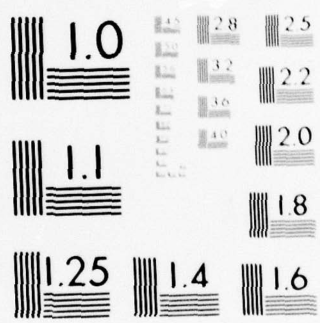
AD-A073 816 NAVAL WEAPONS CENTER CHINA LAKE CA F/G 21/8.2
INTERNAL ACOUSTIC CHARACTERISTICS OF THE NASA SOLID PROPELLANT --ETC(U)
NOV 76 H B MATHES, C J BICKER

UNCLASSIFIED NWC-TM-2822 GIDEP-E115-2182 NL

| OF |

AD A073 816

END
DATE
FILMED
10-79
DDC



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

Technical Memorandum 2822

INTERNAL ACOUSTIC CHARACTERISTICS OF THE NASA SOLID PROPELLANT BOOSTER MOTOR (SRM)

by

H. B. Mathes
C.J. Bicker
Research Department

November 1976

NAVAL WEAPONS CENTER
China Lake, California 93555

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DDC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

(18) GIDEP

26 APR 1978

(9) Technical memo.

GOVERNMENT-INDUSTRY DATA EXCHANGE PROGRAM

GENERAL DOCUMENT SUMMARY SHEET

(19)

Please Type All Information – See Instructions on Reverse

1. ACCESS NUMBER: E115-2182

2. COMPONENT/PART NAME PER GIDEP SUBJECT THESAURUS: Propulsion Parts and Materials, Engines, Fuel, Solid, Main Nozzle

3. APPLICATION: Missile Booster (6)

4. MFR NOTIFICATION: ☐ NOTIFIED ☒ NOT APPLICABLE

5. DOCUMENT ISSUE (Month/Year): (11) November 1976

6. ORIGINATOR'S DOCUMENT TITLE: Internal Acoustic Characteristics of the NASA Solid Propellant Booster Motor (SRM)

7. DOCUMENT TYPE: ☒ GEN RPT ☐ NONSTD PART ☐ SPEC

8. ORIGINATOR'S DOCUMENT NUMBER: (14) NWC-TM-2822

9. ORIGINATOR'S PART NAME/IDENTIFICATION: SRM (12) 88p.

10. DOCUMENT (SUPERSEDES) ([redacted]) ACCESS NO.: E095-2215 (10) H. B. Mathes

11. [redacted]: N/A

12. MANUFACTURER: N/A C. J. Bickel

13. MANUFACTURER PART NUMBER: N/A

14. INDUSTRY/GOVERNMENT STANDARD NUMBER: N/A

15. OUTLINE, TABLE OF CONTENTS, [redacted]

Methods used for determining the characteristics of acoustic waves in the NASA solid propellant booster motor (SRM) are reviewed. The report deals primarily with the use of a quasi three-dimensional finite element method (NASTRAN) for obtaining acoustic standing wave frequencies and acoustic pressure distribution in the motor.

Computer-predicted motor chamber acoustic frequencies are presented for selected axial and transverse waves at three points in the motor's burn history. The influence of assumed nozzle throat conditions, whether closed or open, on the acoustic waves is discussed. Detailed acoustic pressure distributions for the lowest axial (fundamental) frequency are included in an appendix. Also included in the appendices are: (1) use of classical acoustic methods for calculating standing wave frequencies, (2) finite element grid patterns used in the computer solutions, (3) data on grid point coordinates, and (4) data from cold flow acoustic experiments showing effect of nozzle throat-to-port area ratio (J) on fundamental axial mode frequency.

16. KEY WORDS FOR INDEXING: Acoustic Frequencies; Finite Element; Nozzle Throat; Rocket Motor; Computer Calculations; NASTRAN; Standing Wave Frequencies (Doc Des--P)

17. GIDEP REPRESENTATIVE: M. H. Sloan

18. PARTICIPANT ACTIVITY AND CODE: (X7) Naval Weapons Center, China Lake, Calif.

87 DD FORM 1 OCT 77 2000

403 019

1/B1

CONTENTS

3

INTRODUCTION

Recent advances in solid propellant rocket motor combustion stability analysis now make it possible to calculate the stability of a proposed motor design.[1,2] Each of the three solid propellant rocket motor designs to be used on Space Shuttle flights for the National Aeronautics and Space Administration (NASA) is to have stability prediction techniques applied to it as early in the design phase as feasible. A general flow chart outlining the principal items involved in a stability analysis is shown in Figure 1. As indicated in that figure, detailed knowledge of the internal acoustic characteristics of a motor is a necessary prerequisite to determination of the motor's stability. This report is concerned with the acoustic characteristics of the largest of the three Space Shuttle solid propellant motors: the solid propellant booster motor (SRM).

A matter of concern unique to the Space Shuttle relates to the fact that the shuttle vehicle involves two solid propellant booster motors in conjunction with three liquid fuel engines, all of which provide thrust during the launch phase. There is a possibility that a standing acoustic wave in the solid propellant booster motor could mechanically couple through the vehicle structure with the liquid fuel or oxidizer feed system to create an oscillation in the rate of injection into the liquid engines. Previous experience with liquid fueled rocket engines shows that a situation can occur in which the liquid injection fluctuations cause engine thrust perturbations which in turn reinforce and amplify the liquid injection variations. This behavior is known as the POGO effect and it is an undesirable feature of engine operation.

Thus, knowledge of the internal acoustic characteristics of the SRM is not only necessary for the solid propellant motor stability analysis but it is also required for determining the effect of internal standing acoustic waves on structural response such as dynamic loading of the propellant grain, flexures of the motor case, and force perturbations on the nozzle assembly. In addition, knowledge of the frequencies likely to be generated by the SRM can provide useful data to the liquid engine system designers who can apply that information to existing techniques for reducing the probability of having a POGO effect in the shuttle.

---

[1]Chemical Propulsion Information Agency. "Acoustic Stability Characterization of the Trident (C-4) Motors," by M. W. Beckstead, et.al., *11th JANNAF Combustion Meeting*. Silver Spring, Md., CPIA, December 1974, p. 535. (CPIA Pub. 261, Vol. I, publication UNCLASSIFIED.)

[2]------. "Computer Programs for Solid Rocket Motor Stability Predictions," by R. L. Lovine and R. C. Waugh. *12th JANNAF Combustion Meeting*. Silver Spring, Md., CPIA, December 1975, p. 1. (CPIA Pub. 273, Vol. II, publication UNCLASSIFIED.)

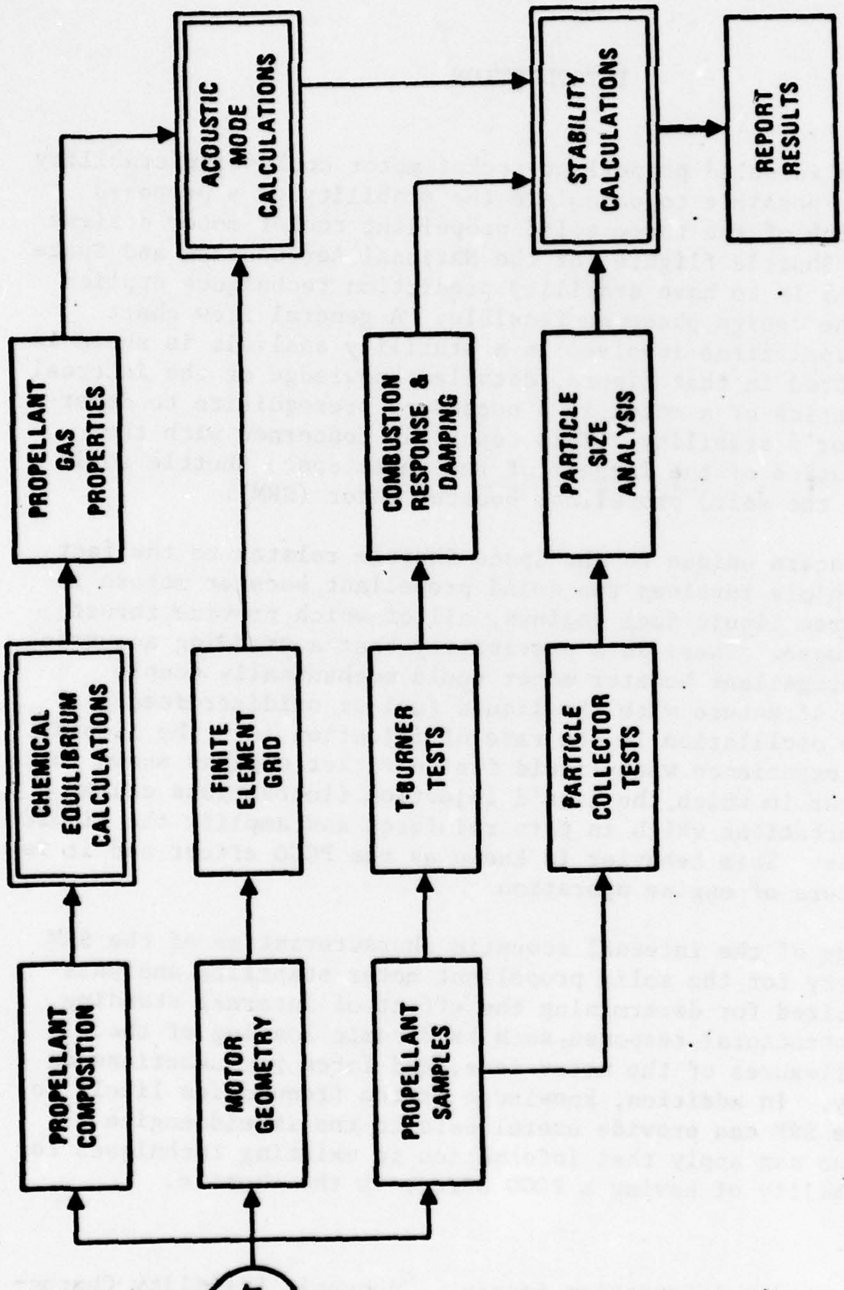


FIGURE 1. Solid Rocket Motor Stability Analysis Flow Chart.

Analysis of the internal acoustics of the SRM was conducted in two phases. The initial phase involved use of equations for acoustic frequency derived from the classical wave equation along with the assumption that the interior motor geometry could be approximated by a right circular cylinder (details of these calculations and results are contained in Appendix A). However, the internal geometry of the SRM departs significantly in some respects from the idealized cylindrical form assumed in the approximate (initial) calculation as shown in Figure 2. The second phase of the analysis of SRM internal acoustics, which is the main subject of this report, involved the use of a relatively sophisticated computer method to provide more accurate predictions of frequency and of acoustic wave structure than could be obtained by the use of classical acoustics. In addition to providing accurate acoustic wave characteristics for a non-cylindrical interior, the computer method of acoustic analysis is an integral part of the motor stability calculation.

INPUT DATA AND METHOD OF CALCULATION

Analysis of the acoustic characteristics of a complicated motor geometry such as the SRM, using presently available techniques, involves use of a finite element formulation of the problem which is solved with the aid of a large, high-speed digital computer. The NASTRAN program, originally developed for NASA to solve problems in structural dynamics, provides a well-established finite element technique which has been adapted to solving the problem of determining the natural standing acoustic waves in cavities which deviate from the geometry of an ideal cylindrical shape.[3,4] Two methods using the NASTRAN program are available at the Naval Weapons Center (NWC). One method involves a quasi-three-dimensional (3D) program which requires that the central region of the cavity be circular in cross-section, that the central region comprise most of the cavity volume, that the symmetry be cyclic, and that slots radiating from the central cavity be narrow in relation to the cavity diameter. The other method developed from the 3D method by the second author, solves the acoustics problem in two-dimensions. The two-dimensional (2D) method does not have the narrow slot restriction which is contained in the 3D method. Both methods require similar input information which includes: cavity geometry, boundary conditions, and parameters relating to properties of the gas filling the cavity. For

---

[3]National Aeronautics and Space Administration. *NASTRAN User's Manual (Level 15)*. NASA, June 1972. (Publication UNCLASSIFIED.)

[4]National Aeronautics and Space Administration. *NASTRAN Theoretical Manual (Level 15)*. NASA, April 1972. (Publication UNCLASSIFIED.)

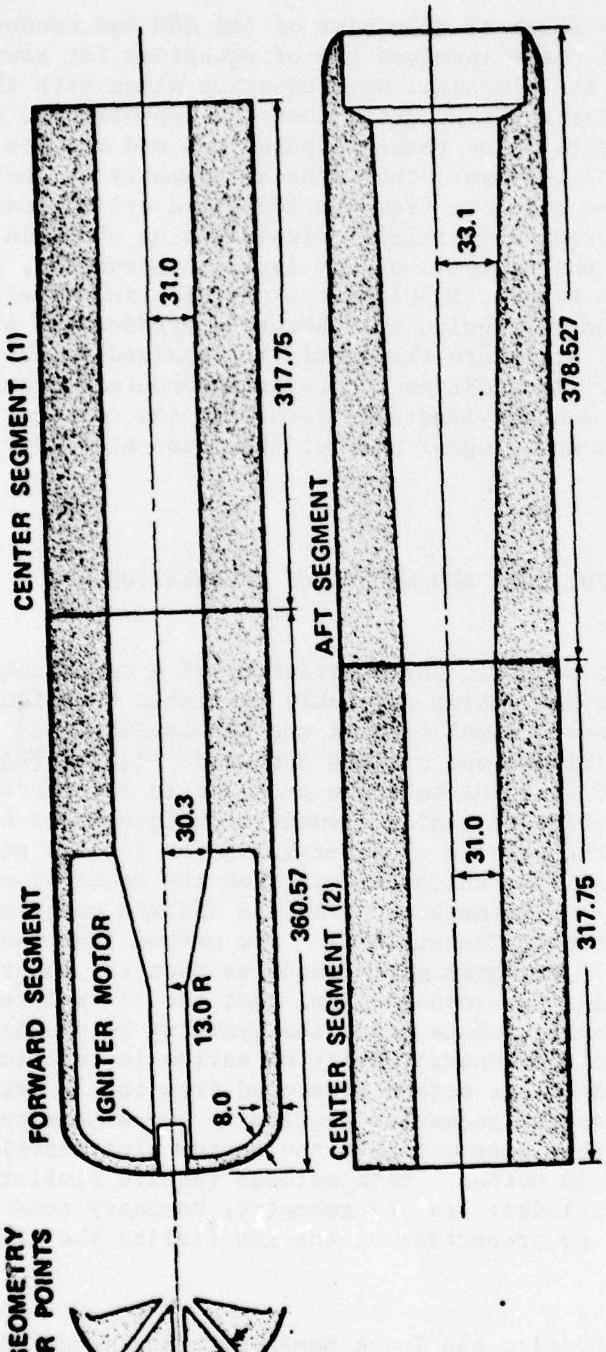


FIGURE 2. Internal Geometry of the SRM.
(Dimensions in inches)

rocket motors, the combustion gas properties are either obtained from data provided by the propellant manufacturer or through the use of a computer Propellant Evaluation Program (PEP) which is available at NWC. If the PEP method is used, as in the case of the SRM, the propellant formulation and the motor operating pressure are required as inputs to the program.

The SRM meets the internal geometry requirements of the 3D NASTRAN method for determining acoustic characteristics. Therefore, since both axial and transverse acoustic modes were of interest, it was determined that the proper approach was to use the 3D program.

Solution of the acoustic characteristics of the booster motor requires setting up a finite-element grid for each time during burn. Grids for three internal configurations were established using large scale drawings of the motor at zero web burn (provided by Thiokol, Wasatch Division) and drawings of the propellant surface regression (furnished by Rockwell International). The three configurations represented web burns of 0, 48, and 86 cm (0, 19, and 34 inches), respectively. The grid system used for the 0-cm web burn, shown in Figure 3, is typical of those used for the other internal configurations. Each of the grids used is shown in detail in Appendix B and grid coordinate data for each of the three configurations are provided in Appendix C.

An important assumption in the acoustic analysis is that the boundaries of the gas-filled interior of the motor are treated as rigid walls. Thus, the acoustic mode program did not allow for transfer of energy from the gas oscillations to the propellant grain or to the motor case. Another assumption used in the present analysis is that the speed of sound in the gas is uniform throughout the cavity. In addition, no allowance is made in the program for mean gas flow. However, the program does allow for the assumption to be made of a closed or an open nozzle throat. Both assumptions have been used in determining the SRM acoustic characteristics as explained in the following paragraphs.

It has been the custom, in assessing rocket motor acoustic characteristics, to assume a closed throat condition. The assumption is a convenience in that it simplifies the analysis, particularly when performing rapid hand calculations (see Appendix A). Furthermore, the closed throat assumption is a reasonable one for the many rocket motors which have a small ratio of nozzle throat area to propellant gas port area. This area ratio, usually termed "J", is not small, however, in the SRM: it is initially 0.716 at ignition and drops to a value of 0.381 at burnout.

The issue of how to treat the nozzle throat acoustically for the SRM is not clear at the present time. One authority suggests that converging gas flow in the nozzle entry region is a possible source of

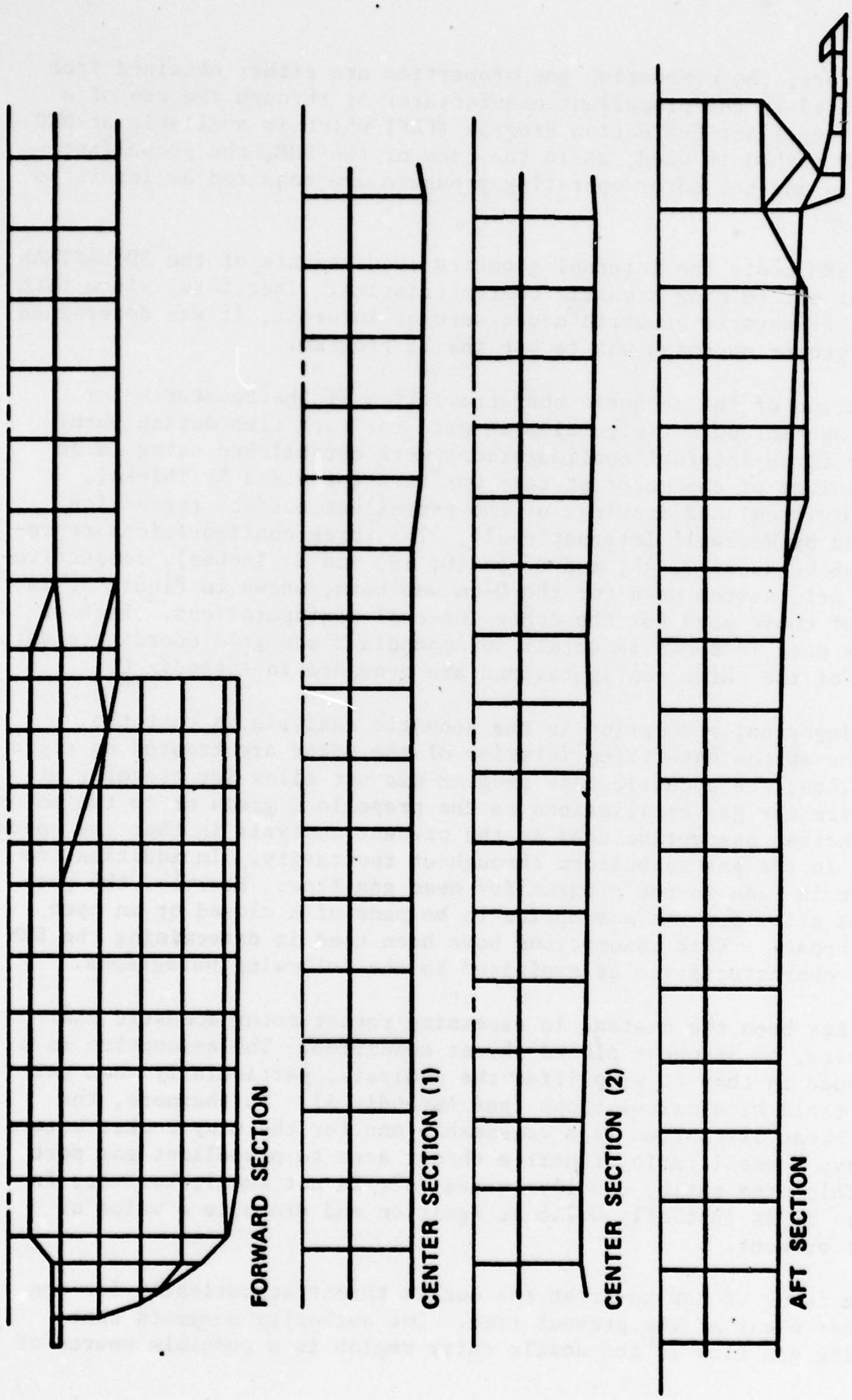


FIGURE 3. SRM Finite Element Grid (0 Web Burn).

acoustic reflection and that it is therefore plausible to treat the nozzle throat as an acoustic reflector (or as a rigid surface).[5] On the other hand, experimental cold gas flow data in small scale model rocket motors indicates that the axial acoustic wave characteristics of the motor are affected by J in a way that suggests the nozzle should be treated as an open or non-reflecting area.[6] A brief discussion of the experimental cold flow data is found in Appendix D.

An additional factor which is known to have an effect on the internal acoustics of the SRM is the flow of gas in the motor and nozzle entry area. However, information regarding gas flow in the motor is not included in the present acoustic calculations so that a quantitative assessment of its effect on motor acoustics is not possible at this time. In regard to gas flow, its importance increases as J increases so that a motor with large J will have two related phenomena affecting its internal acoustics: (1) an essentially geometric effect caused by presence of the nozzle throat as an area in which acoustic waves are "absorbed", and (2) the effect of a net gas flow in the motor which introduces an "asymmetry" into the propagation of acoustic waves: waves traveling in the direction of flow (toward the nozzle) have a greater velocity than waves moving upstream (toward the head end of the motor).

In light of the present situation regarding treatment of the acoustic behavior of the nozzle it seems prudent to present acoustic data for both throat conditions. However, as noted above neither set of data includes the effects of mean gas flow on acoustics.

RESULTS

The 3D NASTRAN acoustics program provides a combination of tabulated and graphic output data. The tabulated data consists primarily of an acoustic pressure distribution which is in the form of a normalized pressure for each point in the finite element grid system. For each acoustic wave solution, the tabulated pressures are expressed as fractions of the maximum pressure in the cavity (which is assigned a value of unity). The graphic output provides a plan view of the finite element

---

[5] Chemical Propulsion Information Agency. "Combustion Instability in Large Solid Rocket Motors," by F. E. C. Culick and R. N. Kumar, *10th JANNAF Combustion Meeting*. Silver Spring, Md., CPIA, December 1973, p. 45. (CPIA Pub. 243, Vol. I, publication UNCLASSIFIED.)

[6] F. G. Buffum, Jr., G. L. Dehority, R. O. Slates, and E. W. Price. "Acoustic Attenuation Experiments on Subscale, Cold-Flow Rocket Motors," *AMER INST AERONAUT ASTRONAUT J*, Vol. 5, No. 2 (February 1967), pp. 272-80.

grid which was used in the problem and isometric views of the grid (one for each acoustic mode) which show the acoustic pressure distribution in a vectorial manner for each standing wave solution.

The tabular pressure distributions are mainly of use only when detailed quantitative information is required of the acoustic pressure and that information is best relegated to an appendix. The isometric graphical output showing the acoustic pressure distribtuion is quite useful for a quick, qualitative view of the nature of the acoustic wave structure and extensive use of isometric graphics is made in describing the results in this report.

The 3D NASTRAN acoustics program results are structured around the order of tangential solutions. The set of solutions for which the tangential order is zero contains all pure axial, pure radial, and combination axial-radial waves. The highest mode number allowed in the analysis was normally set for a value of ten. A mode number in excess of 20 would be needed for the lowest possible radial wave solution to be reached. Therefore, all zero order tangential solutions which were obtained were of axial waves only.

Tangential solutions of order unity include pure first tangential waves, combination first tangential-axial waves, and combination first tangential-axial-radial waves. Only pure first tangential and combination first tangential-axial wave solutions were obtained as the number of modes allowed was not high enough to permit radial solutions to be obtained. Similarly, second order tangential solutions include pure second tangential waves and combinations of second tangential, axial, and radial waves. As with the sets of zero and first order tangential solutions a mode limit of ten was imposed and no solutions containing radial wave motions were obtained. No third or higher order tangential solutions were run.

Isometric graphic displays of the acoustic pressure distributions for the four lowest axial frequencies are shown in Figure 4. These were obtained with the assumption that the nozzle throat is closed. The vertical lines in the figure represent the relative magnitude of the acoustic pressure at each grid point. The pressure distributions shown are the acoustic perturbations about the mean chamber pressure. The perturbed values are presented as if frozen at a point in time when the magnitude of the maximum acoustic pressure in the cavity has reached an arbitrary value of unity. The distribtuions shown in Figure 4, and in all similar figures in this report, are for 0 cm web burn.

Acoustic pressure distributions for the four lowest axial modes with an open throat appear in Figure 5. Two notable differences between closed and open throat solutions are that for the same mode number the closed throat frequencies are higher and there are pressure antinodes

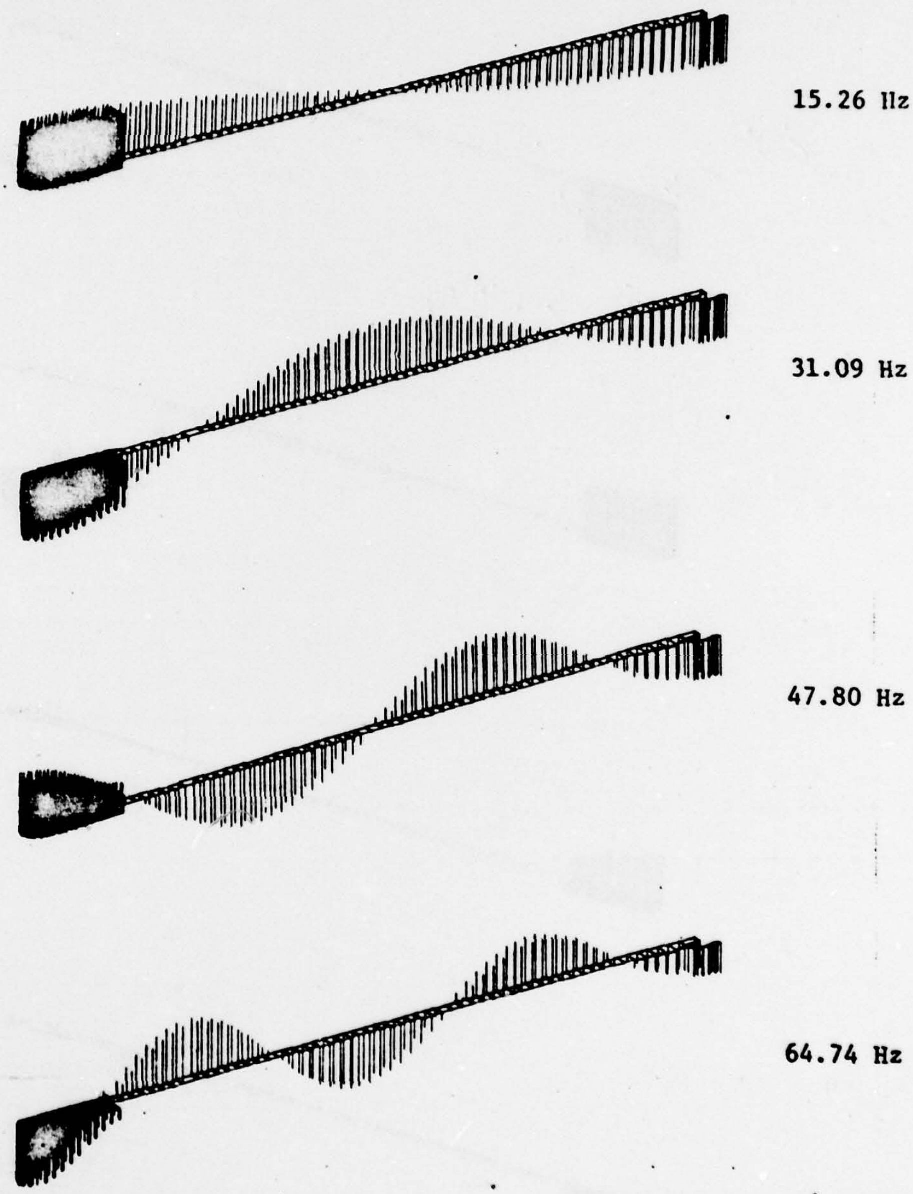


FIGURE 4. Acoustic Pressure Distribution for the Four Lowest Axial Frequencies - Closed Throat. (0 web burn.)

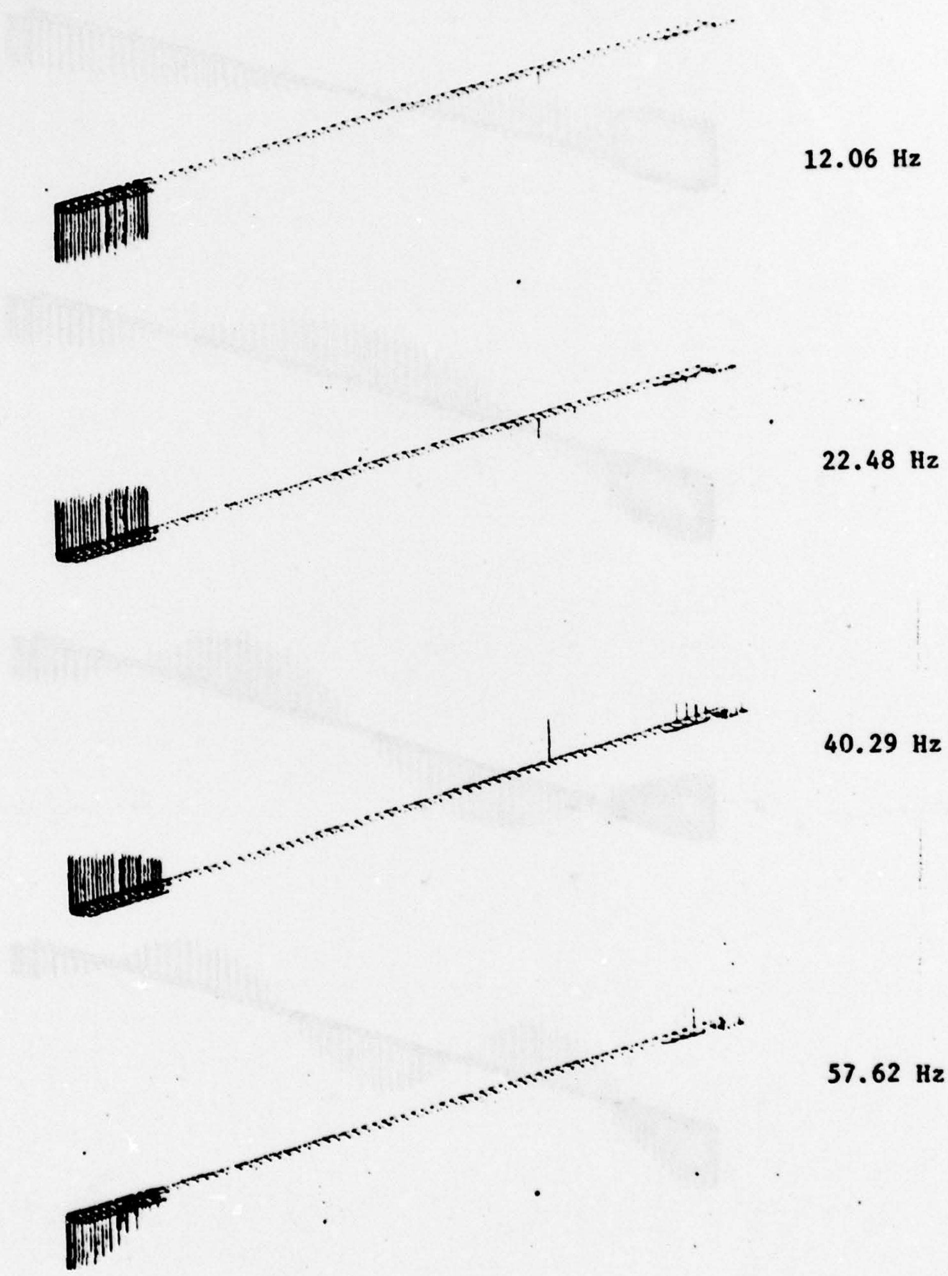


FIGURE 5. Acoustic Pressure Distribution for the Four Lowest Axial Frequencies - Open Throat. (0 web burn.)

present in the nozzle end of the motor when a closed throat is assumed but not when the throat is assumed to be open. A complete listing of axial frequencies for the three web burn distances and with closed and open throat assumptions appears in Table 1.

TABLE 1. SRM Computer-Predicted Frequencies (NASTRAN) Axial Solutions - Hz.

Axial mode No.	Nozzle throat condition	Distance of web burned		
		0 cm (0 in.)	48 cm (19 in.)	86 cm (34 in.)
1	Closed	15.26	13.98	16.19
	Open	12.06	11.49	11.32
2	Closed	31.09	29.89	32.19
	Open	22.48	23.92	24.11
3	Closed	47.80	47.03	48.64
	Open	40.29	38.66	38.61
4	Closed	64.74	64.94	65.72
	Open	57.62	55.85	54.26

Experience with axial mode instability in solid propellant rocket motors indicates that the strongest mode is normally the fundamental (first) mode. Since the acoustic pressure distribution in the SRM of the first axial mode is of interest to structural engineers and to those interested in minimizing POGO effect, first axial mode acoustic pressures are tabulated for each of the three web burns and for both nozzle throat conditions: closed and open. These data are presented in Appendix E.

Graphic acoustic pressure distribution for the four lowest frequencies obtained for solutions of tangential order unity are shown using a closed throat assumption in Figure 6 and for an open throat assumption in Figure 7. It is characteristic of this class of solutions that acoustic wave activity in the lower mode numbers occurs either primarily in the slotted portion of the motor at the forward end or in the annular space that surrounds the nozzle. It is also characteristic

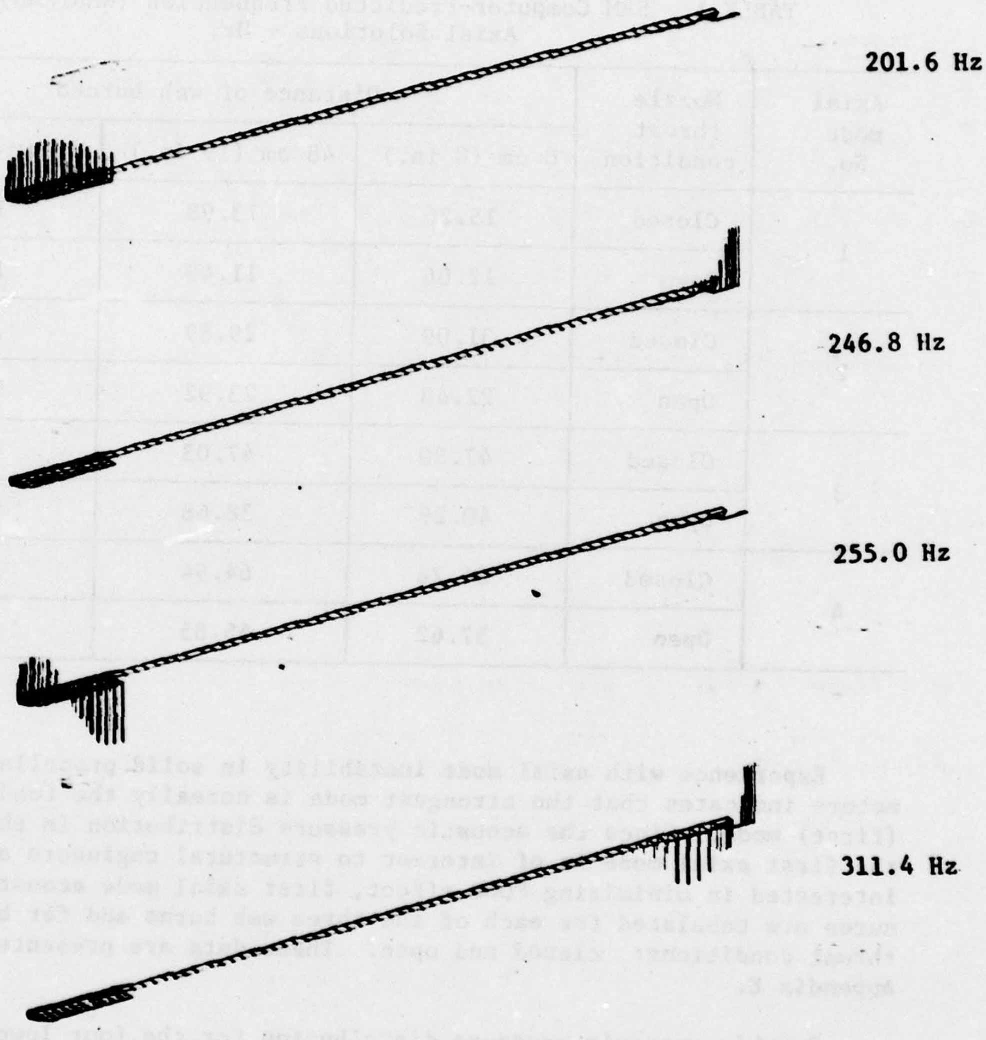


FIGURE 6. Acoustic Pressure Distributions for the Four Lowest First Tangential Frequencies - Closed Throat (0 Web Burn).

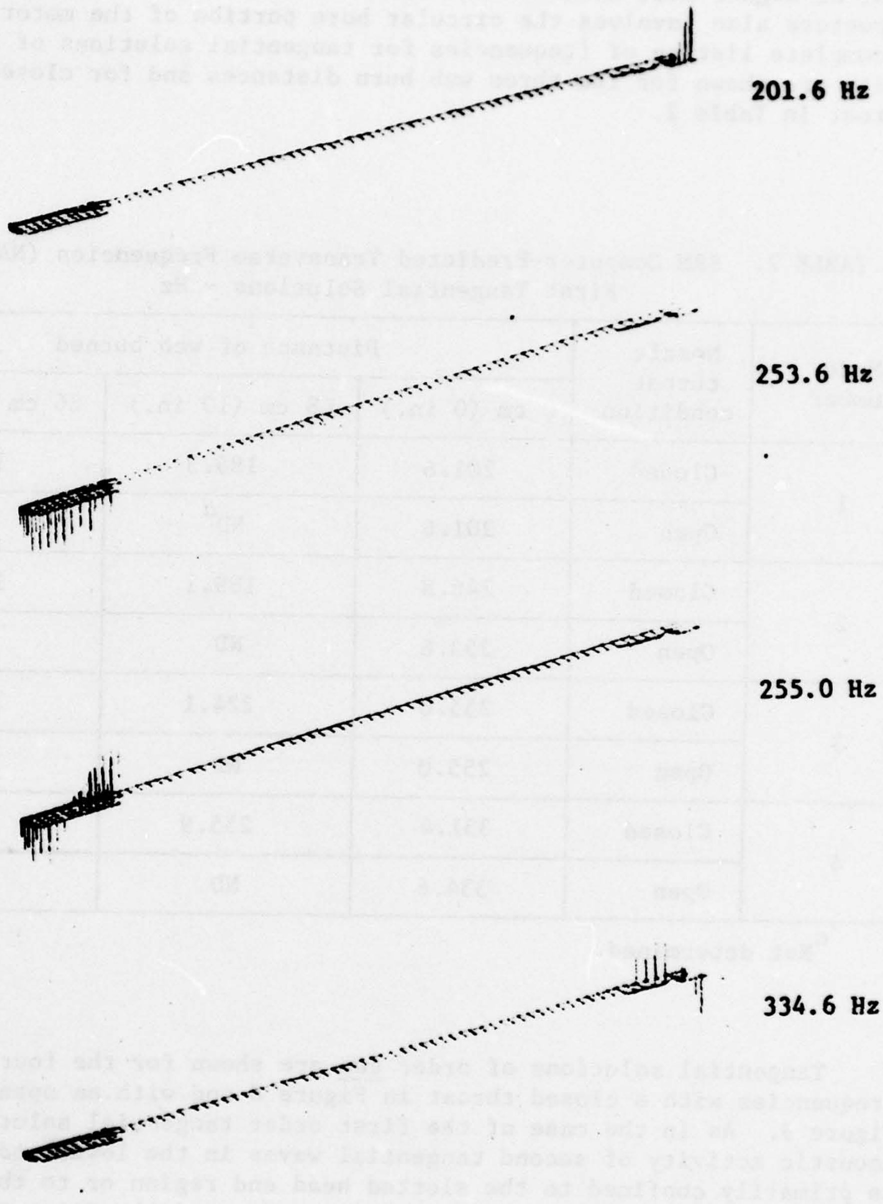


FIGURE 7. Acoustic Pressure Distributions for the Four Lowest First Tangential Frequencies - Open Throat (0 Web Burn).

16

that at higher mode numbers than shown in this report the acoustic wave structure also involves the circular bore portion of the motor cavity. A complete listing of frequencies for tangential solutions of order unity are shown for the three web burn distances and for closed and open throat in Table 2.

TABLE 2. SRM Computer-Predicted Transverse Frequencies (NASTRAN) First Tangential Solutions - Hz

Mode number	Nozzle throat condition	Distance of web burned		
		0 cm (0 in.)	48 cm (19 in.)	86 cm (34 in.)
1	Closed	201.6	186.3	178.0
	Open	201.6	ND[a]	ND
2	Closed	246.8	189.1	186.0
	Open	253.6	ND	ND
3	Closed	255.0	224.1	195.3
	Open	255.0	ND	ND
4	Closed	331.4	255.9	198.9
	Open	334.6	ND	ND

[a]Not determined.

Tangential solutions of order two are shown for the four lowest frequencies with a closed throat in Figure 8 and with an open throat in Figure 9. As in the case of the first order tangential solutions, acoustic activity of second tangential waves in the lower mode numbers is primarily confined to the slotted head end region or to the annular space around the nozzle. Again, as with waves of the first tangential class, second order tangential waves also occur in the central circular bore of the motor but at frequencies higher than are shown here. Frequencies for tangential solutions of order two are shwon for the three burn distances in Table 3.

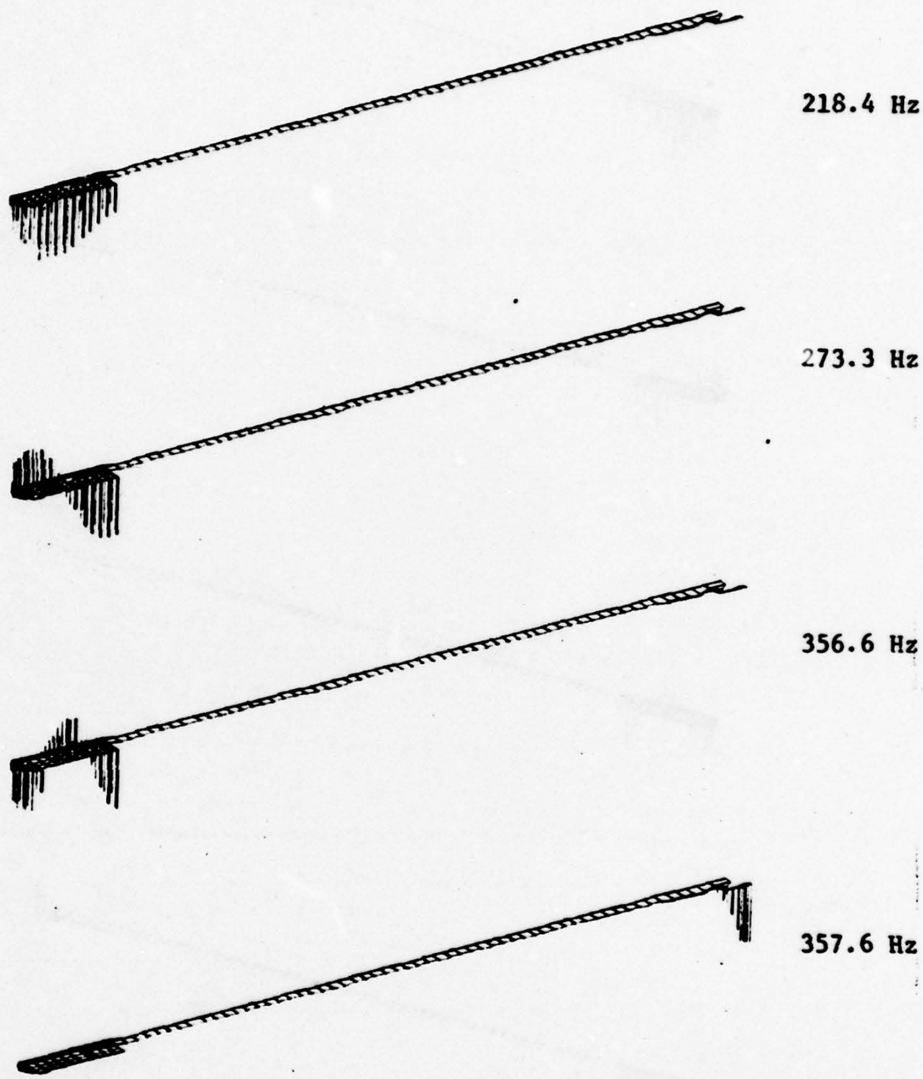


FIGURE 8. Acoustic Pressure Distribution for the Four Lowest Second Tangential Frequencies - Closed Throat (0 Web Burn).

18

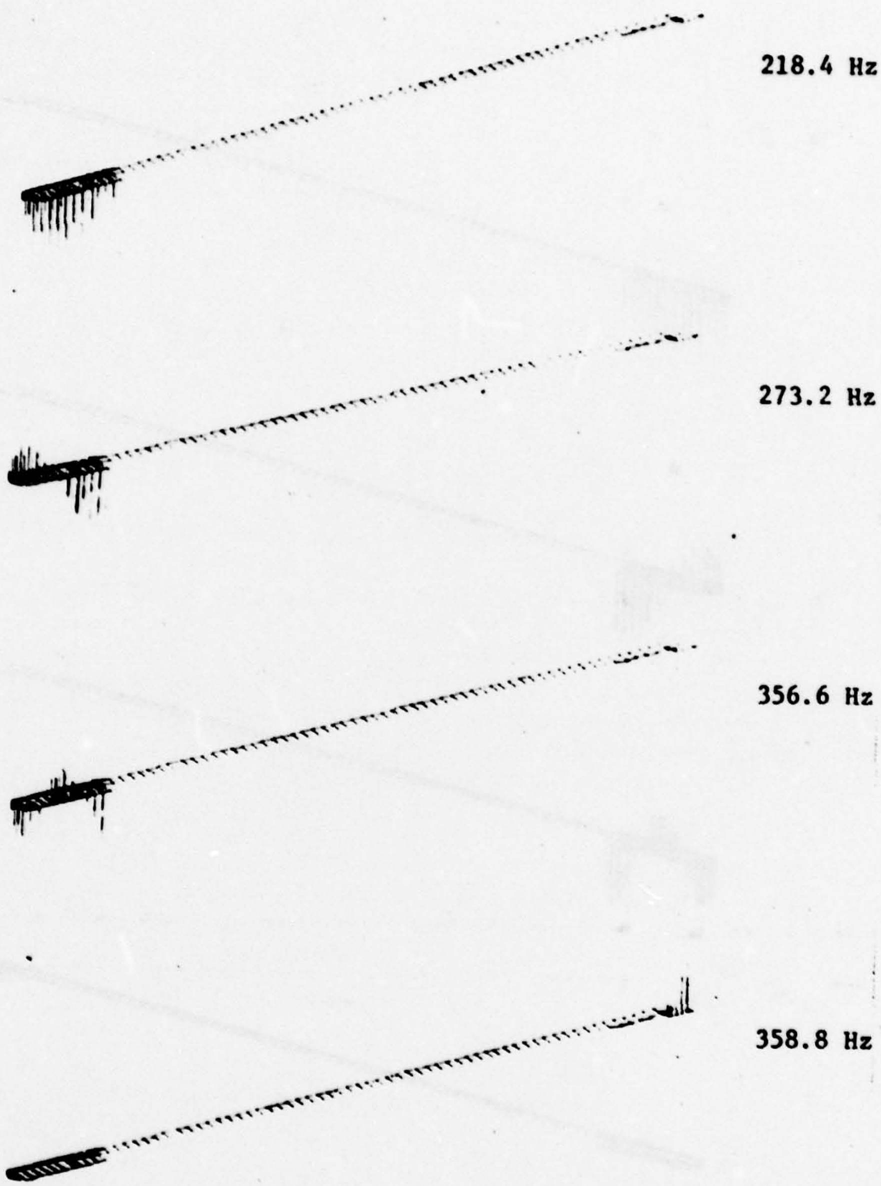


FIGURE 9. Acoustic Pressure Distributions for the Four Lowest Second Tangential Frequencies - Open Throat (0 Web Burn).

TABLE 3. SRM Computer-Predicted Transverse Frequencies (NASTRAN) Second Tangential Solutions - Hz

Mode number	Nozzle throat condition	Distance of web burned		
		0 cm (0 in.)	48 cm (19 in.)	86 cm (34 in.)
1	Closed	218.4	299.7	291.2
	Open	218.4	ND[a]	ND
2	Closed	273.3	304.4	304.9
	Open	273.2	ND	ND
3	Closed	356.6	333.1	319.6
	Open	356.6	ND	ND
4	Closed	357.6	391.8	325.4
	Open	358.8	ND	ND

[a]Not determined.

First and second tangential results for 48- and 86-cm web burns were obtained only for the closed throat condition since the influence of an open throat diminishes with web burn and the cost of additional computer time did not appear to be warranted.

DISCUSSION AND CONCLUSIONS

Initial hand calculations of SRM acoustic characteristics have been supplanted by more accurate 3D NASTRAN results. The hand calculations were limited by assuming that the nozzle throat was an acoustic reflecting surface (closed) and by approximating the actual motor geometry with an equivalent right circular cylinder; the main advantages of hand calculations were speed and economy. The 3D NASTRAN method for obtaining acoustic characteristics accounts for the acoustic effects of slots, tapers, and other geometric complications within the motor and, thereby, generally provides more accurate acoustic solutions than can be obtained by simple hand calculations. The NASTRAN technique allows the option of

20

treating the nozzle throat as a closed or an open area in regard to acoustic wave reflections. Finally, the NASTRAN program also provides detailed data regarding acoustic pressure distribution necessary for performing combustion stability analysis of the motor.

In comparing axial acoustic wave frequencies and wave structure, the differences between the closed and open nozzle throat conditions are apparent: when the closed throat assumption is applied, acoustic waves impinging on the nozzle throat are reflected and a pressure antinode can exist in the aft end of the motor; use of the open throat assumption results in a condition in which a pressure antinode cannot exist in the immediate vicinity of the throat. The effect of the throat is greatest early in burn when J is largest. The effect of the open throat on axial mode frequencies is to cause a lower frequency to exist for a given mode number than for the closed throat frequency. However, the influence of throat condition on frequency diminishes as J decreases and as mode number increases.

It is not possible at this point to know which set of axial wave solutions will prove the most accurate for the SRM. Therefore, solutions for both throat conditions are provided.

Detailed information regarding the finite element grids and the fundamental axial wave pressure distribution are included in Appendices B, C, and E for use by the reader in programs which are involved with the effect of an internal acoustic wave on the motor and Shuttle structures.

The tangential wave solutions are of somewhat more complicated structure than the axial waves. Early in burn when the slotted portion in the forward end of the motor, the cylindrical centerbore, and the annular space surrounding the nozzle are geometrically most distinct from each other, the transverse solutions show acoustic activity primarily in the extreme forward and aft portions of the motor for the lower frequencies. As the frequency increases, transverse waves also involve the circular bore portion of the motor. The tangential solutions show that at later stages of burn as the head, center, and aft portions of the motor become geometrically less distinct from each other, the tangential wave solutions tend to couple more readily between one portion of the motor and another.

In regard to the POGO effect, with its approximately 50 Hz upper frequency limit, the only acoustic waves in the SRM likely to interact with POGO are the lowest axial waves. No transverse wave in the SRM has a predicted frequency below approximately 180 Hz, therefore waves of that class are outside the range of interest to POGO.

Acoustic wave pressure distributions for all modes run on the 3D NASTRAN program will be kept on file at NWC. Should a need for such information arise, it can be obtained on request by contacting either of the authors.

No 2D analyses of the SRM have been made to date as a requirement for 2D data has not been established. However, this program is operational and could be used to obtain higher resolution of transverse acoustic wave characteristics than have been obtained with the 3D program.

Appendix A

USE OF CLASSICAL ACOUSTICS OF A RIGHT CIRCULAR CYLINDER TO ESTIMATE ROCKET MOTOR FREQUENCIES

Resorting to simple methods for predicting rocket motor acoustics which involve use of classical acoustics, simplifying assumptions regarding the interior geometry of the motor, and application of a simple closed-form algebraic relation which allows motor frequencies to be calculated quickly by hand might seem antiquated and out of place when compared with the elegant finite-element methods currently available which permit the frequency and acoustic pressure distribution to be calculated to virtually any desired degree of precision. However, the simple classical approach has its place when time and cost are at a premium and when approximate estimates of acoustic wave frequencies are sufficiently accurate at least on an interim basis.

The first acoustic frequency calculations to be executed at NWC concerning the SRM were based on the classical acoustics model described below and the assumption that the actual motor geometry can be described in terms of an equivalent right circular cylinder. The results were distributed to participants at early meetings concerned with assessment of SRM combustion stability. Since the hand calculations were used in early discussions of SRM combustion stability, they will be discussed in more detail than has been done previously.

Acoustic oscillations in a fluid medium are pressure oscillations of small amplitude and are described mathematically by the classical wave equation. For a right cylindrical cavity with closed ends and ideally rigid walls the acoustic pressure variation can be calculated using:

$$\hat{P}_{m,n,n_z} = \sum_{m,n,n_z} \left[J_m\left(\frac{\pi\alpha_{mn} r}{R}\right)\right] \cos\left(\frac{n_z \pi z}{L}\right) \qquad \text{(A-1)}$$

$$\cdot \left[A_1 \cos(m\phi - \omega t - \delta_1) + A_2 \cos(m\phi - \omega t - \delta_2)\right] \quad \text{(Eq. 3 of footnote 7)}$$

in which

$\hat{P}$ — is the difference between local and space averaged pressure at any point in space and time

r, ϕ, z — Are the cylindrical coordinates with the origin at the center of one end of the cavity

---

[7] R. D. Smith and D. F. Sprenger. "Combustion Instability on Solid Propellant Rockets", Fourth Symposium on Combustion, Williams & Wilkins Co., Baltimore, 1953.

R,L	Radius and length of the cavity
m,n,n_z	Wave numbers characterizing any particular mode of oscillation
J_m	Bessel function of order m
α_{mn}	nth root of the equation $\frac{d}{dx} J_m(\pi x) = 0$ (Some values are given in Table A-1)
A_1,A_2	Arbitrary independent amplitude constants
δ_1,δ_2	Arbitrary independent phase constants
t	Time
ω	Circular frequency

Every possible acoustic mode has its frequency which, for a cylindrical cavity, can be calculated using the following equation:

$$f_{m,n,n_z} = c/2\left[\left(\frac{\alpha_{mn}}{R}\right)^2 + \left(\frac{n_z}{L}\right)^2\right]^{1/2} \quad \text{(A-2)}$$

where c is the velocity of sound of the gas in the cavity.

Any particular mode of oscillation is identified by the wave number in each of the three directions, axial (n_z), radial (n), and tangential (m). Values of α_{mn} for wave numbers up to 3 are given in Table A-1. Where only one wave number is not zero, the corresponding mode is a pure mode. For example, axial acoustic waves have $n_z \neq 0$, m = 0, and n = 0. The axial wave number, n_z, is expressed as a positive integer. Thus axial mode frequencies are given by

$$f = \frac{cn_z}{2L},$$

where $n_z = 1, 2, 3, \ldots$

Likewise, a pure tangential wave frequency is given by the relation

$$f = \frac{c\alpha_{mn}}{2R}$$

where α_{mn} is determined for n = 0 and m any positive integer. In the case of the first tangential wave, for example, $\alpha_{mn} = 0.586$.

TABLE A-1. Values of α_{mn}

Tangential wave No., m	Radial wave number, n			
	0	1	2	3
0	0.000	1.220	2.233	3.238
1	0.586	1.697	2.714	3.726
2	0.972	2.135	3.173	4.192
3	1.337	2.551	3.611	4.643

Although all combinations of pure and mixed waves are possible, it has been the practice to deal primarily with the lowest three or four frequencies of the pure modes. The results for the SRM, using a speed of sound of 9.9×10^4 cm/s (3,250 ft/s), are shown in Table A-2. Dimensions used in the calculations are shown in Table A-3.

TABLE A-2. NASA SRM Acoustic Calculations
(Preliminary Hand Calculations)

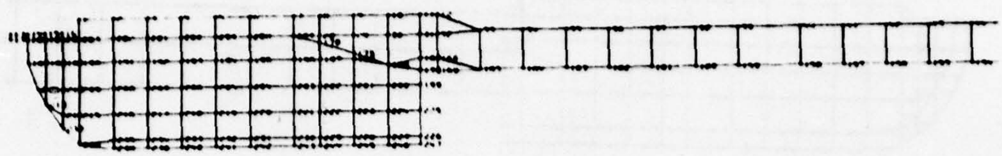
Mode No. (n)	Acoustic frequencies, Hz				
	Axial	Tangential		Radial	
		At ignition	At burnout	At ignition	At burnout
1	15.5	363	160	755	333
2	31.0	602	265	1,382	609
3	46.5	828	365	...	...
4	62.0	...	...	...	...

TABLE A-3

Dimensions used in calculations:

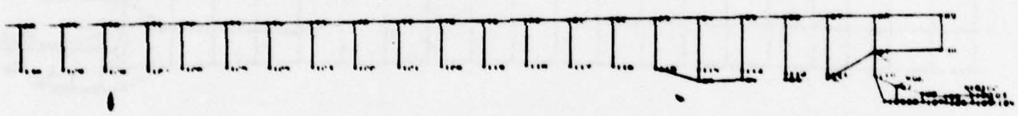
	At ignition	At burnout
Motor length (interior)	3,193 cm (104.75 ft)	3,193 cm (104.75 ft)
Circular perforation diameter	160 cm (63 in.)	363 cm (143 in.)

Appendix B
FINITE ELEMENT GRIDS



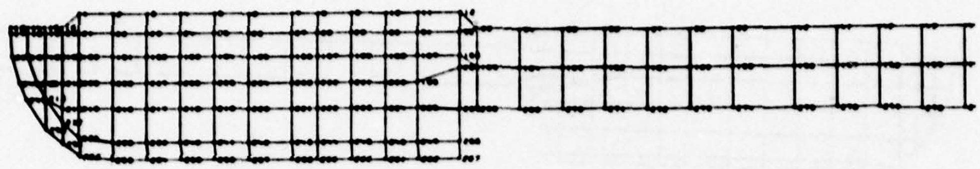
Forward Portion

Center Portion

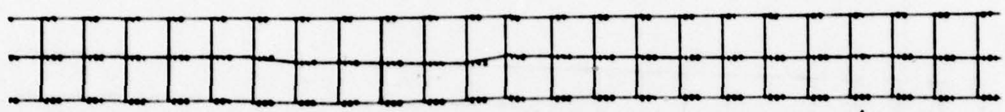


Aft Portion

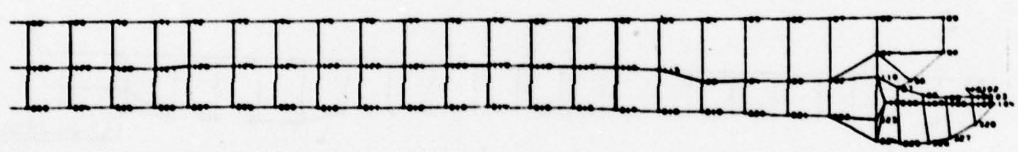
Finite Element Grid for 0-cm Web Burn Acoustic Analysis



Forward Portion

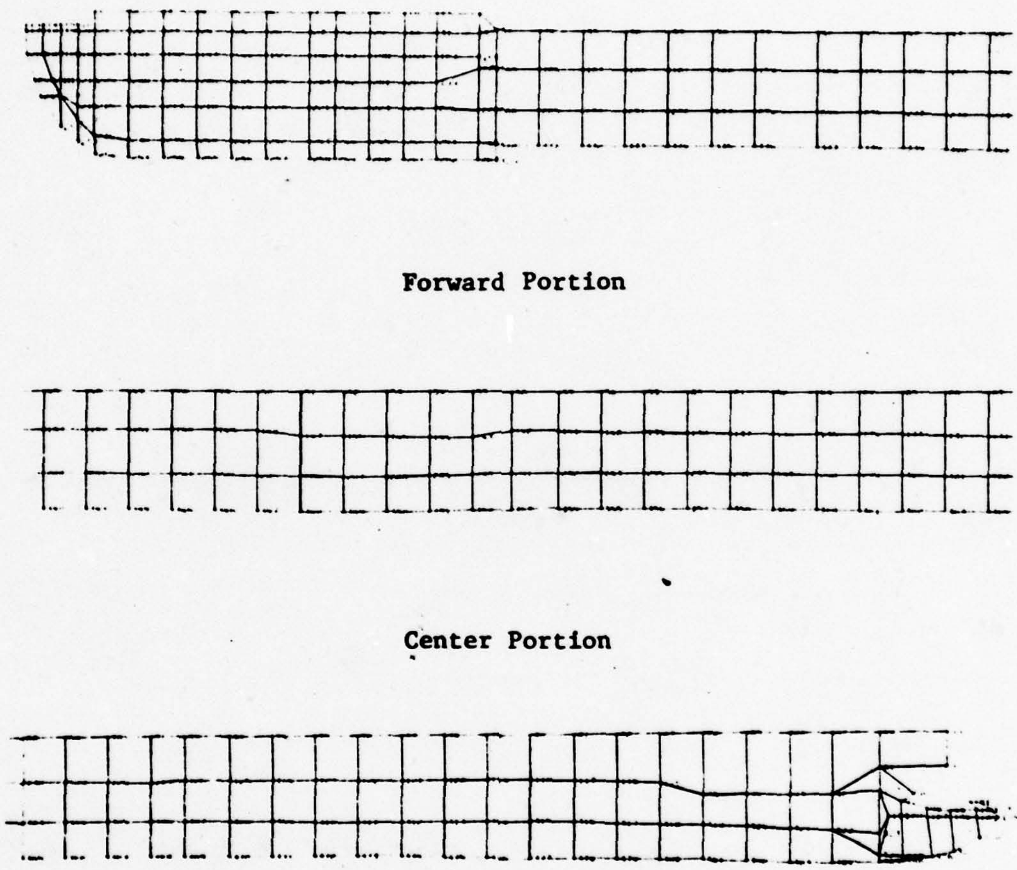


Center Portion



Aft Portion

Finite Element Grid for 48-cm Web Burn Acoustic Analysis.



Forward Portion

Center Portion

Aft Portion

Finite Element Grid for 86-cm Web Burn Acoustic Analysis.

29

Appendix C

FINITE ELEMENT GRID COORDINATE DATA

The following tabulations provide all the necessary data for determining the finite element grids used in the SRM acoustic calculations. Three tables are presented, one for each web burn.

The left hand column identifies the order of the card in the sequence.

The AXSLOT card contains the gas density and bulk modulus, the tangential number and two fields that have a default slot width and number of slots. The SLBDY card(s) lists the grid points along the slot-gas cavity border.

The majority of cards are of two types: element cards and grid cards. These are described in the following:

CAXIF2 are centerbore elements along the centerline.

CAXIF3 are three-sided fluid elements

CAXIF4 are four-sided fluid elements

CSLOT3 are three-sided fluid elements in the slots

CSLOT4 are four-sided fluid elements in the slots

GRIDF points form the corners of the CAXIF elements

GRIDS points form the corner of the CSLOT elements

The second column of the element cards contains the element identification number. The next two, three, or four columns contain the grid identification numbers of the corner points of that element.

The second column of the grid cards is the grid identification number. The third column is the distance from the centerline (R) in inches. The fourth column is the axial distance from the reference point (z) in inches.

PRECEDING PAGE BLANK

TABLE C-1

Grid Coordinate Data for 0-cm Web Burn

31

TABLE C-1 (Contd)

NASA SRM
ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

JANUARY 8, 1976 NASTRAN 1/15/73 PAGE 7

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 .. 7 .. 8 .. 9 .. 10 .
1-	AXSLOT	5.11-7	989.	0	4.0	11
2-	CAXIF2	1	1	2		
3-	CAXIF2	2	2	3		
4-	CAXIF2	3	3	4		
5-	CAXIF2	4	4	5		
6-	CAXIF2	5	5	6		
7-	CAXIF2	6	6	7		
8-	CAXIF2	7	7	8		
9-	CAXIF2	8	8	9		
10-	CAXIF2	9	9	10		
11-	CAXIF2	10	10	11		
12-	CAXIF2	11	11	12		
13-	CAXIF2	94	12	33		
14-	CAXIF2	95	33	34		
15-	CAXIF2	96	34	35		
16-	CAXIF2	97	35	36		
17-	CAXIF2	98	36	37		
18-	CAXIF2	99	37	38		
19-	CAXIF2	100	38	39		
20-	CAXIF2	101	39	40		
21-	CAXIF2	102	40	41		
22-	CAXIF2	103	41	42		
23-	CAXIF2	104	42	43		
24-	CAXIF2	105	43	44		
25-	CAXIF2	106	44	45		
26-	CAXIF2	107	45	46		
27-	CAXIF2	108	46	47		
28-	CAXIF2	109	47	48		
29-	CAXIF2	110	48	49		
30-	CAXIF2	129	49	50		
31-	CAXIF2	130	50	51		
32-	CAXIF2	131	51	52		
33-	CAXIF2	132	52	53		
34-	CAXIF2	133	53	54		
35-	CAXIF2	134	54	55		
36-	CAXIF2	135	55	56		
37-	CAXIF2	136	56	57		
38-	CAXIF2	137	57	58		
39-	CAXIF2	138	58	59		
40-	CAXIF2	139	59	60		
41-	CAXIF2	140	60	61		
42-	CAXIF2	141	61	62		
43-	CAXIF2	142	62	63		
44-	CAXIF2	143	63	64		
45-	CAXIF2	144	64	65		

TABLE C-1 (Contd)

NASA SRM   JANUARY 8, 1976   NASTRAN 1/15/73   PAGE 8
ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 .. 8 .. 9 .. 10 .
46-	CAXIF2	145	65	66			
47-	CAXIF2	163	66	67			
48-	CAXIF2	164	67	68			
49-	CAXIF2	165	68	69			
50-	CAXIF2	166	69	70			
51-	CAXIF2	167	70	71			
52-	CAXIF2	168	71	72			
53-	CAXIF2	169	72	73			
54-	CAXIF2	170	73	74			
55-	CAXIF2	171	74	75			
56-	CAXIF2	172	75	76			
57-	CAXIF2	173	76	77			
58-	CAXIF2	174	77	78			
59-	CAXIF2	175	78	79			
60-	CAXIF2	176	79	80			
61-	CAXIF2	177	80	81			
62-	CAXIF2	178	81	82			
63-	CAXIF2	179	82	83			
64-	CAXIF2	180	83	84			
65-	CAXIF2	181	84	85			
66-	CAXIF2	182	85	86			
67-	CAXIF2	183	86	87			
68-	CAXIF2	184	87	88			
69-	CAXIF2	185	88	89			
70-	CAXIF3	37	27	172	28		
71-	CAXIF3	57	168	170	167		
72-	CAXIF3	111	32	33	12		
73-	CAXIF3	129	169	165	166		
74-	CAXIF3	209	115	114	95		
75-	CAXIF3	214	91	96	90		
76-	CAXIF4	12	17	18	14	13	
77-	CAXIF4	13	18	19	15	14	
78-	CAXIF4	14	19	20	16	15	
79-	CAXIF4	15	20	21	1	16	
80-	CAXIF4	16	21	22	2	1	
81-	CAXIF4	17	22	23	3	2	
82-	CAXIF4	18	23	24	4	3	
83-	CAXIF4	19	24	25	5	4	
84-	CAXIF4	20	25	26	6	5	
85-	CAXIF4	21	26	27	7	6	
86-	CAXIF4	22	27	28	8	7	
87-	CAXIF4	23	28	29	9	8	
88-	CAXIF4	24	29	30	10	9	
89-	CAXIF4	25	30	31	11	10	
90-	CAXIF4	26	31	32	12	11	

TABLE C-1 (Contd)

NASA SRM   JANUARY 8, 1976 NASTRAN 1/15/73 PAGE 9
ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	1	.. 2 ..	3 ..	4 ..	5 ..	6 ..	7 .. 8 .. 9 .. 10 .
91-	CAXIF4	38	172	171	29	28	
92-	CAXIF4	40	171	168	30	29	
93-	CAXIF4	42	168	167	31	30	
94-	CAXIF4	43	167	166	32	31	
95-	CAXIF4	58	170	169	166	167	
96-	CAXIF4	112	166	165	33	32	
97-	CAXIF4	113	165	164	34	33	
98-	CAXIF4	114	164	163	35	34	
99-	CAXIF4	115	163	162	36	35	
100-	CAXIF4	116	162	161	37	36	
101-	CAXIF4	117	161	160	38	37	
102-	CAXIF4	118	160	159	39	38	
103-	CAXIF4	119	159	158	40	39	
104-	CAXIF4	120	158	157	41	40	
105-	CAXIF4	121	157	156	42	41	
106-	CAXIF4	122	156	155	43	42	
107-	CAXIF4	123	155	154	44	43	
108-	CAXIF4	124	154	153	45	44	
109-	CAXIF4	125	153	152	46	45	
110-	CAXIF4	126	152	151	47	46	
111-	CAXIF4	127	151	150	48	47	
112-	CAXIF4	128	150	149	49	48	
113-	CAXIF4	146	149	149	50	49	
114-	CAXIF4	147	148	147	51	50	
115-	CAXIF4	148	147	146	52	51	
116-	CAXIF4	149	146	145	53	52	
117-	CAXIF4	150	145	144	54	53	
118-	CAXIF4	151	144	143	55	54	
119-	CAXIF4	152	143	142	56	55	
120-	CAXIF4	153	142	141	57	56	
121-	CAXIF4	154	141	140	58	57	
122-	CAXIF4	155	140	139	59	58	
123-	CAXIF4	156	139	138	60	59	
124-	CAXIF4	157	138	137	61	60	
125-	CAXIF4	158	137	136	62	61	
126-	CAXIF4	159	136	135	63	62	
127-	CAXIF4	160	135	134	64	63	
128-	CAXIF4	161	134	133	65	64	
129-	CAXIF4	162	133	132	66	65	
130-	CAXIF4	186	132	131	67	66	
131-	CAXIF4	187	131	130	68	67	
132-	CAXIF4	188	130	129	69	68	
133-	CAXIF4	189	129	128	70	69	
134-	CAXIF4	190	128	127	71	70	
135-	CAXIF4	191	127	126	72	71	

TABLE C-1 (Contd)

NASA SRM JANUARY 8, 1976 NASTRAN 1/15/73. PAGE 1C
ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 .. 7 .. 8 .. 9 .. 10 .
136-	CAXIF4	192	126	125	73	72
137-	CAXIF4	193	125	124	74	73
138-	CAXIF4	194	124	123	75	74
139-	CAXIF4	195	123	122	76	75
140-	CAXIF4	196	122	121	77	76
141-	CAXIF4	197	121	120	78	77
142-	CAXIF4	198	120	119	79	78
143-	CAXIF4	199	119	118	80	79
144-	CAXIF4	200	118	117	81	80
145-	CAXIF4	201	117	116	82	81
146-	CAXIF4	202	116	115	83	82
147-	CAXIF4	203	115	95	84	83
148-	CAXIF4	204	95	94	85	84
149-	CAXIF4	205	94	93	86	85
150-	CAXIF4	206	93	92	87	86
151-	CAXIF4	207	92	91	88	87
152-	CAXIF4	208	91	90	89	88
153-	CAXIF4	210	114	113	94	95
154-	CAXIF4	211	113	112	93	94
155-	CAXIF4	212	112	111	92	93
156-	CAXIF4	213	111	110	91	92
157-	CAXIF4	215	110	97	96	91
158-	CAXIF4	216	109	108	97	110
159-	CAXIF4	217	108	107	98	97
160-	CAXIF4	218	107	106	99	98
161-	CAXIF4	219	106	105	103	99
162-	CAXIF4	220	105	104	103	100
163-	CAXIF4	221	100	103	102	101
164-	CSLOT3	41	198	174	175	
165-	CSLOT3	59	213	211	212	
166-	CSLOT3	72	237	214	213	
167-	CSLOT3	84	236	238	235	
168-	CSLOT4	27	187	188	185	186
169-	CSLOT4	28	188	189	184	185
170-	CSLOT4	29	189	190	183	184
171-	CSLOT4	30	190	191	182	183
172-	CSLOT4	31	191	192	181	182
173-	CSLOT4	32	192	193	180	181
174-	CSLOT4	33	193	194	179	180
175-	CSLOT4	34	194	195	178	179
176-	CSLOT4	35	195	196	177	178
177-	CSLOT4	36	196	197	176	177
178-	CSLOT4	39	197	198	175	176
179-	CSLOT4	44	212	211	186	187
180-	CSLOT4	45	211	210	189	188

TABLE C-1 (Contd)

NASA SRM JANUARY 8, 1976 NASTRAN 1/15/73 PAGE 11
ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
181-	CSLOT4	46	210	209	190	189				
182-	CSLOT4	47	209	208	191	190				
183-	CSLOT4	48	208	207	192	191				
184-	CSLOT4	49	207	206	193	192				
185-	CSLOT4	50	206	205	194	193				
186-	CSLOT4	51	205	204	195	194				
187-	CSLOT4	52	204	203	196	195				
188-	CSLOT4	53	203	202	197	196				
189-	CSLOT4	54	202	201	198	197				
190-	CSLOT4	55	201	200	174	198				
191-	CSLOT4	56	200	199	173	174				
192-	CSLOT4	60	213	214	210	211				
193-	CSLOT4	61	214	215	209	210				
194-	CSLOT4	62	215	216	208	209				
195-	CSLOT4	63	216	217	207	208				
196-	CSLOT4	64	217	218	206	207				
197-	CSLOT4	65	218	219	205	206				
198-	CSLOT4	66	219	220	204	205				
199-	CSLOT4	67	220	221	203	204				
200-	CSLOT4	68	221	222	202	203				
201-	CSLOT4	69	222	223	201	202				
202-	CSLOT4	70	223	224	200	201				
203-	CSLOT4	71	224	225	199	200				
204-	CSLOT4	73	237	236	215	214				
205-	CSLOT4	74	236	235	216	215				
206-	CSLOT4	75	235	234	217	216				
207-	CSLOT4	76	234	233	218	217				
208-	CSLOT4	77	233	232	219	218				
209-	CSLOT4	78	232	231	220	219				
210-	CSLOT4	79	231	230	221	220				
211-	CSLOT4	80	230	229	222	221				
212-	CSLOT4	81	229	228	223	222				
213-	CSLOT4	82	228	227	224	223				
214-	CSLOT4	83	227	226	225	224				
215-	CSLOT4	85	238	239	234	235				
216-	CSLOT4	86	239	240	233	234				
217-	CSLOT4	87	240	241	232	233				
218-	CSLOT4	88	241	242	231	232				
219-	CSLOT4	89	242	243	230	231				
220-	CSLOT4	90	243	244	229	230				
221-	CSLOT4	91	244	245	228	229				
222-	CSLOT4	92	245	246	227	228				
223-	CSLOT4	93	246	247	226	227				
224-	EIGR	14	GIV				10			EEE
225-	+EE	MAX								

36

TABLE C-1 (Contd)

NASA SRM — JANUARY 8, 1976 NASTRAN 1/15/73 PAGE 12

ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
226-	GRIDF	1	4.0	24.0
227-	GRIDF	2	4.0	40.0
228-	GRIDF	3	4.0	56.0
229-	GRIDF	4	4.0	72.0
230-	GRIDF	5	4.0	88.0
231-	GRIDF	6	4.0	104.0
232-	GRIDF	7	4.0	124.3
233-	GRIDF	8	4.0	136.3
234-	GRIDF	9	4.0	152.3
235-	GRIDF	10	4.0	168.3
236-	GRIDF	11	4.0	183.3
237-	GRIDF	12	4.0	191.2
238-	GRIDF	13	10.4	-8.0
239-	GRIDF	14	10.4	.0
240-	GRIDF	15	10.4	8.
241-	GRIDF	16	10.4	16.
242-	GRIDF	17	13.2	-8.0
243-	GRIDF	28	13.2	136.3
244-	GRIDF	29	13.2	152.3
245-	GRIDF	30	13.2	168.3
246-	GRIDF	31	13.2	183.3
247-	GRIDF	32	13.2	191.2
248-	GRIDF	33	12.0	211.2
249-	GRIDF	34	12.0	231.2
250-	GRIDF	35	12.0	251.2
251-	GRIDF	36	12.0	271.2
252-	GRIDF	37	12.0	291.2
253-	GRIDF	38	12.0	311.2
254-	GRIDF	39	12.0	331.2
255-	GRIDF	40	12.0	360.3
256-	GRIDF	41	12.0	380.3
257-	GRIDF	42	12.0	400.3
258-	GRIDF	43	12.0	420.3
259-	GRIDF	44	12.0	440.3
260-	GRIDF	45	12.0	460.3
261-	GRIDF	46	12.0	480.3
262-	GRIDF	47	12.0	500.3
263-	GRIDF	48	12.0	520.3
264-	GRIDF	49	12.0	540.3
265-	GRIDF	50	12.0	560.3
266-	GRIDF	51	12.0	580.3
267-	GRIDF	52	12.0	600.3
268-	GRIDF	53	12.0	620.3
269-	GRIDF	54	12.0	640.3
270-	GRIDF	55	12.0	660.3

TABLE C-1 (Contd)

NASA SRM
ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

JANUARY 8, 1976 NASTRAN 1/15/73 PAGE 13

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
271-	GRIDF	56	12.0	678.3
272-	GRIDF	57	12.0	700.0
273-	GRIDF	58	12.0	720.0
274-	GRIDF	59	12.0	740.0
275-	GRIDF	60	12.0	760.0
276-	GRIDF	61	12.0	780.0
277-	GRIDF	62	12.0	800.0
278-	GRIDF	63	12.0	820.0
279-	GRIDF	64	12.0	840.0
280-	GRIDF	65	12.0	660.0
281-	GRIDF	66	12.0	880.0
282-	GRIDF	67	12.0	900.0
283-	GRIDF	68	12.0	920.0
284-	GRIDF	69	12.0	940.0
285-	GRIDF	70	12.0	960.0
286-	GRIDF	71	12.0	980.0
287-	GRIDF	72	12.0	996.0
288-	GRIDF	73	12.0	1016.5
289-	GRIDF	74	12.0	1036.6
290-	GRIDF	75	12.0	1056.5
291-	GRIDF	76	12.0	1076.6
292-	GRIDF	77	12.0	1097.0
293-	GRIDF	78	12.0	1117.0
294-	GRIDF	79	12.0	1136.8
295-	GRIDF	80	12.0	1156.8
296-	GRIDF	81	12.0	1177.2
297-	GRIDF	82	12.0	1197.0
298-	GRIDF	83	12.0	1217.0
299-	GRIDF	84	12.0	1237.4
300-	GRIDF	85	12.0	1257.4
301-	GRIDF	86	12.0	1277.8
302-	GRIDF	87	12.0	1297.4
303-	GRIDF	88	12.0	1319.4
304-	GRIDF	89	12.0	1350.5
305-	GRIDF	90	27.4	1350.5
306-	GRIDF	91	27.8	1319.4
307-	GRIDF	92	40.0	1297.4
308-	GRIDF	93	40.0	1277.8
309-	GRIDF	94	40.0	1257.4
310-	GRIDF	95	40.2	1237.4
311-	GRIDF	96	40.4	1335.0
312-	GRIDF	97	44.0	1329.4
313-	GRIDF	98	47.2	1341.4
314-	GRIDF	99	48.4	1352.1
315-	GRIDF	100	48.2	1364.5

38

TABLE C-1 (Contd)

NASA SRM
ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

JANUARY 8, 1976 NASTRAN 1/15/73 PAGE 14

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
316-	GRIDF	101	44.8	1361.5						
317-	GRIDF	102	44.8	1366.9						
318-	GRIDF	103	48.2	1371.1						
319-	GRIDF	104	51.6	1374.5						
320-	GRIDF	105	51.6	1364.5						
321-	GRIDF	106	51.2	1352.1						
322-	GRIDF	107	51.0	1341.4						
323-	GRIDF	108	50.6	1329.4						
324-	GRIDF	109	50.6	1323.4						
325-	GRIDF	110	38.8	1319.4						
326-	GRIDF	111	38.0	1297.4						
327-	GRIDF	112	37.2	1277.8						
328-	GRIDF	113	36.0	1257.4						
329-	GRIDF	114	35.2	1237.4						
330-	GRIDF	115	34.4	1217.0						
331-	GRIDF	116	33.4	1197.0						
332-	GRIDF	117	33.0	1177.2						
333-	GRIDF	118	32.6	1156.9						
334-	GRIDF	119	32.6	1136.9						
335-	GRIDF	120	32.4	1117.0						
336-	GRIDF	121	32.4	1097.0						
337-	GRIDF	122	32.4	1076.5						
338-	GRIDF	123	32.0	1056.6						
339-	GRIDF	124	32.0	1036.6						
340-	GRIDF	125	32.0	1016.9						
341-	GRIDF	126	32.0	996.0						
342-	GRIDF	127	33.2	980.0						
343-	GRIDF	128	32.6	960.0						
344-	GRIDF	129	32.4	940.0						
345-	GRIDF	130	32.4	920.0						
346-	GRIDF	131	32.0	900.0						
347-	GRIDF	132	31.6	880.0						
348-	GRIDF	133	31.2	860.0						
349-	GRIDF	134	31.2	840.0						
350-	GRIDF	135	31.0	820.0						
351-	GRIDF	136	31.0	800.0						
352-	GRIDF	137	31.0	780.0						
353-	GRIDF	138	30.8	760.0						
354-	GRIDF	139	30.2	740.0						
355-	GRIDF	140	30.2	720.0						
356-	GRIDF	141	29.8	700.0						
357-	GRIDF	142	29.8	678.3						
358-	GRIDF	143	32.8	660.3						
359-	GRIDF	144	32.8	640.3						
360-	GRIDF	145	32.4	620.3						

TABLE C-1 (Contd)

NASA SRM JANUARY 8, 1976 NASTRAN 1/15/73 PAGE 15
ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

SORTED BULK DATA ECHO

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
361-	GRIDF	146	32.0	600.3						
362-	GRIDF	147	32.0	580.3						
363-	GRIDF	148	29.8	560.3						
364-	GRIDF	149	29.8	540.3						
365-	GRIDF	150	29.8	520.3						
366-	GRIDF	151	29.8	500.3						
367-	GRIDF	152	29.8	480.3						
368-	GRIDF	153	29.8	460.3						
369-	GRIDF	154	29.8	440.3						
370-	GRIDF	155	29.8	420.3						
371-	GRIDF	156	29.8	400.3						
372-	GRIDF	157	29.8	380.3						
373-	GRIDF	158	29.8	360.3						
374-	GRIDF	159	29.8	331.2						
375-	GRIDF	160	29.8	311.2						
376-	GRIDF	161	29.8	291.2						
377-	GRIDF	162	29.8	271.2						
378-	GRIDF	163	29.8	251.2						
379-	GRIDF	164	29.8	231.2						
380-	GRIDF	165	29.8	211.2						
381-	GRIDF	166	24.0	191.2						
382-	GRIDF	167	24.0	183.3						
383-	GRIDF	169	29.6	191.2						
384-	GRIDS	173	29.6	183.3		170				
385-	GRIDS	174	26.8	168.3		168				
386-	GRIDS	175	21.6	152.3		171				
387-	GRIDS	176	16.4	136.3		172				
388-	GRIDS	177	13.2	124.3		27				
389-	GRIDS	178	13.2	104.0		26				
390-	GRIDS	179	13.2	88.0		25				
391-	GRIDS	180	13.2	72.0		24				
392-	GRIDS	181	13.2	56.0		23				
393-	GRIDS	182	13.2	40.0		22				
394-	GRIDS	183	13.2	24.0		21				
395-	GRIDS	184	13.2	16.4		20				
396-	GRIDS	185	13.2	8.4		19				
397-	GRIDS	186	13.2	.0		18				
398-	GRIDS	187	24.0	.0						
399-	GRIDS	188	24.0	8.4						
400-	GRIDS	189	24.0	16.4						
401-	GRIDS	190	24.0	24.0						
402-	GRIDS	191	24.0	40.0						
403-	GRIDS	192	24.0	56.0						
404-	GRIDS	193	24.0	72.0						
405-	GRIDS	194	24.0	88.0						

40

TABLE C-1 (Contd)

NASA SRM
ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

JANUARY 8, 1976 NASTRAN 1/15/73 PAGE 16

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
406-	GRIDS	195	24.0	104.0
407-	GRIDS	196	24.0	124.3
408-	GRIDS	197	24.0	136.3
409-	GRIDS	198	24.0	152.3
410-	GRIDS	199	36.4	183.3
411-	GRIDS	200	36.4	168.3
412-	GRIDS	201	36.4	152.3
413-	GRIDS	202	36.4	136.3
414-	GRIDS	203	36.4	124.3
415-	GRIDS	204	36.4	104.0
416-	GRIDS	205	36.4	88.0
417-	GRIDS	206	36.4	72.0
418-	GRIDS	207	36.4	56.0
419-	GRIDS	208	36.4	40.0
420-	GRIDS	209	36.4	24.0
421-	GRIDS	210	36.4	16.4
422-	GRIDS	211	36.4	8.4
423-	GRIDS	212	36.4	4.4
424-	GRIDS	213	43.2	8.4
425-	GRIDS	214	48.0	16.4
426-	GRIDS	215	48.0	24.0
427-	GRIDS	216	48.0	40.0
428-	GRIDS	217	48.0	56.0
429-	GRIDS	218	48.0	72.0
430-	GRIDS	219	48.0	88.0
431-	GRIDS	220	48.0	104.0
432-	GRIDS	221	48.0	124.3
433-	GRIDS	222	48.0	136.3
434-	GRIDS	223	48.0	152.3
435-	GRIDS	224	48.0	168.3
436-	GRIDS	225	48.0	183.3
437-	GRIDS	226	60.0	183.3
438-	GRIDS	227	60.0	168.3
439-	GRIDS	228	60.0	152.3
440-	GRIDS	229	60.0	136.3
441-	GRIDS	230	60.0	124.3
442-	GRIDS	231	60.0	104.0
443-	GRIDS	232	60.0	88.0
444-	GRIDS	233	60.0	72.0
445-	GRIDS	234	60.0	56.0
446-	GRIDS	235	60.0	40.0
447-	GRIDS	236	61.6	24.0
448-	GRIDS	237	54.4	16.4
449-	GRIDS	238	64.0	40.0
450-	GRIDS	239	64.0	56.0

TABLE C-1 (Contd)

NASA SRM
ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

JANUARY 8, 1976 NASTRAN 1/15/73 PAGE 17

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
451-	GRIDS	240	64.0	72.0						
452-	GRIDS	241	64.0	88.0						
453-	GRIDS	242	64.0	104.0						
454-	GRIDS	243	64.C	124.3						
455-	GRIDS	244	64.0	136.3						
456-	GRIDS	245	64.0	152.3						
457-	GRIDS	246	64.0	168.3						
458-	GRIDS	247	64.0	183.3						
459-	SLBDY			173	174	175	176	177	178	+AA
460-	+AA	179	180	181	182	183	184	185	186	
	ENDDATA									

TABLE C-2

Grid Coordinate Data for 48-cm Web Burn

43

TABLE C-2 (Contd)

NASA SRM   JANUARY 13, 1976   NASTRAN 1/15/73   PAGE 6
ZERO TANGENTIAL---SECOND BURN TIME

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 .. 7 .. 8 .. 9 .. 10 .
1-	AXSLOT	5.11-7	989.	6	4.0	11
2-	CAXIF2	1	1	2		
3-	CAXIF2	2	2	3		
4-	CAXIF2	3	3	4		
5-	CAXIF2	4	4	5		
6-	CAXIF2	5	5	6		
7-	CAXIF2	6	6	7		
8-	CAXIF2	7	7	8		
9-	CAXIF2	8	8	9		
10-	CAXIF2	9	9	10		
11-	CAXIF2	10	10	11		
12-	CAXIF2	11	11	12		
13-	CAXIF2	94	12	33		
14-	CAXIF2	95	33	34		
15-	CAXIF2	96	34	35		
16-	CAXIF2	97	35	36		
17-	CAXIF2	98	36	37		
18-	CAXIF2	99	37	38		
19-	CAXIF2	100	38	39		
20-	CAXIF2	101	39	40		
21-	CAXIF2	102	40	41		
22-	CAXIF2	103	41	42		
23-	CAXIF2	104	42	43		
24-	CAXIF2	105	43	44		
25-	CAXIF2	106	44	45		
26-	CAXIF2	107	45	46		
27-	CAXIF2	108	46	47		
28-	CAXIF2	109	47	48		
29-	CAXIF2	110	48	49		
30-	CAXIF2	129	49	50		
31-	CAXIF2	130	50	51		
32-	CAXIF2	131	51	52		
33-	CAXIF2	132	52	53		
34-	CAXIF2	133	53	54		
35-	CAXIF2	134	54	55		
36-	CAXIF2	135	55	56		
37-	CAXIF2	136	56	57		
38-	CAXIF2	137	57	58		
39-	CAXIF2	138	58	59		
40-	CAXIF2	139	59	60		
41-	CAXIF2	140	60	61		
42-	CAXIF2	141	61	62		
43-	CAXIF2	142	62	63		
44-	CAXIF2	143	63	64		
45-	CAXIF2	144	64	65		

44

TABLE C-2 (Contd)

NASA SRM
ZERO TANGENTIAL---SECOND BURN TIME

JANUARY 13, 1976 NASTRAN 1/15/73 PAGE 7

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
46-	CAXIF2	145	65	66						
47-	CAXIF2	163	66	67						
48-	CAXIF2	164	67	68						
49-	CAXIF2	165	68	69						
50-	CAXIF2	166	69	70						
51-	CAXIF2	167	70	71						
52-	CAXIF2	168	71	72						
53-	CAXIF2	169	72	73						
54-	CAXIF2	170	73	74						
55-	CAXIF2	171	74	75						
56-	CAXIF2	172	75	76						
57-	CAXIF2	173	76	77						
58-	CAXIF2	174	77	78						
59-	CAXIF2	175	78	79						
60-	CAXIF2	176	79	80						
61-	CAXIF2	177	80	81						
62-	CAXIF2	178	81	82						
63-	CAXIF2	179	82	83						
64-	CAXIF2	180	83	84						
65-	CAXIF2	181	84	85						
66-	CAXIF2	182	85	86						
67-	CAXIF2	183	86	87						
68-	CAXIF2	184	87	88						
69-	CAXIF2	185	88	89						
70-	CAXIF3	59	213	211	212					
71-	CAXIF3	72	213	237	214					
72-	CAXIF3	111	32	33	12					
73-	CAXIF3	129	264	165	166					
74-	CAXIF3	213	92	110	91					
75-	CAXIF3	214	91	96	90					
76-	CAXIF3	225	250	213	249					
77-	CAXIF3	297	322	324	323					
78-	CAXIF3	298	323	109	110					
79-	CAXIF3	303	328	104	105					
80-	CAXIF3	364	324	109	323					
81-	CAXIF4	12	17	18	14	13				
82-	CAXIF4	13	18	19	15	14				
83-	CAXIF4	14	19	20	16	15				
84-	CAXIF4	15	20	21	1	16				
85-	CAXIF4	16	21	22	2	1				
86-	CAXIF4	17	22	23	3	2				
87-	CAXIF4	18	23	24	4	3				
88-	CAXIF4	19	24	25	5	4				
89-	CAXIF4	20	25	26	6	5				
90-	CAXIF4	21	26	27	7	6				

TABLE C-2 (Contd)

NASA SRM
ZERO TANGENTIAL---SECOND BURN TIME

JANUARY 13, 1976 NASTRAN 1/15/73 PAGE 8

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 .. 7 .. 8 .. 9 .. 10 .
91-	CAXIF4	22	27	28	8	7
92-	CAXIF4	23	28	29	9	8
93-	CAXIF4	24	29	30	10	9
94-	CAXIF4	25	30	31	11	10
95-	CAXIF4	26	31	32	12	11
96-	CAXIF4	27	187	188	19	18
97-	CAXIF4	28	188	189	20	19
98-	CAXIF4	29	189	190	21	20
99-	CAXIF4	30	190	191	22	21
100-	CAXIF4	31	191	192	23	22
101-	CAXIF4	32	192	193	24	23
102-	CAXIF4	33	193	194	25	24
103-	CAXIF4	34	194	195	26	25
104-	CAXIF4	35	195	196	27	26
105-	CAXIF4	36	196	197	28	27
106-	CAXIF4	39	197	198	29	28
107-	CAXIF4	40	198	164	30	29
108-	CAXIF4	42	168	167	31	30
109-	CAXIF4	43	167	166	32	31
110-	CAXIF4	44	212	211	188	187
111-	CAXIF4	45	211	210	189	188
112-	CAXIF4	46	210	209	190	189
113-	CAXIF4	47	209	208	191	190
114-	CAXIF4	48	208	207	192	191
115-	CAXIF4	49	207	206	193	192
116-	CAXIF4	50	206	205	194	193
117-	CAXIF4	51	205	204	195	194
118-	CAXIF4	52	204	203	196	195
119-	CAXIF4	53	203	202	197	196
120-	CAXIF4	54	202	201	198	197
121-	CAXIF4	55	201	200	168	198
122-	CAXIF4	56	200	199	167	168
123-	CAXIF4	60	213	214	210	211
124-	CAXIF4	61	214	215	209	210
125-	CAXIF4	62	215	216	208	209
126-	CAXIF4	63	216	217	207	208
127-	CAXIF4	64	217	218	206	207
128-	CAXIF4	65	218	219	205	206
129-	CAXIF4	66	219	220	204	205
130-	CAXIF4	67	220	221	203	204
131-	CAXIF4	68	221	222	202	203
132-	CAXIF4	69	222	223	201	202
133-	CAXIF4	70	223	224	200	201
134-	CAXIF4	71	224	225	199	200
135-	CAXIF4	73	237	236	215	214

TABLE C-2 (Contd)

NASA SRM JANUARY 13, 1976 NASTRAN 1/15/73 PAGE 9
ZERO TANGENTIAL---SECOND BURN TIME

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..		2 ..	3 ..	4 ..	5 .. 6 .. 7 .. 8 .. 9 .. 10 .
136-	CAXIF4	74	236	238	216	215
137-	CAXIF4	75	238	239	217	216
138-	CAXIF4	76	239	240	218	217
139-	CAXIF4	77	240	241	219	218
140-	CAXIF4	78	241	242	220	219
141-	CAXIF4	79	242	243	221	220
142-	CAXIF4	80	243	244	222	221
143-	CAXIF4	81	244	245	223	222
144-	CAXIF4	82	245	246	224	223
145-	CAXIF4	83	246	247	225	224
146-	CAXIF4	112	264	165	33	32
147-	CAXIF4	113	165	164	34	33
148-	CAXIF4	114	164	163	35	34
149-	CAXIF4	115	163	162	36	35
150-	CAXIF4	116	162	161	37	36
151-	CAXIF4	117	161	160	38	37
152-	CAXIF4	118	160	159	39	38
153-	CAXIF4	119	159	158	40	39
154-	CAXIF4	120	158	157	41	40
155-	CAXIF4	121	157	156	42	41
156-	CAXIF4	122	156	155	43	42
157-	CAXIF4	123	155	154	44	43
158-	CAXIF4	124	154	153	45	44
159-	CAXIF4	125	153	152	46	45
160-	CAXIF4	126	152	151	47	46
161-	CAXIF4	127	151	150	48	47
162-	CAXIF4	128	150	149	49	48
163-	CAXIF4	146	149	148	50	49
164-	CAXIF4	147	148	147	51	50
165-	CAXIF4	148	147	146	52	51
166-	CAXIF4	149	146	145	53	52
167-	CAXIF4	150	145	144	54	53
168-	CAXIF4	151	144	143	55	54
169-	CAXIF4	152	143	142	56	55
170-	CAXIF4	153	142	141	57	56
171-	CAXIF4	154	141	140	58	57
172-	CAXIF4	155	140	139	59	58
173-	CAXIF4	156	139	138	60	59
174-	CAXIF4	157	138	137	61	60
175-	CAXIF4	158	137	136	62	61
176-	CAXIF4	159	136	135	63	62
177-	CAXIF4	160	135	134	64	63
178-	CAXIF4	161	134	133	65	64
179-	CAXIF4	162	133	132	66	65
180-	CAXIF4	186	132	131	67	66

47

TABLE C-2 (Contd)

NASA SRM   JANUARY 13, 1976   NASTRAN 1/15/73   PAGE 10
ZERO TANGENTIAL---SECOND BURN TIME

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 .. 8 .. 9 .. 10 .
181-	CAXIF4	187	131	130	68	67	
182-	CAXIF4	188	130	129	69	68	
183-	CAXIF4	189	129	128	70	69	
184-	CAXIF4	190	128	127	71	70	
185-	CAXIF4	191	127	126	72	71	
186-	CAXIF4	192	126	125	73	72	
187-	CAXIF4	193	125	124	74	73	
188-	CAXIF4	194	124	123	75	74	
189-	CAXIF4	195	123	122	76	75	
190-	CAXIF4	196	122	121	77	76	
191-	CAXIF4	197	121	120	78	77	
192-	CAXIF4	198	120	119	79	78	
193-	CAXIF4	199	119	118	80	79	
194-	CAXIF4	200	118	117	81	80	
195-	CAXIF4	201	117	116	82	81	
196-	CAXIF4	202	116	115	83	82	
197-	CAXIF4	203	115	95	84	83	
198-	CAXIF4	204	95	94	85	84	
199-	CAXIF4	205	94	93	86	85	
200-	CAXIF4	206	93	92	87	86	
201-	CAXIF4	207	92	91	88	87	
202-	CAXIF4	208	91	90	89	88	
203-	CAXIF4	215	110	97	96	91	
204-	CAXIF4	216	109	108	97	110	
205-	CAXIF4	217	108	107	98	97	
206-	CAXIF4	218	107	106	99	98	
207-	CAXIF4	219	106	105	100	99	
208-	CAXIF4	220	105	104	103	100	
209-	CAXIF4	221	100	103	102	101	
210-	CAXIF4	222	263	187	19	17	
211-	CAXIF4	223	248	212	187	263	
212-	CAXIF4	224	249	213	212	248	
213-	CAXIF4	226	250	251	237	213	
214-	CAXIF4	227	251	252	236	237	
215-	CAXIF4	228	252	253	238	236	
216-	CAXIF4	229	253	254	239	238	
217-	CAXIF4	230	254	255	240	239	
218-	CAXIF4	231	255	256	241	240	
219-	CAXIF4	232	256	257	242	241	
220-	CAXIF4	233	257	258	243	242	
221-	CAXIF4	234	258	259	244	243	
222-	CAXIF4	235	259	260	245	244	
223-	CAXIF4	236	260	261	246	245	
224-	CAXIF4	237	261	262	247	246	
225-	CAXIF4	238	262	267	266	247	

48

TABLE C-2 (Contd)

NASA SRM
ZERO TANGENTIAL---SECOND BURN TIME

JANUARY 13, 1976 NASTRAN 1/15/73 PAGE 11

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 .. 8 .. 9 .. 10 .
226-	CAXIF4	239	247	266	265	225	
227-	CAXIF4	240	225	265	264	199	
228-	CAXIF4	241	265	266	165	264	
229-	CAXIF4	242	268	269	164	165	
230-	CAXIF4	243	269	270	163	164	
231-	CAXIF4	244	270	271	162	163	
232-	CAXIF4	245	271	272	161	162	
233-	CAXIF4	246	272	273	160	161	
234-	CAXIF4	247	273	274	159	160	
235-	CAXIF4	248	274	275	158	159	
236-	CAXIF4	249	275	276	157	158	
237-	CAXIF4	250	276	277	156	157	
238-	CAXIF4	251	277	278	155	156	
239-	CAXIF4	252	278	279	154	155	
240-	CAXIF4	253	279	280	153	154	
241-	CAXIF4	254	280	281	152	153	
242-	CAXIF4	255	281	282	151	152	
243-	CAXIF4	256	282	283	150	151	
244-	CAXIF4	257	283	284	149	150	
245-	CAXIF4	258	284	285	148	149	
246-	CAXIF4	259	285	286	147	148	
247-	CAXIF4	260	286	287	146	147	
248-	CAXIF4	261	287	288	145	146	
249-	CAXIF4	262	288	289	144	145	
250-	CAXIF4	263	289	290	143	144	
251-	CAXIF4	264	290	291	142	143	
252-	CAXIF4	265	291	292	141	142	
253-	CAXIF4	266	292	293	140	141	
254-	CAXIF4	267	293	294	139	140	
255-	CAXIF4	268	294	295	138	139	
256-	CAXIF4	269	295	296	137	138	
257-	CAXIF4	270	296	297	136	137	
258-	CAXIF4	271	297	298	135	136	
259-	CAXIF4	272	298	299	134	135	
260-	CAXIF4	273	299	300	133	134	
261-	CAXIF4	274	300	301	132	133	
262-	CAXIF4	275	301	302	131	132	
263-	CAXIF4	276	302	303	130	131	
264-	CAXIF4	277	303	304	129	130	
265-	CAXIF4	278	304	305	128	129	
266-	CAXIF4	279	305	306	127	128	
267-	CAXIF4	280	306	307	126	127	
268-	CAXIF4	281	307	308	125	126	
269-	CAXIF4	282	308	309	124	125	
270-	CAXIF4	283	309	310	123	124	

TABLE C-2 (Contd)

NASA SRM
ZERO TANGENTIAL---SECOND BURN TIME

JANUARY 13, 1976 NASTRAN 1/15/73 PAGE 12

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
271-	CAXIF4	284	310	311	122	123				
272-	CAXIF4	285	311	312	121	122				
273-	CAXIF4	286	312	313	120	121				
274-	CAXIF4	287	313	314	119	120				
275-	CAXIF4	288	314	315	118	119				
276-	CAXIF4	289	315	316	117	118				
277-	CAXIF4	290	316	317	116	117				
278-	CAXIF4	291	317	318	115	116				
279-	CAXIF4	292	318	319	95	115				
280-	CAXIF4	293	319	320	94	95				
281-	CAXIF4	294	320	321	93	94				
282-	CAXIF4	295	321	322	92	93				
283-	CAXIF4	296	322	323	110	92				
284-	CAXIF4	299	324	325	108	109				
285-	CAXIF4	300	325	326	107	108				
286-	CAXIF4	301	326	327	106	107				
287-	CAXIF4	302	327	328	105	106				
288-	CAXIF4	362	199	264	266	267				
289-	EIGR	14	GIV				20			IGR
290-	+GR	MAX								
291-	GRIDF	1	4.0	24.0						
292-	GRIDF	2	4.0	40.0						
293-	GRIDF	3	4.0	56.0						
294-	GRIDF	4	4.0	72.0						
295-	GRIDF	5	4.0	88.0						
296-	GRIDF	6	4.0	104.0						
297-	GRIDF	7	4.0	124.3						
298-	GRIDF	8	4.0	136.3						
299-	GRIDF	9	4.0	152.3						
300-	GRIDF	10	4.0	168.3						
301-	GRIDF	11	4.0	183.3						
302-	GRIDF	12	4.0	203.						
303-	GRIDF	13	10.4	-8.0						
304-	GRIDF	14	10.4	0.0						
305-	GRIDF	15	10.4	8.						
306-	GRIDF	16	10.4	16.						
307-	GRIDF	17	13.2	-8.0						
308-	GRIDF	18	13.2	0.0						
309-	GRIDF	19	13.2	8.4						
310-	GRIDF	20	13.2	16.4						
311-	GRIDF	21	13.2	24.0						
312-	GRIDF	22	13.2	40.0						
313-	GRIDF	23	13.2	56.0						
314-	GRIDF	24	13.2	72.0						
315-	GRIDF	25	13.2	88.0						

TABLE C-2 (Contd)

NASA SRM   JANUARY 13, 1976   NASTRAN 1/15/73   PAGE 13
ZERO TANGENTIAL---SECOND BURN TIME

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
316-	GRIDF	26	13.2	104.0
317-	GRIDF	27	13.2	124.3
318-	GRIDF	28	13.2	136.3
319-	GRIDF	29	13.2	152.3
320-	GRIDF	30	13.2	168.3
321-	GRIDF	31	13.2	183.3
322-	GRIDF	32	13.2	203.
323-	GRIDF	33	12.0	211.2
324-	GRIDF	34	12.0	231.2
325-	GRIDF	35	12.0	251.2
326-	GRIDF	36	12.0	271.2
327-	GRIDF	37	12.0	291.2
328-	GRIDF	38	12.0	311.2
329-	GRIDF	39	12.0	331.2
330-	GRIDF	40	12.0	360.3
331-	GRIDF	41	12.0	380.3
332-	GRIDF	42	12.0	400.3
333-	GRIDF	43	12.0	420.3
334-	GRIDF	44	12.0	440.3
335-	GRIDF	45	12.0	460.3
336-	GRIDF	46	12.0	480.3
337-	GRIDF	47	12.0	500.3
338-	GRIDF	48	12.0	520.3
339-	GRIDF	49	12.0	540.3
340-	GRIDF	50	12.0	560.3
341-	GRIDF	51	12.0	580.3
342-	GRIDF	52	12.0	600.3
343-	GRIDF	53	12.0	620.3
344-	GRIDF	54	12.0	640.3
345-	GRIDF	55	12.0	660.3
346-	GRIDF	56	12.0	678.3
347-	GRIDF	57	12.0	700.0
348-	GRIDF	58	12.0	720.0
349-	GRIDF	59	12.0	740.0
350-	GRIDF	60	12.0	760.0
351-	GRIDF	61	12.0	780.0
352-	GRIDF	62	12.0	800.0
353-	GRIDF	63	12.0	820.0
354-	GRIDF	64	12.0	840.0
355-	GRIDF	65	12.0	860.0
356-	GRIDF	66	12.0	880.0
357-	GRIDF	67	12.0	900.0
358-	GRIDF	68	12.0	920.0
359-	GRIDF	69	12.0	940.0
360-	GRIDF	70	12.0	960.0

51

TABLE C-2 (Contd)

NASA SRM JANUARY 13, 1976 NASTRAN 1/15/73 PAGE 14
ZERO TANGENTIAL---SECOND BURN TIME

SORTED BULK DATA ECHO

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
361-	GRIDF	71	12.0	980.0
362-	GRIDF	72	12.0	996.0
363-	GRIDF	73	12.0	1016.8
364-	GRIDF	74	12.0	1036.6
365-	GRIDF	75	12.0	1056.6
366-	GRIDF	76	12.0	1076.6
367-	GRIDF	77	12.0	1097.0
368-	GRIDF	78	12.0	1117.0
369-	GRIDF	79	12.0	1136.9
370-	GRIDF	80	12.0	1156.9
371-	GRIDF	81	12.0	1177.2
372-	GRIDF	82	12.0	1197.0
373-	GRIDF	83	12.0	1217.0
374-	GRIDF	84	12.0	1237.4
375-	GRIDF	85	12.0	1257.4
376-	GRIDF	86	12.0	1277.8
377-	GRIDF	87	12.0	1297.4
378-	GRIDF	88	12.0	1319.4
379-	GRIDF	89	12.0	1350.5
380-	GRIDF	90	27.4	1350.5
381-	GRIDF	91	27.8	1319.4
382-	GRIDF	92	40.0	1297.4
383-	GRIDF	93	40.0	1277.8
384-	GRIDF	94	40.0	1257.4
385-	GRIDF	95	40.2	1237.4
386-	GRIDF	96	40.4	1335.0
387-	GRIDF	97	44.0	1329.4
388-	GRIDF	98	47.2	1341.4
389-	GRIDF	99	48.4	1352.1
390-	GRIDF	100	48.2	1364.5
391-	GRIDF	101	44.8	1361.5
392-	GRIDF	102	44.8	1366.9
393-	GRIDF	103	48.2	1371.1
394-	GRIDF	104	51.6	1374.5
395-	GRIDF	105	51.6	1364.5
396-	GRIDF	106	51.2	1352.1
397-	GRIDF	107	51.0	1341.4
398-	GRIDF	108	50.6	1329.4
399-	GRIDF	109	50.6	1323.4
400-	GRIDF	110	38.8	1319.4
401-	GRIDF	115	34.4	1217.0
402-	GRIDF	116	33.4	1197.0
403-	GRIDF	117	33.0	1177.2
404-	GRIDF	118	32.6	1156.9
405-	GRIDF	119	32.6	1136.8

52

TABLE C-2 (Contd)

NASA SPN   JANUARY 13, 1976   NASTRAN 1/15/73   PAGE 15
-ZERO TANGENTIAL---SECOND BURN TIME

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
406-	GRIDF	120	32.4	1117.0
407-	GRIDF	121	32.4	1097.0
408-	GRIDF	122	32.4	1076.6
409-	GRIDF	123	32.0	1056.6
410-	GRIDF	124	32.0	1036.6
411-	GRIDF	125	32.0	1016.8
412-	GRIDF	126	32.0	996.0
413-	GRIDF	127	33.2	980.0
414-	GRIDF	128	32.8	960.0
415-	GRIDF	129	32.4	940.0
416-	GRIDF	130	32.4	920.0
417-	GRIDF	131	32.0	900.0
418-	GRIDF	132	31.6	880.0
419-	GRIDF	133	31.2	860.0
420-	GRIDF	134	31.2	840.0
421-	GRIDF	135	31.0	820.0
422-	GRIDF	136	31.0	800.0
423-	GRIDF	137	31.0	780.0
424-	GRIDF	138	30.8	760.0
425-	GRIDF	139	30.2	740.0
426-	GRIDF	140	30.2	720.0
427-	GRIDF	141	29.8	700.0
428-	GRIDF	142	29.8	678.3
429-	GRIDF	143	32.8	660.3
430-	GRIDF	144	32.8	640.3
431-	GRIDF	145	32.4	620.3
432-	GRIDF	146	32.0	600.3
433-	GRIDF	147	32.0	590.3
434-	GRIDF	148	29.6	560.3
435-	GRIDF	149	29.8	540.3
436-	GRIDF	150	29.8	523.3
437-	GRIDF	151	29.8	500.3
438-	GRIDF	152	29.8	480.3
439-	GRIDF	153	29.8	460.3
440-	GRIDF	154	29.8	440.3
441-	GRIDF	155	29.8	420.3
442-	GRIDF	156	29.8	400.3
443-	GRIDF	157	29.8	380.3
444-	GRIDF	158	29.8	360.3
445-	GRIDF	159	29.8	331.2
446-	GRIDF	160	29.8	311.2
447-	GRIDF	161	29.8	291.2
448-	GRIDF	162	29.8	271.2
449-	GRIDF	163	29.6	251.2
450-	GRIDF	164	29.8	231.2

TABLE C-2 (Contd)

NASA SRM
ZERO TANGENTIAL---SECOND BURN TIME

JANUARY 13, 1976 NASTRAN 1/15/73 PAGE 16

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
451-	GRIDF	165	29.8	211.2
452-	GRIDF	166	24.	203.
453-	GRIDF	167	24.0	183.3
454-	GRIDF	168	24.0	169.3
455-	GRIDF	187	24.0	0.0
456-	GRIDF	188	24.0	6.4
457-	GRIDF	189	24.0	16.4
458-	GRIDF	190	24.0	24.0
459-	GRIDF	191	24.0	40.0
460-	GRIDF	192	24.0	56.0
461-	GRIDF	193	24.0	72.0
462-	GRIDF	194	24.0	88.0
463-	GRIDF	195	24.0	104.0
464-	GRIDF	196	24.0	124.3
465-	GRIDF	197	24.0	136.3
466-	GRIDF	198	24.0	152.3
467-	GRIDF	199	36.4	163.3
468-	GRIDF	200	36.4	168.3
469-	GRIDF	201	36.4	152.3
470-	GRIDF	202	36.4	136.3
471-	GRIDF	203	36.4	124.3
472-	GRIDF	204	36.4	104.0
473-	GRIDF	205	36.4	88.0
474-	GRIDF	206	36.4	72.0
475-	GRIDF	207	36.4	56.0
476-	GRIDF	208	36.4	40.0
477-	GRIDF	209	36.4	24.0
478-	GRIDF	210	36.4	16.4
479-	GRIDF	211	36.4	8.4
480-	GRIDF	212	36.4	4.4
481-	GRIDF	213	43.2	8.4
482-	GRIDF	214	48.0	16.4
483-	GRIDF	215	48.0	24.0
484-	GRIDF	216	48.0	40.0
485-	GRIDF	217	48.0	56.0
486-	GRIDF	218	48.0	72.0
487-	GRIDF	219	48.0	88.0
488-	GRIDF	220	48.0	104.0
489-	GRIDF	221	48.0	124.3
490-	GRIDF	222	48.0	136.3
491-	GRIDF	223	48.0	152.3
492-	GRIDF	224	48.0	168.3
493-	GRIDF	225	48.0	183.3
494-	GRIDF	236	61.6	24.0
495-	GRIDF	237	54.4	16.4

TABLE C-2 (Contd)

NASA SRM ZERO TANGENTIAL---SECOND BURN TIME JANUARY 13, 1976 NASTRAN 1/15/73 PAGE 17

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
496-	GRIDF	239	64.0	40.0
497-	GRIDF	239	64.0	56.0
498-	GRIDF	240	64.0	72.0
499-	GRIDF	241	64.0	88.0
500-	GRIDF	242	64.0	104.0
501-	GRIDF	243	64.0	124.3
502-	GRIDF	244	64.0	136.3
503-	GRIDF	245	64.0	152.3
504-	GRIDF	246	64.0	168.3
505-	GRIDF	247	64.0	183.3
506-	GRIDF	248	36.3	-3.9
507-	GRIDF	249	43.8	-0.6
508-	GRIDF	250	58.0	8.5
509-	GRIDF	251	64.7	16.6
510-	GRIDF	252	70.5	25.0
511-	GRIDF	253	72.0	40.5
512-	GRIDF	254	72.0	56.8
513-	GRIDF	255	72.0	72.4
514-	GRIDF	256	72.0	88.6
515-	GRIDF	257	72.0	104.8
516-	GRIDF	258	72.0	124.8
517-	GRIDF	259	72.0	136.5
518-	GRIDF	260	72.0	152.6
519-	GRIDF	261	72.0	168.5
520-	GRIDF	262	72.0	183.6
521-	GRIDF	263	24.0	-7.5
522-	GRIDF	264	29.8	203.0
523-	GRIDF	265	49.0	203.0
524-	GRIDF	266	64.0	203.0
525-	GRIDF	267	72.0	203.0
526-	GRIDF	268	49.0	211.2
527-	GRIDF	269	49.0	231.2
528-	GRIDF	270	49.0	251.2
529-	GRIDF	271	49.0	271.2
530-	GRIDF	272	49.0	291.2
531-	GRIDF	273	49.0	311.2
532-	GRIDF	274	49.0	331.2
533-	GRIDF	275	49.0	360.3
534-	GRIDF	276	49.0	380.3
535-	GRIDF	277	49.0	400.3
536-	GRIDF	278	49.5	420.3
537-	GRIDF	279	49.5	440.3
538-	GRIDF	280	49.5	460.3
539-	GRIDF	281	49.5	480.3
540-	GRIDF	282	50.0	500.3

55

TABLE C-2 (Contd)

NASA SRM — JANUARY 13, 1974 — NASTRAN 1/15/73 — PAGE 18
ZERO TANGENTIAL---SECOND BURN TIME

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 .. 6 .. 7 .. 8 .. 9 .. 10 .
541-	GRIDF	283	50.0	520.3	
542-	GRIDF	284	50.0	540.3	
543-	GRIDF	285	50.5	560.3	
544-	GRIDF	286	50.5	580.3	
545-	GRIDF	287	51.0	600.3	
546-	GRIDF	288	51.0	620.3	
547-	GRIDF	289	50.5	640.3	
548-	GRIDF	290	50.0	660.3	
549-	GRIDF	291	49.3	678.3	
550-	GRIDF	292	49.3	700.0	
551-	GRIDF	293	49.2	720.0	
552-	GRIDF	294	49.2	740.0	
553-	GRIDF	295	49.2	760.0	
554-	GRIDF	296	49.5	780.0	
555-	GRIDF	297	49.5	800.0	
556-	GRIDF	298	50.0	820.0	
557-	GRIDF	299	50.0	840.0	
558-	GRIDF	300	50.0	860.0	
559-	GRIDF	301	50.5	880.0	
560-	GRIDF	302	50.5	900.0	
561-	GRIDF	303	51.0	920.0	
562-	GRIDF	304	51.0	940.0	
563-	GRIDF	305	51.	960.	
564-	GRIDF	306	51.0	980.0	
565-	GRIDF	307	51.0	996.0	
566-	GRIDF	308	51.0	1016.6	
567-	GRIDF	309	51.0	1036.6	
568-	GRIDF	310	51.6	1056.6	
569-	GRIDF	311	51.6	1076.6	
570-	GRIDF	312	51.6	1097.0	
571-	GRIDF	313	51.6	1117.0	
572-	GRIDF	314	51.6	1136.8	
573-	GRIDF	315	51.6	1156.5	
574-	GRIDF	316	52.0	1177.2	
575-	GRIDF	317	53.0	1197.0	
576-	GRIDF	318	53.7	1217.0	
577-	GRIDF	319	54.1	1237.4	
578-	GRIDF	320	55.0	1257.4	
579-	GRIDF	321	56.0	1277.8	
580-	GRIDF	322	57.0	1297.4	
581-	GRIDF	323	58.5	1319.4	
582-	GRIDF	324	68.5	1319.4	
583-	GRIDF	325	69.5	1330.0	
584-	GRIDF	326	69.5	1343.9	
585-	GRIDF	327	67.4	1353.9	

TABLE C-2 (Contd)

```
NASA SRM                                                          JANUARY 13, 1976   NASTRAN  1/15/73   PAGE    19
ZERO TANGENTIAL---SECOND BURN TIME

                              S O R T E D   B U L K   D A T A   E C H O
CARD
COUNT       .  1  ..  2  ..  3  ..  4  ..  5  ..  6  ..  7  ..  8  ..  9  ..  10  .
 596-       GRIDF   328    61.0    1365.8
            ENDDATA
```


57

TABLE C-3

Grid Coordinate Data for 86-cm Web Burn

TABLE C-3 (Contd)

NASA SRM JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 7
ZERO TANGENTIAL---THIRD BURN TIME

SORTED BULK DATA ECHO

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 .. 8 .. 9 .. 10 .
1-	AXSLOT	5.11-7	989.	0	4.0	20	
2-	CAXIF2	1	1	2			
3-	CAXIF2	2	2	3			
4-	CAXIF2	3	3	4			
5-	CAXIF2	4	4	5			
6-	CAXIF2	5	5	6			
7-	CAXIF2	6	6	7			
8-	CAXIF2	7	7	8			
9-	CAXIF2	8	8	9			
10-	CAXIF2	9	9	10			
11-	CAXIF2	10	10	11			
12-	CAXIF2	11	11	12			
13-	CAXIF2	94	12	33			
14-	CAXIF2	95	33	34			
15-	CAXIF2	96	34	35			
16-	CAXIF2	97	35	36			
17-	CAXIF2	98	36	37			
18-	CAXIF2	99	37	38			
19-	CAXIF2	100	38	39			
20-	CAXIF2	101	39	40			
21-	CAXIF2	102	40	41			
22-	CAXIF2	103	41	42			
23-	CAXIF2	104	42	43			
24-	CAXIF2	105	43	44			
25-	CAXIF2	106	44	45			
26-	CAXIF2	107	45	46			
27-	CAXIF2	108	46	47			
28-	CAXIF2	109	47	48			
29-	CAXIF2	110	48	49			
30-	CAXIF2	129	49	50			
31-	CAXIF2	130	50	51			
32-	CAXIF2	131	51	52			
33-	CAXIF2	132	52	53			
34-	CAXIF2	133	53	54			
35-	CAXIF2	134	54	55			
36-	CAXIF2	135	55	56			
37-	CAXIF2	136	56	57			
38-	CAXIF2	137	57	58			
39-	CAXIF2	138	58	59			
40-	CAXIF2	139	59	60			
41-	CAXIF2	140	60	61			
42-	CAXIF2	141	61	62			
43-	CAXIF2	142	62	63			
44-	CAXIF2	143	63	64			
45-	CAXIF2	144	64	65			

59

TABLE C-3 (Contd)

NASA SRM JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 8
ZERO TANGENTIAL---THIRD BURN TIME

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 .. 8 .. 9 .. 10 .
46-	CAXIF2	162	65	66			
47-	CAXIF2	163	66	67			
48-	CAXIF2	164	67	68			
49-	CAXIF2	165	68	69			
50-	CAXIF2	166	69	70			
51-	CAXIF2	167	70	71			
52-	CAXIF2	168	71	72			
53-	CAXIF2	169	72	73			
54-	CAXIF2	170	73	74			
55-	CAXIF2	171	74	75			
56-	CAXIF2	172	75	76			
57-	CAXIF2	173	76	77			
58-	CAXIF2	174	77	78			
59-	CAXIF2	175	78	79			
60-	CAXIF2	176	79	80			
61-	CAXIF2	177	80	81			
62-	CAXIF2	178	81	82			
63-	CAXIF2	179	82	83			
64-	CAXIF2	180	83	84			
65-	CAXIF2	181	84	85			
66-	CAXIF2	182	85	86			
67-	CAXIF2	183	86	87			
68-	CAXIF2	184	87	88			
69-	CAXIF2	185	88	89			
70-	CAXIF3	59	213	211	212		
71-	CAXIF3	72	213	237	214		
72-	CAXIF3	111	32	33	12		
73-	CAXIF3	129	264	165	166		
74-	CAXIF3	213	92	110	91		
75-	CAXIF3	214	91	96	90		
76-	CAXIF3	225	250	213	249		
77-	CAXIF3	297	322	324	323		
78-	CAXIF3	298	323	109	110		
79-	CAXIF3	303	328	104	105		
80-	CAXIF3	360	365	326	324		
81-	CAXIF3	363	366	326	325		
82-	CAXIF3	364	324	109	323		
83-	CAXIF4	12	17	18	14	13	
84-	CAXIF4	13	18	19	15	14	
85-	CAXIF4	14	19	20	16	15	
86-	CAXIF4	15	20	21	1	16	
87-	CAXIF4	16	21	22	2	1	
88-	CAXIF4	17	22	23	3	2	
89-	CAXIF4	18	23	24	4	3	
90-	CAXIF4	19	24	25	5	4	

TABLE C-3 (Contd)

NASA SRM | JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 9
ZERO TANGENTIAL---THIRD BURN TIME

SORTED BULK DATA ECHO

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 .. 10 .
91-	CAXIF4	20	25	26	6	5			
92-	CAXIF4	21	26	27	7	6			
93-	CAXIF4	22	27	28	8	7			
94-	CAXIF4	23	28	29	9	8			
95-	CAXIF4	24	29	30	10	9			
96-	CAXIF4	25	30	31	11	10			
97-	CAXIF4	26	31	32	12	11			
98-	CAXIF4	27	187	188	19	18			
99-	CAXIF4	28	188	189	20	19			
100-	CAXIF4	29	189	190	21	20			
101-	CAXIF4	30	190	191	22	21			
102-	CAXIF4	31	191	192	23	22			
103-	CAXIF4	32	192	193	24	23			
104-	CAXIF4	33	193	194	25	24			
105-	CAXIF4	34	194	195	26	25			
106-	CAXIF4	35	195	196	27	26			
107-	CAXIF4	36	196	197	28	27			
108-	CAXIF4	39	197	198	29	28			
109-	CAXIF4	40	198	168	30	29			
110-	CAXIF4	42	166	167	31	30			
111-	CAXIF4	43	167	166	32	31			
112-	CAXIF4	44	212	211	184	187			
113-	CAXIF4	45	211	210	189	163			
114-	CAXIF4	46	210	209	190	189			
115-	CAXIF4	47	209	208	191	190			
116-	CAXIF4	48	208	207	192	191			
117-	CAXIF4	49	207	206	193	192			
118-	CAXIF4	50	206	205	194	193			
119-	CAXIF4	51	205	204	195	194			
120-	CAXIF4	52	204	203	196	195			
121-	CAXIF4	53	203	202	197	196			
122-	CAXIF4	54	202	201	198	197			
123-	CAXIF4	55	201	200	168	198			
124-	CAXIF4	56	200	199	167	166			
125-	CAXIF4	60	213	214	210	211			
126-	CAXIF4	61	214	215	209	210			
127-	CAXIF4	62	215	216	208	209			
128-	CAXIF4	63	216	217	207	208			
129-	CAXIF4	64	217	218	206	207			
130-	CAXIF4	65	218	219	205	206			
131-	CAXIF4	66	219	220	204	205			
132-	CAXIF4	67	220	221	203	204			
133-	CAXIF4	68	221	222	202	203			
134-	CAXIF4	69	222	223	201	202			
135-	CAXIF4	70	223	224	200	201			

61

TABLE C-3 (Contd)

NASA SRM
ZERO TANGENTIAL---THIRD BURN TIME

JANUARY 16, 1976 NASTRAN 1/25/73 PAGE 13

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 .. 7 .. 8 .. 9 .. 10 .
136-	CAXIF4	71	224	225	199	200
137-	CAXIF4	73	237	236	215	214
138-	CAXIF4	74	236	238	216	215
139-	CAXIF4	75	232	239	217	216
140-	CAXIF4	76	239	240	218	217
141-	CAXIF4	77	240	241	219	218
142-	CAXIF4	78	241	242	220	219
143-	CAXIF4	79	242	243	221	220
144-	CAXIF4	60	243	244	222	221
145-	CAXIF4	81	244	245	223	222
146-	CAXIF4	62	245	246	224	223
147-	CAXIF4	83	246	247	225	224
148-	CAXIF4	112	264	165	33	32
149-	CAXIF4	113	165	164	34	33
150-	CAXIF4	114	164	163	35	34
151-	CAXIF4	115	163	162	36	35
152-	CAXIF4	116	162	161	37	36
153-	CAXIF4	117	161	160	38	37
154-	CAXIF4	118	160	159	39	38
155-	CAXIF4	119	159	158	40	39
156-	CAXIF4	120	154	157	41	40
157-	CAXIF4	121	157	156	42	41
158-	CAXIF4	122	156	155	43	42
159-	CAXIF4	123	155	154	44	43
160-	CAXIF4	124	154	153	45	44
161-	CAXIF4	125	153	152	46	45
162-	CAXIF4	126	152	151	47	46
163-	CAXIF4	127	151	150	48	47
164-	CAXIF4	128	150	149	49	48
165-	CAXIF4	146	149	148	50	49
166-	CAXIF4	147	148	147	51	50
167-	CAXIF4	148	147	146	52	51
168-	CAXIF4	149	146	145	53	52
169-	CAXIF4	150	145	144	54	53
170-	CAXIF4	151	144	143	55	54
171-	CAXIF4	152	143	142	56	55
172-	CAXIF4	153	142	141	57	56
173-	CAXIF4	154	141	140	58	57
174-	CAXIF4	155	140	139	59	58
175-	CAXIF4	156	139	138	60	59
176-	CAXIF4	157	138	137	61	60
177-	CAXIF4	158	137	136	62	61
178-	CAXIF4	159	136	135	63	62
179-	CAXIF4	160	135	134	64	63
180-	CAXIF4	161	134	133	65	64

62

TABLE C-3 (Contd)

NASA SRM   JANUARY 16, 1976   NASTRAN 1/15/73   PAGE 11
ZERO TANGENTIAL---THIRD BURN TIME

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 .. 7 .. 8 .. 9 .. 10 .
181-	CAXIF4	182	133	132	66	65
182-	CAXIF4	186	132	131	67	66
183-	CAXIF4	187	131	130	68	67
184-	CAXIF4	188	130	129	69	68
185-	CAXIF4	189	129	128	70	69
186-	CAXIF4	190	128	127	71	70
187-	CAXIF4	191	127	126	72	71
188-	CAXIF4	192	126	125	73	72
189-	CAXIF4	193	125	124	74	73
190-	CAXIF4	194	124	123	75	74
191-	CAXIF4	195	123	122	76	75
192-	CAXIF4	196	122	121	77	76
193-	CAXIF4	197	121	120	78	77
194-	CAXIF4	198	120	119	79	78
195-	CAXIF4	199	119	118	80	79
196-	CAXIF4	200	118	117	81	80
197-	CAXIF4	201	117	116	82	81
198-	CAXIF4	202	116	115	83	82
199-	CAXIF4	203	115	95	84	83
200-	CAXIF4	204	95	94	85	84
201-	CAXIF4	205	94	93	86	85
202-	CAXIF4	206	93	92	87	86
203-	CAXIF4	207	92	91	88	87
204-	CAXIF4	208	91	90	89	88
205-	CAXIF4	215	110	97	96	91
206-	CAXIF4	216	109	108	97	110
207-	CAXIF4	217	108	107	98	97
208-	CAXIF4	218	107	106	99	98
209-	CAXIF4	219	106	105	100	99
210-	CAXIF4	220	105	104	103	100
211-	CAXIF4	221	103	103	102	101
212-	CAXIF4	222	263	187	18	17
213-	CAXIF4	223	248	212	197	263
214-	CAXIF4	224	249	213	212	246
215-	CAXIF4	226	250	251	237	213
216-	CAXIF4	227	251	252	236	237
217-	CAXIF4	228	252	253	238	236
218-	CAXIF4	229	253	254	239	236
219-	CAXIF4	230	254	255	240	239
220-	CAXIF4	231	255	256	241	240
221-	CAXIF4	232	256	257	242	241
222-	CAXIF4	233	257	258	243	242
223-	CAXIF4	234	258	259	244	243
224-	CAXIF4	235	259	260	245	244
225-	CAXIF4	236	260	261	246	245

63

TABLE C-3 (Contd)

NASA SRM   JANUARY 16, 1976   NASTRAN 1/15/73   PAGE 12
ZERO TANGENTIAL---THIRD BURN TIME

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 .. 8 .. 9 .. 10 .
226-	CAXIF4	237	261	262	247	246	
227-	CAXIF4	238	262	267	266	247	
228-	CAXIF4	239	247	266	265	225	
229-	CAXIF4	240	225	265	264	199	
230-	CAXIF4	241	265	266	165	264	
231-	CAXIF4	242	268	269	164	165	
232-	CAXIF4	243	269	270	163	164	
233-	CAXIF4	244	270	271	162	163	
234-	CAXIF4	245	271	272	161	162	
235-	CAXIF4	246	272	273	160	161	
236-	CAXIF4	247	273	274	159	160	
237-	CAXIF4	248	274	275	158	159	
238-	CAXIF4	249	275	276	157	158	
239-	CAXIF4	250	276	277	156	157	
240-	CAXIF4	251	277	278	155	156	
241-	CAXIF4	252	278	279	154	155	
242-	CAXIF4	253	279	280	153	154	
243-	CAXIF4	254	280	281	152	153	
244-	CAXIF4	255	281	282	151	152	
245-	CAXIF4	256	282	283	150	151	
246-	CAXIF4	257	283	284	149	150	
247-	CAXIF4	258	284	285	148	149	
248-	CAXIF4	259	285	286	147	148	
249-	CAXIF4	260	286	287	146	147	
250-	CAXIF4	261	287	288	145	146	
251-	CAXIF4	262	288	289	144	145	
252-	CAXIF4	263	289	290	143	144	
253-	CAXIF4	264	290	291	142	143	
254-	CAXIF4	265	291	292	141	142	
255-	CAXIF4	266	292	293	140	141	
256-	CAXIF4	267	293	294	139	140	
257-	CAXIF4	268	294	295	138	139	
258-	CAXIF4	269	295	296	137	138	
259-	CAXIF4	270	296	297	136	137	
260-	CAXIF4	271	297	298	135	136	
261-	CAXIF4	272	298	299	134	135	
262-	CAXIF4	273	299	300	133	134	
263-	CAXIF4	274	300	301	132	133	
264-	CAXIF4	275	301	302	131	132	
265-	CAXIF4	276	302	303	130	131	
266-	CAXIF4	277	303	304	129	130	
267-	CAXIF4	278	304	305	128	129	
268-	CAXIF4	279	305	306	127	128	
269-	CAXIF4	280	306	307	126	127	
270-	CAXIF4	281	307	308	125	126	

64

TABLE C-3 (Contd)

NASA SDM — JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 13

ZERO TANGENTIAL---THIRD BURN TIME

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 .. 8 .. 9 .. 10 .
271-	CAXIF4	282	309	309	124	125	
272-	CAXIF4	283	309	310	123	124	
273-	CAXIF4	284	310	311	122	123	
274-	CAXIF4	285	311	312	121	122	
275-	CAXIF4	286	312	313	120	121	
276-	CAXIF4	287	313	314	119	120	
277-	CAXIF4	288	314	315	118	119	
278-	CAXIF4	289	315	316	117	118	
279-	CAXIF4	290	316	317	116	117	
280-	CAXIF4	291	317	318	115	116	
281-	CAXIF4	292	318	319	95	115	
282-	CAXIF4	293	319	320	94	95	
283-	CAXIF4	294	320	321	93	94	
284-	CAXIF4	295	321	322	92	93	
285-	CAXIF4	296	322	323	110	92	
286-	CAXIF4	299	324	325	108	109	
287-	CAXIF4	300	325	326	107	108	
288-	CAXIF4	301	326	327	106	107	
289-	CAXIF4	302	327	328	105	106	
290-	CAXIF4	304	266	330	266	265	
291-	CAXIF4	305	330	331	269	268	
292-	CAXIF4	306	331	332	270	269	
293-	CAXIF4	307	332	333	271	270	
294-	CAXIF4	308	333	334	272	271	
295-	CAXIF4	309	334	335	273	272	
296-	CAXIF4	310	335	336	274	273	
297-	CAXIF4	311	336	337	275	274	
298-	CAXIF4	312	337	338	276	275	
299-	CAXIF4	313	338	339	277	276	
300-	CAXIF4	314	339	340	278	277	
301-	CAXIF4	315	340	341	279	278	
302-	CAXIF4	316	341	342	280	279	
303-	CAXIF4	317	342	343	281	280	
304-	CAXIF4	318	343	344	282	281	
305-	CAXIF4	319	344	345	283	282	
306-	CAXIF4	320	345	346	284	283	
307-	CAXIF4	321	346	347	285	284	
308-	CAXIF4	322	347	348	286	285	
309-	CAXIF4	323	348	349	287	286	
310-	CAXIF4	324	349	350	288	287	
311-	CAXIF4	325	350	351	289	288	
312-	CAXIF4	326	351	352	290	289	
313-	CAXIF4	327	352	353	291	290	
314-	CAXIF4	328	353	354	292	291	
315-	CAXIF4	329	354	355	293	292	

65

TABLE C-3 (Contd)

NASA SRM   JANUARY 16, 1976   NASTRAN 1/15/73   PAGE 14
ZERO TANGENTIAL---THIRD BURN TIME

SORTED BULK DATA ECHO

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
316-	CAXIF4	330	355	356	294	293				
317-	CAXIF4	331	356	357	295	294				
318-	CAXIF4	332	357	358	296	295				
319-	CAXIF4	333	358	359	297	296				
320-	CAXIF4	334	359	360	298	297				
321-	CAXIF4	335	360	361	299	298				
322-	CAXIF4	336	361	362	300	299				
323-	CAXIF4	337	362	363	301	300				
324-	CAXIF4	338	363	364	302	301				
325-	CAXIF4	339	364	365	303	302				
326-	CAXIF4	340	365	366	304	303				
327-	CAXIF4	341	366	367	305	304				
328-	CAXIF4	342	367	368	306	305				
329-	CAXIF4	343	368	369	307	306				
330-	CAXIF4	344	369	370	308	307				
331-	CAXIF4	345	370	371	309	308				
332-	CAXIF4	346	371	372	310	309				
333-	CAXIF4	347	372	373	311	310				
334-	CAXIF4	348	373	374	312	311				
335-	CAXIF4	349	374	375	313	312				
336-	CAXIF4	350	375	376	314	313				
337-	CAXIF4	351	376	377	315	314				
338-	CAXIF4	352	377	378	316	315				
339-	CAXIF4	353	378	379	317	316				
340-	CAXIF4	354	379	380	318	317				
341-	CAXIF4	355	380	381	319	318				
342-	CAXIF4	356	381	382	320	319				
343-	CAXIF4	357	382	383	321	320				
344-	CAXIF4	358	383	384	322	321				
345-	CAXIF4	359	384	385	324	322				
346-	CAXIF4	360	385	386	325	324				
347-	CAXIF4	361	267	329	330	266				
348-	CAXIF4	362	199	264	166	167				
349-	EIGR	14	GIV				20			IGR
350-	+SH	MAX								
351-	GRIDF	1	4.0	24.0						
352-	GRIDF	2	4.0	40.0						
353-	GRIDF	3	4.0	56.0						
354-	GRIDF	4	4.0	72.0						
355-	GRIDF	5	4.0	68.0						
356-	GRIDF	6	4.0	104.0						
357-	GRIDF	7	4.0	124.3						
358-	GRIDF	8	4.0	136.3						
359-	GRIDF	9	4.0	152.3						
360-	GRIDF	10	4.0	168.3						

66

TABLE C-3 (Contd)

NASA SPN JANUARY 16, 1976 NASTRAN 3/15/73 PAGE 15
ZERO TANGENTIAL---THIRD BURN TIME

S O R T E D B U L K D A T A E C H O .

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
361-	GRIDF	11	4.0	183.3
362-	GRIDF	12	4.0	203.
363-	GRIDF	13	10.4	-8.0
364-	GRIDF	14	10.4	0.0
365-	GRIDF	15	10.4	8.
366-	GRIDF	16	10.4	16.
367-	GRIDF	17	13.2	-8.0
368-	GRIDF	18	13.2	0.0
369-	GRIDF	19	13.2	8.4
370-	GRIDF	20	13.2	16.4
371-	GRIDF	21	13.2	24.0
372-	GRIDF	22	13.2	40.0
373-	GRIDF	23	13.2	56.0
374-	GRIDF	24	13.2	72.0
375-	GRIDF	25	13.2	88.0
376-	GRIDF	26	13.2	104.0
377-	GRIDF	27	13.2	124.3
378-	GRIDF	28	13.2	136.3
379-	GRIDF	29	13.2	152.3
380-	GRIDF	30	13.2	168.3
381-	GRIDF	31	13.2	183.3
382-	GRIDF	32	13.2	203.
383-	GRIDF	33	12.0	211.2
384-	GRIDF	34	12.0	231.2
385-	GRIDF	35	12.0	251.2
386-	GRIDF	36	12.0	271.2
387-	GRIDF	37	12.0	291.2
388-	GRIDF	38	12.0	311.2
389-	GRIDF	39	12.0	331.2
390-	GRIDF	40	12.0	360.3
391-	GRIDF	41	12.0	380.3
392-	GRIDF	42	12.0	400.3
393-	GRIDF	43	12.0	420.3
394-	GRIDF	44	12.0	440.3
395-	GRIDF	45	12.0	460.3
396-	GRIDF	46	12.0	480.3
397-	GRIDF	47	12.0	500.3
398-	GRIDF	48	12.0	520.3
399-	GRIDF	49	12.0	540.3
400-	GRIDF	50	12.0	560.3
401-	GRIDF	51	12.0	580.3
402-	GRIDF	52	12.0	600.3
403-	GRIDF	53	12.0	620.3
404-	GRIDF	54	12.0	640.3
405-	GRIDF	55	12.0	660.3

67

TABLE C-3 (Contd)

NASA SRM
ZERO TANGENTIAL---THIRD BURN TIME

JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 16

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
406-	GRIDF	56	12.0	678.3						
407-	GRIDF	57	12.0	700.0						
408-	GRIDF	58	12.0	720.0						
409-	GRIDF	59	12.0	740.0						
410-	GRIDF	60	12.0	760.0						
411-	GRIDF	61	12.0	780.0						
412-	GRIDF	62	12.0	800.0						
413-	GRIDF	63	12.0	820.0						
414-	GRIDF	64	12.0	840.0						
415-	GRIDF	65	12.0	860.0						
416-	GRIDF	66	12.0	880.0						
417-	GRIDF	67	12.0	900.0						
418-	GRIDF	68	12.0	920.0						
419-	GRIDF	69	12.0	940.0						
420-	GRIDF	70	12.0	960.0						
421-	GRIDF	71	12.0	980.0						
422-	GRIDF	72	12.0	996.0						
423-	GRIDF	73	12.0	1016.8						
424-	GRIDF	74	12.0	1036.5						
425-	GRIDF	75	12.0	1056.5						
426-	GRIDF	76	12.0	1076.5						
427-	GRIDF	77	12.0	1097.0						
428-	GRIDF	78	12.0	1117.0						
429-	GRIDF	79	12.0	1136.9						
430-	GRIDF	80	12.0	1156.9						
431-	GRIDF	81	12.0	1177.2						
432-	GRIDF	82	12.0	1197.3						
433-	GRIDF	83	12.0	1217.0						
434-	GRIDF	84	12.0	1237.4						
435-	GRIDF	85	12.0	1257.4						
436-	GRIDF	86	12.0	1277.9						
437-	GRIDF	87	12.0	1297.4						
438-	GRIDF	89	12.0	1319.4						
439-	GRIDF	89	12.0	1350.5						
440-	GRIDF	90	27.4	1350.5						
441-	GRIDF	91	27.8	1319.4						
442-	GRIDF	92	40.0	1297.4						
443-	GRIDF	93	40.0	1277.9						
444-	GRIDF	94	40.0	1257.4						
445-	GRIDF	95	40.2	1237.4						
446-	GRIDF	96	40.4	1335.0						
447-	GRIDF	97	44.0	1329.4						
448-	GRIDF	98	47.2	1341.4						
449-	GRIDF	99	48.4	1352.1						
450-	GRIDF	100	48.2	1364.5						

68

TABLE C-3 (Contd)

NASA SRM
ZERO TANGENTIAL---THIRD BURN TIME

JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 17

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
451-	GRIDF	101	44.8	1361.5						
452-	GRIDF	102	44.6	1366.9						
453-	GRIDF	103	48.2	1371.1						
454-	GRIDF	104	51.6	1374.5						
455-	GRIDF	105	51.6	1364.5						
456-	GRIDF	106	51.2	1352.1						
457-	GRIDF	107	51.0	1341.4						
458-	GRIDF	108	50.6	1329.4						
459-	GRIDF	109	50.6	1323.4						
460-	GRIDF	110	38.8	1319.4						
461-	GRIDF	115	34.4	1217.0						
462-	GRIDF	116	33.4	1197.0						
463-	GRIDF	117	33.0	1177.2						
464-	GRIDF	118	32.6	1156.9						
465-	GRIDF	119	32.6	1136.8						
466-	GRIDF	120	32.4	1117.0						
467-	GRIDF	121	32.4	1097.0						
468-	GRIDF	122	32.4	1076.5						
469-	GRIDF	123	32.0	1056.6						
470-	GRIDF	124	32.0	1036.5						
471-	GRIDF	125	32.0	1016.8						
472-	GRIDF	126	32.0	996.0						
473-	GRIDF	127	33.2	980.0						
474-	GRIDF	128	32.8	960.0						
475-	GRIDF	129	32.4	940.0						
476-	GRIDF	130	32.4	920.0						
477-	GRIDF	131	32.0	900.0						
478-	GRIDF	132	31.6	880.0						
479-	GRIDF	133	31.2	860.0						
480-	GRIDF	134	31.2	840.0						
481-	GRIDF	135	31.0	820.0						
482-	GRIDF	136	31.0	800.0						
483-	GRIDF	137	31.0	780.0						
484-	GRIDF	138	30.8	760.0						
485-	GRIDF	139	30.2	740.0						
486-	GRIDF	140	30.2	720.0						
487-	GRIDF	141	29.8	700.0						
488-	GRIDF	142	29.8	676.3						
489-	GRIDF	143	32.8	660.3						
490-	GRIDF	144	32.8	640.3						
491-	GRIDF	145	32.4	620.3						
492-	GRIDF	146	32.0	600.3						
493-	GRIDF	147	32.0	580.3						
494-	GRIDF	148	29.8	560.3						
495-	GRIDF	149	29.8	540.3						

69

TABLE C-3 (Contd)

NASA SRM JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 18
ZERO TANGENTIAL---THIRD BURN TIME

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
496-	GRIDF	150	29.8	520.3
497-	GRIDF	151	29.8	500.3
498-	GRIDF	152	29.8	480.3
499-	GRIDF	153	29.8	460.3
500-	GRIDF	154	29.8	440.3
501-	GRIDF	155	29.8	420.3
502-	GRIDF	156	29.8	400.3
503-	GRIDF	157	29.8	380.3
504-	GRIDF	158	29.8	360.3
505-	GRIDF	159	29.8	331.2
506-	GRIDF	160	29.8	311.2
507-	GRIDF	161	29.8	291.2
508-	GRIDF	162	29.8	271.2
509-	GRIDF	163	29.8	251.2
510-	GRIDF	164	29.8	231.2
511-	GRIDF	165	29.8	211.2
512-	GRIDF	166	24.	203.
513-	GRIDF	167	24.0	183.3
514-	GRIDF	168	24.0	168.3
515-	GRIDF	187	24.0	0.0
516-	GRIDF	188	24.0	6.4
517-	GRIDF	189	24.0	16.4
518-	GRIDF	190	24.0	24.0
519-	GRIDF	191	24.0	40.0
520-	GRIDF	192	24.0	56.0
521-	GRIDF	193	24.0	72.0
522-	GRIDF	194	24.0	88.0
523-	GRIDF	195	24.0	104.0
524-	GRIDF	196	24.0	124.3
525-	GRIDF	197	24.0	136.3
526-	GRIDF	198	24.0	152.3
527-	GRIDF	199	36.4	183.3
528-	GRIDF	200	36.4	168.3
529-	GRIDF	201	36.4	152.3
530-	GRIDF	202	36.4	136.3
531-	GRIDF	203	36.4	124.3
532-	GRIDF	204	36.4	104.0
533-	GRIDF	205	36.4	88.0
534-	GRIDF	206	36.4	72.0
535-	GRIDF	207	36.4	56.0
536-	GRIDF	208	36.4	40.0
537-	GRIDF	209	36.4	24.0
538-	GRIDF	210	36.4	16.4
539-	GRIDF	211	36.4	6.4
540-	GRIDF	212	36.4	4.4

70

TABLE C-3 (Contd)

NASA SRM
ZERO TANGENTIAL---THIRD BURN TIME

JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 19

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
541-	GRIDF	213	43.2	8.4
542-	GRIDF	214	46.0	16.4
543-	GRIDF	215	46.0	24.0
544-	GRIDF	216	46.0	40.0
545-	GRIDF	217	46.0	56.0
546-	GRIDF	218	48.0	72.0
547-	GRIDF	219	48.0	88.0
548-	GRIDF	220	48.0	104.0
549-	GRIDF	221	48.0	124.3
550-	GRIDF	222	48.0	136.3
551-	GRIDF	223	48.0	152.3
552-	GRIDF	224	48.0	168.3
553-	GRIDF	235	48.0	183.3
554-	GRIDF	236	61.6	24.0
555-	GRIDF	237	54.4	16.4
556-	GRIDF	238	64.0	40.0
557-	GRIDF	239	64.0	56.0
558-	GRIDF	240	64.0	72.0
559-	GRIDF	241	64.0	88.0
560-	GRIDF	242	64.0	104.0
561-	GRIDF	243	64.0	124.3
562-	GRIDF	244	64.0	136.3
563-	GRIDF	245	64.0	152.3
564-	GRIDF	246	64.0	168.3
565-	GRIDF	247	64.0	183.3
566-	GRIDF	248	36.3	-3.9
567-	GRIDF	249	43.6	-0.8
568-	GRIDF	250	58.0	8.3
569-	GRIDF	251	64.7	16.6
570-	GRIDF	252	70.5	25.0
571-	GRIDF	253	72.0	40.5
572-	GRIDF	254	72.0	56.9
573-	GRIDF	255	72.0	72.8
574-	GRIDF	256	72.0	88.6
575-	GRIDF	257	72.0	104.8
576-	GRIDF	258	72.0	124.8
577-	GRIDF	259	72.0	136.5
578-	GRIDF	260	72.0	152.6
579-	GRIDF	261	72.0	169.5
580-	GRIDF	262	72.0	183.8
581-	GRIDF	263	24.0	-7.5
582-	GRIDF	264	29.8	203.0
583-	GRIDF	265	49.0	203.0
584-	GRIDF	266	64.0	203.0
585-	GRIDF	267	72.0	203.0

71

TABLE C-3 (Contd)

NASA SRM
ZERO TANGENTIAL---THIRD BURN TIME

JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 20

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 .. 6 .. 7 .. 8 .. 9 .. 10 .
586-	GRIDF	268	49.0	211.2	
587-	GRIDF	269	49.0	231.2	
588-	GRIDF	270	49.0	251.2	
589-	GRIDF	271	49.0	271.2	
590-	GRIDF	272	49.0	291.2	
591-	GRIDF	273	49.0	311.2	
592-	GRIDF	274	49.0	331.2	
593-	GRIDF	275	49.0	360.3	
594-	GRIDF	276	49.0	380.3	
595-	GRIDF	277	49.0	400.3	
596-	GRIDF	278	49.5	420.3	
597-	GRIDF	279	49.5	440.3	
598-	GRIDF	280	49.5	460.3	
599-	GRIDF	281	49.5	480.3	
600-	GRIDF	282	50.0	500.3	
601-	GRIDF	283	50.0	520.3	
602-	GRIDF	284	50.0	540.3	
603-	GRIDF	285	50.5	560.3	
604-	GRIDF	286	50.5	580.3	
605-	GRIDF	287	51.0	600.3	
606-	GRIDF	288	51.0	620.3	
607-	GRIDF	289	50.5	640.3	
608-	GRIDF	290	50.0	660.3	
609-	GRIDF	291	49.3	678.3	
610-	GRIDF	292	49.3	700.0	
611-	GRIDF	293	49.2	720.0	
612-	GRIDF	294	49.2	740.0	
613-	GRIDF	295	49.2	760.0	
614-	GRIDF	296	49.5	780.0	
615-	GRIDF	297	49.5	800.0	
616-	GRIDF	298	50.0	820.0	
617-	GRIDF	299	50.0	840.0	
618-	GRIDF	300	50.0	860.0	
619-	GRIDF	301	50.5	880.0	
620-	GRIDF	302	50.5	900.0	
621-	GRIDF	303	51.0	920.0	
622-	GRIDF	304	51.0	940.0	
623-	GRIDF	305	51.	960.	
624-	GRIDF	306	51.0	980.0	
625-	GRIDF	307	51.0	996.0	
626-	GRIDF	308	51.0	1016.8	
627-	GRIDF	309	51.0	1036.6	
628-	GRIDF	310	51.6	1056.5	
629-	GRIDF	311	51.6	1076.6	
630-	GRIDF	312	51.6	1097.0	

72

TABLE C-3 (Contd)

NASA SRM
ZERO TANGENTIAL---THIRD BURN TIME

JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 21

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .
631-	GRIDF	313	51.6	1117.0
632-	GRIDF	314	51.6	1136.9
633-	GRIDF	315	51.6	1156.9
634-	GRIDF	316	52.0	1177.2
635-	GRIDF	317	53.0	1197.0
636-	GRIDF	318	53.7	1217.0
637-	GRIDF	319	54.1	1237.4
638-	GRIDF	320	55.0	1257.4
639-	GRIDF	321	56.0	1277.9
640-	GRIDF	322	57.0	1297.4
641-	GRIDF	323	58.5	1317.4
642-	GRIDF	324	68.5	1317.4
643-	GRIDF	325	69.5	1330.0
644-	GRIDF	326	69.5	1343.9
645-	GRIDF	327	67.4	1353.9
646-	GRIDF	328	61.0	1365.8
647-	GRIDF	329	72.2	212.0
648-	GRIDF	330	65.0	211.2
649-	GRIDF	331	65.0	231.2
650-	GRIDF	332	65.0	251.2
651-	GRIDF	333	65.0	271.2
652-	GRIDF	334	65.0	291.2
653-	GRIDF	335	65.0	311.2
654-	GRIDF	336	65.0	331.2
655-	GRIDF	337	65.0	360.3
656-	GRIDF	338	65.0	380.3
657-	GRIDF	339	65.0	400.3
658-	GRIDF	340	65.5	420.3
659-	GRIDF	341	65.5	440.3
660-	GRIDF	342	66.0	460.3
661-	GRIDF	343	66.0	480.3
662-	GRIDF	344	66.0	500.3
663-	GRIDF	345	66.5	520.3
664-	GRIDF	346	66.5	540.3
665-	GRIDF	347	66.5	560.3
666-	GRIDF	348	67.0	580.3
667-	GRIDF	349	67.0	600.3
668-	GRIDF	350	67.0	620.3
669-	GRIDF	351	67.0	640.3
670-	GRIDF	352	66.5	660.3
671-	GRIDF	353	66.0	678.3
672-	GRIDF	354	65.5	700.0
673-	GRIDF	355	65.5	720.0
674-	GRIDF	356	65.5	740.0
675-	GRIDF	357	65.5	760.0

73

TABLE C-3 (Contd)

NASA SRM
ZERO TANGENTIAL---THIRD BURN TIME

JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 22

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 .. 2 .. 3 .. 4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .			
676-	GRIDF	358	65.5	780.0
677-	GRIDF	359	66.0	800.0
678-	GRIDF	360	66.0	820.0
679-	GRIDF	361	66.5	840.0
680-	GRIDF	362	66.8	860.0
681-	GRIDF	363	67.0	880.0
682-	GRIDF	364	67.0	900.0
683-	GRIDF	365	67.2	920.0
684-	GRIDF	366	67.5	940.0
685-	GRIDF	367	67.5	960.0
686-	GRIDF	368	67.5	980.0
687-	GRIDF	369	67.5	995.0
688-	GRIDF	370	67.5	1016.8
689-	GRIDF	371	67.5	1036.5
690-	GRIDF	372	67.5	1056.6
691-	GRIDF	373	67.5	1076.5
692-	GRIDF	374	67.5	1097.0
693-	GRIDF	375	68.0	1117.0
694-	GRIDF	376	68.3	1136.9
695-	GRIDF	377	68.8	1156.8
696-	GRIDF	378	69.2	1177.2
697-	GRIDF	379	69.5	1197.0
698-	GRIDF	380	69.8	1217.0
699-	GRIDF	381	70.0	1237.4
700-	GRIDF	382	70.8	1257.4
701-	GRIDF	383	71.5	1277.9
702-	GRIDF	384	72.0	1297.4
703-	GRIDF	385	71.5	1319.4
704-	GRIDF	386	71.5	1330.
	ENDDATA			

74

Appendix D

EFFECT OF J ON ROCKET MOTOR FREQUENCY

A series of tests involving cold gas flow through a small scale rocket model was conducted to determine the effect of the nozzle on acoustic losses.* The model was excited at its fundamental axial frequency by an acoustic driver. Although there was considerable scatter in some of the data, it was noted that the frequency generally decreased as the ratio of the nozzle throat area to motor gas channel area (J) increased. Figure D-1 is based on data in footnote.* In this figure the data has been fitted with a straight line using a least squares technique. The frequency scale has been normalized, using a frequency of 545 Hz as the normalizing factor. The boundaries of the figure have been expanded to show a range of J from 0 to 1 and the fitted straight line has been extrapolated to higher values of J than were used in obtaining the experimental data.

While the experimental data seems to extrapolate to the approximate vicinity of the classical frequency prediction for J=1, it should be noted that the effects of flow are entirely absent in the classical prediction and that the experimental data is for values of J for which the gas velocity (Mach number) is relatively small. Thus, the existing experimental data does not appear to provide information on the effect of gas flow on acoustics.

The results suggest that the fundamental frequency of a rocket motor is a function of J. Therefore, the assumption that the nozzle throat has no direct influence on an axial acoustic wave may be in error.

---

*The test results conducted by Buffum, et.al, were reported in 1967 in the AIAA Journal (see Ref. 6 on page 9 of this memorandum).

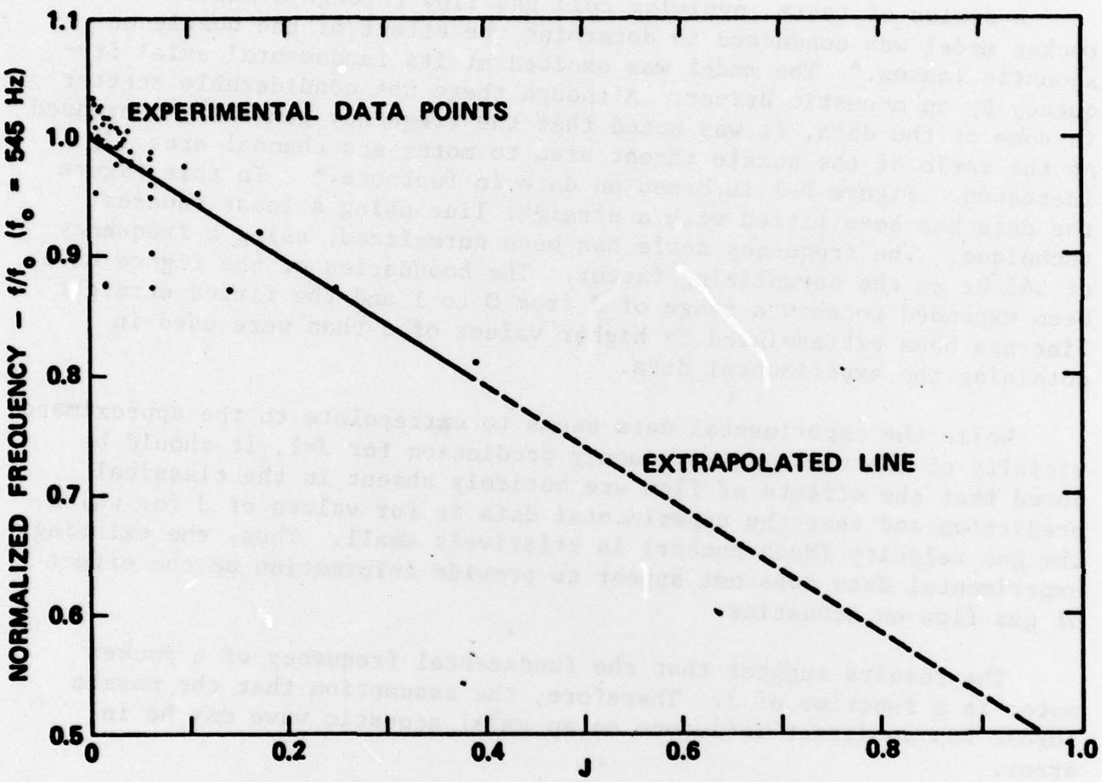


FIGURE D-1. Dependence of Normalized First Axial Mode Frequency on J.

76

Appendix E

RELATIVE ACOUSTIC PRESSURE AT GRID POINTS FOR FIRST AXIAL MODE

The relative pressure at grid points 1 through 6 are listed across row 1. Row 2 contains the pressures for grid points 7 through 12, etc. If a number was not used in the finite element grid, the corresponding point in the pressure listing will be blank.

Headings, Column Designations

T1 = N
T2 = N+1
T3 = N+2
R1 = N+3
R2 = N+4
R3 = N+5
N = number in left column

The type (S) column is not applicable in this tabulation.

TABLE E-1 Relative Acoustic Pressure: 0 cm Web Burn, Closed Throat

NASA SRM JANUARY 8, 1976 NASTRAN 1/15/73 PAGE 48
ZERO TANGENTIAL-FIRST BURN TIME (ZERO BURN)

EIGENVALUE = 9.175896+03

R E A L E I G E N V E C T O R N O . 2

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	S	9.983661-01	9.966018-01	9.935648-01	9.893037-01	9.837771-01	9.758900-01
7	S	9.659592-01	9.566059-01	9.486255-01	9.381924-01	9.270949-01	9.234563-01
13	S	1.000000+00	9.998546-01	9.995981-01	9.990648-01	9.999994-01	9.998433-01
19	S	9.995780-01	9.990797-01	9.984907-01	9.966133-01	9.935689-01	9.893157-01
25	S	9.836063-01	9.769484-01	9.659659-01	9.584441-01	9.485082-01	9.342479-01
31	S	9.272681-01	9.205386-01	9.017076-01	8.812147-01	8.590545-01	8.352728-01
37	S	8.099151-01	7.830296-01	7.546669-01	7.108716-01	6.791150-01	6.450773-01
43	S	6.118207-01	5.764099-01	5.399117-01	5.023953-01	4.639329-01	4.246060-01
49	S	3.845433-01	3.441517-01	3.055266-01	2.665435-01	2.318754-01	1.754526-01
55	S	1.585029-01	1.225295-01	7.525443-02	3.152402-02	-1.174507-02	-5.418206-02
61	S	-9.560425-02	-1.364979-01	-1.770323-01	-2.169932-01	-2.562454-01	-2.944873-01
67	S	-3.313219-01	-3.667123-01	-4.009094-01	-4.339124-01	-4.656457-01	-4.938365-01
73	S	-5.235797-01	-5.539164-01	-5.824974-01	-6.116928-01	-6.397767-01	-6.644292-01
79	S	-6.862505-01	-7.108463-01	-7.321906-01	-7.509409-01	-7.672593-01	-7.791467-01
85	S	-7.876229-01	-7.944303-01	-7.995607-01	-8.039473-01	-8.056164-01	-8.058590-01
91	S	-8.039387-01	-7.994339-01	-7.943708-01	-7.879237-01	-7.809268-01	-8.072192-01
97	S	-8.052222-01	-8.067718-01	-8.080790-01	-8.091163-01	-8.091245-01	-8.091609-01
103	S	-8.091981-01	-8.092462-01	-8.091057-01	-8.060904-01	-8.063765-01	-8.055395-01
109	S	-8.052757-01	-8.042013-01	-7.995187-01	-7.943360-01	-7.878729-01	-7.806604-01
115	S	-7.693936-01	-7.517311-01	-7.325713-01	-7.110362-01	-6.883596-01	-6.645153-01
121	S	-6.390243-01	-6.118636-01	-5.836624-01	-5.539294-01	-5.234866-01	-4.922942-01
127	S	-4.652639-01	-4.341999-01	-4.011726-01	-3.670171-01	-3.319020-01	-2.949737-01
133	S	-2.565361-01	-2.171591-01	-1.771623-01	-1.365531-01	-9.579710-02	-5.457102-02
139	S	-1.215735-02	3.125691-02	7.525624-02	1.241810-01	1.603176-01	1.955554-01
145	S	2.314654-01	2.660597-01	3.042237-01	3.429644-01	3.943478-01	4.245735-01
151	S	4.639276-01	5.023944-01	5.379116-01	5.764099-01	6.118207-01	6.450773-01
157	S	6.791150-01	7.108715-01	7.546668-01	7.830296-01	8.099151-01	8.352728-01
163	S	8.590545-01	8.812172-01	9.017225-01	9.207131-01	9.278056-01	9.335117-01
169	S	9.207553-01	9.264874-01	9.463077-01	9.583367-01	9.306013-01	9.373426-01
175	S	9.487783-01	9.565773-01	9.660196-01	9.769565-01	9.836798-01	9.893171-01
181	S	9.935693-01	9.966135-01	9.984950-01	9.990865-01	9.995769-01	9.973307-01
187	S	9.996662-01	9.994965-01	9.991019-01	9.985237-01	9.966104-01	9.935797-01
193	S	9.893655-01	9.839330-01	9.772421-01	9.668508-01	9.597279-01	9.494346-01
199	S	9.382178-01	9.441764-01	9.527464-01	9.615681-01	9.679156-01	9.776502-01
205	S	9.641139-01	9.894343-01	9.935824-01	9.965587-01	9.994094-01	9.989354-01
211	S	9.992696-01	9.993450-01	9.990676-01	9.966426-01	9.981952-01	9.954678-01
217	S	9.935698-01	9.894866-01	9.842568-01	9.779699-01	9.687013-01	9.628803-01
223	S	9.551719-01	9.486118-01	9.454878-01	9.434444-01	9.507234-01	9.564058-01
229	S	9.635613-01	9.691162-01	9.781434-01	9.843381-01	9.895128-01	9.935496-01
235	S	9.963455-01	9.979027-01	9.984310-01	9.963101-01	9.935465-01	9.695145-01
241	S	9.843434-01	9.781551-01	9.691442-01	9.636071-01	9.564886-01	9.508642-01
247	S	9.466385-01					

TABLE E-2 Relative Acoustic Pressure: 0 cm Web Burn, Open Throat

NASA SRM MAY 25, 1976 NASTRAN 1/15/73 PAGE 54
ZERO TANGENTIAL---- TIME ZERO 666

EIGENVALUE = -5.742890+03

REAL EIGENVECTOR NO. 1

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	S	-9.993417-01	-9.986293-01	-9.974031-01	-9.956823-01	-9.934494-01	-9.936653-01
7	S	-9.865432-01	-9.832865-01	-9.792241-01	-9.749955-01	-9.704911-01	-9.678323-01
13	S	-1.000000+00	-9.999415-01	-9.996379-01	-9.946227-01	-9.999997-01	-9.979368-01
19	S	-9.972398-01	-9.995206-01	-9.993911-01	-9.966336-01	-9.974947-01	-9.956672-01
25	S	-9.934667-01	-9.968387-01	-9.862440-01	-9.882011-01	-9.791766-01	-9.752160-01
31	S	-9.715554-01	-9.678357-01	-9.601950-01	-9.518774-01	-9.428907-01	-9.332228-01
37	S	-9.229217-01	-9.119919-01	-9.004561-01	-8.926203-01	-6.696662-01	-8.581656-01
43	S	-8.421339-01	-8.275939-01	-8.175561-01	-7.970385-01	-7.810573-01	-7.646315-01
49	S	-7.477492-01	-7.307166-01	-7.142557-01	-6.983454-01	-6.824161-01	-6.664123-01
55	S	-6.495787-01	-6.337916-01	-6.126698-01	-5.921085-01	-5.718934-01	-5.517772-01
61	S	-5.312273-01	-5.117911-01	-4.915627-01	-4.712269-01	-4.508308-01	-4.305137-01
67	S	-4.104681-01	-3.906627-01	-3.712221-01	-3.514631-01	-3.320251-01	-3.101356-01
73	S	-2.947235-01	-2.741553-01	-2.532957-01	-2.325489-01	-2.115147-01	-1.908760-01
79	S	-1.724934-01	-1.502267-01	-1.292654-01	-1.099119-01	-9.157092-02	-7.676240-02
85	S	-3.431264-02	-5.100514-02	-3.937919-02	-2.443222-02	.0	.0
91	S	-2.684271-02	-4.224471-02	-5.019975-02	-6.409379-02	-7.471906-02	-1.725665-02
97	S	-2.060973-02	-2.057466-02	-2.058397-02	-2.058712-02	-2.058717-02	-2.058738-02
103	S	-2.056706-02	-2.056795-02	-2.055755-02	-2.059099-02	-2.057255-02	-2.054517-02
109	S	-2.013122-02	-2.445179-02	-3.997466-02	-5.287171-02	-6.418239-02	-7.492874-02
115	S	-6.908576-02	-1.090801-01	-1.269474-01	-1.498176-01	-1.723971-01	-1.939022-01
121	S	-2.114771-01	-2.324224-01	-2.531742-01	-2.741435-01	-2.947820-01	-3.164499-01
127	S	-3.322760-01	-3.513601-01	-3.726693-01	-3.925117-01	-4.121958-01	-4.312434-01
133	S	-4.520702-01	-4.712413-01	-4.914966-01	-5.117640-01	-5.317372-01	-5.515445-01
139	S	-5.716403-01	-5.919340-01	-6.122861-01	-6.345349-01	-6.507951-01	-6.664617-01
145	S	-6.828384-01	-6.961452-01	-7.136979-01	-7.302132-01	-7.477159-01	-7.646178-01
151	S	-7.815559-01	-7.978361-01	-8.125561-01	-8.275939-01	-8.421359-01	-8.561656-01
157	S	-8.650661-01	-8.862203-01	-9.004561-01	-9.119929-01	-9.229219-01	-9.332226-01
163	S	-9.420208-01	-9.518784-01	-9.602040-01	-9.679064-01	-9.707834-01	-9.751251-01
169	S	-9.678225-01	-9.710399-01	-9.793754-01	-9.831576-01	-9.719173-01	-9.754620-01
175	S	-9.792967-01	-9.832551-01	-9.862677-01	-9.936922-01	-9.934627-01	-9.956975-01
181	S	-9.974249-01	-9.906337-01	-9.993959-01	-9.998315-01	-9.996293-01	-9.949317-01
187	S	-9.996653-01	-9.997967-01	-9.996377-01	-9.994044-01	-9.986324-01	-9.974091-01
193	S	-9.957674-01	-9.935126-01	-9.906379-01	-9.860044-01	-9.637212-01	-9.795522-01
199	S	-9.759203-01	-9.774221-01	-9.826985-01	-9.844670-01	-9.873359-01	-9.909732-01
205	S	-9.930839-01	-9.957353-01	-9.974107-01	-9.986115-01	-9.993583-01	-9.995705-01
211	S	-9.997054-01	-9.997356-01	-9.996239-01	-9.994524-01	-9.992719-01	-9.965749-01
217	S	-9.974052-01	-9.957564-01	-9.936496-01	-9.911326-01	-9.873543-01	-9.849968-01
223	S	-9.816730-01	-9.792306-01	-9.779547-01	-9.791538-01	-9.803770-01	-9.823783-01
229	S	-9.852749-01	-9.875225-01	-9.911731-01	-9.936767-01	-9.957671-01	-9.973966-01
235	S	-9.985285-01	-9.991539-01	-9.993671-01	-9.985113-01	-9.973959-01	-9.957678-01
241	S	-9.930789-01	-9.911779-01	-9.875338-01	-9.852934-01	-9.824119-01	-9.801341-01
247	S	-9.792325-01					

TABLE E-3 Relative Acoustic Pressure: 48 cm Web Burn, Closed Throat

NASA SRM JANUARY 13, 1976 NASTRAN 1/15/73 PAGE 50
ZERO TANGENTIAL---SECOND BURN TIME

EIGENVALUE = 7.703534+03

R E A L E I G E N V E C T O R N O . 2

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	S	8.901499-01	8.886538-01	8.852192-01	8.829123-01	8.797155-01	8.736019-01
7	S	8.657284-01	8.602483-01	8.518421-01	8.417788-01	8.301505-01	8.131961-01
13	S	8.916001-01	8.915123-01	8.912560-01	8.907822-01	8.915971-01	8.915383-01
19	S	8.912362-01	8.907996-01	8.902673-01	8.886560-01	8.862151-01	8.829113-01
25	S	8.787198-01	8.736146-01	8.657642-01	8.603133-01	8.519763-01	8.420431-01
31	S	8.306331-01	8.104317-01	8.003436-01	7.729124-01	7.419999-01	7.093819-01
37	S	6.755075-01	6.405239-01	6.045161-01	5.504349-01	5.122192-01	4.737908-01
43	S	4.338716-01	3.940304-01	3.536963-01	3.129436-01	2.719759-01	2.308771-01
49	S	1.896285-01	1.484027-01	1.072957-01	6.632971-02	2.539153-02	-1.558378-02
55	S	-5.777374-02	-9.603925-02	-1.426064-01	-1.855386-01	-2.282685-01	-2.706007-01
61	S	-3.123201-01	-3.532629-01	-3.933552-01	-4.324962-01	-4.707443-01	-5.079452-01
67	S	-5.440119-01	-5.789022-01	-6.126319-01	-6.452907-01	-6.768936-01	-7.013927-01
73	S	-7.321415-01	-7.601648-01	-7.870743-01	-8.125394-01	-8.371058-01	-8.598164-01
79	S	-8.809248-01	-9.007865-01	-9.193744-01	-9.356210-01	-9.501648-01	-9.630475-01
85	S	-9.733434-01	-9.826697-01	-9.894970-01	-9.944794-01	-9.967170-01	-9.958206-01
91	S	-9.947457-01	-9.902757-01	-9.833875-01	-9.742529-01	-9.634065-01	-9.962331-01
97	S	-9.963249-01	-9.982553-01	-9.992542-01	-9.998904-01	-9.999029-01	-9.979319-01
103	S	-9.999602-01	-1.000000+00	-9.998635-01	-9.992620-01	-9.983501-01	-9.958876-01
109	S	-9.961122-01	-9.949791-01				
115	S	-9.503938-01	-9.358712-01	-9.195947-01	-9.009031-01	-8.809699-01	-8.578350-01
121	S	-8.371262-01	-8.125593-01	-7.671867-01	-7.602617-01	-7.321893-01	-7.014090-01
127	S	-6.769062-01	-6.453128-01	-6.126899-01	-5.790512-01	-5.441961-01	-5.081327-01
133	S	-4.709090-01	-4.326112-01	-3.935217-01	-3.534626-01	-3.124631-01	-2.707007-01
139	S	-2.282867-01	-1.854926-01	-1.424899-01	-9.575736-02	-5.729614-02	-1.543251-02
145	S	2.557434-02	6.625301-02	1.071140-01	1.432280-01	1.894691-01	2.307704-01
151	S	2.716780-01	3.128040-01	3.536302-01	3.939644-01	4.337405-01	4.731628-01
157	S	5.121702-01	5.504205-01	6.045146-01	6.405283-01	6.755264-01	7.094517-01
163	S	7.422411-01	7.737847-01	8.036819-01	8.146921-01	8.317876-01	8.426502-01
187	S	8.914425-01	8.911914-01	8.907938-01	8.902651-01	8.886363-01	8.852016-01
193	S	8.829083-01	8.787295-01	8.736431-01	8.656431-01	8.604575-01	8.522771-01
199	S	8.333879-01	8.436124-01	8.527553-01	8.606827-01	8.659644-01	8.736262-01
205	S	8.787423-01	8.929016-01	8.861735-01	8.865783-01	8.901706-01	8.916745-01
211	S	8.910492-01	8.911700-01	8.909329-01	8.904887-01	8.900222-01	8.884991-01
217	S	8.861398-01	8.828931-01	8.787537-01	8.737253-01	8.660770-01	8.639981-01
223	S	8.532386-01	8.447355-01	8.358007-01			
236	S	8.894066-01	8.903554-01	8.883975-01	8.860959-01	8.828818-01	8.737637-01
242	S	8.737624-01	8.661855-01	8.611138-01	8.537469-01	8.459476-01	8.378154-01
248	S	8.913149-01	8.911210-01	8.905392-01	8.900886-01	8.895771-01	8.862407-01
254	S	8.859497-01	8.826961-01	8.755930-01	8.734901-01	8.660022-01	8.617527-01
260	S	8.536662-01	8.460089-01	8.390035-01	8.915363-01	8.134222-01	8.219687-01
266	S	8.318451-01	8.330055-01	8.070573-01	7.745702-01	7.424319-01	7.094996-01
272	S	6.755365-01	6.405309-01	6.045132-01	5.504069-01	5.121048-01	4.728597-01
278	S	4.334287-01	3.938789-01	3.535420-01	3.124764-01	2.714836-01	2.306173-01
284	S	1.891065-01	1.478207-01	1.067608-01	6.601291-02	2.589996-02	-1.479992-02
290	S	-5.648736-02	-9.517682-02	-1.423103-01	-1.854108-01	-2.283095-01	-2.708983-01

80

TABLE E-3 (Contd)

NASA SRM   JANUARY 13, 1976   NASTRAN 1/15/73   PAGE 51
ZERO TANGENTIAL---SECOND BURN TIME

EIGENVALUE = 7.703534+03

REAL EIGENVECTOR NO. 2

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
296	S	-3.127150-01	-3.538068-01	-3.936517-01	-4.327423-01	-4.712203-01	-5.034775-01
302	S	-5.445191-01	-5.793288-01	-6.127489-01	-6.453273-01	-6.769152-01	-7.014212-01
308	S	-7.322434-01	-7.605299-01	-7.674379-01	-8.126456-01	-8.371413-01	-8.578473-01
314	S	-8.810104-01	-9.010787-01	-9.200010-01	-9.363376-01	-9.507207-01	-9.636661-01
320	S	-9.745692-01	-9.837974-01	-9.912227-01	-9.959183-01	-9.964684-01	-9.975454-01
326	S	-9.987577-01	-9.993408-01	-9.998151-01			

TABLE E-4 Relative Acoustic Pressure: 48 cm Web Burn, Open Throat

TIME 2 19 INCHES 56 MAY 25, 1976 NASTRAN 1/15/73 PAGE 60

EIGENVALUE = 5.212545+03

REAL EIGENVECTOR NO. 1

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	S	-9.995549-01	-9.990746-01	-9.983475-01	-9.973306-01	-9.960387-01	-9.944625-01
7	S	-9.920315-01	-9.903361-01	-9.877217-01	-9.846042-01	-9.809329-01	-9.747502-01
13	S	-1.000000+00	-9.999731-01	-9.998944-01	-9.997496-01	-9.999991-01	-9.999720-01
19	S	-9.996667-01	-9.997544-01	-9.995210-01	-9.990962-01	-9.983467-01	-9.973303-01
25	S	-9.960431-01	-9.944060-01	-9.920426-01	-9.903564-01	-9.877726-01	-9.846867-01
31	S	-9.811742-01	-9.748267-01	-9.716272-01	-9.630763-01	-9.533524-01	-9.430704-01
37	S	-9.273324-01	-9.211621-01	-9.090340-01	-8.901397-01	-8.796594-01	-8.669373-01
43	S	-8.537727-01	-8.463346-01	-8.306604-01	-8.126753-01	-7.984407-01	-7.839756-01
49	S	-7.692597-01	-7.543379-01	-7.392267-01	-7.239292-01	-7.083760-01	-6.924127-01
55	S	-6.759103-01	-6.605746-01	-6.410465-01	-6.236373-01	-6.054392-01	-5.870119-01
61	S	-5.054217-01	-5.497415-01	-5.307859-01	-5.121594-01	-4.932330-01	-4.742617-01
67	S	-4.553734-01	-4.362719-01	-4.172319-01	-3.980304-01	-3.787919-01	-3.632049-01
73	S	-3.424619-01	-3.235010-01	-3.039817-01	-2.844273-01	-2.644302-01	-2.447496-01
79	S	-2.026349-01	-2.034573-01	-1.854573-01	-1.663621-01	-1.475353-01	-1.287139-01
85	S	-1.170331-01	-9.283621-02	-7.514892-02	-5.369802-02	.0	.0
91	S	-5.745630-02	-7.633046-02	-9.260756-02	-1.102545-01	-1.282837-01	-4.475670-02
97	S	-5.617247-02	-5.963417-02	-6.025103-02	-6.033733-02	-6.013671-02	-6.003687-02
103	S	-6.034137-02	-6.024455-02	-6.033960-02	-6.026553-02	-6.006686-02	-5.976759-02
109	S	-6.147635-02	-6.166783-02				
115	S	-1.472257-01	-1.560651-01	-1.651967-01	-2.051235-01	-2.251546-01	-2.447301-01
121	S	-2.644136-01	-2.843907-01	-3.036921-01	-3.234765-01	-3.429271-01	-3.632514-01
127	S	-3.757644-01	-3.965376-01	-4.171990-01	-4.361914-01	-4.551755-01	-4.741641-01
133	S	-4.931492-01	-5.121231-01	-5.309049-01	-5.496581-01	-5.683664-01	-5.869673-01
139	S	-6.054701-01	-6.236507-01	-6.415927-01	-6.606858-01	-6.761035-01	-6.925714-01
145	S	-7.084464-01	-7.239321-01	-7.394631-01	-7.542734-01	-7.692013-01	-7.839377-01
151	S	-7.983890-01	-8.126271-01	-8.266424-01	-8.403324-01	-8.536890-01	-8.667948-01
157	S	-8.796432-01	-8.921349-01	-9.040335-01	-9.211834-01	-9.322381-01	-9.430922-01
163	S	-9.534369-01	-9.633494-01	-9.727148-01	-9.761582-01	-9.814940-01	-9.848762-01
187	S	-9.999517-01	-9.998746-01	-9.997526-01	-9.995903-01	-9.993902-01	-9.993421-01
193	S	-9.973294-01	-9.960429-01	-9.944955-01	-9.920672-01	-9.904014-01	-9.875664-01
199	S	-9.619937-01	-9.651765-01	-9.680155-01	-9.904716-01	-9.921050-01	-9.944869-01
205	S	-9.960471-01	-9.973274-01	-9.983335-01	-9.990725-01	-9.995613-01	-9.997160-01
211	S	-9.992710-01	-9.996601-01	-9.997753-01	-9.996593-01	-9.995153-01	-9.990481-01
217	S	-9.992232-01	-9.973346-01	-9.960507-01	-9.945011-01	-9.921402-01	-9.935383-01
223	S	-9.691664-01	-9.826177-01	-9.627472-01			
236	S	-9.994497-01	-9.990105-01	-9.990104-01	-9.967097-01	-9.973214-01	-9.960539-01
242	S	-9.945127-01	-9.921745-01	-9.906701-01	-9.863251-01	-9.859055-01	-9.836587-01
248	S	-9.995125-01	-9.996530-01	-9.996745-01	-9.995362-01	-9.993792-01	-9.989611-01
254	S	-9.960648-01	-9.972643-01	-9.960317-01	-9.944257-01	-9.921174-01	-9.905873-01
260	S	-9.682106-01	-9.859240-01	-9.637476-01	-9.999804-01	-9.757608-01	-9.744308-01
266	S	-9.615165-01	-9.616791-01	-9.737639-01	-9.635944-01	-9.534964-01	-9.431071-01
272	S	-9.323421-01	-9.211842-01	-9.096330-01	-8.921304-01	-8.796214-01	-8.666941-01
278	S	-8.536652-01	-8.403037-01	-8.266120-01	-8.125133-01	-7.982690-01	-7.838833-01
284	S	-7.692738-01	-7.543244-01	-7.390331-01	-7.238138-01	-7.085759-01	-6.928394-01
290	S	-6.764261-01	-6.609166-01	-6.416649-01	-6.236891-01	-6.054186-01	-5.868792-01

TABLE E-4 (Contd)

NASA SRM MAY 25, 1976 NASTRAN 1/15/73 PAGE 61
ZERO TANGENTIAL---- TIME 2 19 INCHES SS

EIGENVALUE = 5.212545+03

REAL EIGENVECTOR NO. 1

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
296	S	-5.682529-01	-5.494979-01	-5.307496-01	-5.120392-01	-4.929905-01	-4.739862-01
302	S	-4.556021-01	-4.363406-01	-4.171674-01	-3.980607-01	-3.787805-01	-3.632416-01
308	S	-3.426876-01	-3.232962-01	-3.037141-01	-2.843593-01	-2.644017-01	-2.447169-01
314	S	-2.251298-01	-2.051262-01	-1.847231-01	-1.654847-01	-1.467685-01	-1.279099-01
320	S	-1.097365-01	-9.167527-02	-7.516171-02	-6.343841-02	-6.324883-02	-6.148408-02
326	S	-6.071650-02	-6.050320-02	-6.038311-02			

TABLE E-5 Relative Acoustic Pressure: 86 cm Web Burn, Closed Throat

NASA SRM — JANUARY 16, 1976 — NASTRAN 1/15/73 — PAGE 65

ZERO TANGENTIAL---THIRD BURN TIME

EIGENVALUE = 1.032890+04

REAL EIGENVECTOR NO. 2

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	S	9.979498-01	9.958520-01	9.923999-01	9.877407-01	9.818461-01	9.747049-01
7	S	9.636378-01	9.564535-01	9.454713-01	9.331169-01	9.201144-01	9.034441-01
13	S	1.000000+00	9.996758-01	9.995133-01	9.988435-01	9.995959-01	9.918703-01
19	S	9.994832-01	9.968680-01	9.941156-01	9.958366-01	9.923926-01	9.877357-01
25	S	9.816443-01	9.747060-01	9.634460-01	9.564658-01	9.454987-01	9.331794-01
31	S	9.202443-01	9.063304-01	8.920030-01	8.665681-01	8.422270-01	8.139884-01
37	S	7.636679-01	7.521252-01	7.189626-01	6.679252-01	6.313123-01	5.935356-01
43	S	5.547659-01	5.151356-01	4.747354-01	4.336246-01	3.916453-01	3.495082-01
49	S	3.066947-01	2.624552-01	2.196643-01	1.760363-01	1.316673-01	8.732099-02
55	S	4.230194-02	1.333015-03	-4.654458-02	-9.473334-02	-1.406659-01	-1.857262-01
61	S	-2.321232-01	-2.766321-01	-3.206894-01	-3.635687-01	-4.053722-01	-4.450701-01
67	S	-4.656575-01	-5.240369-01	-5.612939-01	-5.972432-01	-6.319263-01	-6.587503-01
73	S	-6.923266-01	-7.228694-01	-7.522011-01	-7.301690-01	-8.065089-01	-8.313409-01
79	S	-8.536843-01	-8.743333-01	-8.933649-01	-9.099746-01	-9.245801-01	-9.374648-01
85	S	-9.421097-01	-9.568344-01	-9.631600-01	-9.660951-01	-9.704301-01	-9.724226-01
91	S	-9.681298-01	-9.633760-01	-9.569950-01	-9.462766-01	-9.376448-01	-9.675229-01
97	S	-9.694111-01	-9.713343-01	-9.724148-01	-9.731650-01	-9.731827-01	-9.772158-01
103	S	-9.772497-01	-9.732775-01	-9.731309-01	-9.724211-01	-9.713881-01	-9.6?9176-01
109	S	-9.633497-01	-9.621320-01				
115	S	-9.246657-01	-9.099701-01	-8.934960-01	-8.744626-01	-8.536207-01	-8.314678-01
121	S	-8.267990-01	-7.882157-01	-7.523190-01	-7.229985-01	-6.923342-01	-6.547532-01
127	S	-6.319469-01	-5.972453-01	-5.613710-01	-5.241927-01	-4.857651-01	-4.461923-01
133	S	-4.055314-01	-3.637025-01	-3.205703-01	-2.769926-01	-2.322431-01	-1.857784-01
139	S	-1.405565-01	-9.466479-02	-4.639390-02	1.556599-03	4.258279-02	8.750967-02
145	S	1.319385-01	1.763190-01	2.197948-01	2.633562-01	3.066029-01	3.493590-01
151	S	3.917345-01	4.335271-01	4.740182-01	5.150076-01	5.546435-01	5.934403-01
157	S	6.312638-01	6.677060-01	7.198605-01	7.541331-01	7.836950-01	8.140644-01
163	S	8.425307-01	8.690453-01	8.933606-01	9.031565-01	9.206309-01	9.333163-01
187	S	9.997768-01	9.994216-01	9.948592-01	9.981117-01	9.956092-01	9.923700-01
193	S	9.677236-01	9.619402-01	9.747365-01	9.638596-01	9.564925-01	9.455577-01
199	S	9.207946-01	9.334753-01	9.456433-01	9.565329-01	9.636935-01	9.747122-01
205	S	9.816333-01	9.877726-01	9.923251-01	9.957253-01	9.979768-01	9.935696-01
211	S	9.992198-01	9.993906-01	9.997547-01	9.984259-01	9.977656-01	9.936104-01
217	S	9.922766-01	9.876301-01	9.819202-01	9.747155-01	9.636994-01	9.565720-01
223	S	9.457301-01	9.336776-01	9.212626-01			
236	S	9.974596-01	9.962386-01	9.954434-01	9.927061-01	9.876545-01	9.819166-01
242	S	9.747168-01	9.639170-01	9.566120-01	9.458271-01	9.339122-01	9.219314-01
248	S	9.995956-01	9.993211-01	9.984971-01	9.978588-01	9.971344-01	9.952990-01
254	S	9.919965-01	9.873903-01	9.815736-01	9.743251-01	9.636373-01	9.554893-01
260	S	9.456262-01	9.337590-01	9.215194-01	9.999095-01	9.014106-01	9.031605-01
266	S	9.349570-01	9.056193-01	8.946602-01	8.697758-01	6.427950-01	8.141592-01
272	S	7.839275-01	7.521422-01	7.188573-01	6.678782-01	6.311812-01	5.922379-01
278	S	5.543833-01	5.147375-01	4.743752-01	4.333514-01	3.914939-01	3.491599-01
284	S	3.064261-01	2.631220-01	2.196121-01	1.759800-01	1.320341-01	8.760266-02
290	S	4.304028-02	2.052746-03	-4.606038-02	-9.455144-02	-1.406477-01	-1.858570-01

TABLE E-5 (Contd)

NASA SRM
ZERO TANGENTIAL---THIRD BURN TIME

JANUARY 16, 1976 NASTRAN 1/15/73 PAGE 66

EIGENVALUE = 1.032890+04

REAL EIGENVECTOR NO. 2

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
296	S	-2.324707-01	-2.772842-01	-3.212270-01	-3.641243-01	-4.052164-01	-4.453896-01
302	S	-4.659318-01	-5.243516-01	-5.615246-01	-5.973401-01	-6.319708-01	-6.597669-01
308	S	-6.923395-01	-7.229304-01	-7.523441-01	-7.802607-01	-8.071585-01	-8.316869-01
314	S	-8.540574-01	-8.746850-01	-8.930646-01	-9.101288-01	-9.248047-01	-9.377808-01
320	S	-9.484237-01	-9.571227-01	-9.634772-01	-9.664232-01	-9.680079-01	-9.731043-01
326	S	-9.715933-01	-9.724110-01	-9.730515-01	9.007191-01	6.976888-01	6.733790-01
332	S	6.424292-01	8.141947-01	7.639320-01	7.521449-01	7.198561-01	6.678659-01
338	S	6.311248-01	5.929519-01	5.540543-01	5.143979-01	4.740578-01	4.332265-01
344	S	3.911302-01	3.468375-01	3.063029-01	2.628056-01	2.193016-01	1.759385-01
350	S	1.321030-01	8.620534-02	4.377527-02	2.741911-03	-4.766832-02	-9.447371-02
356	S	-1.402439-01	-1.869191-01	-2.328002-01	-2.776766-01	-3.216116-01	-3.646512-01
362	S	-4.061901-01	-4.465891-01	-4.861109-01	-5.246575-01	-5.616889-01	-5.973790-01
368	S	-6.319402-01	-6.587710-01	-6.923412-01	-7.229084-01	-7.523555-01	-7.803207-01
374	S	-8.073583-01	-8.319989-01	-8.543665-01	-8.749931-01	-8.939016-01	-9.103109-01
380	S	-9.249505-01	-9.379671-01	-9.466445-01	-9.572709-01	-9.635179-01	-9.696209-01
386	S	-9.700932-01					

TABLE E-6 Relative Acoustic Pressure: 86 cm Web Burn, Open Throat

NASA SRM MAY 25, 1976 NASTRAN 1/15/75 PAGE 52
ZERO TANGENTIAL---- TIME 3 --34 INCHES SS

EIGENVALUE = 5.062777+03

R E A L E I G E N V E C T O R N O . 1

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	S	-9.996395-01	-9.985509-01	-9.979223-01	-9.955470-01	-9.950320-01	-9.950731-01
7	S	-9.900979-01	-9.950550-01	-9.950276-01	-9.816165-01	-9.780144-01	-9.725532-01
13	S	-1.000000+00	-9.999551-01	-9.998570-01	-9.996960-01	-9.999959-01	-9.999547-01
19	S	-9.999032-01	-9.995593-01	-9.996352-01	-9.988625-01	-9.977203-01	-9.955655-01
25	S	-9.950715-01	-9.930736-01	-9.900996-01	-9.850556-01	-9.850352-01	-9.815320-01
31	S	-9.780505-01	-9.725215-01	-9.702042-01	-9.635559-01	-9.565207-01	-9.495550-01
37	S	-9.595495-01	-9.503591-01	-9.213435-01	-9.056695-01	-8.900647-01	-8.850198-01
43	S	-8.735711-01	-8.619051-01	-8.496752-01	-8.372055-01	-8.243965-01	-8.112615-01
49	S	-7.979153-01	-7.940559-01	-7.699965-01	-7.556429-01	-7.409527-01	-7.259910-01
55	S	-7.104044-01	-6.960774-01	-6.782957-01	-6.614957-01	-6.445731-01	-6.259775-01
61	S	-6.093626-01	-5.915987-01	-5.736977-01	-5.557179-01	-5.375675-01	-5.195339-01
67	S	-5.012975-01	-4.829553-01	-4.645155-01	-4.459654-01	-4.272641-01	-4.122354-01
73	S	-3.925442-01	-3.735624-01	-3.544597-01	-3.351792-01	-3.156452-01	-2.951141-01
79	S	-2.777475-01	-2.579935-01	-2.396744-01	-2.197230-01	-2.009407-01	-1.315713-01
85	S	-1.624910-01	-1.422572-01	-1.207008-01	-9.941911-02	.0	.0
91	S	-9.723955-02	-1.261565-01	-1.443954-01	-1.631732-01	-1.617151-01	-7.745405-02
97	S	-9.601790-02	-1.052448-01	-1.074095-01	-1.076754-01	-1.076740-01	-1.075905-01
103	S	-1.075891-01	-1.075977-01	-1.075945-01	-1.074491-01	-1.057791-01	-1.054155-01
109	S	-1.050404-01	-1.045797-01				
115	S	-2.005174-01	-2.195390-01	-2.393624-01	-2.577696-01	-2.759247-01	-2.950079-01
121	S	-3.153717-01	-3.351619-01	-3.544536-01	-3.736555-01	-3.925402-01	-4.122353-01
127	S	-4.272749-01	-4.459458-01	-4.644776-01	-4.829049-01	-5.012450-01	-5.194791-01
133	S	-5.375994-01	-5.555545-01	-5.736221-01	-5.915233-01	-6.093161-01	-6.259571-01
139	S	-6.443761-01	-6.415204-01	-6.793481-01	-6.951505-01	-7.105057-01	-7.259573-01
145	S	-7.409751-01	-7.556393-01	-7.699719-01	-7.940265-01	-7.977673-01	-8.112275-01
151	S	-8.243403-01	-8.771759-01	-8.496399-01	-8.617668-01	-8.735547-01	-8.849915-01
157	S	-8.960536-01	-9.056629-01	-9.213628-01	-9.308413-01	-9.399569-01	-9.433751-01
163	S	-9.557773-01	-9.639135-01	-9.705335-01	-9.733075-01	-9.781579-01	-9.815702-01
169	S	-9.999790-01	-9.998420-01	-9.975984-01	-9.996561-01	-9.983547-01	-9.979141-01
193	S	-9.966423-01	-9.950306-01	-9.930741-01	-9.900956-01	-9.880659-01	-9.850516-01
199	S	-9.782036-01	-9.817142-01	-9.850754-01	-9.850771-01	-9.900991-01	-9.930752-01
205	S	-9.950255-01	-9.965556-01	-9.979018-01	-9.938319-01	-9.996473-01	-9.975421-01
211	S	-9.997659-01	-9.998336-01	-9.977419-01	-9.795700-01	-9.993895-01	-9.955005-01
217	S	-9.978875-01	-9.955306-01	-9.950266-01	-9.930751-01	-9.901064-01	-9.880950-01
223	S	-9.851701-01	-9.817725-01	-9.753339-01			
236	S	-9.993050-01	-9.995189-01	-9.957549-01	-9.973594-01	-9.955235-01	-9.950245-01
242	S	-9.930770-01	-9.901095-01	-9.880991-01	-9.551265-01	-9.818359-01	-9.784920-01
248	S	-9.998596-01	-9.993146-01	-9.995395-01	-9.994151-01	-9.992172-01	-9.987154-01
254	S	-9.973125-01	-9.955511-01	-9.949574-01	-9.929689-01	-9.900124-01	-9.880553-01
260	S	-9.850711-01	-9.815017-01	-9.784056-01	-9.999753-01	-9.723220-01	-9.733055-01
266	S	-9.738084-01	-9.739950-01	-9.709432-01	-9.660027-01	-9.564509-01	-9.434025-01
272	S	-9.398658-01	-9.308439-01	-9.213419-01	-9.055746-01	-8.950260-01	-8.849319-01
278	S	-8.734776-01	-8.616352-01	-8.495567-01	-8.371223-01	-8.242862-01	-8.111530-01
284	S	-7.977319-01	-7.839513-01	-7.699137-01	-7.556271-01	-7.410123-01	-7.260593-01
290	S	-7.106639-01	-6.953285-01	-6.794585-01	-6.615599-01	-6.443760-01	-6.259250-01

TABLE E-6 (Contd)

NASA SRM MAY 25, 1976 NASTRAN 1/15/73 PAGE 53
ZERO TANGENTIAL---- TIME 3 --34 INCHES 55

EIGENVALUE = 5.052777+03

REAL EIGENVECTOR NO. 1

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
296	S	-6.392232-01	-5.914366-01	-5.774924-01	-5.554821-01	-5.376761-01	-5.193912-01
302	S	-5.311701-01	-4.925149-01	-4.644120-01	-4.459187-01	-4.272652-01	-4.122250-01
308	S	-3.925751-01	-3.735650-01	-3.566340-01	-3.350902-01	-3.152423-01	-2.953165-01
314	S	-2.757115-01	-2.575590-01	-2.391705-01	-2.176589-01	-2.035929-01	-1.915551-01
320	S	-1.532689-01	-1.451329-01	-1.298409-01	-1.127495-01	-1.147743-01	-1.107363-01
326	S	-1.099944-01	-1.082511-01	-1.078325-01	-9.725306-01	-9.713421-01	-9.561735-01
332	S	-9.564231-01	-9.454123-01	-9.398569-01	-9.338445-01	-9.213415-01	-9.355710-01
338	S	-8.960397-01	-8.942475-01	-8.733904-01	-8.615845-01	-8.494713-01	-8.273941-01
344	S	-8.241892-01	-8.110527-01	-7.976922-01	-7.859498-01	-7.698133-01	-7.555166-01
350	S	-7.610357-01	-7.251793-01	-7.139193-01	-6.955975-01	-6.785979-01	-6.615271-01
356	S	-6.443744-01	-6.258797-01	-6.090921-01	-5.912462-01	-5.733141-01	-5.552553-01
362	S	-5.377112-01	-5.193024-01	-5.013852-01	-4.826812-01	-4.643212-01	-4.458995-01
368	S	-4.272601-01	-4.122251-01	-3.925348-01	-3.736453-01	-3.544262-01	-3.353551-01
374	S	-3.150923-01	-2.955590-01	-2.756316-01	-2.572535-01	-2.379185-01	-2.192595-01
380	S	-2.304976-01	-1.913705-01	-1.629919-01	-1.452037-01	-1.295535-01	-1.169326-01
386	S	-1.139467-01					