CONFIDENTIAL

TECHNICAL REPORT HSM-R114

METHODS OF DETERMINING THE SATURN I BUFFETING RESPONSE FROM RIGID MODEL WIND TUNNEL TESTS

VOLUME II

JUNE 1965

SPACE DIVISION CHRYSLER CORPORATION

HUNTSVILLE OPERATIONS

CCMD/H MASTER LOG

No. 05165

[redacted]

DECLASSIFIED

23635

ABSTRACT

The experimental determination of the buffeting on a launch vehicle is analyzed. The statistical prediction of the gross vehicle loadings and displacements from wind tunnel data obtained from rigid models is considered. The dynamic response of the vehicle in bending and in sloshing is described. Design of a wind tunnel test that will determine the required data is outlined. The instrumentation requirements are discussed. Data reduction techniques are described that generate the power spectral densities of the aerodynamic forcing. The scaling rules are included. Saturn I test data are reduced and the results compared with the results of an aeroelastic test and a flight test. The main portion of the report is contained in Volume I. The classified data and results are contained in Volume II.

[redacted] contains [redacted] 18, U.S.C., [redacted] which in any manner to an [redacted] person is prohibited by law.

GROUP 4

[redacted] intervals; [redacted] after [redacted]

DECLASSIFIED

FOREWORD

This report was prepared by the Aero-Space Mechanics Branch, Structures & Mechanics Engineering Department, Huntsville Space Operations, Chrysler Corporation. The work was authorized by task assignment R-AERO-SAT-I-IB/1-65, work assignment AU-4, Contract NAS8-4016, issued by the Unsteady Aerodynamics Branch, Aerodynamics Division, Aero-Astrodynamics Laboratory, Marshall Space Flight Center. The purpose of this study is to establish the data reduction procedures for wind tunnel buffeting tests conducted with rigid models. Saturn I data are reduced and compared with the results of an aeroelastic test and with flight test data. Suggestions are made concerning the design of rigid model tests.

DECLASSIFIED

LIST OF ILLUSTRATIONS

Figure No.	Title	Page
1	Minimum Full Scale RMS Bending Moment Calculated from PSTL-1 Test Results, for Mode 1, by Cross Spectrum Method.	2
2	Minimum Full Scale RMS Bending Moment Calculated from PSTL-1 Test Results, for Mode 2, by Cross Spectrum Method.	3
3	Minimum Full Scale RMS Bending Moment Calculated from PSTL-1 Test Results, for Mode 3, by Cross Spectrum Method.	4
4	Minimum Full Scale RMS Bending Moment Calculated from PSTL-1 Test Results, for the Total of the First Three Modes, by Cross Spectrum Method	5
5	Maximum Full Scale RMS Bending Moment Calculated from PSTL-1 Test Results, for Mode 1, by Cross Spectrum Method.	6
6	Maximum Full Scale RMS Bending Moment Calculated from PSTL-1 Test Results, for Mode 2, by Cross Spectrum Method.	7
7	Maximum Full Scale RMS Bending Moment Calculated from PSTL-1 Test Results, for Mode 3, by Cross Spectrum Method.	8
8	Maximum Full Scale RMS Bending Moment Calculated from PSTL-1 Test Results, for the Total of the First Three Modes, by Cross Spectrum Method	9
9	Limits of Full Scale RMS Deflection Calculated from PSTL-1 Test Results, for Mode 1, by Cross Spectrum Method.	10
10	Limits of Full Scale RMS Deflection Calculated from PSTL-1 Test Results, for Mode 2, by Cross Spectrum Method.	11
11	Limits of Full Scale RMS Deflection Calculated from PSTL-1 Test Results, for Mode 3, by Cross Spectrum Method.	12
12	Limits of Full Scale RMS Deflection Calculated from PSTL-1 Test Results, for the Total of the First Three Modes, by Cross Spectrum Method	13
13	Comparison of the Computer RMS Pitching Moment Coefficient with the Experimental PSTL-1 Coefficients	14
14	The Power Spectral Density of the Calculated and Measured Moment for the Maximum Case	15

DECLASSIFIED

LIST OF ILLUSTRATIONS (Cont.)

Figure No.	Title	Page
15	The Power Spectral Density of the Calculated and Measured Moment for the Minimum Case	16
16	PSTL-1 RMS Local Normal Force Coefficient Distribution	17
17	Full Scale PSTL-1 Minimum RMS Bending Moment Compared to the Aeroelastic RMS Bending Moment	18
18	Full Scale PSTL-1 Maximum RMS Bending Moment Compared to the Aeroelastic RMS Bending Moment	19
19	Flight Deflection of SA-7 at the Instrument Unit	20

DECLASSIFIED

INTRODUCTION

A study has been made to determine methods for reducing wind tunnel buffeting data taken with rigid models. Data from a series of Saturn I tests, designated PSTL-1, were reduced by these methods. They are compared with those of an aeroelastic model test and a flight test of the Saturn. The analysis is contained in Vol. I, which is unclassified. The PSTL-1 tests are classified despite the fact that the aeroelastic tests and the buffeting data from the flight tests are not classified. The PSTL-1 data are given in Vol. II, which is classified.

The bending moments generated by buffeting are determined by the cross spectrum method. They are shown in figures 1 through 8. The limits of the bending deflections are shown in figures 9 through 12. A comparison of the computed and measured RMS pitching moment coefficients is given in figure 13. The power spectral densities of the moments are given in figure 14 and 15. The local normal force coefficients measured in the PSTL-1 tests are shown in figure 16. The minimum and maximum PSTL-1 bending moment distributions are compared with the bending moment distributions obtained in the aeroelastic test in figures 17 and 18. The vehicle deflection at the instrumentation unit during a Saturn flight is given in figure 19.

CONFIDENTIAL

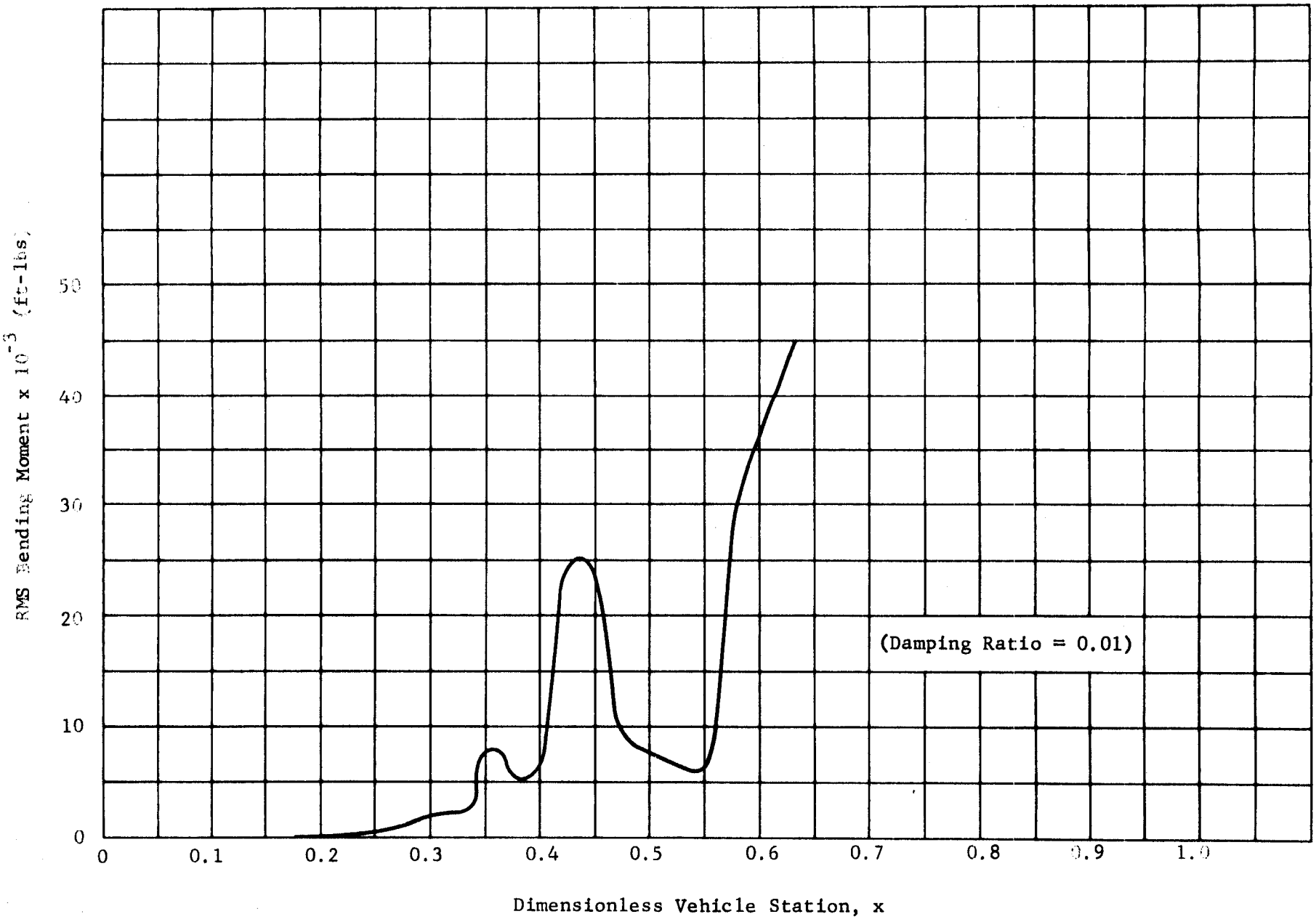


FIGURE 1. MINIMUM FULL SCALE RMS BENDING MOMENT CALCULATED FROM PSTL-1 TEST RESULTS, FOR MODE 1, BY CROSS SPECTRUM METHOD

CONFIDENTIAL

[redacted]

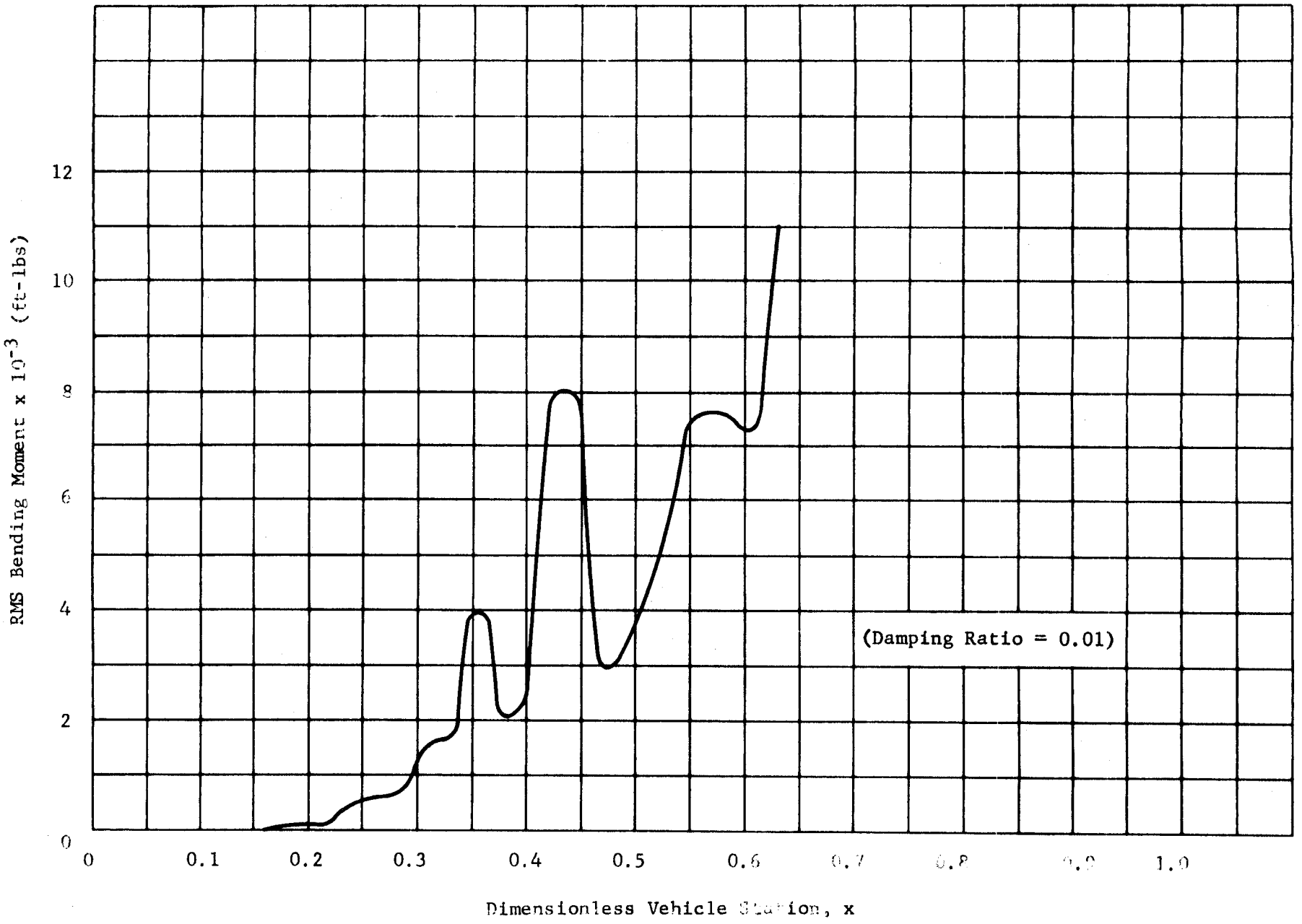


FIGURE 2. MINIMUM FULL SCALE BENDING MOMENT CALCULATED FROM PSEL-1 TEST RESULTS, FOR MODE 2, BY CROSS SPECTRUM METHOD

CONFIDENTIAL

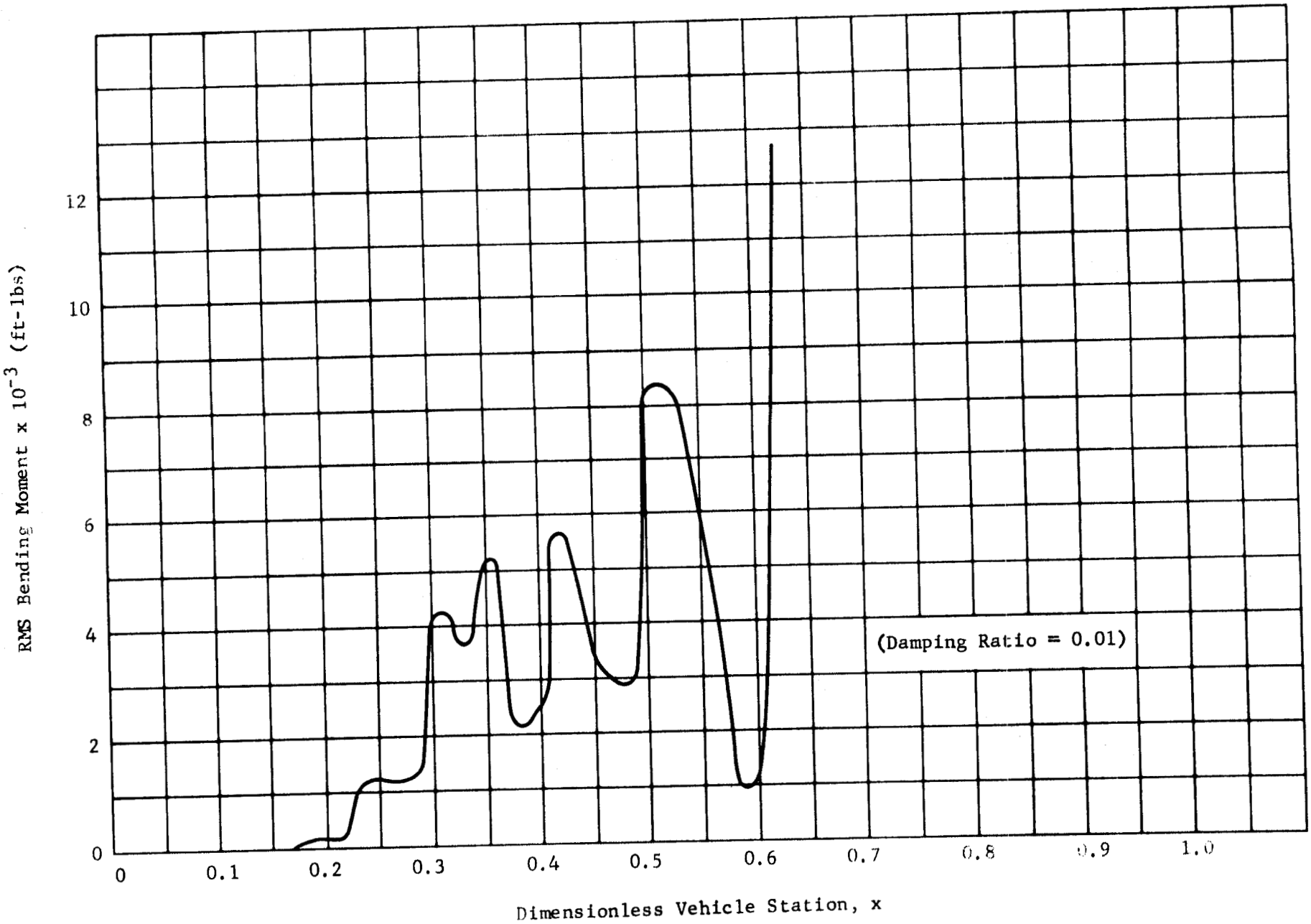


FIGURE 3. MINIMUM FULL SCALE RMS BENDING MOMENT CALCULATED FROM SSL-1 TEST RESULTS, FOR MODE 3, BY CROSS SPECTRUM METHOD

CONFIDENTIAL

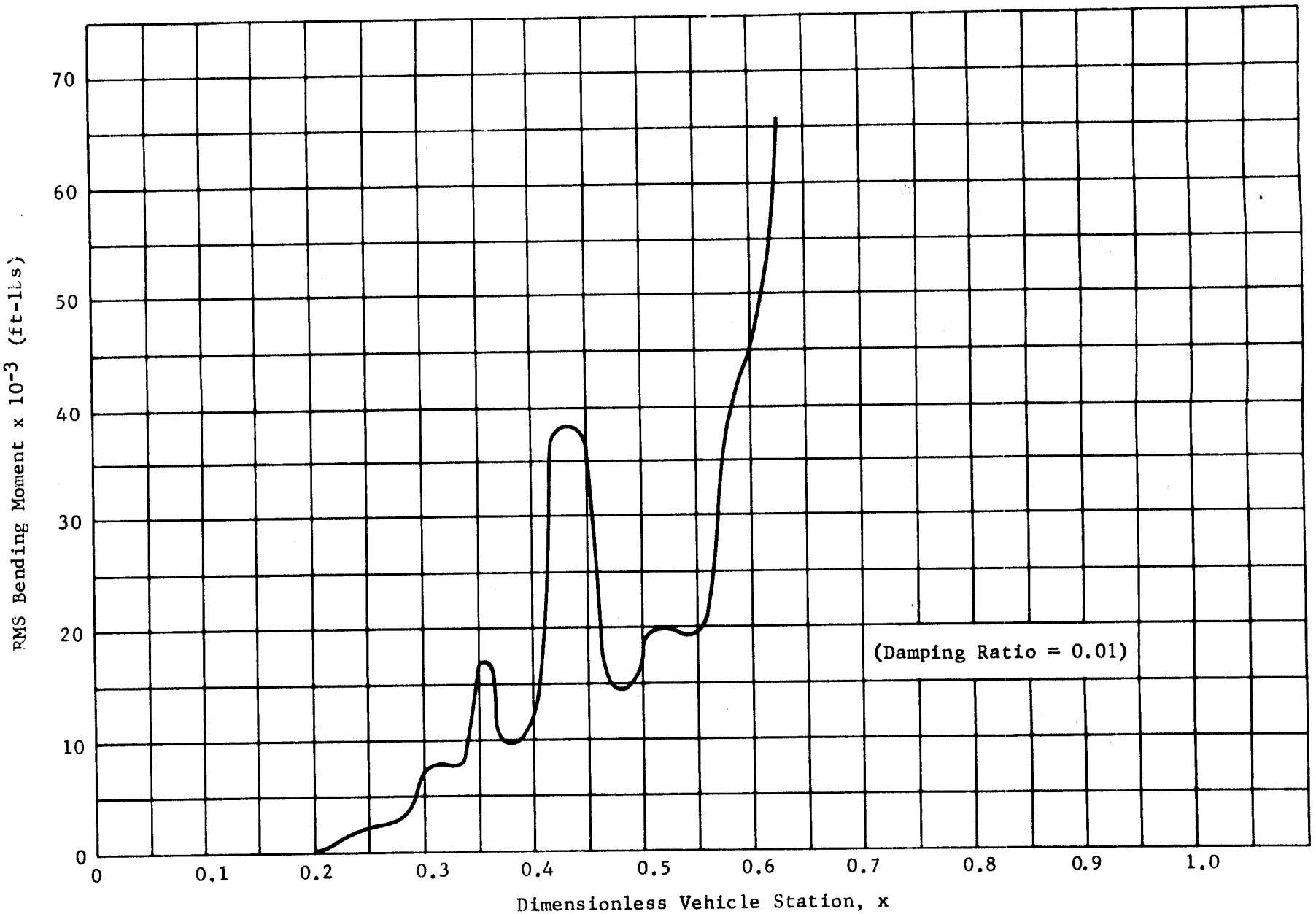


FIGURE 4. MINIMUM FULL SCALE RMS BENDING MOMENT CALCULATED FROM PSTL-1 TEST RESULTS, FOR THE TOTAL OF THE FIRST THREE MODES, BY CROSS SPECTRUM METHOD

CONFIDENTIAL

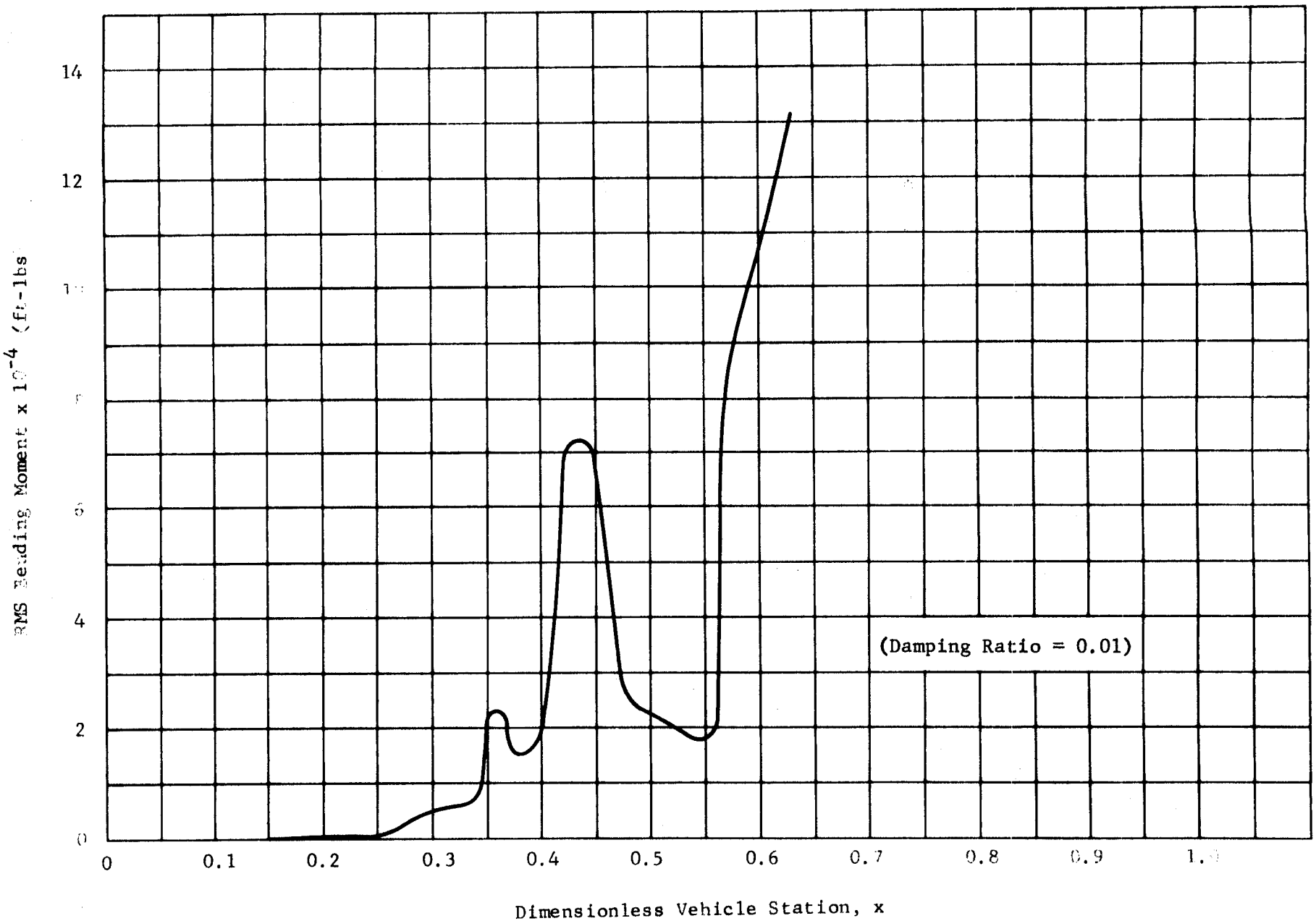


FIGURE 5. MAXIMUM FULL SCALE RMS BENDING MOMENT CALCULATED FROM SSL-1 TEST RESULTS, FOR MODE 1, BY CROSS SPECTRUM METHOD

CONFIDENTIAL

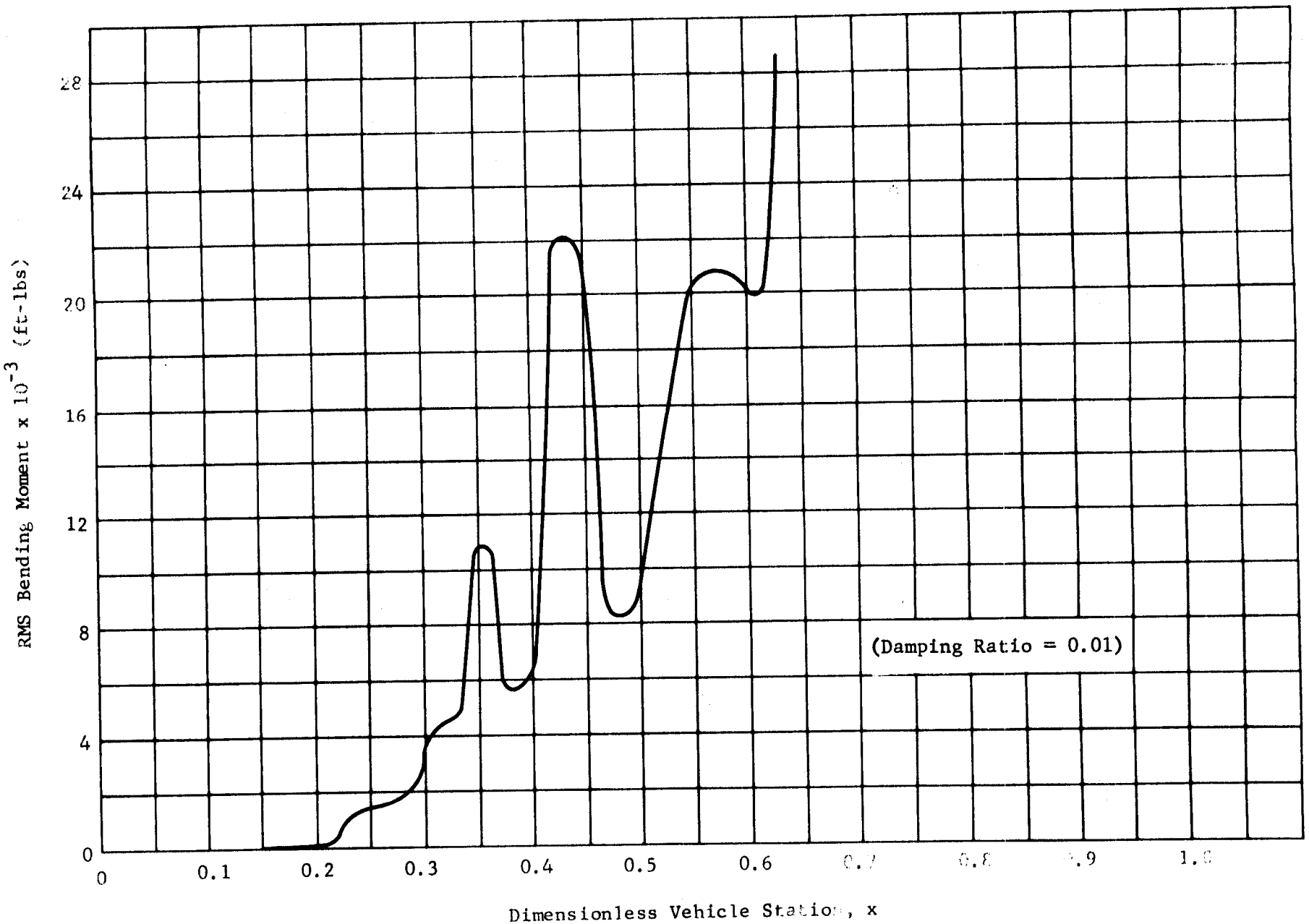


FIGURE 6. MAXIMUM FULL SCALE RMS BENDING MOMENT CALCULATED FROM SSL-3 TEST RESULTS, FOR MODE 2, BY CROSS SPECTRUM METHOD

DECLASSIFIED
CONFIDENTIAL

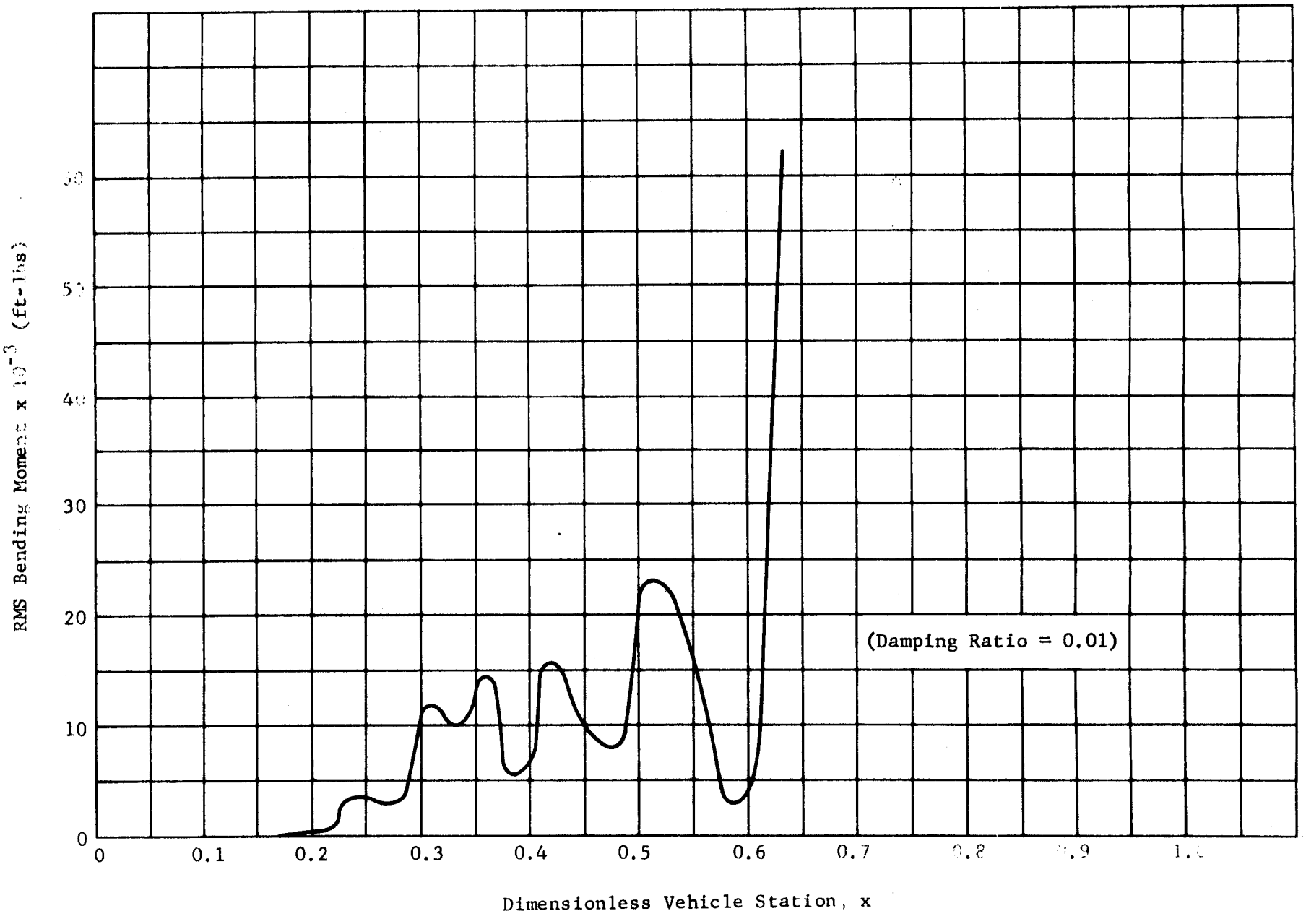


FIGURE 7. MAXIMUM FULL SCALE RMS BENDING MOMENT CALCULATED FROM STL-1 TEST RESULTS, FOR MODE 3, BY CROSS SPECTRUM METHOD

[redacted]

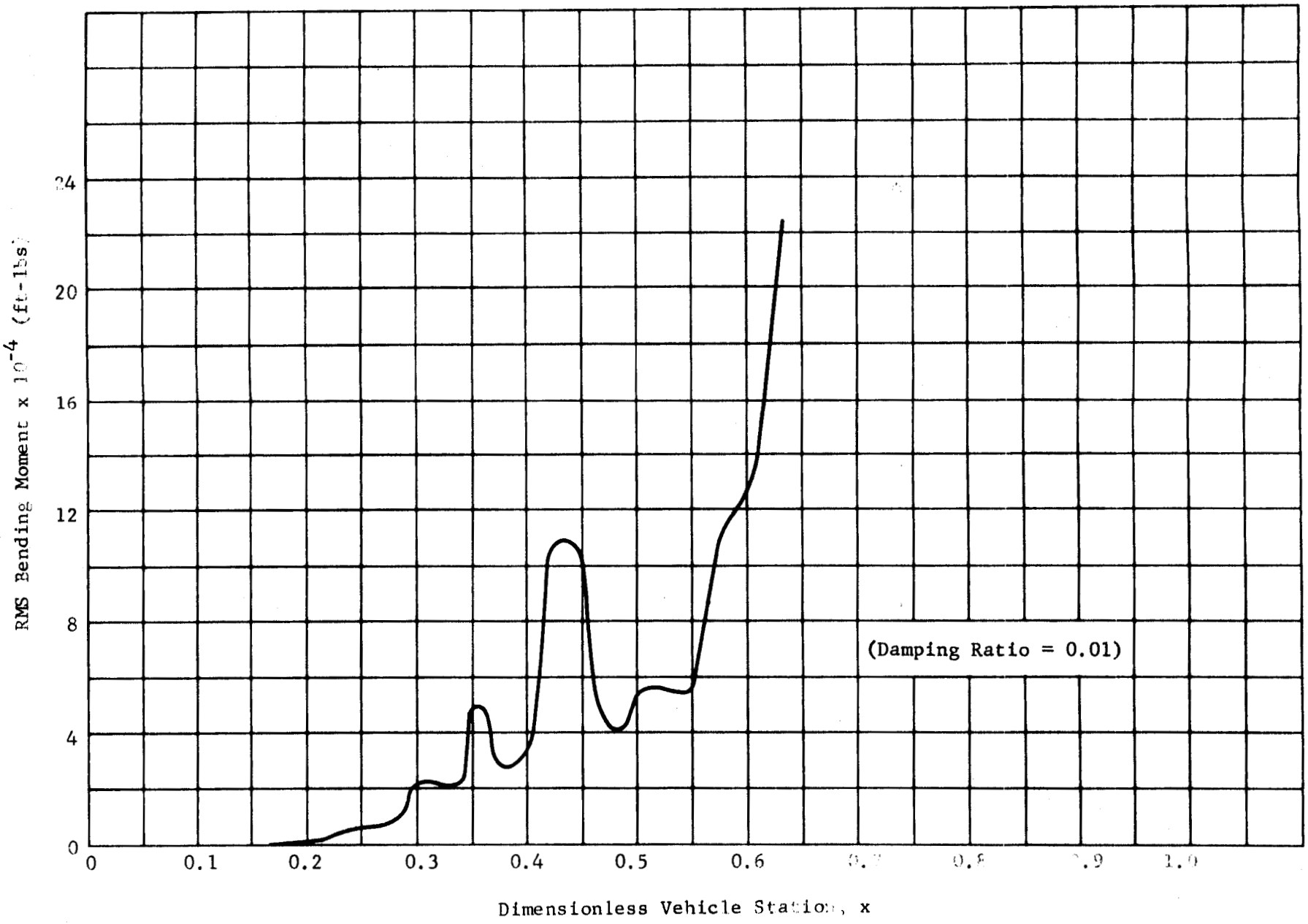


FIGURE 8. MAXIMUM FULL SCALE RMS BENDING MOMENT CALCULATED FROM SCALE TEST RESULTS, FOR THE TOTAL OF THE FIRST [illegible] MODES, BY CROSS SPECTRUM METHOD

CONFIDENTIAL

CONFIDENTIAL

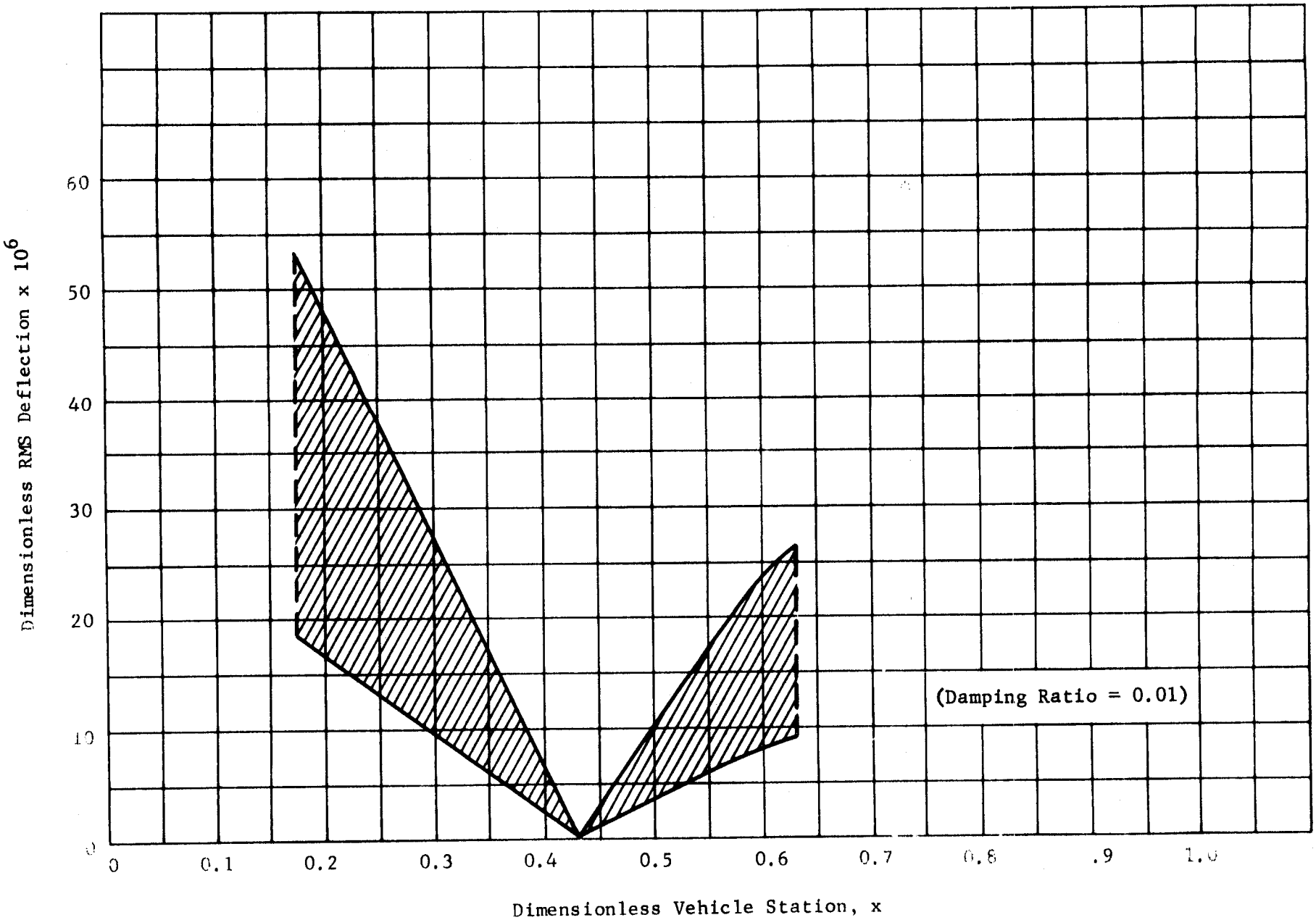


FIGURE 9. LIMITS OF FULL SCALE RMS DEFLECTION CALCULATED FROM SCALE-1 TEST RESULTS, FOR MODE 1, BY CROSS SPECTRUM METHOD

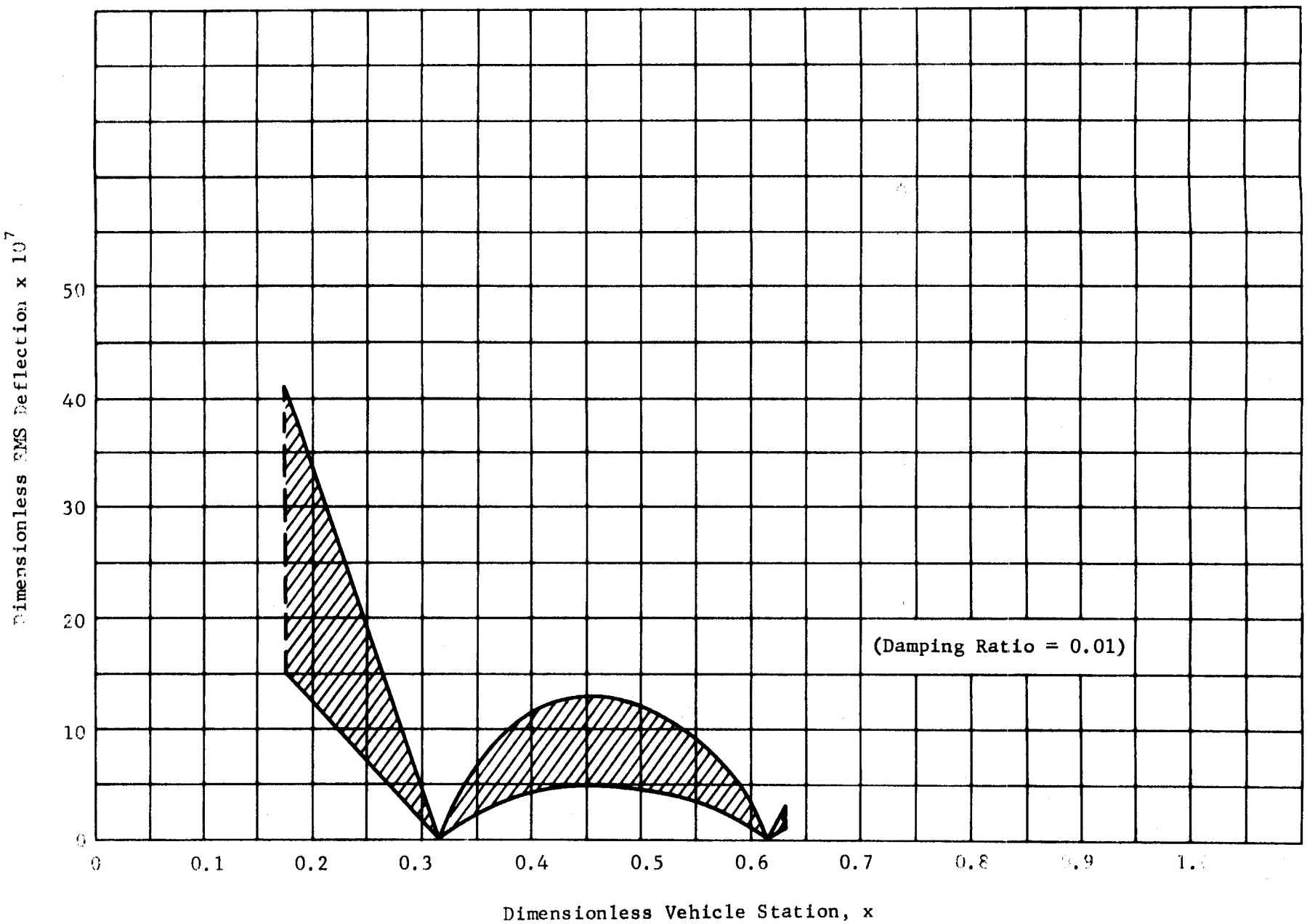


FIGURE 10. LIMITS OF FULL SCALE RMS DEFLECTION CALCULATED FROM SSL-1 TEST RESULTS, FOR MODE 2, BY CROSS SPECTRUM METHOD

CONFIDENTIAL

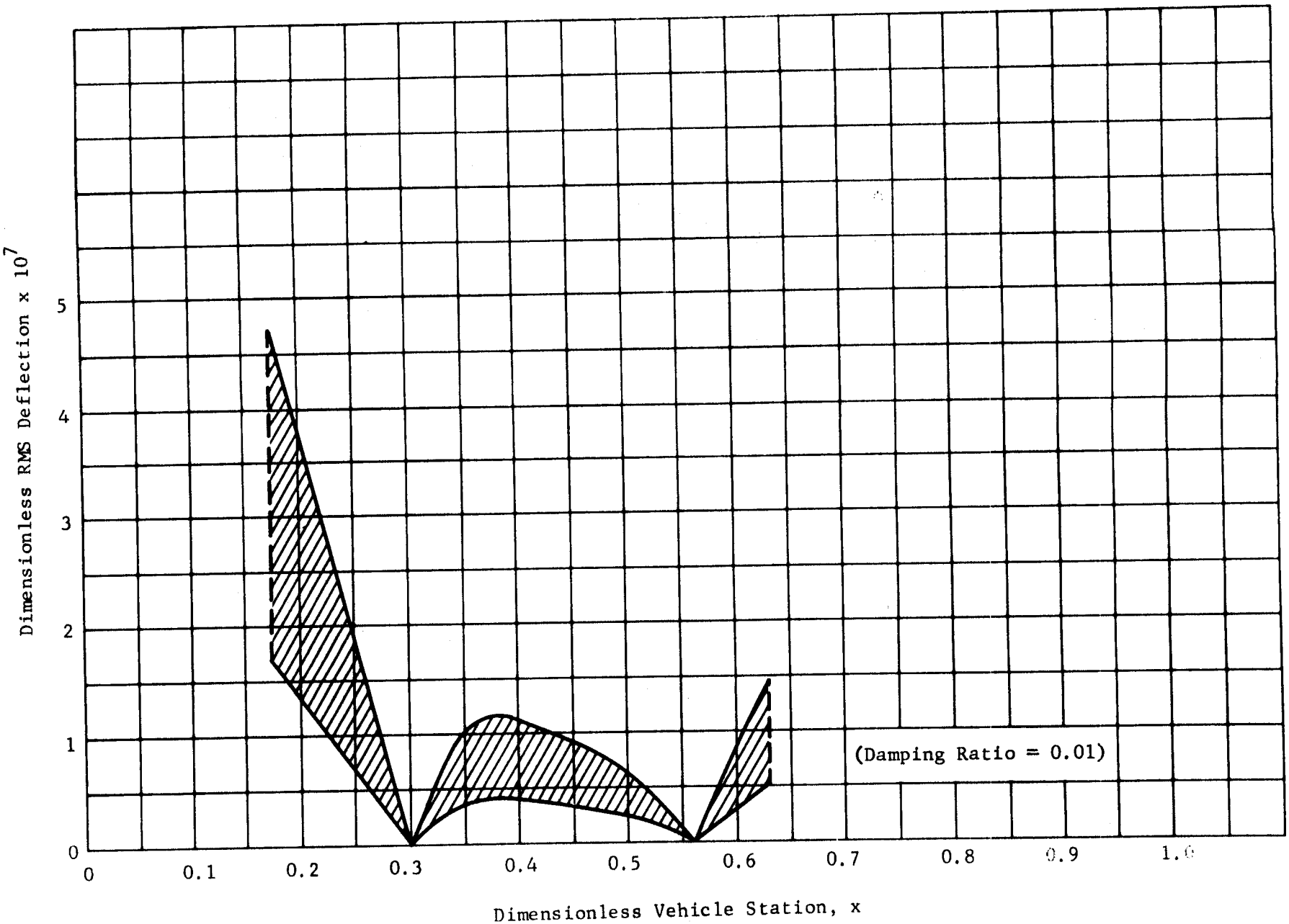


FIGURE 11. LIMITS OF FULL SCALE RMS DEFLECTION CALCULATED FROM STI-1 TEST RESULTS, FOR MODE 3, BY CROSS SPECTRUM METHOD

CONFIDENTIAL

CONFIDENTIAL

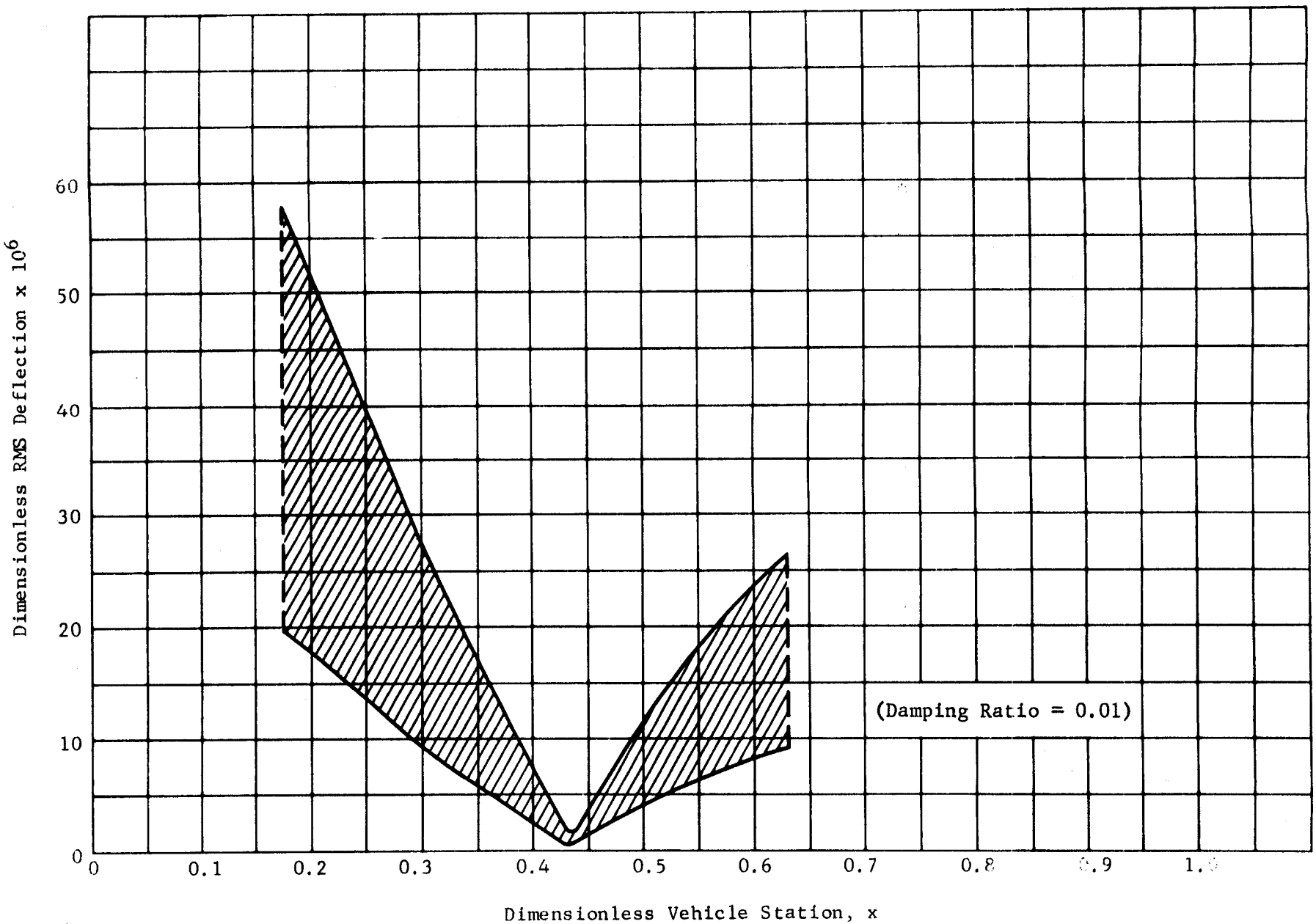


FIGURE 12. LIMITS OF FULL SCALE RMS DEFLECTION CALCULATED FROM [illegible] TEST RESULTS, FOR THE TOTAL OF THE FIRST THREE MODES, BY CROSS SPECTRUM METHOD

CONFIDENTIAL

CONFIDENTIAL

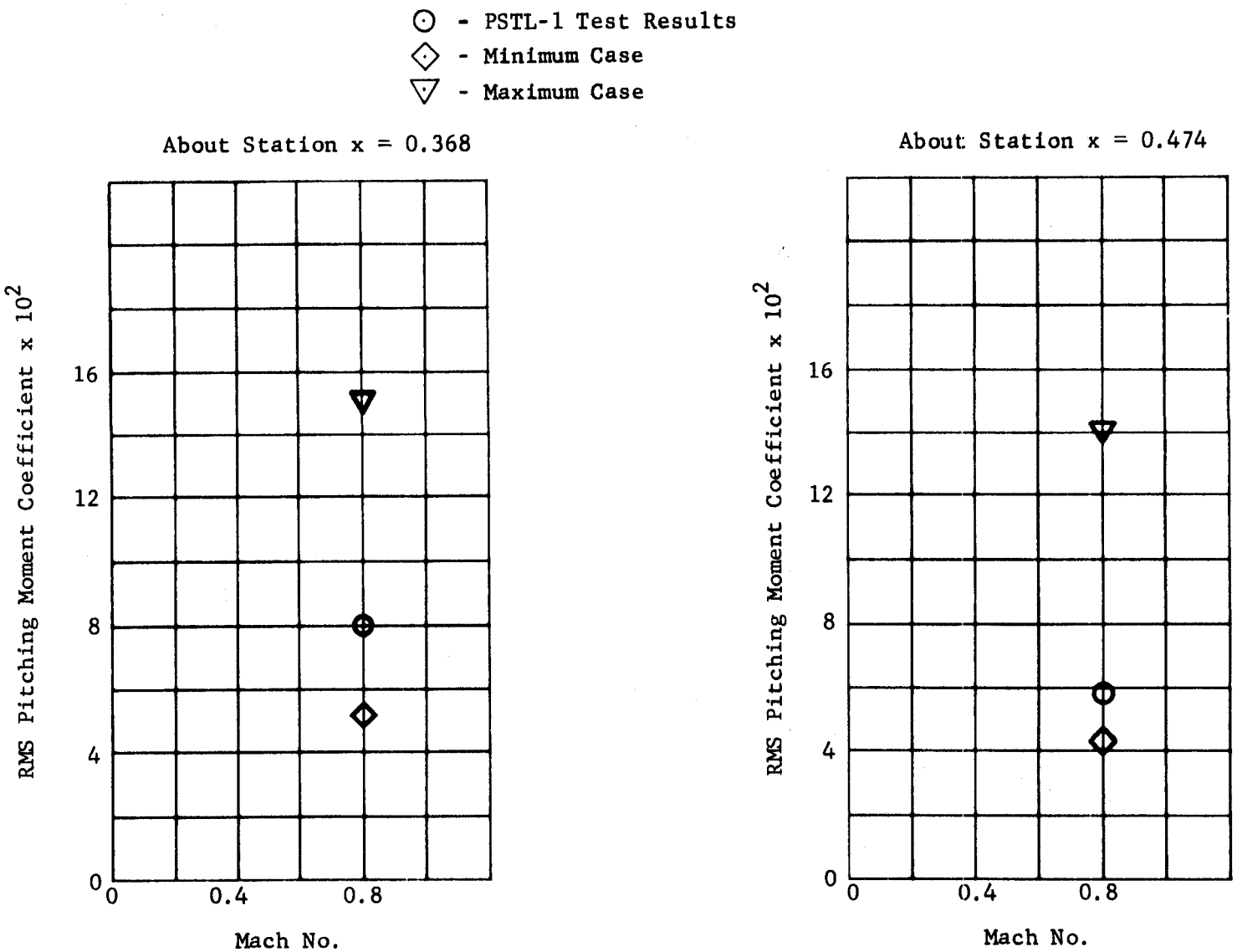


FIGURE 13. COMPARISON OF THE COMPUTED RMS PITCHING MOMENT COEFFICIENT WITH THE EXPERIMENTAL PSTL-1 COEFFICIENTS

CONFIDENTIAL

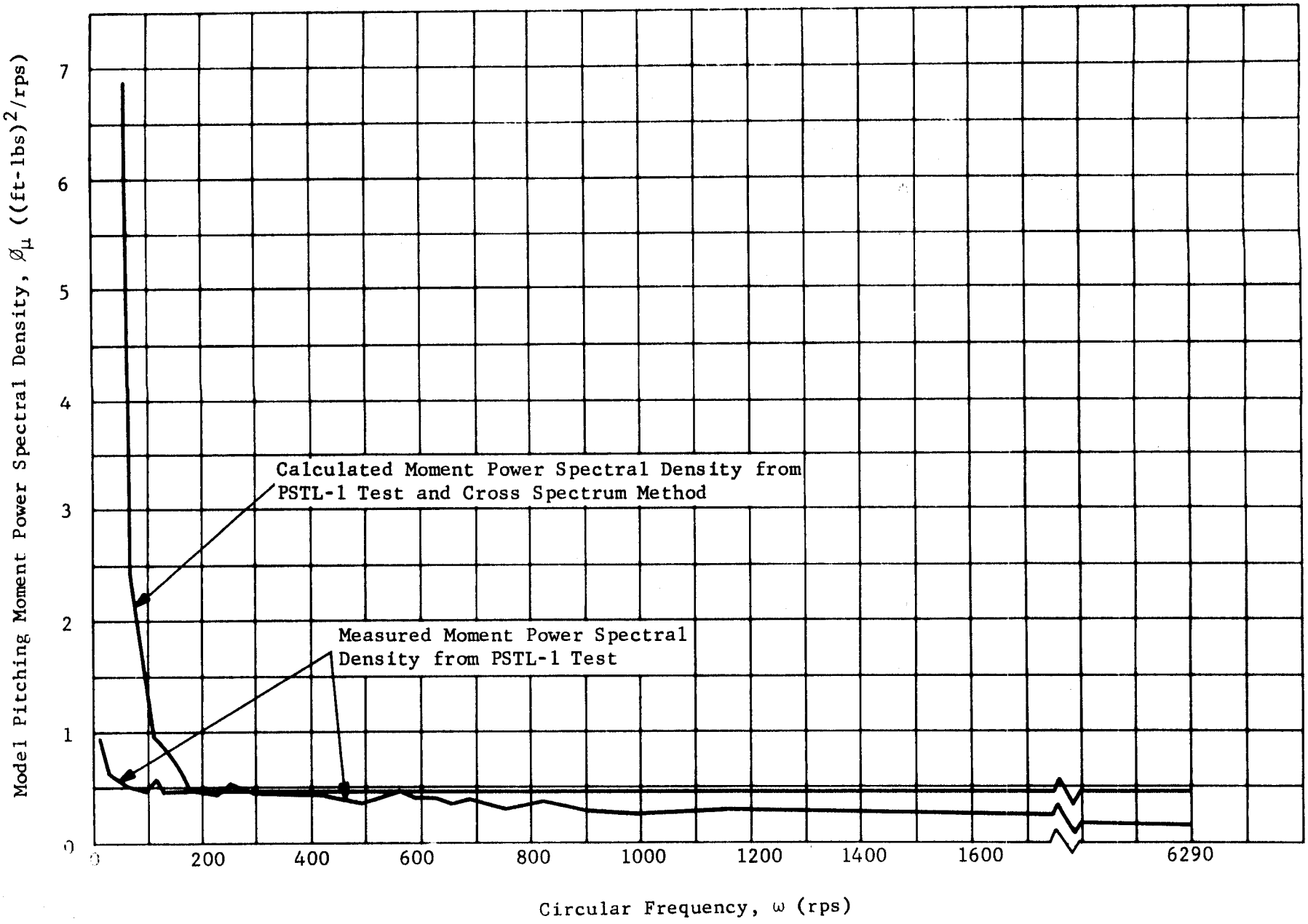


FIGURE 14. THE POWER SPECTRAL DENSITY OF THE CALCULATED AND MEASURED MOMENT FOR THE MAXIMUM CASE

CONFIDENTIAL

CONFIDENTIAL

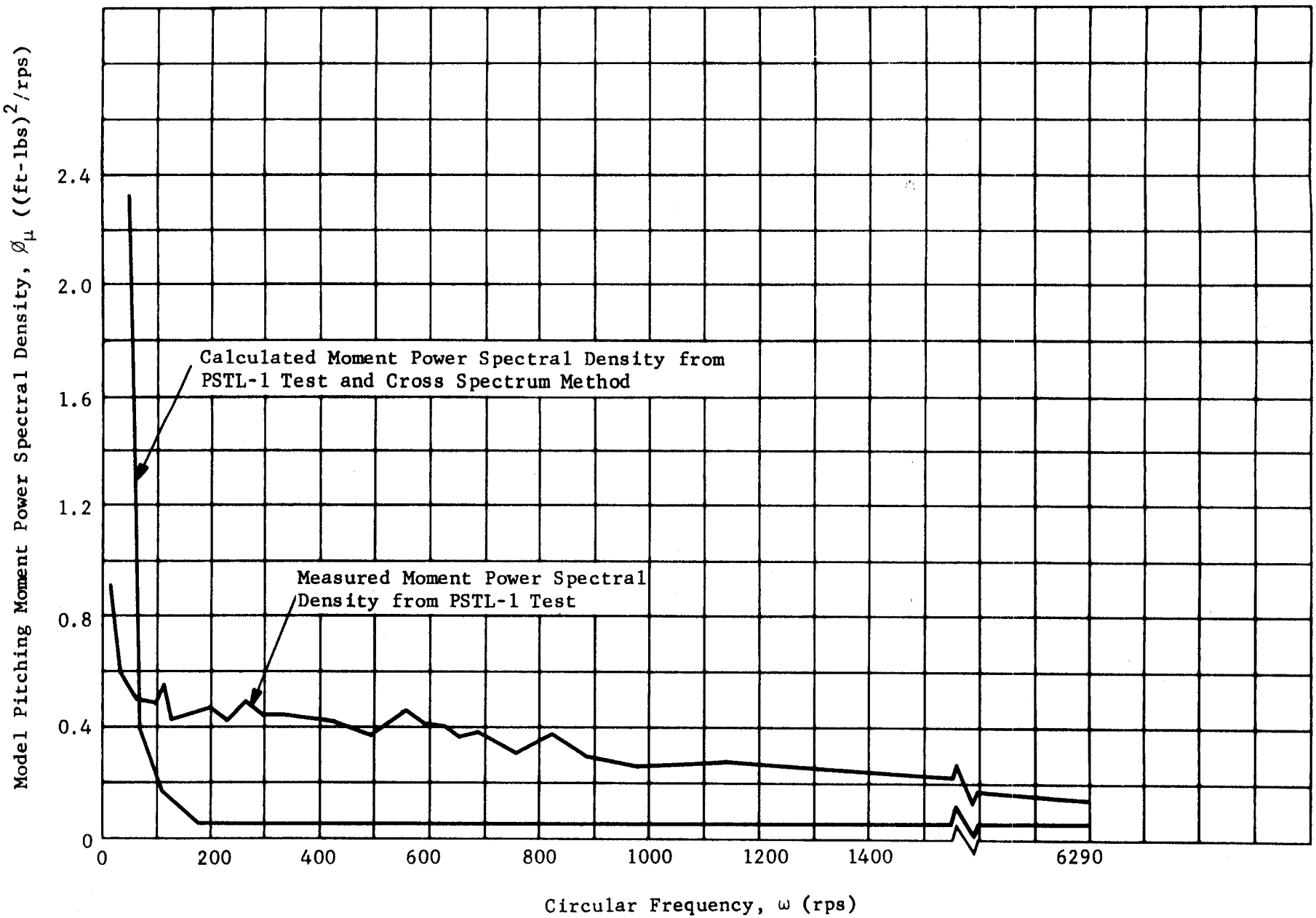


FIGURE 15. THE POWER SPECTRAL DENSITY OF THE CALCULATED AND MEASURED MOMENTS FOR THE MINIMUM CASE

[redacted]

CONFIDENTIAL

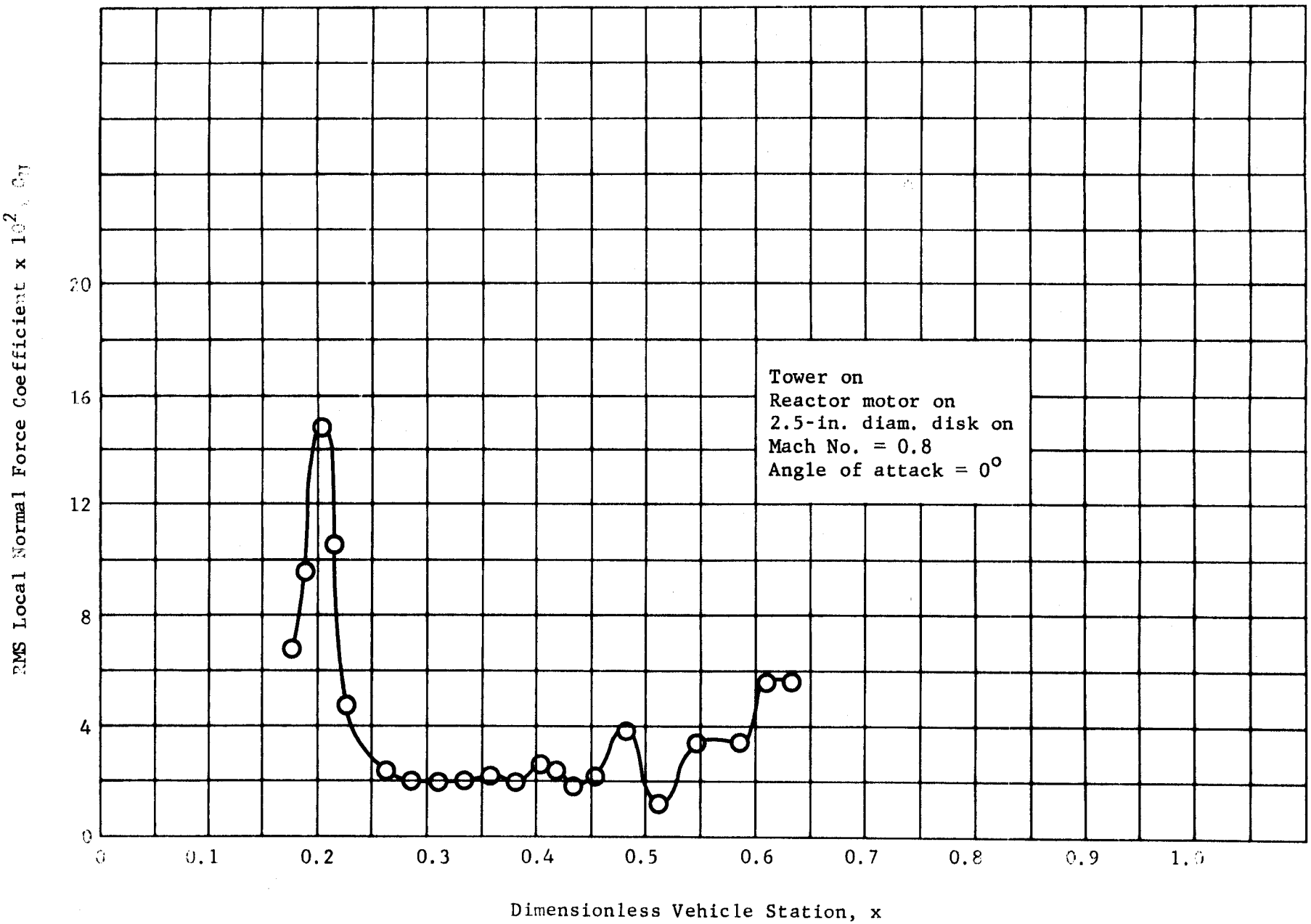


FIGURE 16. PSTL-1 RMS LOCAL NORMAL FORCE COEFFICIENT DISTRIBUTION

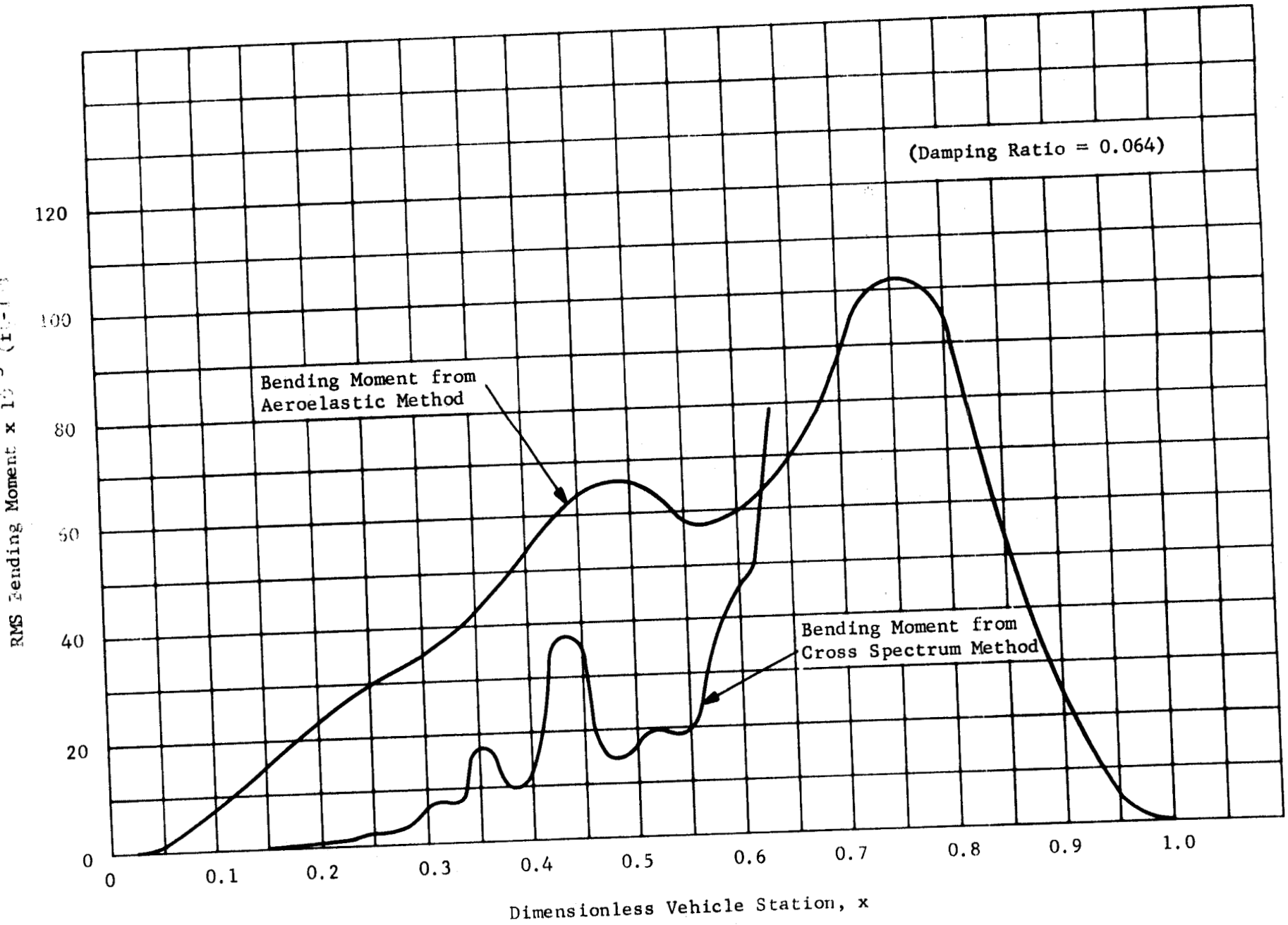


FIGURE 17. FULL SCALE PSTL-1 MINIMUM RMS BENDING MOMENT COMPARED TO THE AEROELASTIC RMS BENDING MOMENT

CONFIDENTIAL

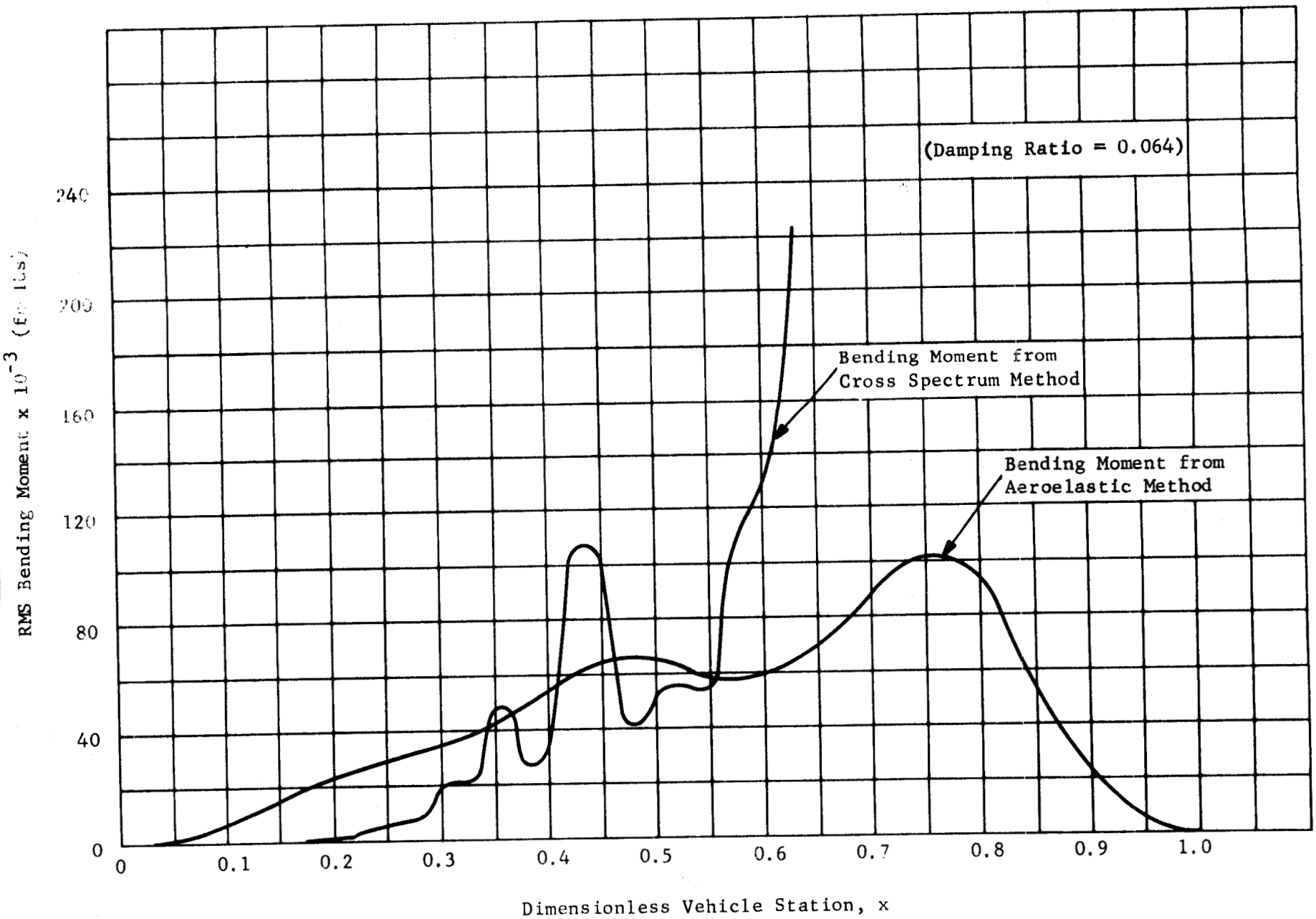
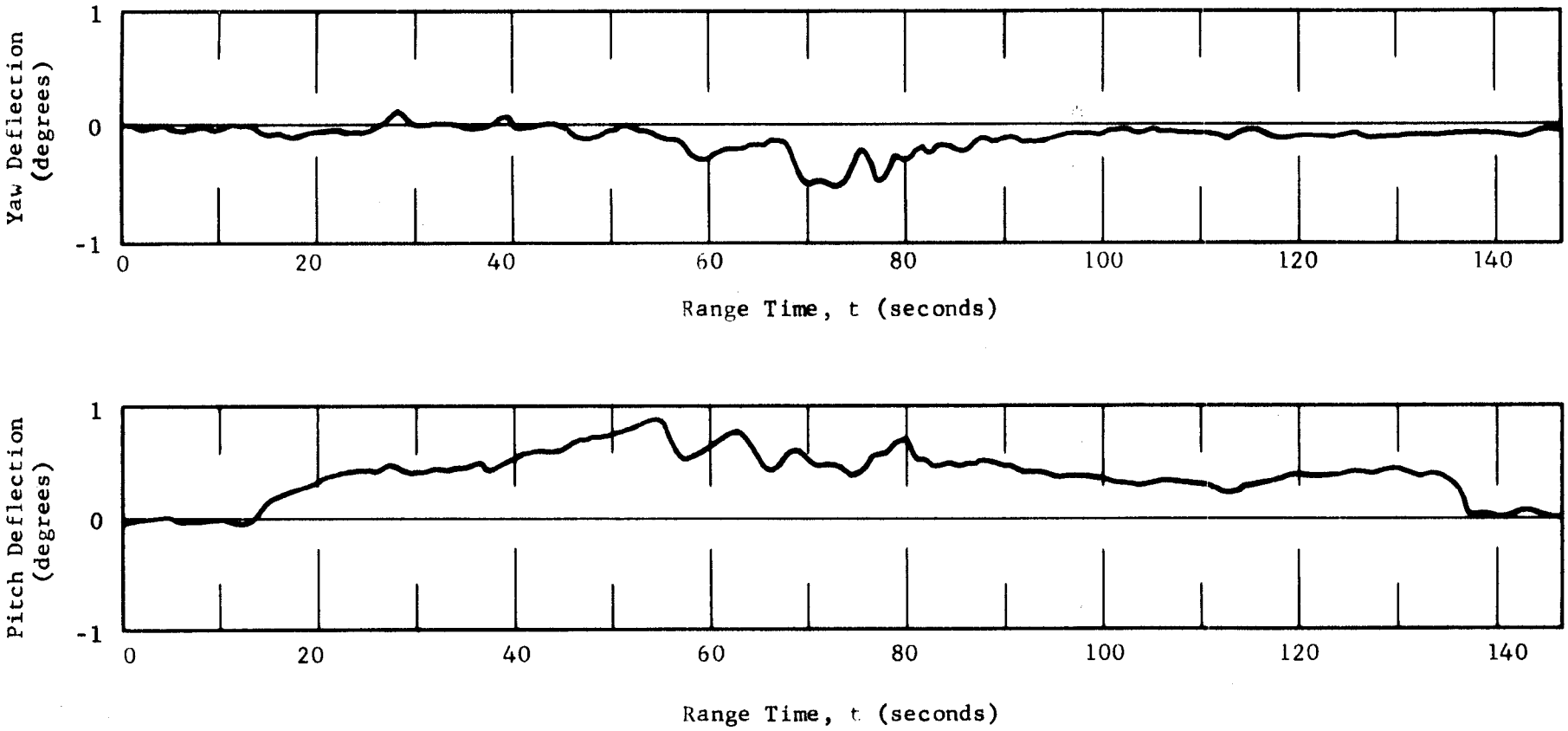


FIGURE 18. FULL SCALE PSTL-1 MAXIMUM RMS BENDING MOMENT COMPARED TO THE AEROELASTIC RMS BENDING MOMENT

CONFIDENTIAL

CONFIDENTIAL



The angular buffeting deflections at the I.U. calculated by cross spectrum method for Mode 1 are:

$$\left.\begin{array}{l}\text{Mimimum case deflection} = 0.00344^{\circ} \\ \text{Maximum case deflection} = 0.0117^{\circ}\end{array}\right\} t = 57 \text{ sec}$$

FIGURE 19. FLIGHT DEFLECTION OF SA-7 AT THE INSTRUMENT UNIT

DECLASSIFIED

Technical Report HSM-R114

METHODS OF DETERMINING THE SATURN I BUFFETING RESPONSE FROM RIGID MODEL WIND TUNNEL TESTS

VOLUME II

June 1965

BY: George F. McCanless
George F. McCanless

James R. Boone
James R. Boone

APPROVED: L. G. Alexakos Jr.
L. G. Alexakos, Jr.
Manager, Aerodynamics
Section

APPROVED: M. L. Bell
M. L. Bell
Manager, Aero-Space
Mechanics Branch