress and pressure adjustment
    - ZONSSS....calculates mechanical sound speed
      - MYSSS..user-supplied mechanical sound speed
  - ZONNEW......transfers new zone variables to arrays

The standard STEALTH constitutive models, described on the following pages, are divided into three categories and additional sub-categories.

- Thermodynamics
    - Pressure equation of state
- Strength
    - Yield stress
    - Shear modulus
    - Spall
- Heat flow
    - Conductivity
    - Specific heat capacity

These are convenient categories for most material modeling considerations. They are particularly useful for describing isotropic material response.

The bulk modulus (inverse of compressibility) is a basic parameter in the pressure equation of state. The zero pressure value is directly related to the zero stress shear modulus in the strength model through relations that can be derived from the theory of elasticity. Table MAT.2 displays various useful relationships for these two "elastic" material constants.

TABLE MAT.2. RELATIONSHIPS BETWEEN ISOTROPIC ELASTIC MATERIAL CONSTANTS

	K,G	G,ν	E,ν	E,G
G =	G	G	$\frac{E}{2(1 + \nu)}$	G
K =	K	$\frac{2G(1 + \nu)}{3(1 - 2\nu)}$	$\frac{E}{3(1 - 2\nu)}$	$\frac{EG}{3(3G - E)}$
E =	$\frac{9KG}{3K + G}$	$2G(1 + \nu)$	E	E
ν =	$\frac{3K - 2G}{GK + 2G}$	ν	ν	$\frac{E}{2G} - 1$

THERMODYNAMIC MODEL

The thermodynamic model is a relationship between scalar properties of a material. Certain sets of properties (e.g., pressure (p), internal energy density (u), and relative volume (V)) form what is called a complete equation of state because mechanical, thermal, and caloric properties are included. The purpose of the pressure equation of state is to compute pressure from internal energy and relative volume. (Use of relative volume requires that a reference density, ρ^0, be defined; $V \equiv \rho^0/\rho$ where ρ is the density.)

Pressure Equation of State

Correspondence between FORTRAN input names and scientific notation is shown below. ($p > 0$ means compression.)

MEOS = equation of state, model-type value (111)*
EOS0 = equation-of-state parameter, b_0 (122)*
EOS1 = equation-of-state parameter, b_1 (122)*
EOS2 = equation-of-state parameter, b_2 (122)*
EOS3 = equation-of-state parameter, b_3 (122)*
EOS4 = equation-of-state parameter, b_4 (122)*
EOS5 = equation-of-state parameter, b_5 (123)*
EOS6 = equation-of-state parameter, b_6 (123)*
EOS7 = equation-of-state parameter, b_7 (123)*
EOS8 = equation-of-state parameter, b_8 (123)*
EOS9 = equation-of-state parameter, b_9 (123)*

MEOS = 1.0

Pressure is a function of compression (μ) where $\mu \equiv \frac{1}{V} - 1.$

$$p = f(b_1, b_2, b_3, b_4, \mu) \qquad b_5 \le \mu \le b_6$$

The functional form f is the standard function type given by the value b_0 (see Appendix "Functions"). For example, if $b_0 = 1.0$, then the pressure equation of state is

$$p = b_1 + b_2\mu + b_3\mu^2 + b_4\mu^3$$

---

*Input record number.

MEOS = 2.0

Pressure is a function of internal energy density (u) where $u \equiv \hat{u}\rho^o$.

$$p = f(b_1, b_2, b_3, b_4, u) \qquad b_5 \le u \le b_6$$

The functional form f is the standard function type given by the value b_0 (see Appendix "Functions"). For example, if b_o = 3.0, then the pressure equation of state is

$$p = (b_1 + b_2 u + b_3 u^2)e^{-b_4 u}$$

MEOS = 3.0

Pressure is a function of internal energy density and compression.

$$p = f_\ell(b_1, b_2, b_3, b_4, \mu) + u[f_m(b_8, b_9, \mu)] \qquad b_5 \le \mu \le b_6$$

The functional forms f_ℓ and f_m are the standard function types* given by the values b_0 and b_7, respectively (see Appendix "Functions"). For example, if b_0 = 5.0, and b_7 = 2.0, then the pressure equation of state is

$$p = b_1 e^{(b_2 e^{b_3 \mu})} + b_4 + u(b_8 + b_9 \mu)$$

For f_2, the coefficients b_8 and b_9 correspond to the first two function coefficients, a_1 and a_2. The other two coefficients, a_3 and a_4, are assumed to be zero.

---

*ℓ and m designate function types 1-10.

MEOS = 4.0

$p - \alpha$ compaction model. For the theoretical background of this model, see the following reference:

W. Herrmann, J. Appl. Phys. 40, p.2490 (1969)

(not yet programmed)

MEOS = 5.0

JWL chemical explosive model For the theoretical background of this model, see the following reference:

E. L. Lee, H. C. Hornig, and J. W. Kury, "Adiabatic Expansion of High Explosive Detonation Products," UCRL-50422, Lawrence Livermore Laboratory, Livermore, California, May 2, 1968

Pressure is a function of relative volume (V) and internal energy density.

$$p = b_0\left(1.0 - \frac{b_4}{b_2 V}\right) e^{-b_2 V} + b_1\left(1.0 - \frac{b_4}{b_3 V}\right) e^{-b_3 V} + b_4 \frac{u}{V} .$$

MEOS = 6.0, 7.0, 8.0, 9.0, 10.0

User-supplied, pressure equation-of-state models. Model logic is programmed into subroutine MYPRH. An example of MYPRH is presented at the end of this Appendix.

STRENGTH MODEL

The standard strength model is made up of a yield stress (Y) model, a shear modulus (G) model, and a spall strength (p_{min}) model. Each model contributes to the strength calculation in a different way.

Yield Stress Model

Correspondence between FORTRAN input names and scientific notation is shown below. ($Y \geq 0.$)

MYLD = yield stress model-type value (112)*
YLD0 = yield stress parameter, y_o (132)*
YLD1 = yield stress parameter, y_1 (132)*
YLD2 = yield stress parameter, y_2 (132)*
YLD3 = yield stress parameter, y_3 (132)*
YLD4 = yield stress parameter, y_4 (132)*

MYLD = 1.0

Yield stress is zero (hydrodynamic model, i.e., s_{ij} are set to zero).

$$Y = 0.0$$

MYLD = 2.0

Yield stress is a constant.

$$Y = y_o$$

---

*Input record number.

MYLD = 3.0

Yield stress is a function of pressure (p) only.

$$Y = f(y_1, y_2, y_3, y_4, p)$$

The functional form f is the standard function type given by the value y_0 (see Appendix "Functions"). For example, if y_0 = 2.0, then the yield stress model is

$$Y = \frac{y_1 + y_2 p}{1 + y_3 p + y_4 p^2}$$

MYLD = 4.0

Yield stress is a function of internal energy density (u) only.

$$Y = f(y_1, y_2, y_3, y_4, u)$$

The functional form f is the standard function type given by the value y_0 (see Appendix "Functions"). For example, if y_0 = 4.0, then the yield stress model is

$$Y = y_1 + y_2 e^{(y_3 u^2 + y_4 u)}$$

MYLD = 5.0

Yield stress is a function of the absolute value of distortional energy density ($|Z|$) only.

$$Y = f(y_1, y_2, y_3, y_4, |Z|)$$

The functional form f is the standard function type given by the value y_0 (see Appendix "Functions"). For example, if y_0 = 1.0, then the yield stress model is

$$Y = y_1 + y_2 |Z| + y_3 |Z|^2 + y_4 |Z|^3$$

MYLD = 6.0, 7.0, 8.0, 9.0, 10.0

User-supplied yield stress models. Model logic is programmed into subroutine MYYLD.

Shear Modulus Model

Correspondence between FORTRAN input names and scientific notation is shown below. ($G \geq 0.$)

MSHR	= shear modulus model-type value	(112)*
SHR0	= shear modulus parameter, g_0	(134)*
SHR1	= shear modulus parameter, g_1	(134)*
SHR2	= shear modulus parameter, g_2	(134)*
SHR3	= shear modulus parameter, g_3	(134)*
SHR4	= shear modulus parameter, g_4	(134)*

MSHR = 1.0

Shear modulus is zero (hydrodynamic model, i.e., s_{ij} are set to zero).

$$G = 0.0$$

MSHR = 2.0

Shear modulus is a constant.

$$G = g_0$$

MSHR = 3.0

Shear modulus is a function of relative volume (V) only.

$$G = f(g_1, g_2, g_3, g_4, V)$$

The functional form f is the standard function type given by the value g_0 (see Appendix "Functions"). For example, if $g_0 = 2.0$, then the shear modulus model is

$$G = \frac{g_1 + g_2 V}{1 + g_3 V + g_4 V^2}$$

---

[*] Input record number.

MSHR = 4.0

Shear modulus is a function of internal energy density (u) only.

$$G = f(g_1, g_2, g_3, g_4, u)$$

The functional form f is the standard function type given by the value g_0 (see Appendix "Functions"). For example, if $g_0 = 4.0$, then the shear modulus model is

$$G = g_1 + g_2 e^{(g_3 u^2 + g_4 u)}$$

MSHR = 5.0

Shear modulus is a function of pressure (p) only.

$$G = f(g_1, g_2, g_3, g_4, p)$$

The functional form f is the standard function type given by the value g_0 (see Appendix "Functions"). For example, if $g_0 = 1.0$, then the shear modulus model is

$$G = g_1 + g_2 p + g_3 p^2 + g_4 p^3$$

MSHR = 6.0, 7.0, 8.0, 9.0, 10.0

User-supplied shear modulus models. Model logic is programmed in subroutine MYSHR.

Spall Model

Correspondence between FORTRAN input names and scientific notation is shown below. (When $p \le p_{min}$ and $p_{min} \le 0.0$, then s_{ij} and p are set to zero and c_ℓ is set to $c_{\ell_{min}}$. When $p \le p_{min}$ and $p_{min} > 0.0$, then s_{ij} is set to zero, p is set to p_{min}, and c_ℓ is computed from the equation of state.)

MSPL = spall model-type value	(112)*
SPL0 = spall parameter, s_0	(136)*
SPL1 = spall parameter, s_1	(136)*
SPL2 = spall parameter, s_2	(136)*
SPL3 = spall parameter, s_3	(136)*
SPL4 = spall parameter, s_4	(136)*

MSPL = 1.0

Spall is zero (hydrodynamic model).

$$p_{min} = 0.0$$

MSPL = 2.0

Spall is a constant. (A large negative value will inhibit spall. A small positive value is a pseudo vapor pressure.)

$$p_{min} = s_o$$

MSPL = 3.0

Spall is a function of relative volume (V) only.

$$p_{min} = f(s_1, s_2, s_3, s_4, V)$$

The functional form f is the standard function type given by the value s_0 (see Appendix "Functions"). For example, if $s_0 = 2.0$, then the spall model is

$$p_{min} = \frac{s_1 + s_2 V}{1 + s_3 V + s_4 V^2}$$

---

*Input record number.

MSPL = 4.0

Spall is a function of internal energy density (u) only.

$$p_{min} = f(s_1, s_2, s_3, s_4, u)$$

The functional form f is the standard function type given by the value s_0 (see Appendix "Functions"). For example, if s_0 = 4.0, then the spall model is

$$p_{min} = s_1 + s_2 e^{(s_3 u^2 + s_4 u)}$$

MSPL = 5.0

Spall is a function of the absolute value of distortional energy density ($|Z|$) only.

$$p_{min} = f(s_1, s_2, s_3, s_4, |Z|)$$

The functional form f is the standard function type given by the value s_0 (see Appendix "Functions"). For example, if s_0 = 1.0, then the spall model is

$$p_{min} = s_1 + s_2 |Z| + s_3 |Z|^2 + s_4 |Z|^3$$

MSPL = 6.0, 7.0, 8.0, 9.0, 10.0

User-supplied spall models. Model logic is programmed into subroutine MYSPL.

ENERGY RELEASE MODEL

The energy release model is a relationship between the chemically evolved energy density (E) of a material and the chemical components of the material.

Correspondence between FORTRAN input names and scientific notation is shown below.

MERL = energy release model-type value (113)*
ERL0 = energy release parameter, r_0 (142)*
ERL1 = energy release parameter, r_1 (142)*
ERL2 = energy release parameter, r_2 (142)*
ERL3 = energy release parameter, r_3 (142)*
ERL4 = energy release parameter, r_4 (142)*

MERL = 1.0

Energy release is zero.

$$E = 0.0$$

MERL = 2.0

Energy release is a Chapman-Jouguet explosive

(logic to be added)

MERL = 3.0, 4.0, 5.0

No models presently defined.

MERL = 6.0, 7.0, 8.0, 9.0, 10.0

User-supplied energy release models. Model logic is programmed into subroutine MYERL.

---

*Input record number.

HEAT FLOW MODEL

The heat flow model is made up of a conductivity (k) model and a specific heat capacity (C_V) model. Each model contributes to the heat flow calculation in a different way.

Conductivity Model

Correspondence between FORTRAN input names and scientific notation is shown below. ($k \geq 0.$)

MCON = conductivity model-type value (114)*

CON0 = conductivity parameter, k_0 (152)*

CON1 = conductivity parameter, k_1 (152)*

CON2 = conductivity parameter, k_2 (152)*

CON3 = conductivity parameter, k_3 (152)*

CON4 = conductivity parameter, k_4 (152)*

MCON = 1.0

Conductivity is zero (no heat conduction model).

$$k = 0.0$$

MCON = 2.0

Conductivity is a constant.

$$k = k_0$$

---

*Input record number.

MCON = 3.0

Conductivity is a function of temperature (T) only.

$$k = f(k_1, k_2, k_3, k_4, T)$$

The functional form f is the standard function given by the value k_o (see Appendix "Functions"). For example, if $k_o = 2.0$, then the conductivity model is

$$k = \frac{k_1 + k_2 T}{1 + k_3 T + k_4 T^2}$$

MCON = 4.0, 5.0

No models presently defined.

MCON = 6.0, 7.0, 8.0, 9.0, 10.0

User-supplied, conductivity models. Model logic is programmed into MYCON.

Specific Heat Capacity Model

Correspondence between FORTRAN input names and scientific notation is shown below. ($C_V \geq 0.$)

MSHC	= specific heat capacity model-type value	(114)*
SHC0	= specific heat capacity parameter, c_0	(156)*
SHC1	= specific heat capacity parameter, c_1	(156)*
SHC2	= specific heat capacity parameter, c_2	(156)*
SHC3	= specific heat capacity parameter, c_3	(156)*
SHC4	= specific heat capacity parameter, c_4	(156)*

MSHC = 1.0

Specific heat capacity is zero.

$$C_V = 0.0$$

MSHC = 2.0

Specific heat capacity is a constant.

$$C_V = c_0$$

---

*Input record number.

MSHC = 3.0

Specific heat capacity is a function of temperature (T) only.

$$T = f(c_1, c_2, c_3, c_4, T)$$

The functional form f is the standard function given by the value c_0 (See Appendix "Functions"). For example, if c_0 = 2.0, then the specific heat capacity model is

$$C_V = \frac{c_1 + c_2 T}{1 + c_3 T + c_4 T^2}$$

MSHC = 4.0, 5.0

No models presently defined.

MSHC = 6.0, 7.0, 8.0, 9.0, 10.0

User-supplied, specific heat capacity models. Model logic is programmed into MYSHC.

EXAMPLE OF USER-SUPPLIED MODEL

```
      SUBROUTINE MYPRH
C
C           PURPOSE  -
C                     (*) CALCULATE THE PRESSURE
C                         FROM A USER SPECIFIED MODEL
C           DATA IN  -
C                     (*) CMN VAR RLVN,    /ZONVAR/
C                     (*) CMN VAR ZIEN,    /ZONVAR/
C                     (*) CMN VAR NCCYC,   /PRBVAR/
C           DATA OUT -
C                     (*) CMN VAR PRHN,    /ZONVAR/
C
C           THIS IS A MIXED, TWO-PHASE EQUATION OF STATE FOR WATER.
C           44 POINTS DEFINE THE SATURATION LINE FOR WATER AND STEAM.
C           THE ROUTINE HAS A TABLE SEARCH THROUGH LINES OF CONSTANT
C           PRESSURE AND CONSTANT TEMPERATURE, FOLLOWED BY A LINEAR
C           INTERPOLATION BETWEEN LINES.
C
C           *****  THIS ROUTINE ASSUMES A REFERENCE DENSITY OF 1.0  *****
C
C
*CALL ZONVAR
*CALL PRBVAR
*CALL TIMVAR
C
      DIMENSION TSAT(44),PSAT(44),VSATL(44),VSATV(44),
     1          ESATL(44),ESATV(44)
C
      DATA BMOD /19575.6/
      DATA NSW /2/
```

```
C
C         TSAT IS THE SATURATION TEMPERATURE (CELCIUS)
C         PSAT IS THE SATURATION PRESSURE (BARS)
C         VSATL IS THE SPECIFIC VOLUME OF SATURATED LIQUID (CC/GM)
C         VSATV IS THE SPECIFIC VOLUME OF SATURATED VAPOR (CC/GM)
C         ESATL IS THE ENTHALPH OF SATURATED LIQUID (J/GM)
C         ESATV IS THE ENTHALPY OF SATURATED VAPOR (J/GM)
C
      DATA (TSAT(L),L=1,44)  /0.0,.01,10.,20.,30.,40.,50.,60.,70.,80.,
     190.,100.,110.,120.,130.,140.,150.,160.,170.,180.,190.,200.,210.,
     2220.,230.,240.,250.,260.,270.,280.,290.,300.,310.,320.,330.,340.,
     3350.,360.,370.,371.,372.,373.,374.,374.15/
      DATA (PSAT(L),L=1,44)  /.006108,.006112,.012271,.023368,.042418,
     1.07375,.12335,.19919,.31161,.47358,.70109,1.01325,1.4327,1.9854,
     22.7011,3,6136,4.7597,6.1804,7.9202,10.027,12.553,15.55,19.08,
     323.202,27.979,33.48,39.776,46.941,55,052,64.191,74.449,85.917,
     498,694,112.89,128.64,146.08,165.37,186.74,210.53,213.06,215.63,
     5218.2,220.9,221.2/
      DATA (VSATL(L),L=1,44) /1,00021,1.0002101,1.0004,1.0018,1.0044,
     11.0079,1.0121,1.0171,1.0228,1.029,1.0359,1.0435,1.0515,1.0603,
     21.0697,1.0798,1.0906,1.1021,1.1144,1.1275,1,1415,1.1565,1.1726,
     31.19,1.2087,1.2291,1,2512,1.2755,1.3023,1.3321,1.3655,1.4036,
     41.4475,1.4992,1.562,1.639,1.741,1.894,2.22,2.29,2.38,2.51,2.8,
     53.17/
      DATA (VSATV(L),L=1,44) /206288.,206146.,106422.,57836.,32929.,
     119546.,12045.,7677.6,5045.3,3408.3,2360.9,1673.,1210.1,891.71,
     2668.32,508.66,392.57,306.85,242.62,193.85,156.35,127.19,104.265,
     386.062,71.472,59.674,50.056,42.149,35.599,30.133,25.537,21.643,
     418.316,15.451,12.967,10.779,8.805,6.943,4.93,4.68,4.4,4.05,3.47,
     53.17/
      DATA (ESATL(L),L=1,44) /-.0416,.000611,41.99,83.86,125.66,167.47,
     1209.3,251.1,293.,334.9,376.9,419.1,461.3,503.7,546.3,589.1,632.2,
     2675.5,719.1,763.1,807.5,852.4,897.7,943.7,990.3,1037.6,1085.8,
     31135.,1185.2,1236.8,1290.,1345.,1402.,1462.,1526.,1596.,1672.,
     41762.,1892.,1913.,1937.,1969.,2032.,2095./
      DATA (ESATV(L),L=1,44) /2501.,2501.,2519.,2538.,2556.,2574.,2592.,
     12609.,2626.,2643.,2660.,2676.,2691.,2706.,2720.,2734.,2747.,2758.,
     22769.,2778.,2786.,2793.,2798.,2802.,2803.,2803.,2801.,2796.,2790.,
     32780.,2766.,2749.,2727.,2700.,2666.,2623.,2565.,2481.,2331.,2305.,
     42273.,2230.,2146.,2095./
```

```
C
C          PUT NAME OF THIS SUBROUTINE IN COMMON /PRBVAR/
      CALL SBRENT(3H MY,3HPRH)
C
C          CONVERT AND PRINT OUT DATA FOR SATURATION LINE - PERFORMED ONCE
C          CONVERT ENTHALPY TO INTERNAL ENERGY (.1*J/GM)
C          TIME IS NOW IN MILLISECONDS
      GO TO (100,10),NSW
   10 NSW = 1
      DO 20 L = 1,44
      ESATL(L) = 10.*ESATL(L) - PSAT(L)*VSATL(L)
   20 ESATV(L) = 10.*ESATV(L) - PSAT(L)*VSATV(L)
      WRITE(NFPRT,25)(TSAT(L),PSAT(L),VSATL(L),VSATV(L),
     1                ESATL(L),ESATV(L),L=1,44)
      WRITE(NFMSG,25)(TSAT(L),PSAT(L),VSATL(L),VSATV(L),
     1                ESATL(L),ESATV(L),L=1,44)
   25 FORMAT(1H1,33X,24HSATURATION LINE (METRIC),///4X,11HTEMPERATURE,
     15X,8HPRESSURE,14X,13HVOLUME (CC/G),10X,25HINTERNAL ENERGY  (.1*J/G
     2)/4X,11H  (DEG C)  ,5X,8H (BARS) ,9X,5HWATER,10X,5HSTEAM,10X,
     35HWATER,10X,5HSTEAM/(1P6E15.5))
C
C          BEGIN SEARCH FOR ENERGIES WHICH BRACKET ZIEN
C          ZIEN IS THE ZONE INTERNAL ENERGY
C          RLVN IS THE ZONE RELATIVE VOLUME
C          AQTY IS THE QUALITY AT K
C          ZIEK IS THE INTERNAL ENERGY AT K
C          ZIEL IS THE INTERNAL ENERGY AT L
  100 CONTINUE
      AQTY = (RLVN - VSATL(1))/(VSATV(1) - VSATL(1))
      ZIEL = ESATL(1) + (ESATV(1) - ESATL(1))*AQTY
      DO 110 K = 2,43
      KK = K
      AQTY = (RLVN - VSATL(K))/(VSATV(K) - VSATL(K))
      ZIEK = ESATL(K) + (ESATV(K) - ESATL(K))*AQTY
      IF (ZIEN .LT. ZIEK) GO TO 120
      IF (AQTY .GT. 1. .OR. AQTY .LT. 0.0)GOTO 120
      ZIEL = ZIEK
  110 CONTINUE
      KK = 44
      ZIEK = ESATL(KK)
      IF(ZIEN .LT. ZIEK) GO TO 120
      GO TO 1000
```

```
      SUBROUTINE MYSSS
C
C           PURPOSE  -
C                       (*) CALCULATE SOUND SPEED SQUARED
C                           FROM USER SPECIFIED MODEL
C           DATA IN  -
C                       (*) CMN VAR PRHN,   /ZONVAR/
C                       (*) CMN VAR RLVN,   /ZONVAR/
C                       (*) CMN VAR ZIEN,   /ZONVAR/
C                       (*) CMN VAR DNSN,   /ZONVAR/
C                       (*) CMN VAR EX2N,   /ZONVAR/
C                       (*) CMN VAR SSSMIN, /PRBVAR/
C           DATA OUT -
C                       (*) CMN VAR SSSN,   /ZONVAR/
C
*CALL ZONVAR
*CALL PRBVAR
C
      DATA BMOD /19575.6/
C
C           PUT NAME OF SUBROUTINE IN COMMON /PRBVAR/
      CALL SBRENT(3H MY,3HSSS)
C
C           SSSN IS THE ZONE SOUND SPEED SQUARED
C           QTY IS THE ZONE QUALITY
C           PRHN IS THE ZONE PRESSURE
C           RLVN IS THE ZONE RELATIVE VOLUME
C           DNSN IS THE ZONE DENSITY
C
C           TEST FOR LIQUID OR MIXED PHASE
      QTY = EX2N
      IF (PRHN .GT. EX6N .AND. QTY .LT. 0.0)GO TO 100
C
C           MIXED PHASE SOUND SPEED WITH AN EFFECTIVE GAMMA
      GAM = 1. + PRHN*RLVN/ZIEN
      SSSN = GAM*PRHN/DNSN
      GOTO 200
C
C           COMPRESSED LIQUID SOUND SPEED
  100 SSSN = BMOD/DNSN
  200 IF(SSSN .LT. SSSMIN) SSSN = SSSMIN
C
C           DETERMINE IF ERROR EXIT IS NECESSARY
      CALL SBREXT(3H MY,3HSSS)
C
C           END OF SUBROUTINE MYSSS
      RETURN
      END
```

```
C
C          PERFORM LINEAR INTERPOLATION BETWEEN TWO SATURATION STATES
C          THE ENERGY FRACTION IS THE INTERPOLATION PARAMETER
C          EFRAC IS THE ENRGY FRACTION
C          PRHMIX IS THE TWO-PHASE MIXTURE PRESSURE
C          PRHLIQ IS THE LIQUID PRESSURE
C          TMPN IS THE ZONE TEMPERATURE
C          QTY IS THE ZONE QUALITY
C          RLVL IS THE RELATIVE VOLUME OF LIQUID
C          RLVV IS THE RELATIVE VOLUME OF VAPOR
  120 EFRAC = (ZIEN - ZIEL)/(ZIEK - ZIEL)
      L = KK - 1
      IF (NCCYC .EQ. 1) PRHO = 68.95
      IF (NCCYC .EQ. 1) CONN = EX50
      PRHLQD = PRHO - BMOD*ALOG(RLVN/RLVO)
      PRHMIX = PSAT(L) + EFRAC*(PSAT(KK) - PSAT(L))
      TMPN = TSAT(L) + EFRAC*(TSAT(KK) - TSAT(L))
      RLVL = VSATL(L) + EFRAC*(VSATL(KK)-VSATL(L))
      RLVV = VSATV(L) + EFRAC*(VSATV(KK) - VSATV(L))
      QTY = (RLVN - RLVL)/(RLVV - RLVL)
C
C          TEST FOR LIQUID OR MIXED PHASE STATE
      IF (PRHLQD .LE. EX60   .OR. QTY .GE. 0.0) PRHN = PRHMIX
      IF (PRHLQD .GT. EX60   .AND. QTY .LT. 0.0) PRHN = PRHLQD
  170 EX1N = 14.5038*PRHN
      EX2N = QTY
      EX3N = RLVL
      EX4N = RLVV
      EX5N = TMPN
      EX6N = EX60
      GO TO 990
C
C          INTERNAL ENERGY IS ABOVE THE SATURATION LINE
C          AND QUALITY IS ALWAYS BETWEEN ZERO AND ONE
 1000 CONTINUE
      WRITE(NFPRT,1010) I,ZIEN,RLVN
      WRITE(NFMSG,1010) I,ZIEN,RLVN
 1010 FORMAT(//10X,23HINTERNAL ENERGY AT ZONE,I5,33H IS OUT OF THE RANGE
     1 OF THE TABLE/10X,7HZIEN = ,1P1E15.5,10X,7HRLVN = ,1P1E15.5)
      NSERR = 2
      NSEXT = 2
C
C          DETERMINE IF ERROR EXIT IS NECESSARY
  990 CALL SBREXT(3H MY,3HPRH)
C
C          END OF SUBROUTINE MYPRH
      RETURN
      END
```

This page intentionally left blank.

APPENDIX

MAXIMUMS (MAX)

Variable	COMMON block	STEALTH Code 1D	2D	3D	Maximum Allowance
MAXGRD	/PRBVAR/	25	25	25	Grids
MAXBLK	/PRBVAR/	25	25	25	Blocks
MAXMAT	/PRBVAR/	10	10	10	Materials
MAXGPT	/PRBVAR/	201	51	21	Grid points (I-lines)
MAXZON	/PRBVAR/	200	51	21	Zones along I-line
MAXROW	/PRBVAR/	1000	1000	21	Rows (J-lines)
MAXPLN	/PRBVAR/	1000	1000	1000	Planes (K-lines)
MAXRZN	/PRBVAR/	10	10	10	Rezone zones
MAXBDY	/PRBVAR/	50	50	50	Boundary value locations
MAXMBD	/PRBVAR/	10	10	10	Momentum boundary data
MAXTBD	/PRBVAR/	10	10	10	Thermal boundary data
MAXWPT	/PRBVAR/	100	100	100	Wall points
MAXREG	/PRBVAR/	20	20	20	Regions
MAXPLT	/PRBVAR/	100	100	100	Plots
MAXEDT	/PRBVAR/	10	10	10	Edit specifications
MAXSEG	/PRBVAR/	25	25	25	Segments
MAXVAR	/PRBVAR/	100	100	100	Variables
MAXTTL	/PRBVAR/	70	70	70	Title characters
MAXCDN	/PRBVAR/	24	24	24	Code name characters
MAXDAT	/PRBVAR/	6	6	6	Date characters
MAXTIM	/PRBVAR/	6	6	6	Time characters
MAXEOS	/PRBVAR/	10	10	10	Equation-of-state models
MAXYLD	/PRBVAR/	10	10	10	Yield models
MAXSHR	/PRBVAR/	10	10	10	Shear modulus models
MAXSPL	/PRBVAR/	10	10	10	Spall models
MAXERL	/PRBVAR/	10	10	10	Energy release models
MAXCON	/PRBVAR/	10	10	10	Conductivity models
MAXSHC	/PRBVAR/	10	10	10	Specific heat capacity models
MAXPBP	/GPTPRM/	100	100	100	Point-by-point initializations

This page intentionally left blank.

APPENDIX
MESSAGES (MSG)

The messages described in this Appendix are from standard ___ERR subroutines. This list of messages is by no means comprehensive. It only includes those messages not explicitly identified on input record documentation.

In addition, there are numerous PROCESSOR messages which may result from errors during execution of the physics equations. These messages are usually self-explanatory. Other messages relating to standard output are described in Appendix OPT.

CHRERR message

```
**********
 E R R O R
INPUT TYPE
CHARACTER NAME aaa
IS INCORRECT
ERROR OCCURRED IN SUBROUTINE *aaaaaa*
*************************************
```

FLDERR message

```
**********
 E R R O R
FIELD i
ON INPUT RECORD TYPE iii
HAS A VALUE eeeeeeeeeeee
WHEN IT SHOULD BE ZERO OR BLANK.
ERROR OCCURRED IN SUBROUTINE *aaaaaa*
*************************************
```

LIMERR message

```
**********
 E R R O R
INPUT RECORD TYPE iii
HAS INCORRECT LIMITS.
FIELD i CONTAINS MINIMUM VALUE iiiii
FIELD i CONTAINS MAXIMUM VALUE iiiii
ERROR OCCURRED IN SUBROUTINE *aaaaaa*
*************************************
```

MDLERR message

```
**********
 E R R O R
MODEL NUMBER i
IS NOT ALLOWED FOR aaaaaa
ERROR OCCURRED IN SUBROUTINE *aaaaaa*
AT STATEMENT NUMBER iii
*************************************
```

RGEERR message

```
**********
 E R R O R
FIELD NUMBER i
ON INPUT RECORD TYPE iii
HAS A VALUE OUT OF PERMISSIBLE RANGE.
THE VALUE = iiiiii
MIN VALUE = iiiiii
MAX VALUE = iiiiii
ERROR OCCURRED IN SUBROUTINE *aaaaaa*
*************************************
```

(Note: The message, "ON INPUT RECORD TYPE iii", doesn't appear in PROCESSOR-related errors.)

SBRERR message

```
**********
 E R R O R
NO LOGIC IN SUBROUTINE *aaaaaa*
*******************************
```

TYPERR message

```
**********
 E R R O R
INPUT TYPE iii
IS INCORRECT.
FIRST
DIGIT OF INPUT TYPE
IS OUT OF PERMISSIBLE RANGE
VALUE IS i
RANGE IS 1 TO 6
SECOND
DIGIT OF INPUT TYPE
IS OUT OF PERMISSIBLE RANGE
VALUE IS i
RANGE IS 1 TO 8
THIRD
DIGIT OF INPUT TYPE
IS OUT OF PERMISSIBLE RANGE
VALUE IS i
RANGE IS 1 TO 9
ERROR OCCURRED IN SUBROUTINE *aaaaaa*
*************************************
```

FLDCHK message

```
**********
 E R R O R
FIELD i ON INPUT RECORD aaa
CONTAINS A NON-ZERO VALUE eeeeeeeeeeee
ITS VALUE SHOULD HAVE BEEN ZERO OR
THE FIELD SHOULD HAVE BEEN LEFT BLANK.
```

This page intentionally left blank.

APPENDIX

NOTATION (NTN)

Independent Variables

t	time
x_i	components of material position
x,y,z	Cartesian coordinates (components of material position)
r,θ,z	cylindrical (axial) coordinates (components of material position)
r,θ,φ	spherical coordinates (components of material position)

Dependent Variables

$\dot{x},\dot{y},\dot{z},\dot{r},\dot{\theta},\dot{\varphi}$	components of material velocity
v	material velocity (components are v_x,v_y,v_z)
$\ddot{x},\ddot{y},\ddot{z},\ddot{r},\ddot{\theta},\ddot{\varphi}$	components of material acceleration
ρ	density (ρ^o is reference density)
$\mathcal{V}$	true volume
V	relative volume, ρ^o/ρ (V^o is reference relative volume)
η	$1/V$ (C is compression)
μ	$\eta - 1$
Δ	cubical dilatation
e_{ij}	strain deviator tensor
ϵ_{ij}	total strain tensor
p	pressure (mean stress)
q	artificial viscosity
s_{ij}	stress deviator tensor
σ_{ij}	total stress tensor
J_i'	stress deviator invariants
K	bulk modulus
G	shear modulus
E	Young's modulus
ν	Poisson's ratio
λ	Lamé constant
c_ℓ	longitudinal sound speed
c_s	shear wave sound speed

Y	yield stress
z	distortional energy density (per reference volume)
u	internal energy density (per reference volume)
h	heat transfer
k	heat conductivity
ζ	viscosity
C_p	specific heat at constant pressure
C_v	specific heat at constant specific volume
γ	ratio of specific heats
Γ	Grüneisen coefficient
g	gravity
τ	time constant
U	source or sink of energy
S	surface area
a,b	material constants or coefficients

Superscripts (physical equations)

$\dot{}$	ordinary derivative with respect to time
$''$	per unit area
$'''$	per unit volume
$\hat{}$	per unit mass

Vector Notation (physical equations)

$\underline{\ }$	one line under vector
$\underline{\underline{\ }}$	two lines under tensor

Index Notation (physical equations)

$(\ )_{ij}$	standard summation notation
δ_{ij}	Kronecker delta

Tensor Notation (physical equations)

$:$	dyadic product

Superscripts (numerical equations)

$n+1$	new time
$n+\frac{1}{2}$	new half-time
n	old time
$n-\frac{1}{2}$	old half-time
$n-1$	previous time

Subscripts (numerical equations)

$i-1$	left grid point with respect to point i
i	grid point i currently under consideration
$i+1$	right grid point with respect to point i
$j-1$	bottom grid point with respect to point j
j	grid point j currently under consideration
$j+1$	top grid point with respect to point j
$k-1$	aft grid point with respect to point k
k	grid point k currently under consideration
$k+1$	front grid point with respect to point k
$i-\frac{1}{2}$	zone between $i-1$ and i
$j-\frac{1}{2}$	zone between $j-1$ and j
$k-\frac{1}{2}$	zone between $k-1$ and k

This page intentionally left blank.

APPENDIX

OUTPUT (OPT)

I. OUTPUT FEATURES

The STEALTH codes have a sophisticated output system that allows a user to choose the type of output as well as the medium upon which this output is placed. Eight distinct types of output are available. They are: Extensive printed grid point output (PRT), message grid point output (MSG), regional summary printed output (RSY), restrart output (RST), archive output (ARV), storage output (STG), plot output (PLT), trace output (TRC), and debug output (DBG). Each has unique content characteristics.

PRT output is a complete listing of the state of a grid at a particular cycle with all the grid point variables being printed. These data are written on a file called NFPRT (Number of File PRinT) which can be directed to go to a high speed printer, to microfiche, or to an output device which is most practical for large volumes of printed output.

A subset of PRT, called MSG (MeSsaGe), contains printed grid point output which is reduced considerably in volume. MSG data are written on a file called NFMSG. This output is intended for a remote terminal printer or any slow speed output device for printed data. The user can control the variables as well as the number of grid points to be printed on the message file. The message file is always a subset of the print file. Certain minimal data appear that the user cannot suppress. For example, error messages and one-line cycle printouts will always be written on NFMSG.

RSY (Regional SummarY) output is also printed output. It is written on files NFPRT and NFMSG. RSY print data deal with regions of grid points as specified by the user.

Restart data (RST) are written on a file called NFRSO (Number of File for ReStart Output) for use in subsequent STEALTH runs to restart the problem. The user has no control over the contents of the data that are put on this file. However, he can control the frequency with which the data are put on the file. The data are unformated and are intended primarily for tape or disk units. (Restart data are read from file NFRSI - Number of File for ReStart Input.)

Archive data (ARV) are similar to restart data in that the file is unformated and is intended for permanent storage media such as tape or disk. However, unlike the restart file, the contents of the archive data file can be chosen by the user. Archive data are written on a file called NFARO (Number of File for ARchive Output). (Archive data are read by the STEALTH program ADAPRO, Archive DatA PROcessor, described in this Appendix.)

Plot output is written on an intermediate data file, NFPLT, which is read by the program GRADIS upon completion of a 1D, 2D, or ADAPRO run (see Ref. 1). GRADIS creates the appropriate system files for CALCOMP plots, CRT plots, printer plots, etc. Plot capabilities within STEALTH include time histories, snapshots, and mesh-oriented plots. The user has control over which plots are made and the frequency of time history samplings. Time histories are specified at a particular location, while snapshots and mesh-oriented plots are specified at a particular time. Several variations on these types of plots are available. Time histories can have a variable plotted explicitly against time, or two variables plotted against each other with time as an implied parameter. Snapshots include capabilities to do a spatial profile of a variable in the grid where a cut through the grid along an i- or j-line is plotted as the variable versus the distance along the cut. Mesh-oriented plot capabilities include: (a) Mesh plots in x-y space, (b) contour plots of a variable over the grid, (c) vector (velocity) plots, (d) tensor (stress) plots, (e) isometric contours in which a variable is shown as a surface above the grid in a three-dimensional representation. The user has control over which part of the grid is plotted in all mesh-oriented and snapshot plots.

Storage (STG) data are written on a file called NFSTG (Number of File for SToraGe output). It consists of a formatted dump of all the STEALTH COMMON blocks. The user specifies the frequency at which storage edits are written. COMMON blocks are actually dumped in an unformatted form on an intermediate file called NFCMN (Number of File for unformatted CoMmoN block dumps) which is re-read and formatted upon exit from the STEALTH GENERATOR and PROCESSOR phase groups.

Trace (TRC) output contains a trace of subroutine calls written to the files NFPRT and NFMSG. Trace output is activated in the "enter" (PHSENT and SBRENT) subroutines called from the beginning of each subroutine. The user can control when tracing is to occur and may activate TRC output in both the GENERATOR and PROCESSOR phase groups.

Debug (DBG) output contains formatted COMMON block dumps written to the files NFPRT and NFMSG. Debug output is activated in the "exit" (PHSEXT and SBREXT) subroutines called at the end of each subroutine. The user can control when dumping is to occur and may activate DBG output in both the GENERATOR and PROCESSOR phase groups. Which COMMON blocks are dumped is determined from the phase in which the subroutine is located. COMMON blocks are actually dumped in an unformatted form on an intermediate file called NFCMN (Number of File for unformatted CoMmoN block dumps) which is re-read and formatted upon exit from the STEALTH GENERATOR and PROCESSOR phase groups.

II. OUTPUT FILE CHARACTERISTICS

PRT FILE OUTPUT (Input records 611,612,621,631,632)

Printed output from STEALTH on file NFPRT* comes from both the GENERATOR and the PROCESSOR phase groups.

In the GENERATOR phase group, printed output is grouped by phase. Each phase that is activated produces output blocks in the following sequence:

___INP	lists the input records that have been read with record-by-record error messages;
___CHK	prints out an analysis (a check) of the input with phase error messages;
___PRT	prints the data of the phase in a clear format;
___PLT	prints information about the plots that have been produced;

where ___ is the phase name identifier. Each block of output begins on a new page with an appropriate heading that designates the phase and the block. These headings are produced in the following subroutines:

INPHDG	produces the heading for ___INP
CHKHDG	produces the heading for ___CHK
PRTHDG	produces the heading for ___PRT
PLTHDG	produces the heading for ___PLT

As a minimum, phases CMN, PRB, and TIM are required; they will produce 12 blocks of GENERATOR printed output. If all eight phases are activated, then 32 blocks of printed output will be written on file NFPRT.

---

*See Appendix "Files".

In addition to the four blocks of printed output from each GENERATOR phase, the GENERATOR also automatically produces a "complete" printout of all the variables prior to transferring control to the PROCESSOR phase group. This printout is divided into six "blocks" of data. Four of the blocks print one "logical page" of variables. The other two blocks print one or more pages, depending on the dimensionality of the code being used. A "logical page" is defined as the information following a line at the top of a physical page which includes the problem title, the code name and version number, the date, the time, and sequential page number. Below the title line (on each page) are the row and plane numbers, j and k (j = 0, k = 0 for one-dimensional runs and k = 0 for two-dimensional runs), and a summary of time-step information under the following headings:

Heading	Description of heading
CYCLE	n+1, cycle number
TIMN	t^{n+1}, time at cycle n+1
DLTH	$\Delta t^{n+\frac{1}{2}}$, time step from t^n to t^{n+1}
DLTGRF	f_{GRF}, time step growth factor
DLTMIN	Δt_{MIN}, minimum allowable time step
DLTMAX	Δt_{MAX}, maximum allowable time step
DLTSFR	f_{SFR}, time step safety factor
LOCDLT	i_{LOC}, j_{LOC}, k_{LOC}, location of controlling time step
KRLDLT	τ_{KRL}, type of time step control where the following control definitions apply: MOM = mechanical sound speed EGY = thermal diffusivity MIN = mimimum MAX = maximum VOI = void closure SOR = start or restart

The information shown above comes from subroutine TIMHDG.

Following the title and time step information, the values of the physical variables are listed vertically (under appropriate three-letter mnemonic headings. (See Appendix "Conventions" in Volume 3, Programmer's Manual of the STEALTH documentation for additional definitions of these headings.) The data on a particular logical page are listed by grid-point index for a given row and plane in the mesh. Therefore, the grid-point index (GPT) is always the leftmost heading. Also, on every logical page, just to the right of the column containing GPT data, are the material property number (MPN) and the material state indicator (IND), respectively, for the zone associated with that grid point. Below is a summary of the variables printed in each output block.

Output Block 1

Heading for STEALTH 1D (one logical page):

GPT MPN IND XPN YPN XVL YVL XAC YAC GXK GYK

where

Heading	Description of heading
GPT	grid point index, i
MPN	material property number
IND	material state indicator where HYD = hydrodynamic, ELS = elastic, PLS = plastic
XPN	x-position, x_i^{n+1}
YPN	y-position, y_i^{n+1}
XVL	x-velocity, $\dot{x}_i^{n+\frac{1}{2}}$
YVL	y-velocity, $\dot{y}_i^{n+\frac{1}{2}}$
XAC	x-acceleration, $\ddot{x}_i^{n}$
YAC	y-acceleration, $\ddot{y}_i^{n}$
GXK	x-grid point kinetic energy, $KE_x^{n+\frac{1}{2}}$
GYK	y-grid point kinetic energy, $KE_y^{n+\frac{1}{2}}$

Output Block 1 (continued)

Headings for STEALTH 2D and 3D (two logical pages each):

First logical page

GPT MPN IND XPN YPN ZPN XVL YVL ZVL TXY QDA

where

Heading	Description of heading
GPT	grid point index, i
MPN	material property number
IND	material state indicator where HYD = hydrodynamic, ELS = elastic, PLS = plastic
XPN	x-position, x^{n+1}
YPN	y-position, y^{n+1}
ZPN	z-position, z^{n+1}
XVL	x-velocity, $\dot{x}^{n+\frac{1}{2}}$
YVL	y-velocity, $\dot{y}^{n+\frac{1}{2}}$
ZVL	z-velocity, $\dot{z}^{n+\frac{1}{2}}$
TXY	xy-total stress, σ_{xy}^{n+1}
QDA	quadrilateral area, A^{n+1} (2D only)

The index subscripts for XPN, YPN, ZPN, XVL, YVL, and ZVL are as follows:

2D	i,j
3D	i,j,k

The index subscripts for TXY and QDA are as follows:

2D	$i-\frac{1}{2}$, $j-\frac{1}{2}$
3D	$i-\frac{1}{2},j-\frac{1}{2},k-\frac{1}{2}$

Output Block 1 (continued)

Second logical page

GPT MPN IND XAC YAC ZAC GXK GYK GZK TYZ TXZ

where

Heading	Description of heading
GPT	grid point index, i
MPN	material property number
IND	material state indicator where HYD = hydrodynamic, ELS = elastic, PLS = plastic
XAC	x-acceleration, $\ddot{x}^n$
YAC	y-acceleration, $\ddot{y}^n$
ZAC	z-acceleration, $\ddot{z}^n$
GXK	x-grid point kinetic energy, $KE_x^{n+\frac{1}{2}}$
GYK	y-grid point kinetic energy, $KE_y^{n+\frac{1}{2}}$
GZK	z-grid point kinetic energy, $KE_z^{n+\frac{1}{2}}$ (3D only)
TYZ	yz-total stress, σ_{yz}^{n+1} (3D only)
TXZ	xz-total stress, σ_{xz}^{n+1} (3D only)

The index subscripts for XAC, YAC, ZAC, GXK, GYK, and GZK are as follows:

2D	i,j
3D	i,j,k

The index subscripts for TYZ and TXZ are as follows:

2D	$i-\frac{1}{2},j-\frac{1}{2}$
3D	$i-\frac{1}{2},j-\frac{1}{2},k-\frac{1}{2}$

Output Block 2

Heading applicable to all STEALTH general-purpose codes (one logical page):

GPT MPN IND PRH AVS TXX TYY TZZ SXX SYY SZZ

where

Heading	Description of heading
GPT	grid point index, i
MPN	material property number
IND	material state indicator where HYD = hydrodynamic, ELS = elastic, PLS = plastic
PRH	pressure, p^{n+1}
AVS	artificial viscosity, $q^{n+\frac{1}{2}}$
TXX	xx-total stress, σ_{xx}^{n+1}
TYY	yy-total stress, σ_{yy}^{n+1}
TZZ	zz-total stress, σ_{zz}^{n+1}
SXX	xx-deviatoric stress, s_{xx}^{n+1}
SYY	yy-deviatoric stress, s_{yy}^{n+1}
SZZ	zz-deviatoric stress, s_{zz}^{n+1}

The index subscripts for these physical variables are as follows:

1D	$i-\frac{1}{2}$
2D	$i-\frac{1}{2},j-\frac{1}{2}$
3D	$i-\frac{1}{2},j-\frac{1}{2},k-\frac{1}{2}$

Output Block 3

Heading applicable to all STEALTH general-purpose codes (one logical page):

GPT MPN IND COM RLV VSR DNS ZMS TRV DLL SSP

where

Heading	Description of heading
GPT	grid point index, i
MPN	material property number
IND	material state indicator where HYD = hydrodynamic, ELS = elastic, PLS = plastic
COM	compression, $1 - V^{n+1}$
RLV	relative volume, V^{n+1}
VSR	volume strain rate, $\dot{V}^{n+\frac{1}{2}}/V^{n+\frac{1}{2}}$
DNS	density, ρ^{n+1}
ZMS	mass, m
TRV	true volume, $\mathcal{V}^{n+1}$
DLL	distance across zone in the direction of the acceleration vector, d^{n+1}
SSP	longitudinal sound speed, c_{ℓ}^{n+1}

The index subscripts for these physical variables are as follows:

1D	$i-\frac{1}{2}$
2D	$i-\frac{1}{2},j-\frac{1}{2}$
3D	$i-\frac{1}{2},j-\frac{1}{2},k-\frac{1}{2}$

Rev. 1
30 SEP 80

Output Block 4

Headings applicable to all STEALTH general-purpose codes (two logical pages):

First logical page

GPT MPN IND YLD SHR BFS ACT ZHE ZDE ZSE ZKE

where

Heading	Description of heading
GPT	grid point index, i
MPN	material property number
IND	material state indicator where HYD = hydrodynamic, ELS = elastic, PLS = plastic
YLD	yield stress, Y^{n+1}
SHR	shear modulus, G^{n+1}
BFS	burn fraction or spall indicator
ACT	activity time, t_A^n
ZIE	internal energy density, u^{n+1}
ZDE	distortional energy density, Z^{n+1}
ZSE	source energy density, S^n
ZKE	kinetic energy, $KE^{n+\frac{1}{2}}$

The index subscripts for these physical variables are as follows:

1D	$i-\frac{1}{2}$
2D	$i-\frac{1}{2}, j-\frac{1}{2}$
3D	$i-\frac{1}{2}, j-\frac{1}{2}, k-\frac{1}{2}$

Output Block 4 (continued)

Second logical page

GPT MPN IND ZHE TMP CON SHC NBT XHF YHF ZHF*

where

Heading	Description of heading
GPT	grid point index, i
MPN	material property number
IND	material state indicator where HYD = hydrodynamic, ELS = elastic, PLS = plastic
ZHE	heat energy density, h^{n+1}
TMP	temperature, T^{n+1}
CON	heat conductivity, k^{n+1}
SHC	specific heat capacity, C_V^{n+1}
NBT	thermal boundary number
XHF	x-heat flux, $\dot{h}''^{\,n+\frac{1}{2}}_x$ or x-temperature gradient, $\left(\frac{\partial T}{\partial x}\right)^{n+\frac{1}{2}}$
YHF	y-heat flux, $\dot{h}''^{\,n+\frac{1}{2}}_y$ or y-temperature gradient, $\left(\frac{\partial T}{\partial y}\right)^{n+\frac{1}{2}}$
ZHF*	z-heat flux, $\dot{h}''^{\,n+\frac{1}{2}}_z$ or z-temperature gradient, $\left(\frac{\partial T}{\partial z}\right)^{n+\frac{1}{2}}$

The index subscripts for ZHE, TMP, CON and SHC are as follows:

1D	$i-\frac{1}{2}$
2D	$i-\frac{1}{2},j-\frac{1}{2}$
3D	$i-\frac{1}{2},j-\frac{1}{2},k-\frac{1}{2}$

The index subscripts for NBT, XHF, YHF, and ZHF are as follows:

1D	i
2D	i,j
3D	i,j,k

---

*Not available in 1D code.

This page intentionally left blank.

Output Block 5

Heading applicable to all STEALTH general-purpose codes (one logical page):

GPT MPN IND NOR NBM NBV IGN

where

Heading	Description of heading
GPT	grid point index, i
MPN	material property number
IND	material state indicator where HYD = hydrodynamic, ELS = elastic, PLS = plastic
NOR	orientation number
NBM	momentum boundary number
NBV	boundary value number
IGN	ignition fraction

Output Block 6

Heading applicable to all STEALTH general-purpose codes (one logical page):

GPT MPN IND EX1 EX2 EX3 EX4 EX5 EX6

where

Heading	Description of heading
GPT	grid point index, i
MPN	material property number
IND	material state indicator where HYD = hydrodynamic, ELS = elastic, PLS = plastic
EX1	extra variable 1
EX2	extra variable 2
EX3	extra variable 3
EX4	extra variable 4
EX5	extra variable 5
EX6	extra variable 6

This page intentionally left blank.

At the end of the GENERATOR phase group, one of the following messages is written, corresponding to the appropriate error level, NSERR, when the exit level, NSEXT, is not equal to 1.

```
**********************
*                    *
* SIMPLE CHECK ERROR *        NSEXT ≠ 1
*    HAS OCCURRED    *        NSERR = 2
*                    *
**********************


**********************
*                    *
* COMPATIBILITY ERROR*        NSEXT ≠ 1
*    HAS OCCURRED    *        NSERR = 3
*                    *
**********************


**********************
*                    *
* VERY SERIOUS ERROR *        NSEXT ≠ 1
*    HAS OCCURRED    *        NSERR = 4
*                    *
**********************
```

The error levels are set in phase subroutines in approximately the following way:

NSERR = 2	comes primarily from ___ INP, but sometimes comes from ___ CHK .
NSERR = 3 or 4	comes primarily from ___ CHK (especially from GENCHK) but sometimes comes from ___ INP and ___ PRT .

Using the error levels as a guide, one can look back through the printout to uncover more specific messages that were written when the error was detected.

When NSERR is equal to 1, the following message is written:

```
**********************
*                    *
* GENERATOR COMPLETE *        NSEXT = 2
* NO OBVIOUS ERRORS  *        NSERR = 1
*                    *
**********************
```

Only when this latter message is printed does the STEALTH code enter the PROCESSOR phase group. These messages come from subroutine GENEXT.

Under the GENERATOR COMPLETE message, accounting units and CP seconds are printed out in the following format:

```
** ACCTG UNITS USED -         **
** CP  SECONDS USED -         **
```

These data are current values which have been calculated relative to the beginning of the GENERATOR. The data are recalculated at the end of the PROCESSOR and are printed under the PROCESSOR COMPLETE message in the same format. (See Page OPT. 15 for PROCESSOR COMPLETE message.)

In the PROCESSOR phase group, printed output takes the form of the previously described "complete" printout and may be specified to be a function of time or cycle number. The first and last cycles are automatically printed.

In addition to the "complete printout at the zeroth, first, and last cycles, STEALTH automatically prints a one-line summary edit every cycle. This edit includes:

Heading	Description of heading
CYCLE	cycle number
TIME	problem time
TIME STEP	problem time step
DLTLOC	index location of zone of time step control (i,j)
TOTAL IE	total internal energy
TOTAL DE	total distortional energy
TOTAL HE	total heat energy
TOTAL EGY	total zone energy
TOTAL XM	total x-momentum
TOTAL XK	total grid-point x-kinetic energy
TOTAL YM	total y-momentum
TOTAL YK	total grid point y-kinetic energy
ACCTG UNITS	total computer accounting units used since the start of the STEALTH run

When a problem terminates under program control at the end of the PROCESSOR phase group, one of the following messages is written:

```
**********************
*                    *
* TIME RELATED ERROR *        NSEXT ≠ 1
*    HAS OCCURRED    *        NSERR = 2
*                    *
**********************


**********************
*                    *
* ZONE RELATED ERROR *        NSEXT ≠ 1
*    HAS OCCURRED    *        NSERR = 3
*                    *
**********************


**********************
*                    *
* VERY SERIOUS ERROR *        NSEXT ≠ 1
*    HAS OCCURRED    *        NSERR = 4
*                    *
**********************
```

If one of these messages appears, look back through the printout to uncover more specific messages that were written when the program decided to terminate.

When NSEXT is equal to 2 and NSERR is equal to 1, the following message is written:

```
**********************
*                    *
* PROCESSOR COMPLETE *        NSEXT = 1,2
* NO OBVIOUS ERRORS  *        NSERR = 1
*                    *
**********************
```

If this last message is written, then the calculation has passed all of STEALTH's many error checks.

Regional summary output from STEALTH is printed output that comes only from the PROCESSOR. It may be specified to be a function of time or cycle number -- the first and last cycles are automatically printed.

Regional summary edits follow print edits when a print edit is specified for the same cycle. However, there is no need to have print and regional summary edits specified at the same time or cycle unless the user desires them.

The format of the regional summary edit begins with a line at the top of a physical page containing the problem title, the code name, and the date and time that the problem entered the computer. Under this line are two lines of time-step information identical to the information printed on each page of a "complete" printout. (This information has already been described in this Appendix.) Next, the heading

REGIONAL SUMMARY EDIT

is printed, followed by the columns of regional summary data under the following headings:

REGION DEFINITION*
REG ILFT IRHT JBOT JTOP

REGION SUMMARY DATA
REG RIE RDE RHE RKE RMS RXM RXK RYM RYK

---

*Values of zones not contained in user-defined regions are automatically included in region number MAXREG (see Appendix "Maximums").

These headings are described as follows:

REGION DEFINITION

Heading	Description of heading
REG	region number
ILFT	leftmost i index of grid point in region
IRHT	rightmost i index of grid point in region
JBOT	bottommost j index of grid point in region
JTOP	topmost j index of grid point in region

REGION SUMMARY DATA

Heading	Description of heading
REG	region number
RIE	region internal energy
RDE	region distortional energy
RHE	region heat energy
RKE	region zonal kinetic energy
RMS	region mass
RXM	region x-momentum
RXK	region x-grid point kinetic energy
RYM	region y-momentum
RYK	region y-grid point kinetic energy

If trace or debug edits are selected, the PRT file will contain additional output generated by these options. Tracing produces one line for each subroutine traced. Debug output consists of selected common block dumps. An identifying message is written when the dumps are made, while the actual dumps are appended to GENERATOR and PROCESSOR phase group printout.

MSG FILE OUTPUT (Input records 611,612,621,622,623,631,632)

Printed and regional summary output from STEALTH on file NFMSG may be an exact duplicate or a subset of the output data on file NFPRT. As a minimum, error messages, one-line cycle summary data, and regional summary output are automatically put on the message file. The main difference offered by MSG output is the ability to control the volume of printed output by reducing either the number of variables or the number of grid points printed. A list of possible output variables appears in Appendix "Identifiers".*

RST FILE OUTPUT (Input records 613,641)

Restart output from STEALTH is a complete unformatted dump of COMMON blocks. In the one-dimensional code, the COMMON blocks are written on file NFRSO in the following order:

/PRBARY/
/PRBVAR/
/MATARY/
/GPTARY/
/ZONARY/
/MBDARY/
/TBDARY/
/BDYARY/
/TIMVAR/

In the two-dimensional code, all but two of these COMMON blocks are dumped. These exceptions are /GPTARY/ and /ZONARY/. These COMMON blocks contain only a small portion of the possible GPT and ZON data. The data normally stored in these COMMON blocks are dumped one row at a time after all the

---

*A glossary describing the variable identifiers may be found in Appendix "Glossary". Appendix "Glossary" is in Volume 3, Programmer's Manual.

other COMMON blocks have been dumped. The data written to file NFRSO is as follows:

/PRBARY/
/PRBVAR/
/MATARY/
/MBDARY/
/TBDARY/
/BDYARY/
/TIMVAR/

Row 1, GPT and ZON variables for all points on row 1.
Row 2, GPT and ZON variables for all points on row 2.
Row 3, GPT and ZON variables for all points on row 3.
.
.
.
Row NCROW, GPT and ZON variables for all points on row NCROW.

The storage requirements for the two-dimensional restart file may be calculated as follows. For each restart edit, the saved COMMON blocks contain different numbers of words as shown below.

/PRBARY/	183 words
/PRBVAR/	142 words
/MATARY/	732 words
/MBDARY/	332 words
/TBDARY/	332 words
/BDYARY/	1,102 words
/TIMVAR/	36 words
Total:	2,859 words

Rows in the grid contain 56 records, each of which is NCGPT words in length. A complete restart edit results in $7 + 56 \times \text{NROW}$ records of data on the restart file; NROW is the number of rows in the grid.

(1) Tape requirements for restart edits, assuming 7-track, 800-BPI tape drives, are as follows:

$$\text{NI} = 100 + \text{NROW} \times 56 \times \left(\frac{\text{NGPT}}{80} + .75\right)$$

where

NI	is the number of inches of tape required for each restart edit
NROW	is the number of rows in the grid
NGPT	is the number of grid points per row

For example, for a grid with 26 rows and 40 grid points per row,

$$\text{NI} = 100 + 26 \times 56 \times \left(\frac{40}{80} + .75\right)$$

$$= 1820.0 \text{ inches, or } 152 \text{ feet.}$$

Assuming a magnetic reel of tape to be 2,400 feet, no more than 15 restart edits for this grid could be saved on one tape.

(2) The equivalent formula for the number of disk sectors (NS) per restart edit required on a CDC 7600 (e.g., at Lawrence Berkeley Laboratory) is

$$\text{NS} = \frac{4075 + (\text{NGPT} + 1) \times 56 \times \text{NROW}}{512}$$

Thus, for the 40 × 26 grid,

$$\text{NS} = \frac{4075 + (40 + 1) \times 56 \times 26}{512}$$

$$\approx 125 \text{ sectors.}$$

ARV FILE OUTPUT (Input records 614,651,652,653)

Archive output from STEALTH is a dump of code data that may be used for post-run analysis. These data are saved in a format that makes them easily used by data reduction and graphic display post-processors. The format of the archive record will be described later in this Appendix.

The default set of variables saved on an archive file is dependent upon code dimensionality. Below are listed the default variables for general-purpose STEALTH.

List of Default Archive Variables

Group 1

XPN	XVL	XAC	TXX	TYY	TZZ		
NOR	NBM	NBV	MPN	RLV	VSR	ZMS	DLL
ZIE	ZDE	PRH	AVS	SSP	YLD	SHR	BFS
NBT	ZHE	TMP	CON	SHC			

Group 2

YPN	YVL	YAC	TXY

Group 3

ZPN	ZVL	ZAC	TYZ	TXZ

Correspondence Between Codes and Variables

Code	Groups	Number of Variables
STEALTH 1D	1	27
STEALTH 2D	1 + 2	31
STEALTH 3D	1 + 2 + 3	36

It is a good idea to override the default set with a problem-specific set (input record 653) in order to insure that the proper variables are saved.

When choosing the number of variables to be saved, it is important to know how many reels of tape will be required. Below is a two-dimensional example calculation, assuming 800 bpi tape density. The number of reels of tape required for archive edits for STEALTH 2D is approximately

$$NR \cong \frac{2 \times 10^6}{NCOL \times NROW \times NVAR \times NEDT}$$

where NCOL is the number of i-lines, NROW is the number of j-lines, NVAR is the number of variables specified, and NEDT is the number of archive cycles saved. For a 40 x 26 grid with 16 user-specified variables and 100 edits,

$$NR \cong \frac{2 \times 10^6}{40 \times 26 \times 16 \times 100}$$

$\cong$ 1.2 tape reels (or 80 edits per reel).

The archive data are blocked by the I/O routines into fixed-length records (500 words).

PLT FILE OUTPUT (Input records 616,671,672,674,675)

Plot output from STEALTH is an unformatted dump of the minimum amount of data that are required to produce graphic output with the program GRADIS. For each STEALTH plot request, the options specifying the manner in which a plot is constructed, the plot data, and the plot labels are saved on the plot output file (NFPLT). The options are contained in 50 words; the labels are contained in approximately 150 words; and the length of the data itself will depend on the type of plot specified, the number of grid points, and the frequency of edits requested for time history plots.

The plot data are blocked by the plot routines into fixed length records (500 words).

STG FILE OUTPUT (Input records 615,661)

Storage output consists of formatted dumps of STEALTH COMMON blocks. For each storage edit, the following COMMON blocks are dumped on file NFSTG:

	Number of Pages		
Block	1D	2D	3D
/PRBARY/	2	2	2
/PRBVAR/	2	2	2
/MATARY/	6	6	6
/MATVAR/	1	1	1
/GPTARY/	20	7	12
/GPTVAR/	10	10	10
/ZONARY/	58	15	25
/ZONVAR/	6	6	6
/RZNARY/	3	3	3
/RZNVAR/	1	1	1
/MBDARY/	5	5	5
/TBDARY/	5	5	5
/BDYARY/	4	4	4
/TIMVAR/	1	1	1
/EDTARY/	5	5	5
/PRTVAL/	4	4	4
/RSYVAL/	3	3	3
/ARVVAL/	4	4	4
/PLTVAL/	3	3	3

For STEALTH 1D, this results in approximately 140 pages per STG edit. For STEALTH 2D, the number of pages is approximately 90 for each row, while for STEALTH 3D, it is over 100 pages per row.

TRC FILE OUTPUT (Input records 618,662)*

DBG FILE OUTPUT (Input records 619,663)*

---

*No documentation at the present time.

STEALTH also uses four intermediate files called NFIO1, NFIO2, NFIO3, and NFIO4 (Number of File for intermediate Input/Output 1, 2, 3, and 4). These files are used to read and write binary (unformatted) data that normally reside on mass storage. STEALTH 2D uses all four of these files in the GENERATOR phase group, and two of the files (NFIO1 and NFIO4) in the PROCESSOR phase group. STEALTH 1D does not employ any of these files, but they are available to the user for special logic, as are NFIO1 and NFIO4 in the STEALTH 2D PROCESSOR phase group.

The approximate number of words written to these files in STEALTH 2D is as follows:

	GENERATOR Phase Group	PROCESSOR Phase Group
NFIO1	5 X number of grid points	56 X number of grid points
NFIO2	13 X number of grid points	0
NFIO3	5 X number of grid points	0
NFIO4	56 X number of grid points	56 X number of grid points

III. ADAPRO

GENERAL INFORMATION

The ADAPRO[*] computer program is designed to provide low overhead access to, and analysis of, STEALTH archive data.

Specifically, this program allows the STEALTH user to access all, or part of, the archive data produced by a STEALTH run for the purposes of printing, plotting, or further data reduction. As in the STEALTH codes, the use of input directives allows the user complete control over the variables to be processed and the times at which specific processes will occur.

Input specifications are provided to ADAPRO in exactly the same format as that used for STEALTH input. Further, the same numeric identifiers assigned to individual input records have exactly the same interpretation in both sets of programs. However, ADAPRO will recognize only a certain subset of the STEALTH input records as being valid. In particular, ADAPRO will only accept input records belonging to the PRB and EDT phase input blocks as being valid. If an invalid input record type is detected by an ADAPRO program, it will terminate immediately with a TYPERR message (see Appendix "Messages".)

As in the STEALTH programs, input data are provided to ADAPRO in blocks. However, ADAPRO recognizes only two (as opposed to seven in STEALTH) distinct blocks of input. The title record (TTL) must always be the first record of input and it must always be immediately followed by the PRB phase input block. (See Section 7.0 for a detailed description of the input records required by this phase.) The PRB input block can then be followed by an EDT phase input block. Individual print, plot, or archive edit requests are made through input records in the EDT phase. The last record of each input

---

[*] Archive DAta PROcessor.

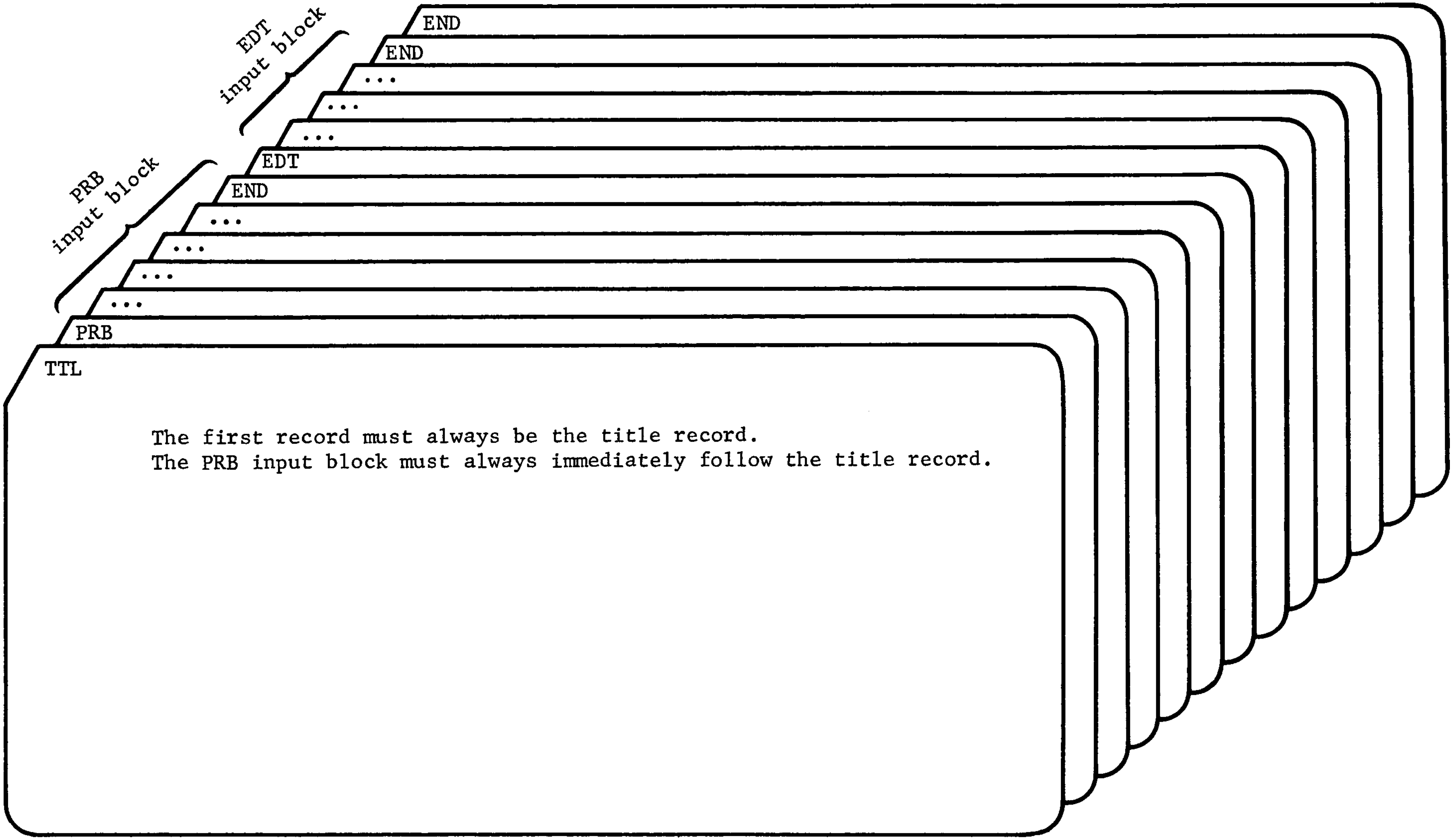
block must always be an END input record. The last input block must also be followed by an END input record. This last END card is in addition to the END record of the last input block. (See Figure OPT.1 for an illustration of a sample input deck.)

With proper use of EDT phase input directives, the user can direct ADAPRO to print, plot, or save certain variables of interest from a STEALTH archive file at specific times of interest. Thus, for all practical purposes, ADAPRO allows the user complete access to, and control over, all information contained on an archive data file. However, because a user may sometimes request that a variable not saved on an archive data file be printed or plotted, ADAPRO checks internally against this possibility and ignores print or plot requests for variables not found on the data file.

In order to further reduce the overhead of an ADAPRO run, ADAPRO has been given the capability of writing "second-generation" archive files. If a user is only interested in a certain set of variables, a section of a grid, or a range of times, he may often find it cost effective to write and save an edited archive data file for further post-run analyses.

ARCHIVE TAPE FORMAT

The STEALTH archive output file consists of problem data saved on a permanent storage medium where it can be retrieved for analysis after the completion of a STEALTH run. The amount of archive data generated by a STEALTH run can be quite voluminous; therefore, information is saved on the archive data file, using a logical record format designed to minimize the amount of physical storage needed. Information is saved during a STEALTH run only when it is necessary for that problem data to be reconstructed at a later time.



The first record must always be the title record.
The PRB input block must always immediately follow the title record.

Figure OPT.1. General structure of an ADAPRO input deck.

Each logical record has the following format:

NWIR	IDREC	DATA

NWIR = number of words in the record

IDREC = an integer identifying the contents of the DATA array

DATA = an array containing NWIR - 1 words

The possible values of IDREC are as follows:

IDREC	Contents of the DATA Array		
201	TTL	Problem title (70 words)	
202	CDN	Code name (24 words)	
203	DAT	Creation date (6 words)	
204	TIM	Creation time (6 words)	
205	NSPRO	PROCESSOR type	
301	TIMN	Time	
302	NCCYC	Cycle	
303	NCGPT	Number of columns	
304	NCROW	Number of rows	
305	NCWPT	Number of wall points	
306	MINJ	Minimum row number	
307	MAXJ	Maximum row number	
308	NCPLN	Number of planes	3D only
309	MINK	Minimum plane number	
310	MAXK	Maximum plane number	
311	XWL	Wall point, x-coordinate	
312	YWL	Wall point, y-coordinate	
313	NWO	Wall point orientation number	
314	ZWL	Wall point, z-coordinate (3D only)	
401	JE	Number of row being edited	
402	MINI	Minimum grid point number	
403	MAXI	Maximum grid point number	
404	KE	Number of plane being edited	

APPENDIX

PHYSICAL UNITS (PHU)

The basic STEALTH physics equations contain no conversion factors in their formulation. Therefore, it is imperative to use a consistent set of physical units when specifying code input. Consistent units mean that each of the conservation equations will provide answers in the same physical units that were used as input, i.e., units of input are units of output. Listed below are four convenient sets of units -- two sets are metric and two are English. The kg-m-s units shown below are often referred to as "SI" units.

	Metric		English	
Mass	g	kg	slug	snail
Length	cm	m	ft	in
Time	μs	s	s	s
Density	g/cm^3	kg/m^3	slugs/ft^3	snail/in^3
Velocity	cm/μs	m/s	fps	ips
Force	10^{12} dyne	N	lbf	lbf
Stress	Mbar	Pa	lbf/ft^2	psi
Energy	10^{12} erg ≡ eu	J	ft-lbf	in-lbf
Acceleration	cm/μs^2	m/s^2	f/s^2	in/s^2

where 1 bar ≡ 10^6 dynes/cm^2 ≡ 10^5 N/m^2 = 10^5 Pa

1 atm ≡ 1.013 bars ≡ 14.7 psi ≡ 2116 lbf/ft^2 ≡ 9.807×10^4 Pa

1 erg ≡ 1 dyne-cm = 10^{-7} J

1 joule ≡ 1 N ≡ 1 W-s

1 slug ≡ 1 lbf-s^2/ft = 14.59 kg

1 snail ≡ 1 lbf-s^2/in

1 gravity ≈ 9.81 m/s^2 ≡ 981 cm/s^2 ≡ 9.81×10^{-10} cm/μs

1 Pascal ≡ 1 N/m^2

Rev. 1
30 SEP 80

Although STEALTH is in consistent units, material property data are often found in various forms. Below is a table of some convenient conversion factors between the most common English and metric units.

Variable	English Units	SI Units
k (thermal conductivity)	1 BTU/(hr • ft • ^{o}F)	1.7306 J/(s • m • ^{o}K)
C_V (specific heat capacity)	1 BTU/(1b$_m$ • ^{o}F)	4.1865 × 10^3 J/(kg • ^{o}K)
E (Young's modulus)	1 psi	6.89476 × 10^3 Pa
α (coeff. of linear expansion)	1 $\left(\frac{\mu\ in}{in}\right)$ /^{o}F	1.8 × 10^{-6} $\left(\frac{m}{m}\right)$/^{o}K
mass density	1 slug/ft^3	5.15 × 10^2 kg/m^3
volume	1 ft^3	2.8317 × 10^{-2} m^3

where

1 slug = 32.17 $1b_m$
1 $1b_f$ = 32.17 poundals = 4.448 N
1 BTU = 252 cal = 1055 J