U.S. Department of Housing and Urban Development
Office of Policy Development and Research

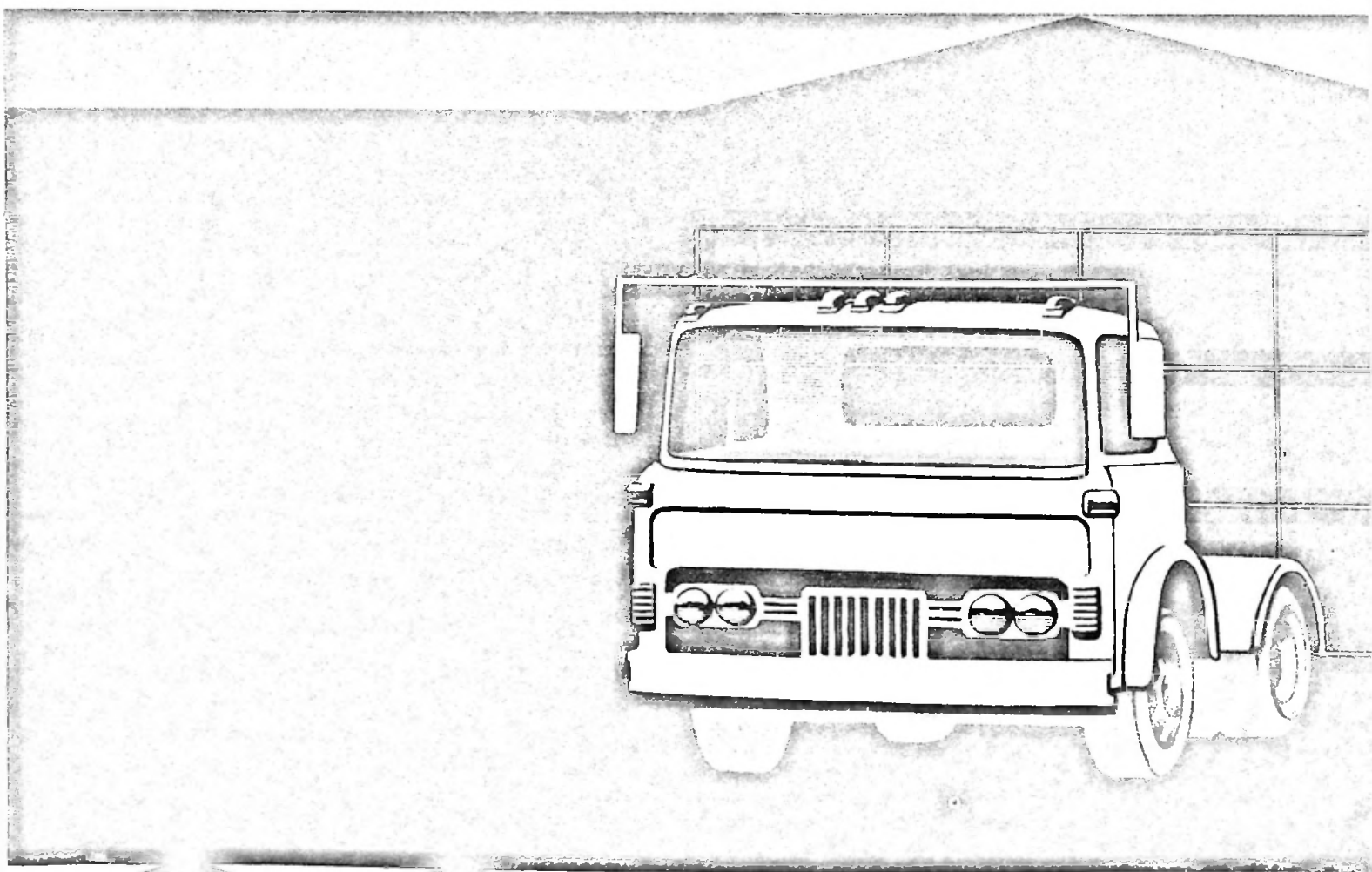
Mobile Home Research

Recommend Revisions to Federal Mobile Home Construction and Safety Standard Resulting From the Transportation Study

Transportation and Site-Installation

Volume 5

Final Report



MOBILE HOME RESEARCH

TRANSPORTATION AND SITE-INSTALLATION

RECOMMENDED REVISIONS TO FEDERAL MOBILE HOME CONSTRUCTION AND SAFETY STANDARD RESULTING FROM THE TRANSPORTATION STUDY

VOLUME 5
FINAL REPORT

By

Southwest Research Institute

Prepared for

U.S. Development of Housing and Urban Development
Office of Policy Development and Research

Contract Number H-2411

March 1979

FOREWORD

At the present time, 10 million Americans live in mobile homes. For them, and for the increasing numbers of people who will come to live in such homes in the future, HUD, at the request of the Congress, has undertaken research to improve mobile home safety and durability. Out of that research, HUD is to develop, promulgate, and enforce one nation-wide construction standard for the industry.

The six volumes that constitute this report should prove invaluable to those who develop standards as well as those architects and engineers who design both manufactured housing and mobile homes. That some of the research may be controversial is only to be expected. It is pioneering work that offers a new approach to resolving difficult problems.

The Division of Energy, Building Standards and Technology of HUD's Office of Policy Development and Research should be recognized for its contribution to this worthwhile project.

Moon Landrieu
Secretary

TABLE OF CONTENTS

INTRODUCTION

RECOMMENDED REVISIONS TO SUBPART D
"BODY AND FRAME CONSTRUCTION"

RECOMMENDED REVISIONS TO SUBPART E
"TESTING"

RECOMMENDED REVISIONS TO SUBPART J
"TRANSPORTATION"

SUMMARY

The research contained herein was undertaken to provide a basis for determining the adequacy of the Mobile Home Construction and Safety Standards, effective June 15, 1976. "Adequate" is defined as Standards that result in mobile homes with sufficient durability to provide the homeowner with an acceptable useful life; currently defined for purposes of this Study as a minimum of 15 years for a single-wide and as a minimum of 20 years for a double-wide unit. The research methodology to evaluate the standard included: (1) the development of analytical methods to determine transportation and site-installation induced loads and the resulting member stresses, joint-loads and deflections; (2) the development of a means to predict degradation caused by the aforementioned forces; (3) the conduct of a test program that compares analytically determined input loads and predicted degradation with actual physical test measurements and observations; (4) if required, proposed changes to the Standards; and (5) analytical or test methodology that could be used by enforcement agencies to evaluate proposed mobile home designs.

To determine mobile home structural member loads caused by in-transit conditions, computer modeling techniques were used. Critical in-transit conditions (i.e., road roughness and towing velocity) were analytically related to critical structural parameters (i.e., torsional stiffness, flexural stiffness, and damping) in order to calculate estimated member loads. This analysis also related analytically predicted changes in structural parameters to degradation of the mobile home. Equations were developed that, in part, statistically compare structural parameters of any given mobile home to a home that is considered to be 100 percent degraded. Solution of these equations result in an estimation of mobile home degradation. These equations were modified as required to provide "best fit" estimates consistent with test data and are subject to further modification as additional data becomes available. This research activity is described in Volumes 1 and 4. A detailed rationale for analytical equations is not presented since emphasis was put on the "best fit" relationship of analytical computer simulations and test data.

Volumes 1 and 4 also includes a computer oriented methodology for the analysis of mobile home structures. This data provides a basis for future research oriented to the rapid analysis of mobile home member stresses, joint loads and structural deflections.

A test program was conducted to obtain data that could be compared to analytically derived data. Emphasis was placed on measured test data which resulted in equation modifications as necessary to "best fit" experimental data. Test data was obtained from single-wide and double-wide homes built per the current standard and from homes built prior to implementation of the current standard. Test homes were subjected to transportation and site-installation conditions to simulate years of actual use. Volume 2 describes the test program with supportive data sheets included in Volume 3.

The objective of proposed revisions to the Standards is to reduce the incremental degradation of mobile homes where current design practices result in predicted and observed degradation that exceeds acceptable levels. Volume 5 contains proposed changes to the current standard based on an analysis of data contained in Volumes 1 through 4. The proposed changes include increased design loads to resist in-transit and on-site forces; increased design criteria for attachment of joints as required to minimize loosening of joints during transportation; and a requirement for a minimum integrated structure stiffness criteria to ensure that degradation with respect to time is consistent with a reasonable useful life. Recommended design loads were based on actual measured test data multiplied by a factor selected to account for rough roads and highway speeds greater than 45 MPH. Minimum stiffness criteria were based on values obtained from the single-wide home built to the current standards.

Volume 6 contains a proposed field test method that could be used to measure the stiffness parameters of new or used mobile homes. These parameters are required to verify adherence to the proposed standard, and to perform calculations necessary to predict the remaining useful life of the mobile home.

Volume 7 (yet to be printed) will summarize the major results of the other six volumes and will provide a cohesive evaluation for the reader interested primarily in understanding the broader aspects rather than becoming technically involved in the specific technical aspects of the study.

The Southwest Research Institute's Study offers an innovative approach in terms of a concept and a model upon which to assess mobile home structural durability, or conversely, structural degradation. The Study's findings should offer a base upon which to develop proposed Standards.

The rationale of using degradation of torsional and flexural rigidity as a measure of mobile home durability is innovative for mobile home design and would appear to be basically sound. Changes in stiffness (torsional and flexural) and damping, have been used for several years in engineering practice as a measure of structural degradation in other applications. The concept of seeking a measurable parameter that is sensitive to degradation appears to have merit.

This Study's findings should therefore be considered in the whole context of the research effort rather than narrowly disected. Certain assumption's made upon the best available information from data, may later be modified as experience is gained in the use and application of the Study's results.

RELATED DOCUMENTATION

The research program, from which this volume and six others were derived, was originally organized into eight project tasks under each of which a varying number of reports were written; e.g., Task I consisted of Volumes I, II, III, and IV. In order to reduce the number of separate volumes produced from this research, certain reports that were considered related were combined into one volume.

Volume 1 consists of Task I, Vols I, II, III, IV;
Volume 2 consists of Task II and Task III, Vol I, Parts I & II;
Volume 3 consists of Task III, Vol I, Part II Raw Data;
Volume 4 consists of Task III, Vols II & III;
Volume 5 consists of Task IV, Vols I, II, & III;
Volume 6 consists of Tasks V, VI, & VII; and
Volume 7 consists of Task VIII.

The reader is made aware of this in order to understand the cross-references that occur throughout these documents as they were originally written. Thus, for example, references to Task I, Vols I and II can be found in the first two parts of what is now Volume 1. It is hoped that any confusion created by this compilation will be offset by the convenience of having fewer volumes of analogous material.

NOTE: Volume 3 is available through the National Technical Information Service; 5282 Port Royal Road, Springfield, Va. 22161. To order by phone call (703) 557-4610. This volume was not printed by the Government Printing Office since it is believed that the demand for Raw Data will be relatively small.

ACKNOWLEDGMENT

The authors are indebted to many professionals for contributions and guidance that made this study possible. Our thanks include:

- Battelle Memorial Institute - for their earlier research study into mobile home flexural rigidity;
- U.S. National Bureau of Standards - for Dr. Robert Crist's evaluation of the predictive analysis theory;
- U.S. Department of Transportation - for their Federal Highway Administration and the Bureau of Motor Carrier Safety organizations for providing transportation insights;
- State of Texas Department of Labor and Standards; for the valuable assistance of Mr. Michael Alexander (Manufactured Housing Division) in evaluating the structural dynamics portions of the study;
- State of Texas Department of Public Safety; for Colonel Wilson Spear's assistance during the highway testing phase;
- Boeing Aerospace Company - for the quality of Mr. John Stevens penetrating assessments during the development of each of the several products of the research;
- American Association of State and Highway Transportation Officials - for the coordination of the highway safety survey;
- Manufactured Housing Institute - for coordinating the attendance of key engineering personnel at the several project status reviews and demonstrations conducted during the research.

INTRODUCTION

I. INTRODUCTION

The requirements of Task IV involve a detailed review, evaluation and analysis of the Federal Mobile Home Construction and Safety Standard, Subpart J, Transportation and its affect upon Subparts D and E .

The evaluation consists of a detailed analysis of each paragraph of Subparts J, D and E and relation of these paragraphs to the results of the predictive analysis and test program delineated in Tasks I and III, respectively. This task effort identifies the appropriate portions of the Standard in terms of being;

- Acceptable as is,
- Excessive,
- Too weak,
- Ambiguous, or
- In some instances, new material was added to the standard.

The paragraphs that need changing, additions, or deletions have been noted within the context of this volume by first recording the Standard as it is currently written in the first column followed by the recommended language in the third column. The language used within the recommended rewrite is based on performance criteria similar to that already used in the standard.

The technical basis for the recommended changes is discussed briefly in Part II of each of the three Subparts, including reference to applicable documentation. These references are predominantly found in the various volumes of Tasks I and III (currently compiled in Volumes 1 through 4).

SUBPART D "CONSTRUCTION"

RECOMMENDED REVISIONS TO SUBPART D "BODY AND FRAME CONSTRUCTION"

by

C. R. Ursell, II
C. E. Kimball

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language *	*	†	**	††	Recommended Language	Justification for Change
280.301 Scope	This Subpart covers the minimum requirements for materials, products, equipment & workmanship needed to assure that the mobile home will provide (a) structural strength & rigidity, (b) protection against corrosion, decay insects & other similar destructive forces, (c) protection against hazards of windstorm, (d) resistance to the elements, & (e) durability & economy of maintenance.	X					
280.302 Definitions	(a) The following definitions are applicable to Subpart D only: (1) "Anchoring Equipment" means straps, cables, turnbuckles, & chains, including tensioning devices, which are used with ties to secure a mobile home to ground anchors.	X					
	(2) "Anchoring System" means a combination of ties, anchoring equipment, & ground anchors that will, when properly designed & installed resist overturning & lateral movement of the mobile home from wind forces	X					
	(3) "Tie", means strap, cable, or securing device used to connect the mobile home to ground anchors.	X					
	(4) "Diagonal Tie", means a tie intended to primarily resist horizontal forces, but which may also be used to resist vertical forces."	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

* "Mobile Home Construction and Safety Standards," Federal Register, Dec. 18, 1975.

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.302 Definitions (Cont'd)	(5) "Vertical Tie", means a tie intended to resist the uplifting or overturning forces.	X					
	(6) "Footing" means that portion of the support system that transmits loads directly to the soil.	X					
	(7) "Ground Anchor" means any device at the mobile home stand designed to transfer mobile home anchoring loads to the ground.	X					
	(8) "Hurricane Resistive Mobile Home" means a mobile home which meets the wind design load requirements for Zone II in 280.305 (c) (2).	X					
	(9) "Loads" (i) "Dead Loads" means the weight of all permanent construction including walls, floors, roof, partition, & fixed service equipment. (ii) "Live Load" means the weight superimposed by the use & occupancy of the mobile home, including wind load & snow load, but not including dead load. (iii) "Wind Load" means the lateral or vertical pressure or uplift on the mobile home due to wind blowing in any direction.		X			(9) "Loads" (i) "Dead Loads" means the weight of all permanent construction including chassis, walls, floors, roof, partition, & fixed service equipment. (ii) "Live Load" means the weight superimposed by the use & occupancy of the mobile home, including wind load & snow load, but not including dead load. (iii) "Wind Load" means the lateral or vertical pressure or uplift on the mobile home due to wind blowing in any direction. (iv) "Transportation Loads" means induced loads caused by acceleration due to vibration and shock generated by the mobile home during the transportation mode (see Subpart J.)	Transportation loads may be of larger magnitude than static design loads.

* Acceptance
† Weak
** Ambiguous
†† Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.302 Definitions (Cont'd)			Added			(10) "Site-installation loads" means loads induced during the mobile home set-up or take-down operations. (11) "Shear Walls" means those walls that are designed to transfer lateral forces caused by wind or transportation induced inertia loads to the mobile home main frame.	Tasks I and III.
	(12) "Main Frame" means the structural component on which is mounted the body of the mobile home.						
	(13) "Pier" means that portion of the support system between the footing & the mobile home exclusive of caps and shims.						
	(14) "Sheathing" means material which is applied on the exterior side of a building frame under the exterior weather resistant covering.	X					
	(15) "Stabilizing Devices" means all components of the anchoring & support systems such as piers, footings, ties, anchoring equipment, ground anchors, & any other equipment which supports the mobile home & secures it to the ground.	X					
	(16) "Support System" means a combination of footings, piers, caps, & shims that will, when properly installed, support the mobile home.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.303 General Requirements	(a) Minimum requirements. The design & construction of a mobile home shall conform with the provisions of this standard. Requirements for any size, weight, or quality of material modified by the terms of "minimum", "not less than," "at least," & similar expressions are minimum standards. The manufacturer or installer may exceed these standards provided such deviation does not result in any inferior installation or defeat the purpose & intent of this standard.	X					
	(b) Construction. All construction methods shall be in conformance with accepted engineering practices to insure durable, livable, & safe housing & shall demonstrate acceptable workmanship reflecting journeyman quality of work of the various trades.	X					
	(c) Structural analysis. The strength & rigidity of the component parts &/or the integrated structure shall be determined by engineering analysis or by suitable load tests to simulate the actual loads & conditions of application that occur. (See Subparts E & J).	X					
	(d) Hurricane resistive design. Only mobile homes which meet the applicable requirements of 280.305(c)(2) may be designated "Designed for Hurricane Zone." No similar designation which would imply hurricane resistance shall be used when the mobile home does not meet these requirements.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.303 General Requirements (Cont'd)	(e) New materials & methods. (1) Any new material or method of construction not provided for in this standard & any material or method of questioned suitability proposed for use in the manufacture of the structure shall nevertheless conform in performance to the requirements of this standard.	X					
	(2) Unless based on accepted engineering design for the use indicated, all new mobile home materials, equipment, systems or methods of construction not provided for in this standard shall be subjected to the tests specified in para. (g) of this section.	X					
	(f) Allowable design stress. The design stresses of all materials shall conform to accepted engineering practice. The use of materials not identified as to strength or stress grade shall be limited to the minimum allowable stresses under accepted engineering practice.	X				(g) Testing of Structural Components 1) Tests shall be performed in compliance with listed and prescribed standards.	
	(g) Alternate test procedures. In the absence of listed & prescribed standards, the manufacturer shall develop or cause to be developed necessary tests to demonstrate the structural properties & the significant characteristics of the method employed. Such tests shall be witnessed by an independent licensed professional engineer or architect or by a recognized testing organization. Copies of the test results shall be kept on file by the mobile home manufacturer		X			2) Verification by testing - In the absence of listed & prescribed standards, the manufacturer shall develop or cause to be developed necessary qualification tests to demonstrate the structural properties & the significant characteristics of the method employed. Such tests shall be conducted in accordance with an approved test procedure developed prior to testing and be witnessed by an independent licensed professional engineer or architect or by a nationally recognized	Need to conduct test programs in an approved manner to insure proper methodology, instrumentation and data.

* Acceptance
† Weak
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†† Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Juatification for Change
280.303 General Requirements (Cont'd)						testing organization. Copies of the test results shall be kept on file by the mobile home manufacturer.	
280.304 Materials	(a) Dimension & board lumber shall not exceed 19% moisture content at time of installation.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.304 Materials (Cont'd)	(b) (1) Standards for some of the generally used materials & methods of construction are listed in the following table. (2) Materials & methods of construction utilized in the design & construction of mobile homes which are covered by the standards in the following table or any applicable portion thereof shall comply with these requirements. (3) Engineering analysis & testing methods contained in these references shall be utilized to judge conformance with accepted engineering practices required in 280.303 (c). (4) Materials & methods of installation conforming to these standards shall be considered acceptable when installed in conformance with the requirements of this Part. (5) Materials meeting the standards (or the applicable portion thereof) are considered acceptable unless otherwise specified herein or unless substantial doubt exists as to conformance.		X			(b) (1) Standards for some of the generally used materials & methods of construction are listed in the following table. (2) Materials & methods of construction utilized in the design & construction of mobile homes which are covered by the standards in the following table or any applicable portion thereof shall comply with these requirements. (3) Engineering analysis & testing methods contained in these references applicable to these materials shall be utilized to judge conformance with accepted engineering practices required in 280.303(c). (4) Materials & methods of assembly and/or installation conforming to these standards shall be considered acceptable when installed in conformance with requirements of this Part. (5) Materials meeting the requirements of the standards (or the applicable portions thereof) are considered acceptable unless otherwise specified herein.	Future design.

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.304 Materials (Cont'd)	TABLE Aluminum: Aluminum Construction Manual, specifications for AA-1971 aluminum structures. Steel: Specification for design, fabrication, and erection of structural steel for buildings with supplements 1,2 and 3 (junior beams meeting ASTM A36 are acceptable if designed to meet the loadings and performance requirements of this standard). Specification for the design of cold-formed steel structural AISI-1968 members with supplement 1. Specification for the design of light-gage cold-formed stainless AISI-1972 steel structural members. Standard specifications for open web steel joists, J- and H-Series AISC and SJI Criteria for structural applications of steel cables for buildings--wood and wood products: AISI-1973 Hardboard..... PS 58,59, and CO-1973 Hardwood and decorative plywood USDC PS-31-71 Structural design guide for hardwood plywood..... HPMA-SG-71 Timber, structural glued laminated-inspection..... AITC-200-1973 Timber, structural glued laminated.....USD PS 56-73 Construction and industrial plywood.....PS 1-74 Plywood residential construction guide.....APA-1975 Design specifications for plywood-lumber components.....APA-1974 Fabrication specifications of plywood-lumber components.....APA-1975 Stress grade lumber and its fastening--national design specifications for (and supplement). (N)FPA-1973 Structural design data--wood (N) FPA--1970 Span tables for joists and rafters (PS 20-70).....(N) FPA-1973	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.304 Materials (Cont'd)	Working stresses for joists and rafters. .....(N) FPA-1974 Timber construction standards..... .....AITC-100-1972 Design specifications for light metal plate connected wood trusses. TPI-74 Span tables for light metal place connected wooden trusses.....TPI-1972 Particleboard for mobile home decking.... Mat-formed wood particleboard....CS236-66 All plywood beams for mobile homes..... APA124-74 Wood flush doors (interior, exterior).... .....NWMA I.S.1-74 Wood window units...:.....ANSI A200.1-74 (NWMA I.S.2-73) Water repellent preservative treating for millwork.....NWMA I.S.-4-70 Wood patio doors.....NWMA I.S.3-70 Other: Gypsum wallboard.....ASTM C36 Fasteners: Nails, brads, staples and spikes, wire, cut and wrought.....F.S.FF-N-1 5b Pneumatic and mechanically driven building construction fasteners I-SANTA-19-73 Windows and glazing: Transparent safety glazing material used in buildings ANSIA97.1-1972 Unclassified: Building code requirements for minimum design loads in buildings and other structures ANSI A58.1-1972						

* Acceptance
† Weak
** Ambiguous
†† Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.304 Materials (Cont'd)	(c) Wood products shall be identified as complying with the appropriate standards.	X					
280.305 Structural Design Requirements	(a) Each mobile home shall be designed & constructed as a completely integrated structure capable of sustaining the design load requirements of this standard & shall be capable of transmitting these loads to stabilizing devices without exceeding the allowable loads stresses or deflections. Roof framing shall be securely fastened to wall framing, walls to floor structure, & floor structure to chassis to secure & maintain continuity between the floor & chassis, so as to resist wind overturning & sliding as imposed by design loads in this Part. Uncompressed finished flooring greater than 1/8" in thickness, shall not extend beneath load bearing walls which are fastened to the floor structure.		X			(a) Each mobile home shall be designed & constructed as a completely integrated structure capable of sustaining the design load requirements of this standard & shall be capable of transmitting these loads to stabilizing devices without exceeding the allowable loads, stresses or deflections. Roof framing shall be securely fastened to wall framing, walls to floor structure, & floor structure to chassis to secure & maintain continuity between the floor & chassis, so as to resist wind overturning & sliding as imposed by design loads in this Part. For each design analysis, the complete mobile home assembly shall be analyzed to determine member loads and stresses, joint integrity, torsional stiffness ($\overline{GJ}$) and vertical bending stiffness ($\overline{EI}$) sufficient to insure minimum degradation during design life (including the transportation phase). Calculations or test data are required with detailed plans of all structures and systems. (Note: A methodology for obtaining $\overline{GJ}$ and $\overline{EI}$ as required to withstand the transportation phase is defined and presented in Subpart E, "Testing.")	Degraded areas of mobile home agree with finite element stress plots. (Task III, Vol. III.)

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.305 Structural Design Requirements (Cont'd)	(b) Design Loads. (1) Design dead loads. Design dead loads shall be the actual dead load supported by the structural assembly under consideration.		X			(b) Design Loads. (1) Design dead loads. Design dead loads shall be the actual dead load supported by the structural assembly under consideration when the mobile home assembly is static.	Differentiate between static and dynamic
	(2) Design live loads. The design live loads & wind & snow loads shall be as specified in this Section & shall be considered to be uniformly distributed. The roof live load or snow load shall not be considered as acting simultaneously with the wind load & the roof live or snow load & floor live loads shall not be considered as resisting the overturning moment due to wind.		X			(2) Design live loads. The wind & snow loads shall be as specified in this Section and shall be considered to be uniformly distributed. The roof live load or snow load shall not be considered as acting simultaneously with the wind load & the roof live or snow load & floor live loads shall not be considered as resisting the overturning moment due to wind. The transportation design loads required by Subpart "J" shall be checked and compared to the loads of this part. The design of the mobile home shall be based on the larger of loads required by Subparts "D" or "J". Loads due to the transportation phase shall not be considered to act simultaneously with wind loads because transportation is restricted under high wind conditions.	Tests indicated need for design for increased dynamic loads. Task III, Vol. I, Part II; Vol. II; and Vol. III.
	(3) When engineering calculations are performed, allowable unit stresses may be increased as provided in the documents referenced in 280.304 except as shown otherwise in 280.306(a).						

* Acceptance
† Weak
** Ambiguous
†† Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.305 Structural Design Requirements (Cont'd)	(c) Wind, Snow & Roof Loads. (1) Standard Wind (Zone I). When a mobile home is not designed as "Hurricane Resistive," the mobile home & each wind resisting part & portion thereof shall be designed for horizontal wind loads not less than 15 psf & a net uplift load of not less than 9 psf.		X			(c) Wind, Snow & Roof Loads. (1) Standard Wind (Zone I). When a mobile home is not designed as "Hurricane Resistive," the mobile home & each wind resisting part & portion thereof shall be designed for horizontal wind loads not less than 15 psf & a net uplift load of not less than 9 psf. The transportation loads required by Subpart "J" shall govern if they exceed wind load requirements.	Task III.
	(2) Hurricane Resistive (Zone II). (i) When a mobile home is designated as "Hurricane Resistive," the home & each wind resisting part & portion thereof shall be designed for horizontal wind loads not less than 25 psf & a net uplift not less than 15 psf. (ii) For exposures in coastal & other areas where wind records indicate significant differences, 125 mph or greater from the wind loads stated above, the Department may establish more stringent requirements for homes known to be destined for such areas.		X			(2) Hurricane Resistive (Zone II). (i) When a mobile home is designated as "Hurricane Resistive," the home & each wind resisting part & portion thereof shall be designed for horizontal wind loads not less than 25 psf & a net uplift not less than 15 psf. (ii) For exposures in coastal & other areas where wind records indicate greater wind loads than those stated above, the Department may establish more stringent requirements for homes known to be destined for such areas. The transportation loads required by Subpart "J" shall govern if they exceed wind load design requirements.	Tests indicated need for increased dynamic loads, which may be greater than design static and live loads. (Task III)

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.305 Structural Design Requirements (Cont'd)	(3) Roof Loads. (i) Flat, curved & pitched roofs shall be designed to resist the following live loads, applied downward on the horizontal projection as appropriate for the design zone marked on the mobile home: Pounds per square foot North Zone.....40 Middle Zone.....30 South Zone.....20		X				
	(ii) For exposures in areas (mountainous or other) where snow or wind records or experience indicate significant differences from the loads stated above, the Department may establish more stringent requirements for homes known to be destined for such areas. For snow lands, such requirements are to be based on a roof snow load of 0.6 of the ground snow load for areas exposed to wind and a roof snow load of 0.8 of the ground snow load for sheltered areas. (iii) Eaves & cornices shall be designed for a net uplift pressure of 2.5 times the design uplift wind pressure cited in 280.305(c)(1) & (2).					(ii) For exposures in areas (mountainous or other) where snow or wind records or experience indicate significant differences from the loads stated above, the Department may establish more stringent requirements for homes known to be destined for such areas. For snow loads, such requirements are to be based on a roof snow load of 0.6 of the ground snow load for areas exposed to wind and a roof snow load of 0.8 of the ground snow load for sheltered areas. (iii) Eaves & cornices shall be designed for a net uplift pressure of 2.5 times the design uplift wind pressure cited in 280.305(c)(1) & (2). The design loads for the transportation phase in Subpart "J" shall govern if they exceed roof load design requirements.	Tests indicated need for increased dynamic loads which may now be greater than design static and live loads. Task III.

* Acceptance
† Weak
** Ambiguous
†† Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.305 Structural Design Requirements (Cont'd)	(4) The Data Plate posted in the mobile home (See 280.5) shall show for which structural zone(s) of the USA the mobile home has been designed & the actual design external snow &/or windlive loads. The data plate shall include reproduction of the Load Zone Maps shown in the Section & related information. The Load Zone Maps shall be not less than 1/2 the size illustrated.		Added			(4) Site Installation Loads. The manufacturers instructions shall include provisions for temporary supports during installation. Consideration should be given to unsymmetrical reactions supporting the design load. As a precautionary measure, stresses caused during site installation shall be determined and compared to stresses caused by transportation. Design loads shall be the dead load of the mobile home plus a 3 lb/ft^2 floor dead load (representing furniture and miscellaneous items). Distribution of design loads to mobile home structure shall be based on the same assumptions made to satisfy the transportation requirements of Subpart J. The temporary support provisions shall not induce stresses that exceed those levels determined from analysis of transportation loads.	Degradation measured due to site installation (Task III.)
		X				(5) The Data Plate posted in the mobile home (See 280.5) shall show for which structural zone(s) of the USA the mobile home has been designed & the actual design external snow &/or windlive loads. The data plate shall include reproduction of the Load Zone Maps shown in the Section & related information. The Load Zone Maps shall be not less than 1/2 the size illustrated.	

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.305 Structural Design Requirements (Cont'd)	(d) Design Load Deflection. When a structural assembly is subjected to a total design live load, the deflection for structural framing members shall not exceed the following: Floor.....L/240 Roof and ceiling.....L/180 Headers, beams, and girders (vertical load).....L/180 Walls and partitions.....L/180 Where L equals the clear span between supports or two times the length of a cantilever.		Added			(1) Torsional stiffness ($\overline{GJ}$) and vertical bending stiffness (EI) shall be a consideration of the overall design criteria for the integrated mobile home assembly to insure rigidity that will withstand the transportation phase. (See Subpart J).	Tasks I and III.

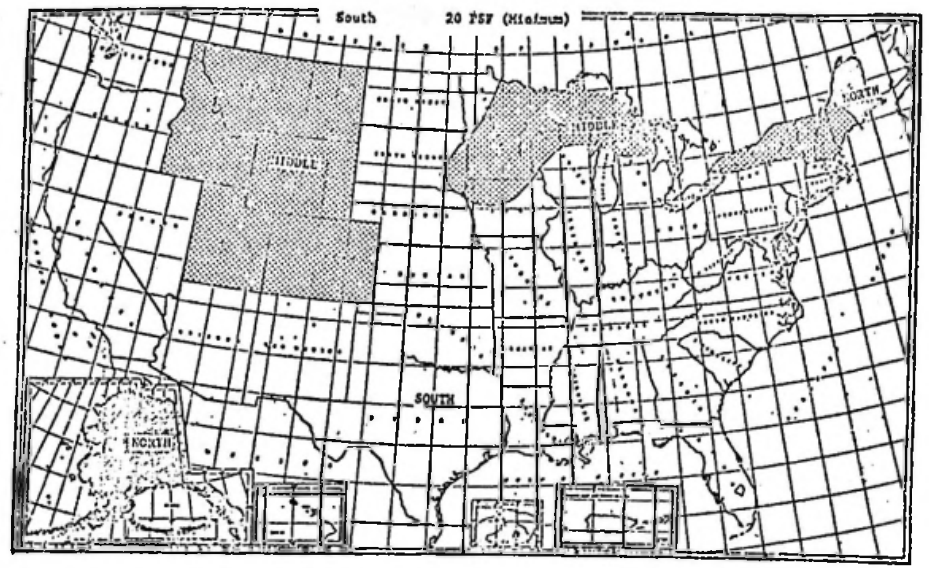
* Acceptance
† Weak
** Ambiguous
†† Excessive

ROOF LOAD ZONE MAP

North 40 PSF (Snow)

Middle 30 PSF (Snow)

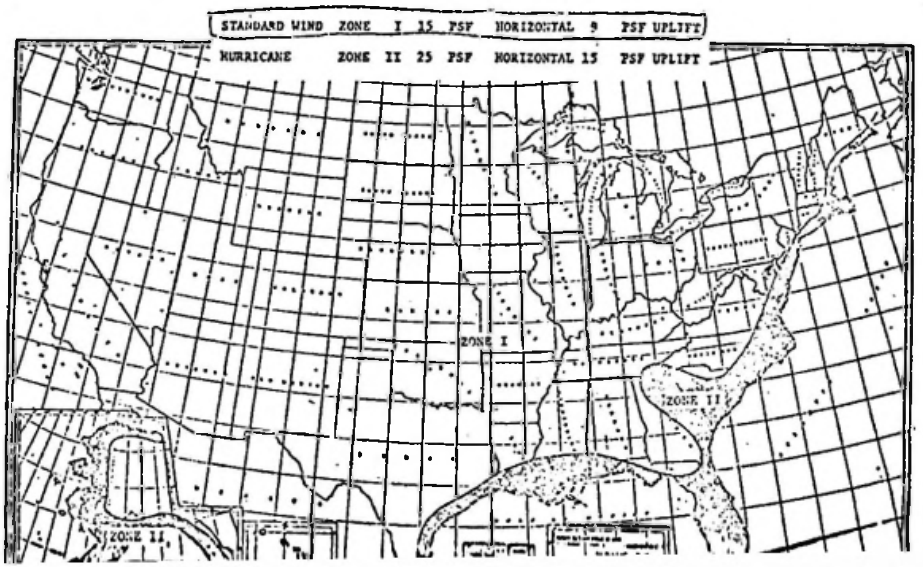
South 20 PSF (Minimum)



WIND ZONE MAP

STANDARD WIND ZONE I 15 PSF HORIZONTAL 9 PSF UPLIFT

HURRICANE ZONE II 25 PSF HORIZONTAL 15 PSF UPLIFT



1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.305 Structural Design Requirements (Cont'd)	(e) Fastening of Structural Systems. Roof framing shall be securely fastened to wall framing, walls to floor structure & floor structure to chassis to secure & maintain continuity between the floor & chassis, so as to resist wind overturning & sliding as imposed by design loads in this Part.		X			(e) Fastening of Structural Systems. Roof framing shall be securely fastened to wall framing, walls to floor structure & floor structure to chassis to secure & maintain continuity between the floor & chassis in order to resist vertical bending and torsion due to shock and vibration, wind overturning & sliding as imposed by design loads in this Part and Subpart J. Since the roof to wall joint is considered as structural, soft finished ceiling material shall not be inserted between the wall top plate and the roof trusses. No floor covering material of any type shall extend beneath load bearing walls that are fastened to the floor structure.	Task III. Results of Tow Tests and degradation fround in joints due to crushing of softer material viz 10-Hz frequency.
	(f) Walls. The walls shall be of sufficient strength to withstand the load requirements as defined in 280.305(c) of this part, without exceeding the deflections as specified in 280.305(d). The connections between the bearing walls, floor & roof framework members shall be fabricated in such a manner as to provide support for the material used to enclose the mobile home & to provide for transfer of all lateral & vertical loads to the floor & chassis.		X			(f) Walls. The walls shall be of sufficient strength to withstand the load and stiffness requirements defined in 280.305(c) of this part without exceeding the deflections as specified in 280.305(d). The connections between bearing walls, floor & roof framework members shall be fabricated in such a manner as to provide for transfer of all structural longitudinal, lateral, & vertical loads to the floor & chassis.	Tasks I and III.

* Acceptance
† Weak
** Ambiguous
†† Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.305 Structural Design Requirements (Cont'd)	(1) Except where substantiated by engineering analysis or tests, studs shall not be notched or drilled in the middle one-third of their length.	X					
	(2) Interior walls & partitions shall be constructed with structural capacity adequate for the intended purpose & shall be capable of resisting a horizontal load of not less than 5 lb. per sq ft. Finish of walls & partitions shall be securely fastened to wall framing.		X			(2) Interior walls & partitions shall be constructed with structural capacity adequate for the intended purpose & shall be capable of resisting a horizontal load of not less than 5 lb. per sq ft. Finish of walls & partitions shall be securely fastened to wall framing.	
			Added			(3) Shear walls shall be designed & attached to withstand the design loads generated by the transportation phase [Subpart "J," 280.904(b)(3)] and wind loads noted in this part. The requirements of the greater loads shall be used.	To resist torsion loads. (Tasks I and III.)
	(g) Floors. (1) Floor assemblies shall be designed in accordance with accepted engineering practice standards to support a minimum uniform live load of 40 lb/ft^2 plus the dead load of the materials. In addition (but not simultaneously), floors shall be able to support a 200-lb concentrated load on a one-inch diameter disc at the most critical location with a maximum deflection not to exceed one-eighth inch relative to floor framing: Perimeter wood joists of more than six inches in depth shall be stabilized against overturning from superimposed loads as follows: at ends by solid		X			(g) Floors. (1) Floor assemblies shall be designed in accordance with accepted engineering practice standards to support a minimum uniform live load of 40 lb/ft^2 plus the dead load of the materials. In addition (but not simultaneously), floors shall be able to support a 200-lb concentrated load on a one-inch diameter disc at the most critical location with a maximum deflection not to exceed 1/8 inch relative to floor framing.	

* Acceptance
† Weak
** Ambiguous

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.305 Structural Design Requirements (Cont'd)	blocking not less than two-inch thickness by full depth of joist, or by connecting to a continuous header not less than two-inch thickness & not less than the depth of the joist with connecting devices; at eight feet maximum intermediate spacing by solid blocking or by wood cross-bridging of not less than one inch by three inches, metal-cross-bridging of equal strength, or by other approved methods.	X				Perimeter wood joists of more than 6 inches in depth shall be stabilized against overturning from superimposed loads as follows: at ends by solid blocking not less than 2-inch thickness by full depth of joist, or by connecting a continuous header not less than 2-inch thickness & not less than the depth of the joist with connecting devices; at 8 feet maximum intermediate spacing by solid blocking or by wood-cross-bridging of not less than 1 x 3 inches, metal-cross-bridging of equal strength, or by other approved or acceptable methods.	
	(2) Wood, wood fibre or plywood floors or subfloors in kitchens, bathrooms (including toilet compartments), laundry rooms, water heater compartments,& any other areas subject to excessive moisture shall be moisture resistant by sealing or by an overlay of nonabsorbent material applied with water-resistant adhesive. Carpets &/or carpet pads shall not be installed in concealed spaces subject to excessive moisture such as plumbing fixture spaces.	X				(2) Wood, wood fibre or plywood floors or subfloors in kitchens, bathrooms (including toilet compartments), laundry rooms, water heater compartments, & any other areas subject to excessive moisture shall be moisture resistant or shall be made moisture resistant by sealing or by an overlay of nonabsorbent material applied with water-resistant adhesive. Carpets &/or carpet pads shall not be installed in concealed spaces subject to excessive moisture such as plumbing fixture spaces.	

* Acceptance
† Weak
** Ambiguous
†† Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.305 Structural Design Requirements (Cont'd)	(3) Except where substantiated by engineering analysis or tests: (i) Notches on the ends of joists shall not exceed 1/4 the joist depth. (ii) Holes bored in joists shall not be within 2 inches of the top or bottom of the joist, & the diameter of any such hole shall not exceed 1/3 the depth of the joist. (iii) Notches in the top or bottom of the joists shall not exceed 1/6 the depth & shall not be located in the middle third of the span.	X					
	(4) Bottom board material (with or without patches) shall meet or exceed the level of 48-inch-pounds of puncture resistance as tested by the Beach Puncture Test in accordance with ASTM D-781-68. The material shall be suitable for patches & the patch life shall be equivalent to the material life. Patch installation instruction shall be included in the mobile home manufacturer's instructions.	X	X			(4) Bottom board material (with or without patches) shall meet or exceed the level of 48-inch-pounds of puncture resistance as tested by the Beach Puncture Test in accordance with ASTM D-781-68. The material shall be suitable for patches & the patch life shall be equivalent to the material life. Patch installation instruction shall be included in the mobile home manufacturer's instructions. Bottom board material shall provide a seal against intrusion of insects and rodents. Attachments and fasteners shall be spaced to provide no more than 0.75 inches sag.	Bottom boards have been a source of problem on SwRI/ HUD fleet. (Task III.)

* Acceptance
† Weak
** Ambiguous

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.305 Structural Design Requirements (Cont'd)	(h) Roofs. (1) Roofs shall be of sufficient strength to withstand the load requirements as defined in 280.305 (b) & (c) without exceeding the deflections specified in 280.305(d). The connections between roof framework members & bearing walls shall be fabricated in such a manner to provide for the transfer of design vertical & horizontal loads to the bearing walls & to resist uplift forces.		X			(h) Roofs. (1) Roofs shall be of sufficient strength to withstand the load requirements as defined in 280.305(b) & (c) without exceeding the deflections specified in 280.305(d). The connections between roof framework members & bearing walls shall be fabricated in such a manner to provide for the transfer of design vertical, horizontal and torsional loads to the bearing walls & to resist uplift forces and torsional loads generated during transportation, and anticipated loading during setup/takedown and on-site operations. (Refer to paragraphs 280.305(a); (b)2; (c)1; (c)2; (c)2ii; (d)1 & 2.	Added torsional loads defined by Tasks I and III.
	(2) Roofing membranes shall be of sufficient rigidity to prevent deflection which would permit ponding of water or separation of seams due to wind, snow, ice, erection or transportation forces.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.305 Structural Design Requirements (Cont'd)	(3) Cutting of roof framework members for passage of electrical, plumbing or mechanical systems shall not be allowed except where substantiated by engineering analysis.	X				(3) Cutting of roof framework members for passage of electrical, plumbing or mechanical systems shall not be allowed except where substantiated by engineering analysis or tests.	
	(4) All roof penetrations for electrical, plumbing or mechanical systems shall be properly flashed & sealed. In addition, where a metal roof membrane is penetrated, a wood backer shall be installed. The backer plate shall be not less than 5/16 inch plywood, with exterior glues, secured to the roof framing system beneath the metal roof, & shall be of a size to assure that all screws securing the flashing are held by the backer plate.		X		Added	(4) All roof penetrations for electrical, plumbing or mechanical systems shall be properly flashed and sealed. In addition, where a metal roof membrane is penetrated, a wood backer plate shall be installed. The backer plate shall be not less than 5/16 inch plywood, with exterior glues, secured to the roof framing system beneath the metal roof, & shall be of a size to assure that all screws securing the flashing are held by the backer plate. Or, alternate designs of the backer plate shall be of sufficient strength to withstand all design loads generated by torsional and vertical bending loads derived from the transportation, setup/takedown and on-site phases.	Joints and splices have been proven to be the source of degradation in mobile homes. Tasks I, III, V.
					Added	(5) Joints and splices shall be designed to resist the dynamic and static loads imposed by the transportation and on-site phases. The more rigid the joints are, the greater the vertical bending stiffness (EI) and the torsional stiffness (GJ) which minimizes the tendency for the joints to loosen during transportation. Refer to Subpart "J" Transportation" for recommended EI and GJ design criteria. Splices for structural members throughout the mobile home shall be staggered in accordance with acceptable engineering design practices in order to minimize the potential of several critical splices occurring in one cross-section. Splices shall be designed to develop the full	

* Acceptance
† Weak

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.306 Windstorm protection	(a) Provisions for support & Anchoring Systems. Each mobile home shall have provisions for support & anchoring systems, which, when properly designed & installed, will resist overturning & lateral movement (sliding) of the mobile home as imposed by the respective design loads. The design wind loads to be utilized for calculating resistance to overturning & lateral movement shall be the wind loads indicated in 280.305(c)(1) & (2) increased by a factor of safety of 1.5. The basic allowable stresses of materials required to resist overturning & lateral movement shall not be increased in the design & proportioning of these members.	X					
	(1) The provisions of this section shall be followed & the support & anchoring systems shall be designed by a Registered Professional Engineer or Architect.	X					

*Acceptance
†Weak
**Ambiguous
††Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.306 Windstorm protection (Cont'd)	(2) The manufacturer of each mobile home is required to make provision for the support & anchoring systems but is not required to provide the anchoring equipment or stabilizing devices. When the manufacturer's installation instructions provide for the main structure to be used as the points for connection of diagonal ties, no specific connecting devices need be provided on the main frame structure.	X					
	(b) The manufacturer shall provide printed instructions with each mobile home specifying the location & required capacity of stabilizing devices on which the design is based. The manufacturer shall provide drawings & specifications certified by a registered professional engineer indicating at least one acceptable system of anchorage including the details of required straps or cables, their end connections & all other devices needed to transfer the wind loads from the mobile home to the ground anchors.	X					

*Acceptance
†Weak
**Ambiguous
††Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.306 Windstorm protection (Cont'd)	(c) The provisions made for anchoring systems shall be based on the following design criteria for mobile homes.	X					
	(1) The minimum number of ties required per side shall be as required to resist the design loads stated in 280.305 (c)(1) & (2).	X					
	(2) Ties shall be as evenly spaced as practicable along the length of the mobile home with not more than 8 feet open-end spacing on each end.	X					
	(3) When continuous straps are provided as vertical ties, such ties shall be positioned at rafters & studs. Where a vertical tie & diagonal tie are located at the same place both ties may be connected to a single ground anchor capable of carrying both loadings.	X					
	(4) Add-on sections of expandable mobile homes shall have provisions for vertical ties at the exposed ends.	X					
		*Acceptance †Weak **Ambiguous ††Excessive					

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.306 Windstorm protection (Cont'd)	(d) Double-wide mobile homes require only diagonal ties. These shall be placed along the main frame & below the outer side walls.	X					
	(e) Protection shall be provided at sharp corners where the anchoring system requires the use of external cables or straps. Protection shall also be provided to minimize damage to roofing or sliding by the cable or strap.	X					
	(f) Anchoring equipment shall be capable of resisting an allowable working load equal to or exceeding 3,150 lbs & shall be capable of withstanding a 50% overload (4,725 lbs total) without failure of either the anchoring equipment or the attachment point on the mobile home.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.306 Windstorm protection (Cont'd)	(g) Anchoring equipment exposed to weathering shall have a resistance to weather deterioration at least equivalent to that provided by a coating of zinc on steel of not less than 0.30 ounces per sq foot of surface coated.	X					
	(1) Slit or cut edges of zinc-coated steel strapping do not need to be zinc coated.	X					
	Type 1, Finish B, Grade 1 steel strapping, 1¼ inches wide & 0.035 inch thick, conforming with Federal Specification QQ-S-781-H, is judged to conform with the provisions of this section & para. (f) above.	X					

*Acceptance
†Weak
**Ambiguous
††Excessive

SUBPART D

BODY & FRAME CONSTRUCTION REQUIREMENTS

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.307 Resistance to elements & use.	(a) Exterior coverings shall be moisture & weather resistive materials attached with corrosion resistant fasteners to resist wind, snow & rain. Metal coverings & exposed metal structural members shall be of corrosion resistant materials or shall be protected to resist corrosion. All joints between portions of the exterior covering shall be designed, & assembled to protect against the infiltration of air & water, except for any designed ventilation of wall or roof cavity.	X					
	(b) Joints between dissimilar materials & joints between exterior coverings & frames of openings shall be protected with a compatible sealant suitable to resist infiltration of air or water.	X					
	(c) Where adjoining materials or assemblies of materials are of such nature that separation can occur due to expansion, contraction, wind loads or other loads induced by erection or transportation, sealants shall be of a type that maintains protection against infiltration or penetration by air, moisture or vermin.						
	(d) Exterior surfaces shall be sealed to resist the entrance of rodents.					(d) Exterior surfaces, including roof, walls, and underside of the mobile home shall be sealed to resist the entrance of rodents.	

* Acceptance
† Weak
** Ambiguous
†† Excessive

PART II

RATIONALE FOR DESIGN RECOMMENDATIONS

The recommended changes noted in Subpart "J" (Volume I of this Task) are those resulting from the various tests and analysis conducted on the different models of mobile homes selected for the program. Since Subpart "D" covers the Body and Frame Construction Requirements and the program has developed forces/loads input by the transportation mode (Subpart "J"), the cross correlation of these two Subparts needs to be conducted.

Due to the loads/forces/accelerations recommended in Subpart "J", it is possible that, in many cases, the transportation loads will be greater than the static dead and live loads required by Subpart "D". Therefore, the designer will necessarily have to determine which loads are greater and use them accordingly. For these reasons several paragraphs have been cross referenced to Subpart "J" to cover this subject.

The critical design criteria that have been added to Subpart "J" are also noted in Subpart "D" and these are:

- Torsional stiffness
- Vertical stiffness
- Vibration

Since the application is primarily a result of the transportation mode, the basic requirement was inserted in Subpart "J" and cross referenced to Subpart "D".

Definitions for these items and joint integrity (as a function of stiffness) have been added to the list of definitions of Subpart "D".

Tests to be conducted on mobile homes, components or materials need to be properly programmed by submission of a test plan for approval prior to conducting the tests. This is for two reasons:

1. The agencies involved need to approve the methodology, equipment, fixtures and data retrieval or instrumentation while scheduling their manpower (if they need be present).
2. The agencies may be able to save the cost of the test by furnishing reference material already available or suggest alternate methods to assist the manufacturer or testing facility.

The Dynamic Model/Analysis as well as the Finite Element Model/Analysis both require considerable detail for development, application and use. This amount of data would be entirely too voluminous for the Standard and for this reason it is suggested that it be contained or referenced in an Interpretive Bulletin for access by those who desire to use it or apply it to any specific design.

The comments noted in the Discussion Section of Subpart "J" should be read along with those contained in this volume since the basic reasons for revision to Subpart "D" are the changes in Subpart "J".

The wind and snow loads are not to be considered as acting simultaneously with the transportation forces because the dynamics associated with the towing of a mobile home would preclude the snow load from piling on the roof. Also, wind limits are set by most states for the transporting of mobile homes.

Setup and takedown loads/forces have not been included heretofore and have been measured as being a significant factor in the degradation cycle. A good setup crew will introduce minimum deflections in a mobile home by raising it very evenly with minimum out-of-level conditions. However, the result of witnessing numerous setups and takedowns proved that:

- The majority of crews assume that the mobile home box structure can easily support itself, or
- They (the crew) have no knowledge of mobile home structure, or
- They (the crew) are in a hurry to complete the job and permit

maximum loads and deflections to be generated during the setup/ takedown mode, or

- Insufficient equipment and personnel are on hand to properly do the job.

The testing of the mobile home in order to develop the deflection measurements for calculating $\overline{EI}$, $\overline{GJ}$, and $\overline{J}$ is also a detailed procedure. However, it is inserted in Subpart E, testing for use in both testing and developing the $\overline{EI}$, $\overline{GJ}$, and $\overline{J}$ for design purposes. Continuing experience should provide an increasing confidence factor for use of the deflection measurements as indicators of degradation. Application of the $\overline{EI}/\overline{GJ}/\overline{J}$ factors to the design criteria of mobile homes could probably be best contained in an Interpretive Bulletin where details and examples could be presented.

One of the direct factors resulting from the SwRI test program is the loosening of joints that result in increased deflections, both torsionally and vertically. In order to generate the maximum in stiffness, the critical joints must have rigidity and integrity. These factors cannot be achieved if the joint has the capability of loosening up under dynamic, vibratory and cyclic load conditions. Anytime a soft material is inserted in a multiple interface joint, and the joint is subjected to vibratory and cyclic loads in all three axes the soft material will be compressed, chaffed or destroyed if the loading is applied long enough. The sidewall upper joint to roof and the lower joint to floor are considered as critical joints since the sidewalls are the primary resistance to vertical bending and assist the shear walls in torsion type bending. When the soft material inserted in these joints gradually deteriorates, the joints loosen-up and the deflections increase which results in increased stresses or loads. Both Celotex and gypsum board in the upper sidewall to roof joints and the 1/8" asphalt or vinyl in the lower sidewall to floor joint are considered as soft materials that result in an "unstable joint" and have caused looseness

due to deterioration during cyclic loading and the 5-10-Hz vibration frequency.

Shear walls and stiff joints are the greatest resistance to the torsional mode. Therefore, the attachments of the shear walls to the sidewalls, floor and roof are considered as critical.

The following specific paragraphs need to be clarified:

280.305 - Structural Design Requirements.

The loss of rigidity in the wall structure can be caused by the soft joint between the base plate and the floor. This joint normally contains the vinyl floor covering. The accelerations and cyclic loading on the soft vinyl causes compression of the material, thereby loosening the attachments. This increased the flexibility of the joint to move or the wall to rotate. For example, an 8-ft 2 x 3 stud in a wide wall compresses the 1/8-in. vinyl only 0.015 in., permitting the top of the stud to move laterally 0.32 in. This 0.32 in. is considered a significant degree of movement and will cause increasingly larger deflections due to the associated dynamics. The wall to floor deflections were measured and increased with miles on the highway during the test program (see Task III, Vol. I, Part II).

Also, inspection of the test mobile home and the crushed vinyl flooring under the plates, verifies the deflections. The same process is taking place at the upper plate if soft celotex is placed between the roof truss and the plate.

280.305(c)(1) & (2) - Standard Wind (Zone I) & Hurricane Resistive (Zone II).

The new design criteria recommended in Subparts D and J, resulting from the transportation study, do not affect the wind loads specified in Subpart D. It will be necessary for the designer to evaluate the requirements in each Subpart of the Standard in order to determine which criteria is more

critical by introducing the greater loads. Generally, the wind loading will be more critical. However, it must be remembered that the wind loads are introduced into the mobile home when it is fully supported on the piers and with adequate tie-downs to resist the loads. The transportation loads plus the 5-10-Hz vibration factors are introduced into the mobile home while traveling on the running gear with the maximum in dynamic action in evidence. Therefore, for the first few designs, both criteria need to be checked to determine which will control. The Zone II wind loads are high, but the mobile home is well supported and restrained for load distribution. Unless the mobile home components have a high weight factor in the walls or roof construction, the critical criteria may indicate that the only area to check against Subpart J are the roof loads when designing for Zone I winds.

280.305(c)(3) - Roof Loads.

As stated in 280.305(c)(1) & (2), the designer will have to make several checks to determine which is more critical, the Zone I or II wind/uplift loads of Subpart D or the transportation requirements of Subpart J. Once several iterations of this process are completed, a precedent will be established for the designer who will be able to effectively plot the relationship, and thereby, eliminate the costly process of checking both areas. It appears that the Zone II wind loads may be more critical than the transportation forces. However, a detailed check will be required to verify this factor for each size of mobile home.

280.305(c)(4) - Setup/Takedown Design Loads.

Setup and takedown are critical static conditions to which a mobile home unit may be subjected. Manufacturers provide procedures for each of these maneuvers for the purpose of minimizing induced loads. However, it cannot be assumed that these procedures will be followed exactly. Hence,

designers must allow for asymmetrical loading conditions, for instance, supporting with minimum jack assistance. The loads are determined by knowing the mobile home weight distribution. It is believed that the Torsion Test described in Task III, Volume I, Part I results in typical forces and deflections for this condition. In order to examine the effect of this possible load condition on localized structure, the finite element model was analyzed for one typical asymmetrical loading condition. This condition assumes that the mobile home is partially lifted from a level position by applying a vertical up-load at a point near the rear end of the right longitudinal I beam. The adjacent structure effected by this loading condition is shown by the stress distribution figures for Load Case 4 in Task I, Volume III. The same structure is effected by removing support from under the same point on the longitudinal I beam; tension members are then loaded in compression and vice versa.

The test data in support of the recommendations are presented in Task III. Typical forces and deflections for these conditions are tabulated and are those in excess of the forces required to support that corner of the mobile home under level conditions. In Task III, the first and last tests are presented indicating the increase in deflections. See Volume 3 for total data collected from inspection.

280.305(e) - Fastening of Structural Systems

The history of the integrity of the mobile home structural system indicates that in very few cases have the basic structural members failed, such as studs, floor joints, or roof trusses. In the majority of cases, the joints or fasteners loosen to a significant degree causing greater flexibility and resulting deflections. The use of adhesives has contributed to an integral structural system, but the large pre-assembled components such as side walls, shear walls, and roofs must still be joined together. These joints then

become the critical areas subject to torsion and bending. These same joints are further degraded by the insertion of soft celotex ceiling material in the upper plate to roof joint and soft vinyl floor material in the lower plate to floor joint. These joints start out "soft" with the fasteners in bending and tension, rather than shear. These are also the two joints that are critical in the torsion mode as is evidenced by the wall deflection data and verified by the visual inspection of degraded areas. The loosening of the metal straps from stud to floor and roof truss to stud are excellent indicators of this phenomena. Direct reference to data in this area are the torsion and vertical bending deflection tests/data plus the wall deflection data and the visual inspections for correlation of actual degradation versus predicted degradation (Task III).

280.305(g) - Floors

Moisture of a significant degree deteriorates particle board very quickly. Results of tests performed to date indicate:

- 300 hours in 100-percent relative humidity deteriorates 5/8-in. particle board flooring to the point that it can be flaked away by hand and it falls far below the test requirement of a 200-lb load on a 1-in. diameter disc.

- The leaking faucet test (one drip every 10 seconds for two weeks) in a new mobile home resulted in buckling the bathroom floor 3.6-in. upward. When the board dries out, it does not regain its original position or strength. The areas of the mobile home floor requiring frequent replacement are:

  Bathroom - all areas,
  Kitchen - under sink,
  Service room - under clothes washer,
  Hot water heater closet.

SUBPART E "TESTING"

RECOMMENDED REVISIONS TO SUBPART E "TESTING"

by

C. R. Ursell, II
C. E. Kimball

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language *	*	†	**	††	Recommended Language	Justification for Change
280.401 Structural load tests.	Every structural assembly shall be capable of meeting the Proof Load Test or the Ultimate Load Test as follows:						
	(a) Proof load tests. Every structural assembly tested shall be capable of sustaining its dead load plus superimposed live loads equal to 1.75 times the required live loads for a period of 12 hours without failure. Tests shall be conducted with loads applied and deflections recorded in 1/4 design live load increments at 10-minute intervals until 1.25 times dead load has been reached. Additional load shall then be applied continuously until 1.75 times design live load plus dead load has been reached. Assembly failure shall be considered as design live load deflection (or residual deflection measured 12 hours after live load removal) which is greater than the limits set in 280.305 (d), rupture, fracture, or excessive yielding. An assembly to be tested shall be of the minimum quality of materials and workmanship of the production. Each test assembly, component or subassembly shall be identified as to type & quality or grade of material. All assemblies, components or subassemblies qualifying under this section shall be subject to a continuing qualification testing program acceptable to the Department.	X					
	(b) Ultimate load tests. Ultimate load tests shall be performed on a minimum of three assemblies to generally evaluate the structural design. Every structural assembly tested shall be capable of sustaining	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

* "Mobile Home Construction and Safety Standards," Federal Register, Dec. 18, 1975.

SUBPART E - TESTING

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.401 Structural load tests (cont'd)	its total dead load plus live loads increased by a factor of safety consistent with the material being tested. Factors of safety shall be based on nationally recognized standards and approved by the Department. Tests shall be conducted with loads applied and deflections recorded in 1/4 design live load increments at 10-minute intervals until 1.25 times design live load plus dead load have been reached. Additional loading shall then be applied continuously until failure occurs or 1.50 times the factor of safety times the design live load plus the dead load is reached. Assembly failure shall be considered as design live load deflection greater than the limits set in 280.305(d) rupture, fracture, or excessive yielding. Assemblies to be tested shall be representative of average quality or materials and workmanship of the production. Each test assembly, component, or subassembly shall be identified as to type and quality or grade of material. All assemblies, components, or subassemblies qualifying under this section shall be subject to a periodic qualification testing program acceptable to the Department.	X					
280.402 Test procedure for roof trusses.	(a) Roof load tests. The following is an acceptable test procedure, consistent with the provisions of 280.401, for roof trusses that are supported at the ends and support design loads. Where roof trusses act as support for other members, as cantilevers or as support for concentrated loads, they shall be tested accordingly.	X					

* Acceptance
† Weak
** Ambiguous

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.402 Test procedures for roof trusses (cont'd)	(b) General. Trusses may be tested in pairs or singly, & simulated lateral support of the test assembly may be provided, but in no case shall this lateral support exceed that which is specified for the completed mobile home. When tested in pairs, the trusses shall be spaced at the design spacing and shall be mounted on solid support accurately positioned to give the required clear span distance (L) as specified in the design. The top and bottom chords shall be braced and covered with the material, with connections or method of attachment, as specified by the completed mobile home.	X					
	(1) As an alternate test procedure, the top chord may be sheathed with 1/4 inch by 12 inch plywood strips. The plywood strips shall be at least long enough to cover the top chords of the trusses at the designated design truss spacing. Adjacent plywood strips must be separated by at least 1/8 inch. The plywood strip shall be nailed with 4d nails or equivalent staples not closer than 8 inches on center along the top chord of one truss only. The bottom chords of the adjacent trusses may be either (i) Unbraces, (ii) laterally braced together (not cross braced) with 1" x 2" stripping not closer than 24 inches on center nailed with only one 6d nail at each truss, or (iii) covered with the material, with connections or methods of attachment, as specified for the completed mobile home.	X					
	(2) Truss deflections will be measured relative to a taut wire running over the support & weighted at the end to insure constant tension or other approved methods.		X				

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.402 Test procedure for roof trusses (cont'd)	Deflections will be measured at the two quarter points & at mid-span. Loading shall be applied to the top chord through a suitable hydraulic, pneumatic, or mechanical system using masonry units or weights to simulate design loads. Load units for uniformity distributed loads shall be separated so that arch action does not occur, and shall be spaced not greater than 12 in. on center so as to simulate uniform loading.						
	(c) Nondestructive test procedure. (1) Dead load plus live load. (i) Noting fig. A, measure and record initial elevation of the truss in test position at no load. (ii) Apply load units to the top chord of the truss equal to the full dead load of roof and ceiling. Measure and record deflections (iii) Maintaining the dead load, add live load in approximate 1/4 design live load increments. Measure the deflections after each loading increment. Apply incremental loads at a uniform rate such that approximately one-half hour is required to establish the total design load condition. Measure & record the deflections five minutes after loads have been applied. The maximum deflection due to design live load (deflection measured in step (iii) minus step (ii) shall not exceed L/180, where L is a clear span measured in the same units. (iv) Continue to load truss to dead load plus 1.75 times the design live load. Maintain this loading for 12 hours & inspect the truss for failure. (v) Remove the total superimposed live load. Trusses not recovering to at least the L/180 position within 12 hours shall be considered as failing.	X					

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.402 Test procedure for roof trusses (cont'd)	(2) Uplift loads. This test shall only be required for truss designs which may be critical under uplift load conditions. (i) Measure & record initial elevation of the truss in an inverted test position at no load. Bottom chord of the truss shall be mounted in the horizontal position. (ii) Apply the uplift load as stated in 280.305(c) to the bottom chord of the truss. Measure & record the deflections 5 minutes after the load has been applied. (iii) Continue to load the truss to 1.75 times the design uplift load. Maintain this load for 3 hours & inspect the truss for failure. (iv) Remove applied loads & within three hours the truss must recover to at least L/180 position where L is a clear span measured in the same units.	X					
	(d) Destructive test procedure. (1) Destructive tests shall be performed on 3 trusses to generally evaluate the truss design. (2) Noting figure A-1, apply the load units to the top chord of the truss assembly equal to full dead load of roof & ceiling. Measure & record deflections. Then apply load & record deflections in 1/4 design live load increments at 10-minute intervals until 1.25 times design live load plus dead load has been reached. (3) Additional loading shall then be applied continuously until failure occurs or the factor of safety times the design live load plus the dead load is reached. (4) Assembly failure shall be considered as design live load deflection greater than the limits set in 280.305(d), rupture, fracture, or excessive yielding. (5) The assembly shall be capable of sustaining the dead load plus the applicable factor of safety times the design live load (the applicable factor of safety for wood trusses shall be taken as 2.50).	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.402 Test procedure for roof trusses (cont'd)	(e) Trusses qualifying under the nondestructive test procedure. Tests 280.402(c) (1) & (2) (when required), shall be subject to a continuing qualification testing program acceptable to the Department. Trusses qualifying under the destructive test procedures, Tests 280.402(c) (2) (when required), and (d), shall be subject to periodic tests only.	X					
280.403 Standard for windows & sliding glass doors used in mobile homes.	(a) Scope. This section sets the requirements for prime windows & sliding glass doors used in mobile homes except for windows used in entry doors. Windows so mounted are components of the door & thus are excluded from this standard.	X					
	(b) Materials & methods. Any material or method of construction, whether or not provided for in this standard, & any material or method of questioned suitability, proposed for use in manufacture, shall nevertheless conform in performance as outlined in paragraph (c) of this Section & proof of capability of structural integrity shall be presented. If applicable, units shall comply with the following:	X					
	(1) Wood & wood based products. (i) Wood. Wood parts including plywood & particleboard parts of window units shall have a moisture content of 6 to 12 percent at the time of fabrication. Wood parts, except inside stops & trim shall be manufactured utilizing wet-use adhesive requirements as defined in ASTM D-3110 & preservative treated in accordance with NWMA IS-4.	X					

* Acceptance
† Weak

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.403 Standard for windows and sliding glass doors used in mobile homes (cont'd)	(2) Aluminum. (i) Alloys. Aluminum shall be of a commercial quality and of proper alloy for window construction, free from defects imapiring strength and/or durability, as follows: Wrought aluminum alloys shall be those in which the alloying elements do not exceed the following maximum limits: Silicone ---------- 7.0% Magnesium ---------- Manganese ---------- 6.0% Chromium ---------- Iron ---------- 1.0% Copper ---------- 0.4% Zinc ---------- 1.0% Other ---------- 0.5% Aluminum ---------- Balance	X					
	These limits apply to both bare products & to the core clad products.. The cladding of clad products shall be within the same limits except that the maximum zinc limit may be 3.0% in order to assure that the cladding is anodic to the core. Where aluminum extrusions are used for the main frame & sash or ventilator sections, they shall have a minimum ultimate tensile strength of 22,000 psi & a yield of 16,000 psi.	X					
	(ii) Finish. The exposed surface of all aluminum members shall be clean & free from serious surface blemishes. If exposed welded joints are used, they shall be dressed & finished.	X					
	(3) Glass. (i) Safety glazing materials, where used, shall meet ANSI Z97.1-1972. Tempered glass, where used, shall also meet FS DD-G-1403A. (ii) Insulated glass, when used, shall meet or exceed the requirements	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.403 Standard for windows and sliding glass doors used in mobile homes (cont'd)	of Sealed Insulating Glass Manufacturers Association (SIGMA) & shall be permanently identified with the name of the insulating glass manufacturer. (iii) Glass tolerances & areas shall meet or exceed the values in the Glass Table below.	X					

Glass dimensional tolerances and maximum allowable areas—short plane

Nominal thickness (inches)	Minimum thickness (inches)	Maximum area [1] (square feet) at 15 lb./ft.²	Maximum area [2] (square feet) at 25 lb./ft.²
1/8 or	0.078	11	10
5/32	.065	15	11
3/16	.108	18	14
1/4	.115	20	15
5/16	.182	45	30
3/8	.278	58	45
1/2	.326	72	65

[1] For other types of glass see Federal Specification DD-G-451c, dated Jan. 15, 1958.
[2] Maximum areas shown are based on minimum glass thicknesses set forth. Maximum areas shown apply for rectangular lites of annealed glass firmly supported on all 4 sides in a vertical position.

	Tabulated areas may be increased as noted for use of tempered, heat strengthened or sealed insulating glass & shall be decreased as noted for use of sandblasted, wire or laminated glass. Glass louvers installed in jalousies shall be not less than 7/32" thick nor longer than 36" & exposed edges shall be seamed, ground or polished.	X					

ADJUSTMENT FACTORS
RELATIVE RESISTANCE TO WIND LOADS [1]

Glass type:	Approximate relationship
Regular plate	1.0
Laminated	0.6
Wire	0.5
Heat strengthened	2.0
Fully tempered	4.0
Factory fabricated insulating glass [2]	1.5
Rough rolled or patterned surface	1.0
Sand blasted annealed glass	0.4

[1] To determine the maximum allowable area for the glass types listed multiply the allowable area established by the appropriate adjustment factor.
[2] Use thickness of thinner of the two lights, not thickness of unit.

* Acceptance
† Weak

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.403 Standard for windows and sliding glass doors used in mobile homes (cont'd)	(4) Glazing. Any method of glazing conforming to the Performance Requirements (para. (c) of this section) and Material & Methods Requirements (para. b of this section) shall be acceptable.	X					
	(5) Hardware & Fasteners. All hardware components & fasteners when considered as individual components, whether commercially available, or proprietary, must be capable of performing to the criteria stipulated in Performance Requirements, para. (c) of this section.	X					
	(c) Performance Requirements. Test procedures as outlined in paragraphs (c) (1) thru (4) of this section are applicable to preproduction prototype units of prime windows & sliding glass doors. Production line units shall be equivalent in design & materials to the tested & passed prototype units & shall also meet the requirements of 280.403(c) (5).	X					
	(1) Size of test specimen. Production line units shall have width & height dimensions equal to or less than the corresponding dimensions of the prototype unit tested & passed. No inference of compliance to these requirements is to be made for products exceeding the size of the tested & passed prototype.	X					
	(2) Structural performance test - (i) Zone I. There shall be no glass breakage, permanent deflection or any other condition which would cause the specimen to be inoperable	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.403 Standard for windows and sliding glass doors used in mobile homes (cont'd)	after being subjected to an exterior pressure, 15 pounds per square foot. The test method applicable to this requirement shall be ASTM E-330. (ii) Zone II. There shall be no glass breakage, permanent deflection or any other condition which would cause the specimen to be inoperable after being subjected to exterior pressure of 25 pounds per square foot. The test method applicable to this requirement shall be ASTM E-330. (iii) Interior pressure. There shall be no glass breakage, permanent deflection or any other condition which would cause the specimen to be inoperable after being subjected to an interior pressure equal to 1/2 the requirements in either paragraphs (c)(2)(i) or (c)(2)(ii). The test method applicable to this requirement shall be ASTM E-330 except that no artificial means of containing pressure shall be allowed.. Should pressure not be obtainable due to lack of air, the testing agency will report the pressure achieved, the theoretical air flow supplied to the unit, and certify that no additional flow from the equipment in use was available. Laboratory equipment used for this test must be capable of developing 10 x air flow determined in 280.403(c)(3).						
	(3) Air infiltration test. Air infiltration shall not exceed 0.50 CFM per square foot of window area when tested in accordance with ASTM E-283 at an exterior pressure differential of 1.567 pounds per square foot (0.30" of water pressure).	X					
	(4) Water resistance test. No leakage shall pass the interior face of the test specimen at a test pressure of 2.86 psf (0.55" water pressure) when tested in accordance with ASTM E-547 with a test period consisting of four cycles, each cycle consisting of five minutes with pressure released, during which the water spray will be continuously applied. (i) For the purpose of compliance with paragraph (c)(4), all units which	X					

* Acceptance
† Weak

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.403 Standard for windows and sliding glass doors used in mobile homes (cont'd)	shall be tested first with screens in place & thereafter with screens removed. (ii) For the purpose of compliance with paragraph (c)(4), penetration, as referenced in ASTM #-331-70, paragraph 4.3, shall not include drops passing the interior face by energy developed in the bursting of sill drain system bubbles created by a pressure differential applied to the exterior face of the specimen.						
	(5) Production Line Units. Production line units of primewindows & sliding glass doors shall comply with: (i) The structural performance test to the zone limit certified in paragraph (c)(2) of this section &; (ii) the air infiltration test in paragraph (c)(3) of this section &; (iii) the water resistance test in paragraph (c)(4) of this section except that the test pressure shall be 1.56 psf (0.30" water column) & the water application rate shall be 2.5 GPH, per square foot of window surface area, all other parameters being the same as set forth in paragraph (c)(4) of this section.	X					
	(d) Test sequence. The sequence of tests shall be performed as they are listed above except that Structural Performance Test to Zone I (15 psf) exterior pressure may be followed by Zone I interior pressure (7.5 psf), which may be followed by the Air Infiltration Test, which may be followed by the Water Resistance Test, which may be followed by the Structural Performance Test to Zone II & (25 psf) exterior pressure, which may be followed by the Zone II & interior pressures (12.5 psf), which may be	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.403 Standard for windows and sliding glass doors used in mobile homes (cont'd)	followed by the Air Infiltration Test, which may be followed by the Water Resistance Test. The Air Infiltration Test may be performed after the Water Resistance Test providing all sealed areas are thoroughly dried.						
	(e) Screens. (1) Screen, when specified, shall be provided with fastening devices, suited particularly for application to the specific window for which they are intended, & be of sufficient strength to perform satisfactorily.	X					
	(2) Insect screening shall be of a material compatible with aluminum & shall meet CS 138-55, "Insect Wire Screening," FS RR-W-365, "Screening, Wire, Insect," CS 248-64, "Vinyl Coated Glass Fibre Insect Screening & Louver Cloth," or FS L-S-125a "Screening, Non Metallic Insect."	X					
	(f) Assembly. Windows shall be assembled in a secure & workmanlike manner to perform as hereinafter specified & to assure neat & weather tight construction. A permanent-type water-tight joint shall be made at the junction of the sill & side frame members.	X					
	(g) Shipping. Units may be shipped as a subassembly unit but not as a KD or open unit. A KD unit is a unit that is complete in its entirety with the exception of glass, glazing material, an[illegible]	X					

* Acceptance
† Weak
** [illegible]

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.403 Standard for windows and sliding glass doors used in mobile homes (cont'd)	is shipped in an assembled condition & later glazed according to the instruction of the manufacturer, utilizing all of the components supplied by the manufacturer.						
	(1) An open unit is a unit that is complete in its entirety with the exception of glass, glazing materials, or screen, which is shipped in an assembled condition & later glazed according to the instruction of the manufacturer, utilizing all of the components supplied by the manufacturer.	X					
	(2) A subassembly unit is a unit that is complete in its entirety including the glazing of glass or other glazing panels into their respective fixed or moving sash frames, which is shipped with such glazed panels separate from each other or from any master frame. (Master frame may be either disassembled or assembled.) The connection of such master frame to glazed, fixed, or moving panels is to take place later according to the instructions of the manufacturer utilizing all of the components supplied by the manufacturer.	X					
	(3) A completely assembled unit is one that is complete in its entirety & is shipped with all parts & subassemblies in complete connection with each other & no separate pieces.	X					
	(h) Permanent identification. (1) As identification, each unit shall bear a certification label containing a code number traceable to the manufacturer through the certifying agency or the name of the manufacturer or brand name together with the city and state location of the manufacturer or main office of the manufacturer.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.403 Standard for windows and sliding glass doors used in mobile homes (cont'd)	(2) The label shall be of a permanent-type designed to discourage easy removal, & shall remain legible under normal operating conditions for a period of not less than five years from date of product installation.	X					
	(3) Acceptable means of identification are, but are not limited to, the following: Embossed, stamped, cast or molded characters becoming an integral part of the material on which they are located; flexible colorfast and durable labels, decals, stickers, etc., affixed with a permanent-type adhesive; or rigid metal or plastic name plates affixed mechanically or with a permanent-type adhesive.	X					
	(4) Location of the label shall be such that it is accessible for normal direct viewing purposes from the interior side of the product, after the unit is installed, without the necessity of product disassembly. Identification located only on the glass or screen shall not be acceptable.	X					
	(i) Certification. The manufacturer shall show evidence of continued compliance by affixing a quality certification label to the product in accordance with ANSI Z34.1, "American National Standard Practice for Certification Procedures." In determining certifiability under this section, compliance shall consist of preproduction specimen testing in accordance with each and every requirement of this section followed by an inplant inspection & production unit	X					

* Acceptance
† Weak

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.403 (cont'd)	two such inspections per year by an inde-pendent quality assurance agency.						
280.404 Standard for egress windows for use in mobile homes.	(a) Scope & Purpose. The purpose of this section is to establish the design, construction, & installation of windows and approved devices intended to be used as an emergency exit during conditions encountered in a fire or similar disaster.	X					
	(b) Requirements. - (1) Installation. Window manufacturers shall provide the home manufacturer with written installation instructions.	X					
	(2) Performance. The egress window including auxiliary frame and seals, if any, shall meet the requirements of 280.403 "Standard for Window & Sliding Glass Doors Used in Mobile Homes."	X					
	(3) Dimensions. (i) All egress windows shall have a minimum clear dimension of 22 inches when determined in accordance with Test A paragraph (d)(1) of this section. (ii) All egress windows shall have a minimum clear opening of 5 sq. feet when determined in accordance with Test B, paragraph (d)(2) of this section.	X					
		* Acceptance † Weak ** Ambiguous †† Excessive					

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.404 Standard for egress window for use in mobile homes (cont'd)	4) Operational. (i) Operating instructions shall be applied to each egress window & carry the legend "Do Not Remove". In addition, the instructions should include a reminder to remove all shipping clips on screens, storm windows, & other appurtenances for exiting purposes. (ii) The number of locks & latches shall not exceed 2, not including the 4 appurtenance attachment mechanisms permitted by para. (c)(2)(i) of this section. (iii) Locks, latches, lifting & operational forces shall not exceed a force of 20 lbs. when tested in accordance with Test C, para (d)(3) of this section. (iv) Any handle or latch required to operate the emergency egress provisions of the window shall be attached in the factory by either a permanent method or a mechanical method which requires a tool not commonly available in the home, unless removal of the latch or handle will in no way limit the effectiveness of the egress provision. (v) Any window whose egress provisions are dependent on the operation of a rotary operator is acceptable. Example: Awning windows utilizing a single vent for activation is unacceptable, whereas an awning window set in a separate frame whose activation requires only a 180° twist of the lock to allow egress is acceptable even though a rotary operator is present for normal operation.	X					
	(c) Appurtenances. (1) The addition or inclusion of screens, storm windows, or other appurtenances shall not encroach upon the dimensional requirements set forth in para. (b)(3).	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.404 Standard for egress windows for use in mobile homes (cont'd)	(2) Any mechanism used to attach an appurtenance such as a screen or storm window to the window shall meet the following requirements of paragraph (c)(3): (i) The number of mechanisms shall not exceed 4 &; (ii) The operating force of the mechanisms shall not exceed 5 lbs. tested in accordance with Test D para. (d)(4) & (iii) The mechanisms shall be designed so that that cannot be misapplied utilizing normal household tools such as screwdrivers, pliers & wrenches exceeding the aforementioned forces; & (iv) The surface to which the operating force is applied shall have a minimum cross-sectional area of 0.25 square inches.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.404 Standard for egress windows for use in mobile homes (cont'd)	(3) If an appurtenance such as a screen or storm window is attached to the window in such a manner that it need not be removed or disengaged in any way in order to effect a fully opened exit, the requirements of para. (c) (2) need not be met.	X					
	(4) The operating instructions detailed in para. (b) (4) (i) shall include instructions on the required removal & replacement of any screen and/or storm sash appurtenance.	X					
	(d) Test Methods - (1) Test Method A - Minimum Dimensions. The minimum dimension of 22" required by para. (b)(3)(i) shall be tested as follows: When the window is in the final position for egress, a 22" dowel shall be passed through the opening at the point of its least dimension while contacting only one point of the window frame, at either the horizontal or vertical orientation of the dowel. (i) Example: In a horizontally opening window (sliding or rolling) the minimum dimension requirement may be met as follows: When the window is in the final position for egress, place one end of the dowel perpendicularly against the portion of the main frame side (bottom) projecting furthest towards the center of the opening, & pass the dowel through the opening in a horizontal (vertical) plane without touching any portion of the device except the main frame side (bottom) on which it is pivoted. (ii) Example: Any type of window may be mounted in a side, bottom, or top hinged or pop-out egress frame which in the fully opened position meets the minimum dimension & area requirements.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.404 Standard for egress windows for use in mobile homes (cont'd)	(2) Test Method B - Minimum Area. The minimum area requirement of 5 Sq. Ft. contained in para. (b)(3)(ii) shall be determined by multiplying the minimum dimension (which may exceed 22") by the clear dimension measured perpendicularly to the minimum dimension & in the the plane of the window main frame. (i) Example: In a vertically operating window whose minimum dimension is from the main frame bottom to that portion of the operating vent projecting furthest toward the horizontal center line of the egress opening when in the fully opened position, the minimum area shall be determined by multiplying the minimum dimension by the inside side-to-side dimension.	X					
	(3) Test Method C - Operating Forces. (i) For horizontal or vertical moving windows, a force gage shall be attached to the manual pull bar at its centerpoint. After opening the latch or lock, a force not to exceed 20 lbs. shall be exerted in a direct pull parallel to the window in order to obtain movement in the opening direction. The window shall be in a closed & latched position prior to the test & shall have been subjected to 5 opening & closing cycles prior to the test. (ii) Locks & latches shall be tested as noted in section (d)(3)(i) except that the force gage shall be located in the center of the latch or lock handle.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.404 Standard for egress windows for use in mobile homes (cont'd)	(e) Test Report. (1) The test report include all requirements of this standard listed in their order shown in this standard. Where certain provisions of the standard do not apply, the notation "N.A." (Not applicable) shall so denote these items. Where certain pertenances are not supplied; such as storm windows or screen, the notation "N.S." (Not supplied) shall so denote those items.	X					
	(2) The test report shall be complete with manufacturers assembly drawing, extrusion drawings, parts list, weather-strip description, glazing method, description including backbedding & glazing method, installation & operating instructions. Where the unit tested is not in its actual installation, a clause stating the following shall be included in the test report: "This unit tested as submitted. Actual installation must be in accordance with the instructions included with this report or this report is not valid."	X					
	(3) The test report on all units submitted for test not having appurtenances listed in para. (c) shall include a statement as follows: "This unit tested without storm windows (or screen). The installation of these items with this product invalidates this test report."	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.404 Standard for egress windows for use in mobile homes (cont'd)	(4) For any test on component parts, such as balances, friction positioners, etc., certification by an independent testing agency shall be acceptable for evidence of compliance. If such certification is used, the test report shall so state, & give the name of the agency.	X					
	(5) Test reports used to demonstrate compliance with this standard to any governmental body shall be made available to the public upon request.	X					
280.405 Standard for swinging exterior passage doors for use in mobile homes.	(a) Introduction. This standard applies to all exterior passage door units, excluding sliding doors & doors used for access to utilities & compartments. This standard applies only to the door frame consisting of jambs, head & sill & the attached door or doors.	X					
	(b) Purpose. It is the purpose of this standard to establish the requirements for exterior passage door units irrespective of the type of material used in the manufacture of these products.	X					
	(c) General requirements & materials of construction. (1) The design & construction of the exterior passage door units shall conform with the provisions of this standard Requirements for any size, weight, or quality of material modified by the terms of "minimum", "not less than," "at least," and similar expressions are minimum standards.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.405 Standard for swinging exterior passage doors for use in mobile homes (cont'd)	The manufacturer may exceed these standards provided such deviation does not result in an inferior product or defeat the purpose & intent of this standard. Units may be shipped as a completely assembled unit, but not as KD or open unit. A KD unit is a unit that is complete in its entirety, which is shipped in a disassembled condition & later assembled & glazed according to the instructions of the manufacturer. An open unit is a unit that is complete in its entirety with the exception of a window insert, which is shipped in an assembled condition & later glazed according to the instructions of the manufacturer. A completely assembled unit is one that is complete in its entirety & and is shipped with all parts & subassemblies in complete connection with each other & no separate pieces, except for: Lock-knobs only & keys, door chain & attachments, storm door latch, chain & attachments, threshold extension, screw cover, drip cap.						
	(2) Workmanship. All construction methods, materials & workmanship shall be in conformance with accepted engineering practices to insure durable, livable, & safe housing.	X					
	(d) Materials & methods. Any material or method of construction, whether or not provided for in this standard, & any material or method of questioned suitability, proposed for use in manufacture, shall nevertheless conform in performance as outlined in para. (e) of this standard & proof of capability of structural integrity shall be	X					

* Acceptance
† Weak
** Ambiguous
†† Burdensome

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.405 Standard for swinging exterior passage doors for use in mobile homes (cont'd)	presented. If applicable, units shall comply with the following:						
	(1) Wood & wood based products - (i) Wood. Wood door parts shall be manufactured of suitable lumber having a moisture content of 6 to 12 percent at time of fabrication. Wood parts except interior trim shall be manufactured utilizing wet-use adhesive requirements as defined in ASTM D-3110 & Preservative Treated in accordance with NWMA I.S.-4 standard. Doors shall conform to the Type 1 requirements of NWMA I.S. 1-74. (ii) Plywood. Plywood shall be exterior type & preservative treated in accordance with NWMA I.S.-4. (iii) Hardboard parts shall meet or exceed the requirements for 1/8" tempered hardboard in accordance with the latest edition of PS 58.	X					
	(2) Hardware & fasteners. All hardware components & fasteners when considered as individual components, whether commercially available, or proprietary, must be capable of performing to the criteria stipulated in this section & in the Performance Requirements Section, Para. (e) of these specifications.	X					
	(3) Glass. All glazing in doors shall be safety glazing material meeting ANSI Z97.1-72. Glass in jalousies shall also be at least 7/32" in thickness & not longer than 36". Exposed edges shall be seamed, ground or polished to prevent injury.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.405 Standard for swinging exterior passage doors for use in mobile homes (cont'd)	(4) Weatherstripping. A tight threshold & weatherstripping to reduce air infiltration & improve water resistance shall be provided capable of conforming to the criteria stipulated in the Performance Requirements Section, Para. (e) of this standard.	X					
	(e) Performance requirements. - (1) Size of test specimen. All tests shall be performed on exterior passage door units with all operable portions closed & all criteria herein are applicable to exterior passage doors of the largest type that the producer desires to qualify under this specification. No inference of compliance to these requirements is to be made for products exceeding the size of the test specimen submitted. Largest unit size is determined by the maximum width & height dimensions of production units that are equal to or less than corresponding dimensions in that unit tested & passed.	X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.405 Standard for swinging exterior passage doors for use in mobile homes (cont'd)	(2) Structural performance test - (i) Wind pressure resistivity. There shall be no glass breakage or permanent deflection or any other condition which would cause the specimen to be inoperable after being subjected to exterior pressures of 25 lbs. per sq. ft. The test method applicable to this requirement shall be ASTM E-330. (ii) Interior pressure. There shall be no glass breakage or permanent deflection or any other condition which would cause the specimen to be inoperable after being subjected to an interior pressure equal to 1/2 the requirements in para. (3)(2)(i). The test method applicable to this requirement shall be ASTM E-330 except that no artificial means of containing pressure shall be allowed. Should pressure not be obtainable due to lack of air, the testing agency will report the pressure achieved, the theoretical air flow supplied to the unit, & certify that no additional flow from the equipment in use was available. Laboratory equipment used for this test must be capable of developing 10 x air flow determined in para. (e)(2)(iii) of this specification. (iii) Air infiltration test. Air infiltration shall not exceed the limits set forth below when tested in accordance with ASTM E-283 at an exterior pressure differential of 1.56 lbs. per sq. ft. (0.300" water pressure). 1.35 CFM per sq.ft. of door - Jan 1, 1975 1.2 CFM per sq.ft. of door - Jan 1, 1976 1.0 CFM per sq.ft. of door - Jan 1, 1977 (iv) Water resistance test. No water shall pass the interior face of the test specimen at a test pressure of 0 psf when tested in accordance with ASTM E-331. (v) The sequence of tests shall be performed as they are listed above. The Air Infiltration Test may be performed after the Water Resistance Test providing all sealed areas are thoroughly dried.	X X					

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness			Added			(a) General. The torsion and vertical deflection tests noted in paragraphs (b) and (c) of this section are to be conducted on mobile homes in order to: (1) obtain data necessary to verify structural durability requirements as stated in paragraph 280.904(b)(3) of Subpart J. The calculations furnished herein are to convert test data to the required structural parameters (GJ, EI).	
			Added			(b) Torsion Test. This method of test outlines a procedure for determining the degradation of a mobile home box structure and its reduction of torsional rigidity due to degradation. (1) APPARATUS. In addition to a mobile home, the apparatus shall consist of the following: (a) 6 hydraulic jacks; (b) 2 "load cell" jacks-calibrated to read as a minimum 0-5000 lbs in 50-lb increments; (c) 48" to 52" plumb line pendulum bob; (d) steel rule-at least 6" long, 0.01" increments; (e) paper, pencil, masking tape, and data sheet, or equivalents; (f) spirit and optical level. (2) PROCEDURE. CAUTION!! ACCURACY IS REQUIRED TO OBTAIN USABLE DATA. This method of the test involves jacking up to level position and above plus permitting the weight to sag on each corner of a leveled mobile home in prescribed weight increments. At each prescribed load, the corner deflection	

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						(3) NOTES. (a) Record all information required on the data sheet, such as lengths between supports, mobile home identification, and date. (b) One convenient method of adding the required weight is to install a pair of 55 gallon drums at the proper location in the mobile home. Adding water to the calibrated empty drums accomplishes the incremental loading.	

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						and the horizontal displacement or rotation of an end wall mounted pendulum (plumb bob) are recorded. The test procedure steps and suggested data recording sheet are as follows: (a) Position 6 jacks, or support piers, beneath mobile home, 3 under each of the 2 longitudinal I-beams, 2 forward, 2 aft and 2 immediately in front of the forward axle or hangers. (b) Jack up the home until load is off the wheels and home is roughly leveled using spirit level or engineer's level. (c) Using engineer's level, level bottom of I-beams front-to-rear and side-to-side to level home with ±.01" accuracy. (d) Hang 50" plumb line and bob on front inside wall at center line of mobile home. (e) Secure blank sheet of paper flat under plumb bob, almost touching. (f) Place the two load cell jacks under the front cross beam or I-beam, 48" off center. Retain level position. (g) Using load cell jack, jack up to just relieve the force on the corner's supporting jack without disturbing level conditions of mobile home. (h) Mark plumb bob position on blank position as "zero pendulum displacement" and record weight on jack or jack pressure indicated as "PSI." Calibration can furnish weight conversion from jack pressure.	

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						(i) Jack up using load cell jack, increasing load in 500-lb increments. (j) At each incremental load, record load on load cell jack and corner deflection reading. Also mark pendulum displacement on data sheet inside mobile home. Use a fine line pencil for marking. (k) Continue jacking until mobile home is lifted clear of the other supporting jack at that end. Record data at that "clear" load. Jacking up beyond this point bends rather than twists mobile home. (l) Reduce load on load cell jack back to original level load and record data. Mechanical set is normal such that mobile home may not return to original level condition or the load may vary. (m) Continue to reduce load downward in 500-lb increments, recording corresponding data until zero load is attained and jack is free or clear of load. (n) Increase load to original load, record data, set and replace original jack. Record data at that "clear" load. (o) Repeat setps (e) - (n) for the other side of the front end of the mobile home. (p) Repeat steps (d) - (o) for the rear end. Load cell jack is placed under longitudinal I-beam in rear if no cross beam is present. Measure spacing.	

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						(3) NOTES. (a) Record other information required on data sheet, such as lengths from front to middle and middle to rear support jacks, width between rear support jacks, length of pendulum (48" - 52"), date, project no. and mobile home identification plus calibrations. (b) Proper execution of this test requires three technicians but can be accomplished by two. One technician records all data and marks the pendulum inside. The others jack up the corner, measure the corner deflections, and monitor the "clear/not clear" status of the other support jack (Part 3(k)). (4) ALTERNATE PROCEDURE. This method of the test involves releasing the load on each corner of a leveled mobile home in prescribed weight increments. At each load, the corner deflection and the horizontal displacement of an end wall mounted pendulum are recorded. The data sheet suggested for the previous procedure is applicable here. The procedural steps are as follows: (a) Position 6 jacks or piers beneath mobile home; 3 under each of the 2 longitudinal I-beams; 2 forward, 2 aft, and 2 immediately in front of the forward axle or hangers. (b) Jack up the mobile home until the load is off the wheels and the home is approximately level using spirit level or transit. (c) Using transit, level bottom of I-beams front-to-rear and side-	

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						to-side ±.01" to further level home. (d) Install plumb line pendulum on front inside wall at center line of mobile home. Secure blank sheet of paper flat under plumb bob, almost touching. (Paper to be on floor.) (e) Place the two load cell jacks under the front cross-beam or I-beam, 48" off center. (f) Mark plumb bob position on blank sheet as "zero displacement" and record weight (or pressure) on load cell jack. (g) Reduce the load on the jack in 500-lb increments by relieving the jack pressure. (h) At each incremental load, record load on load cell jack and corner deflection reading. Also mark pendulum displacement to be measured later. (i) Continue lowering the jack until it is free of the mobile home. Record load and corner deflections and mark pendulum displacement at this zero load condition. (j) Raise the jack until its load equals the original level condition load (step (g) above). Record load and corner deflection and mark pendulum displacement. Mechanical set of permanent set is normal such that the mobile home structure may not return to original level position at the same load. (k) If set is evident, jack up corner approximately an inch above level and return to level position and record load.	

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)			Added			(l) Repeat items (e) - (m) for the other side of the front end of mobile home. (m) Repeat items (d) - (n) for the rear end of the mobile home. Load cell jack is placed under aft end longitudinal I-beams in rear if no cross-beam is present. (5) CALCULATIONS. (a) Formula and parameters. The formula for calculating the apparent torsional stiffness $\overline{GJ}$ for the front and rear sections of a mobile home is: $\overline{GJ} = Ty/\theta$ where, T is the applied torque, y is the length of the twisted member (distance from mobile home center supports to end supports), and θ is the resulting angular deflection. The values for T and θ can be calculated as follows: $T = Ph$ $\theta = \tan^{-1}(W/l)$ where, P is the applied vertical force which raises or lowers a corner from level, h is the moment arm length (distance from mobile home centerline to applied force), W is the horizontal displacement of the pendulum point, and l is the pendulum length.	

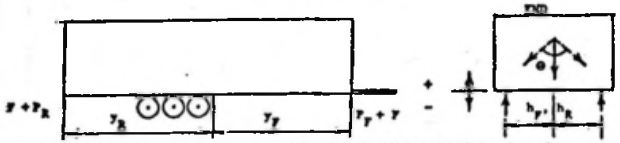
* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test Procedures to determine structural stiffness (cont'd)						Units are lb and in. to calculate $\overline{GJ}$ in lb-in.^{2}. The force P does not include the force required to support the unit in a level condition. P is either the force added to the level support force to raise a corner or the portion of the level support force which is relieved to lower the corner. Zero angular deflection (or pendulum displacement) and applied torque (or applied vertical force) correspond with the leveled state of the unit. (b) Application of formula. Apparent torsional stiffness values are calculated for each data pair T and θ (or P and W) and averaged to produce a $\overline{GJ}$ for each of the four corners. The values for the corners of each end are averaged to produce an apparent torsional stiffness for each end or section, front and rear.	

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)							

Table 1

TORSION TEST DATA SHEET



Mobile Home_____ Support Spacings Pendulum Lengths
Date_____ h_F = _____ in. ℓ_F = _____ in.
Inspector_____ h_R = _____ in. ℓ_R = _____ in.
y_F = _____ in.
y_R = _____ in.

FRONT LEFT CORNER

Jack Pressure (psi)	$P_F + F^*$ (lbs)	Corner Deflection (in.)	F (in.) Pendulum Deflection
	F =		

FRONT RIGHT CORNER

Jack Pressure (psi)	$P_F + F^*$ (lbs)	Corner Deflection (in.)	F (in.) Pendulum Deflection
	F =		

REAR LEFT CORNER

Jack Pressure (psi)	$P_R + F^*$ (lbs)	Corner Deflection (in.)	F (in.) Pendulum Deflection
	F =		

REAR RIGHT CORNER

Jack Pressure (psi)	$P_R + F^*$ (lbs)	Corner Deflection (in.)	F (in.) Pendulum Deflection
	F =		

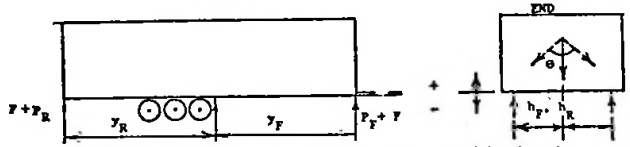
*F = force required to support corner in level position
P_f, P_r = force at a front or rear corner, respectively, required to raise or lower the corner; the torque-inducing force

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)							

TABLE 1a. SAMPLE DATA AND CALCULATIONS

TORSION TEST DATA SHEET



Mobile Home T-1
Date 1/15/78
Inspector Raine

Support Spacings
h_F = 48 in.
h_R = 48 in.
y_F = 396 in.
y_R = 324 in.

Pendulum Lengths
L_F = 50 in.
L_R = 50 in.

FRONT LEFT CORNER

Jack Pressure (psi)	$P_F + F^*$ (lbs)	Corner Deflection (in.)	Δ_F (in.) Pendulum Deflection
1000	F=2330	1.81	0
1250	2920	2.19	.16
1500	3500	2.63	.28
1750	4080	2.79	.41
1800	4200	3.00	.44
1000	2330	2.15	0
750	1750	1.75	-.09
500	1150	1.38	-.22
250	580	1.00	-.34
0	0	0.50	-.47
1000	2330	1.81	0

FRONT RIGHT CORNER

Jack Pressure (psi)	$P_F + F^*$ (lbs)	Corner Deflection (in.)	Δ_F (in.) Pendulum Deflection
750	F=1750	1.63	0
1000	2330	1.94	.5
1250	2920	4.2[illegible]	.22
1500	3500	4.56	.34
1750	4080	4.70	.53
750	1750	1.75	0
500	1170	3.63	-.13
250	580	3.38	-.30
0	0	3.13	-.36
750	1750	1.69	0

REAR LEFT CORNER

Jack Pressure (psi)	$P_R + F^*$ (lbs)	Corner Deflection (in.)	Δ_R (in.) Pendulum Deflection
650	F=1520	1.85	0
900	2100	2.00	0
1150	2680	2.38	.13
1250	2920	2.50	.19
650	1520	2.00	0
400	930	1.63	-.09
150	350	1.25	-.16
0	0	1.06	-.22
650	1520	1.95	0

REAR RIGHT CORNER

Jack Pressure (psi)	$P_R + F^*$ (lbs)	Corner Deflection (in.)	Δ_R (in.) Pendulum Deflection
700	F=1630	1.94	0
950	2220	2.38	.19
1200	2800	2.78	.33
1250	2930	2.50	.32
700	1630	2.00	0
450	1050	1.81	-.13
200	470	1.50	-.19
0	0	1.13	-.31
700	1630	1.95	0

*F = force required to support corner in level position

P_f, P_r = force at a front or rear corner, respectively, required to raise or lower the corner; the torque-inducing force

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						TABLE 1a. (Cont'd) SAMPLE CALCULATIONS FRONT END $(\overline{GJ})_F = P_F h_F y_F / \tan^{-1}(W_F/l_F)$ h_F = 48 in. l_F = 50 in. y_F = 396 in.	

Jack Pressure (psi)	$P_F + F$ (lb)	P_F (lb)	W_F (in.)	$\overline{GJ}$ (lb - in.^{2})
Left Corner				
1000	2330	0	0	-
1250	2920	590	0.16	6.12×10^7
1500	3500	1170	0.28	6.93
1750	4080	1750	0.41	7.08
1800	4200	1870	0.44	7.05
1000	2330	0	0	-
750	1750	-580	-0.09	10.7
500	1150	-1180	-0.22	8.90
250	580	-1750	-0.34	8.54
0	0	-2330	-0.47	8.22

MEAN $(\overline{GJ})_F$ Left = 7.94×10^7 (lb - in.^{2})

Right Corner				
750	1750	0	0	-
1000	2330	580	0.15	6.41×10^7
1250	2920	1170	0.22	8.82
1500	3500	1750	0.34	8.54
1750	4080	2330	0.53	7.29
750	1750	0	0	-
500	1170	-580	-0.13	7.40
250	580	-1170	-0.29	6.69
0	0	-1750	-0.39	7.44

MEAN $(\overline{GJ})_F$ Right = 7.51×10^7 (lb - in.^{2})

MEAN $(\overline{GJ})_F$ = 7.73×10^7 (lb - in.^{2})

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						TABLE 1e. (Cont'd) SAMPLE CALCULATIONS REAR END $(\overline{GJ})_R = \gamma_R b_R \gamma_R / \cos^{-1}(W_R/l_R)$ b_R = 48 in. γ_R = 324 in. l_R = 50 in.	

Jack Pressure (psi)	$P_R + F$ (lb)	P_R (lb)	W_R (in.)	$(\overline{GJ})_R$ (lb - in.^{2})
Left Corner				
650	1520	0	0	-
900	2100	580	0	-
1150	2680	1160	0.13	12.1×10^7
1250	2920	1400	0.19	10.0
650	1520	0	0	-
400	930	-590	-0.09	8.90
150	350	-1170	-0.16	9.92
0	0	-1520	-0.22	9.38

MEAN $(\overline{GJ})_R$ Left = 10.1×10^7 (lb - in.^{2})

Right Corner				
700	1630	0	0	-
950	2220	590	0.19	4.21×10^7
1200	2800	1170	0.31	5.12
1300	3030	1400	0.37	5.14
700	1630	0	0	-
450	1050	-580	-0.13	6.04
200	470	-1160	-0.19	8.29
0	0	-1630	-0.31	7.14

MEAN $(\overline{GJ})_R$ Right = 5.99×10^7 (lb - in.^{2})

MEAN $(\overline{GJ})_R$ = 8.05×10^7 (lb - in.^{2})

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						(c) Vertical Deflection Test. This method of test outlines a procedure for determining the degradation of a mobile home box structure via the reduction in bending stiffness. (1) APPARATUS. In addition to a mobile home, the apparatus shall consist of the following: (a) 6 hydraulic jacks; (b) 2 load cell jacks; (c) 1 dial indicator, at least 1" maximum deflection reading in .01" increments; (d) 1000 lb of portable weights to be installed in mobile home such as 2 each calibrated 55 gallon drums to be filled with water; (e) data sheet and pencil, or equivalents; (f) spirit and optical level. (2) PROCEDURE. CAUTION!! ACCURACY IS REQUIRED TO OBTAIN USABLE DATA. This test method involves leveling the home on 6 points, removing designated supports to measure dead weight sag followed by adding weight to that area, and all the while measuring the vertical deflection. The procedure steps and suggested data recording sheet are as follows:	

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						(a) Position six (6) jacks, or support piers, beneath mobile home; 3 under each of the 2 longitudinal I-beams; 2 jacks forward, 2 aft, and 2 immediately in front of the forward axle or hangers. (b) Jack up home until load is qff wheels and home is level using spirit or optical level for appropriate level position. (c) Using optical level (transit on level), level bottom of I-beams, front-to-rear and side-to-side, to further level home. (d) Install the dial indicator along the mobile home centerline, under a cross member located approximately halfway between the front cross-beam and the two support jacks located in front of the forward axle. (e) Check the two longitudinal I-beams at this midpoint for level. If the I-beams are sagging, use load jacks to raise them to level and record load. With this pre-load in the level position set the dial indicator at zero. (f) Remove the two pre-loaded support jacks and measure the dead weight sag at this point using the dial indicator. Record this measurement in .001" units. (g) Add weight inside mobile home over this midpoint in equal increments up to 1000 lb of added weight. Measure and record deflection at each incremental accumulated weight. Weight of technician inside mobile home must be considered.	

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						(h) Let the final total weight set for 30 minutes. Measure and record any added deflection due to "creep" in .001" units. (i) Remove all added weight. Measure and record new no-load (dead weight) deflection in .001" units. Mechanical set is normal such that mobile home may not return to original unloaded deflection. (j) Relocate the dial indicator along the centerline at the rear of mobile home (or longitudinal I-beams), where a deflection reading can be taken on the mobile home structure, preferably on the rear-most steel cross-member. (k) With the mobile home level use the load jacks to measure the weight on the two rear supports. Record this data. Zero the dial indicator. Remove the two rear supports and measure the dead weight sag without adding any weight. Record this data. (l) As in item (g), add weight in mobile home above dial indicator in equal increments up to 1000 lb of added weight. Measure and record deflection at each incremental accumulated weight, also considering weight of technician inside mobile home. (m) Let the final total weight set for 30 minutes. Measure and record any added deflection due to "creep." (n) Remove all added weight. Measure and record new no load (dead weight) deflection. Mechanical set is normal. (o) Calculate apparent (EI)'s front and rear. (See Calculations in data table.)	

* Acceptance
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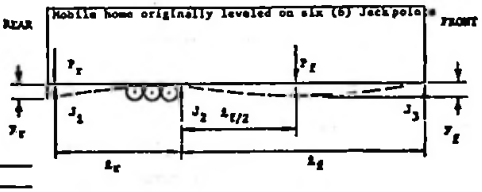
1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						TABLE 2 BENDING DEFLECTION TEST Trip No.: _____ SwRI No.: _____ Date: _____ Manufacturer: _____ Model No.: _____  ℓ_r = _____ ℓ_f = _____ FORWARD LOADING LOAD P_f (lbs) / DEFLECTION y_f (inches) 0 (level) — 0 (dead load weight) — (dead load sag) + 250 = + 500 = + 750 = +1000 = REAR LOADING LOAD P_r (lbs) / DEFLECTION y_r (inches) 0 (level) — 0 (dead load weight) — (dead load sag) + 250 = + 500 = + 750 = +1000 =	

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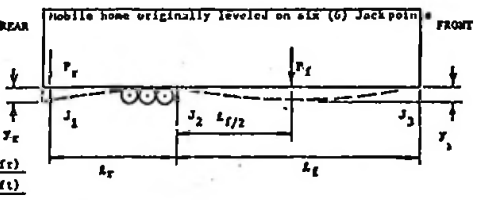
1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)						TABLE 2a. BENDING DEFLECTION TEST DATA SHEET Trip No.: 3 SwRI No.: T-1A Date: 8/11/77 Manufacturer: Double wide Model No.: Wet half  L_r = 11 (ft) L_f = 35 (ft) FORWARD LOADING LOAD P_f (lbs) / DEFLECTION Y_f (inches) 0 (level) 0 (dead load weight) 5200 (dead load def.) .600 5200 + 250 = 5450 .663 5200 + 500 = 5700 .718 5200 + 750 = 5950 .770 5200 +1000 = 6200 .826 REAR LOADING LOAD P_r (lbs) / DEFLECTION Y_r (inches) 0 (level) 0 (dead load weight) 3100 (dead load def.) 2.690 + 250 = 3350 2.924 + 500 = 3600 3.178 + 750 = 3850 3.575 +1000 = 4100 3.885 * Acceptance † Weak ** Ambiguous †† Excessive	

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.406 Test procedure to determine structural stiffness (cont'd)							

TABLE 2a (Cont'd)

VERTICAL BENDING TEST CALCULATIONS

$$(\overline{EI})_f = 36\ell_f^3\left(\frac{P}{y}\right)_f \text{ \& } (\overline{EI})_r = 575\ell_r^3\left(\frac{P}{y}\right)_r\left[1 + \frac{\ell_f}{\ell_r}\right]$$

FORWARD LOADING ℓ_f = 35 ft

P_f (lb)	y_f (in)	$\left(\frac{P}{y}\right)_f$ (lb/in)	$(\overline{EI})_f$ (lb-in^2)
5200	.600	8667	1.34×10^{10}
5450	.668	8159	1.26×10^{10}
5700	.728	7830	1.21×10^{10}
5950	.780	7628	1.18×10^{10}
6200	.826	7506	1.16×10^{10}
			AVG = 1.23×10^{10} (lb-in^2)

REAR LOADING ℓ_r = 21 ft

P_r (lb)	y_r (in)	$\left(\frac{P}{y}\right)_r$ (lb/in)	$(\overline{EI})_r$ (lb-in^2)
3100	2.690	1152	1.64×10^{10}
3350	2.924	1146	1.63×10^{10}
3600	3.210	1121	1.59×10^{10}
3850	3.515	1095	1.56×10^{10}
4100	3.885	1055	1.50×10^{10}
			AVG = 1.58×10^{10} (lb-in^2)

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Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.407 Standard For Brake Test Procedure						(1) Conduct 20-40 stop tests Purpose: To establish effectiveness of mobile home braking system for control and stops. Equipment: Tape (100 ft) Marking paint for asphalt and wheel/tires Level road, 40 ft wide, 1/4 mile long C.B. radio or walkie/talkie communications Fifth wheel or calibrated speedometer for speed control Mobile home of known weight Tow tractor of known weight greater than 9000 lb Test Procedure: Select a level, smooth stretch of asphalt highway or road which can be used for test. Consider areas at each end for turnaround purposes. Select a test section at one end and paint two parallel lines across the road 40 feet apart. Use a contrasting color. Paint 90° radial lines on the wheel and tires of the tow tractor and also on the mobile home wheels and tires. Paint only on the side that will be facing the observers. Set up one observer at the first and second 40 ft marks with adequate field-of-view for tractor and front wheels. Set up the 40 ft. marks to key on the mobile home wheels. An automatic or remote control brake application system can be used if desired. In order to include the operator's reaction time, a communication system can be used where the ground operator stands on the first line and voices the signal to the driver to apply the brakes when he crosses the first stripe. Determine if both the tractor and mobile home brakes produced a skid. Measure the	

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1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.407 Standard For Brake Test Procedure (Cont'd)						skid distance. Determine the stopping distance (including reaction time) from the first mark. Measure the tractor skid marks for actual stopping distance, less reaction time. Determine if the skid is straight forward. (Does tractor have to control the mobile home?) (i) Conduct three tests in accordance with the above and record data on each stop. Average the results. (ii) Conduct three additional tests in accordance with the above using or applying only the tractor brakes. Average the results. (iii) Conduct three additional tests in accordance with the above using or applying only the mobile home brakes. The mobile home and tractor must stop within the 40-foot marks for items (i) and (ii). The stopping distance for (iii) must not be greater than 80 feet. Tests (ii) and (iii) are not required per 280.904(10)(ii) but are recommended.	

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SUBPART J "TRANSPORTATION"

RECOMMENDED REVISIONS TO SUBPART J "TRANSPORTATION"

by

C. R. Ursell, II
C. E. Kimball

TABLE I. COMPARATIVE PARAGRAPH ANALYSIS

SUBPART J - TRANSPORTATION

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language*	*	†	**	††	Recommended Language	Justification for Change
280.901 Scope	Subpart J of this Standard covers the general requirement for designing the structure of the mobile home to fully withstand the adverse effects of transportation shock and vibration without degradation of the integrated structure or of its component parts and the specific requirements pertaining to the transportation system and its relationship to the structure.		X			Subpart J of this Standard covers the general requirement for designing the structure of the mobile home to fully withstand the aiverse effects of transportation (i.e., berding, torsion, shock and vibration) without degradation of the integrated structure or of its component parts and the specific requirements pertaining to the transportation system and its relationship to the structure.	Degradation Modes Defined Via Tests. (Refer to Tasks I and III.)
280.902 Definitions	(a) "Chassis" means the entire transportation system comprising the following subsystems: drawbar and coupling mechanism, frame, running gear assembly and lights.	X					No change
	(b) "Drawbar and Coupling Mechanism" means the rigid assembly, (usually an "A" frame) which connects the mobile home's frame to the towing vehicle.	X					No change

* Acceptance
† Weak
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* "Mobile Home Construction and Safety Standards," Federal Register, Dec. 18, 1975.

TABLE I. COMPARATIVE PARAGRAPH ANALYSIS
SUBPART J - TRANSPORTATION

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.902 Definitions (Cont'd)	(c) "Frame" means the fabricated rigid substructure, which provides considerable support to the affixed mobile home structure both during transport and on-site; and also provides a platform for securement of the running gear assembly, the drawbar and coupling mechanism.			X		(c) "Frame" means the fabricated substructure, which provides support to the affixed mobile home structure both during transport and on-site; and also provides a platform for securement of the running gear assembly, the drawbar and coupling mechanism.	Frame is not rigid by definition. Considered ambiguous.
	(d) "Running Gear Assembly" means the subsystem consisting of suspension springs, axles, bearings, wheels, hubs, tires, and brakes, with their related hardware.	X					No change
	(e) "Lights" means those safety lights and associated wiring required by applicable U.S. Department of Transportation regulations.		X			Delete.	Regulation of "lights" does not fall under the authority of the Dept. of Urban Development.
	(f) "Transportation System," (Same as Chassis, above).	X					

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† Weak
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†† Excessive

TABLE I. COMPARATIVE PARAGRAPH ANALYSIS

SUBPART J - TRANSPORTATION

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.902 Definitions (Cont'd)	(g) "Highway," includes all roads and streets to be legally used in transporting the mobile home.	X					
	(h) "Length," for purposes of transportation only, means the distance from the extreme front of the mobile home to the extreme rear, including the drawbar and coupling mechanism, but not including expandable features that do not project from the body during transportation.	X					
						(i) "Joint," comprises the interface of two or more parts, pieces, components, or assemblies that are attached by a designated fastener or attaching system.	Joint integrity is required to resist degradation. (see Tasks I and III.)
						(j) "Fasteners" means the devices used to attach or join any two or more structural members.	Ibid.
						(k) "Composite structure," means a structure consisting of different materials which are joined together to form a single structural member.	
						(l) "Torsional Stiffness," means the ability of the structural systems to resist twisting about the mass center along the longitudinal axis and termed as $\overline{GJ}$.	Sensitive mode related to degradation. (Tasks I and III)

* Acceptance
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TABLE I. COMPARATIVE PARAGRAPH ANALYSIS

SUBPART J - TRANSPORTATION

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.902 Definitions (Cont'd)						(m) "Vertical Stiffness," means the ability of the integrated structural system to resist vertical bending and termed as "EI."	Sensitive mode related to degradation. (Tasks I and III.)
						(n) "Joint Integrity, Stiffness, and Rigidity" refers to the numerous joints that make up the mobile home. EI and GJ are considered to be a function of the joint integrity, stiffness, and rigidity.	
						(o) "Inertia Loads" means those loads resulting from the relation between force, mass, and acceleration of a structural member as expressed by the formula: $F = \frac{W}{g}a$ where F = force in pounds, W = weight in pounds, a = acceleration in the direction of the force in feet per second per second, and g = acceleration of gravity in feet per second per second. As applied to this standard, the formula becomes F = W x acceleration factor, since acceleration (a) = acceleration factor (A.F.) x g.	
						(p) "Reuse," refers to the removal of the running gear components from a delivered/ setup mobile home and the programming of the assemblies for reuse on subsequent production mobile home units.	Requirement per contract.
						(q) "Bottom board" is defined as the closure membrane located beneath the floor joists which extends from front to rear and across the width of a mobile home. Its purpose is to enclose the cavity beneath a mobile home in which plumbing, air ducts, wiring, and insulation are installed.	

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TABLE I. COMPARATIVE PARAGRAPH ANALYSIS

SUBPART J - TRANSPORTATION

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.903 General requirements for designing the structure to withstand transportation shock and vibration	(a) The cumulative effect of highway transportation shock and vibration upon a mobile home structure may result in incremental degradation of its designed performance in terms of providing a safe, healthy and durable dwelling. Therefore, the mobile home shall be designed, in terms of its structural, plumbing, mechanical and electrical systems, to fully withstand such transportation forces during its intended life. (See 280.303 (c) and 280.305 (a)).		X	X	X	(a) The mobile home structural body, chassis, plumbing, mechanical and electrical systems shall be designed in their entirety to resist transportation forces defined in 280.904(b). Transportation forces shall be considered to act in only one direction at a given instant in time, and shall not be considered as acting simultaneously with wind loads and the roof live or snow load.	Definitive load data. (Task III)
	(b) Particular attention shall be given to maintaining watertight integrity and conserving energy by assuring that structural components in the roof and walls (and their interfaces with vents, windows, doors, etc.) are capable of resisting highway shock and vibration forces during primary and subsequent secondary transportation moves.	X					

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†† Excessive

TABLE I. COMPARATIVE PARAGRAPH ANALYSIS

SUBPART J - TRANSPORTATION

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.903 General requirements (Cont'd)	(c) In place of an engineering analysis, either of the following may be accepted: (1) Documented technical data of suitable highway tests that were conducted to simulate transportation loads and conditions; or (2) Acceptable documented evidence of actual transportation experience that meets the intent of this subpart.		X	X		(c) An engineering analysis, test verification or a combination of both is required to substantiate the design. Engineering analysis shall be certified by a registered professional engineer. Supporting tests shall be witnessed by an independent licensed professional engineer or architect or by a recognized testing organization.	Need for detailed requirements and utilization of controlled and instrumented test data.
280.904 Specific requirements for designing the transportation system.	(a) General. The entire system (frame, drawbar and coupling mechanism, running gear assembly, and lights) shall be designed and constructed as an integrated, balanced and durable unit which is safe and suitable for its specified use during the intended life of the mobile home. In operation, the transportation system (supporting the mobile home structure and its contents) shall effectively respond to the control of the towing vehicle in terms of tracking and braking, while traveling at applicable highway speeds and in normal highway traffic conditions. (NOTE: While the majority of mobile homes utilize a fabricated steel frame assembly, upon which the mobile home structure is constructed, it is not the intent of this standard to limit innovation. Therefore, other concepts, such as integrating the frame function into the mobile home structure, are acceptable provided that such design meets the intent and requirements of this part.)		X	X		(a) General. The complete transportation system (frame, drawbar, coupling mechanism, running gear assembly, and safety lights) shall meet the requirements of 280.904(b) and shall be designed and constructed as an integrated, balanced, and durable unit that is safe and suitable for its specified use during the intended life of the mobile home. During the transportation mode, the transportation system shall respond efficiently and safely to the control of the towing vehicle with respect to tracking, braking and directional control while traveling at applicable highway speeds and under normal traffic conditions. (NOTE: While the majority of mobile homes utilize a fabricated steel frame assembly, upon which the mobile home structure is constructed, it is not the intent of this standard to limit innovation. Therefore, other concepts, such as stiffening the frame or integrating the frame function into the mobile home structure, are acceptable provided that such designs meet the intent and requirements of this part.)	Need for specific design requirements. (Task III)

* Acceptance
† Weak
** Ambiguous
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TABLE I. COMPARATIVE PARAGRAPH ANALYSIS

SUBPART J - TRANSPORTATION

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)	(b) Specific requirements -- (1) Drawbar. The drawbar shall be constructed of sufficient strength, rigidity and durability to safely withstand those dynamic forces experienced during highway transportation. It shall be securely fastened to the mobile home frame by either a continuous weld or by bolting.		X			(b) Specific requirements-- (1) Drawbar. The drawbar or A-frame shall be constructed to be of sufficient strength, rigidity, and durability to safely withstand dynamic forces experienced during highway transportation It shall be securely fastened to the mobile home frame by either a continuous weld or by bolting. As a minimum, the drawbar shall be capable of withstanding the following loads applied at the coupler ball joint. Vertical = Tongue Weight x 3.6 Longitudinal = Tongue Weight x 2.6 Laterial = Tongue Weight x 1.6 Tongue weight is identified as 25 percent of the mobile home gross weight. Design calculations are required for: (1) maximum stresses in the drawbar and its attachment to the mobile home, (2) verification of the external stability of the drawbar.	Specific design requirements needed. Task III, Vol. I, Part II. (Also, see "Rationale for Design Recommendations" in this volume.)

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TABLE I. COMPARATIVE PARAGRAPH ANALYSIS

SUBPART J - TRANSPORTATION

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)	(2) Coupling mechanism. The coupling mechanism (which is usually of the socket type) shall be securely fastened to the drawbar in such a manner as to assure safe and effective transfer of the maximum loads, between the mobile home structure and the hitch-assembly of the towing vehicle. The coupling shall be equipped with a manually operated mechanism so adapted as to prevent disengagement of the unit while in operation The coupling shall be so designed that it can be disconnected regardless of the angle of the mobile home to the towing vehicle. With the mobile home parked on level ground, the center of the socket of the coupler shal not be less than 20 inches nor more than 26 inches from ground level.		X			(2) Coupling mechanism. The coupling mechanism (which is usually of the socket type) shall be securely fastened or attached to the drawbar or A-frame in such a manner as to assure safe and effective transfer of the design loads, set forth in 280.904(b)(1) between the mobile home structure and the hitch assembly. The coupling shall be equipped with a manually operated mechanism with positive lock so as to prevent disengagement of the unit while in operation. The coupling shall be so designed that it can be manually disconnected regardless of the angle of the mobile home to the towing vehicle. With the mobile home parked on level ground and the mobile home itself level, the center of the socket of the coupler shall not be less than 20 inches nor more than 26 inches from ground level.	Specific design load criteria needed. (Task III, Vol.I, Part II.)
	(3) Chassis. The chassis, in conjunction with the mobile home structure, shall be designed and constructed to effectively sustain the designed loads consisting of the dead load plus a minimum of 3 lbs per sq. foot floor load, (example: freestanding range, refrigerator, and loose furniture) and the superimposed dynamic load resulting from highway movement but shall not be required to exceed twice the dead load. The integrated design shall be capable of insuring rigidity and structural integrity of the complete mobile home structure and to insure against deformation of structural or finish members during the intended life of the home.		X			(3) Mobile Home Structure and Frame (i) Structural Members/Assemblies-- In order to withstand the inertia loads that occur during transportation, structural members/assemblies within the mobile home shall be designed based on their dead load times the appropriate Acceleration Factor (A.F.).	Task III. Task VII

* Acceptance
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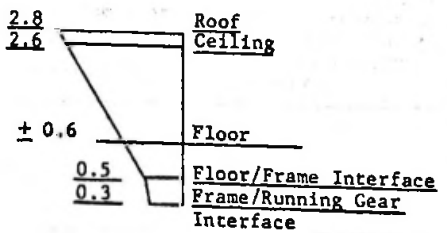
1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)						Acceleration factors are listed as follows: A.F. Vertical 3.6 (including 1-g static load), 1.6 up from zero A.F. Longitudinal ±1.8 A.F. Lateral shall vary with respect to the component (or composite) height above the interface of frame and running gear according to the following diagram:  	Task III, Vol I, Part II. (Also, see "Rationale for Design Recommendations: in this volume.)

* Acceptance
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Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)						Calculations required to verify compliance with transportation design requirements contained in 280.904 (b) (3) shall be submitted for all transportable units; i.e., single wides and each portion of multi-wides. For purposes of applying acceleration factors, engineering analyses shall consider the following: (1) When calculating the inertia loads for the design of structural assemblies, it shall be assumed that adjoining structural assemblies are accelerating in the same direction. (2) When calculating the inertia loads at the interface of structural assemblies for the design of attachments, it shall be assumed that one structural assembly is stationary while the adjoining assembly is accelerating. (3) The lateral inertia loads from the upper half of walls are reacted through the ceiling/roof structure, and the lower half through the floor structure. (4) To determine the adequacy of individual longitudinal structural components to resist the in-transit design loading, a load distribution based on the relative flexural rigidity and shear stiffness of each component may be utilized. Further, by proper precambering of the chassis assembly, additional loading may be distributed to the chassis, and the remaining loading may be distributed to each of the load carrying components by the relative stiffness principle. (5) When it can be demonstrated that adjoining structural members act as a composite structure then the load on the	

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)						composite structure may be distributed in accordance with the relative stiffness of the members. In addition, the analysis should include consideration for: (1) Location of openings in the sidewall during transport and, when appropriate, provisions for reinforcement of the structure and/or chassis at the opening. (2) Sidewall component member sizing and joint-splice analysis (i.e., top plate, etc.), and connections between load carrying elements. A typical design load calculation follows to illustrate methodology.	

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)						Objective: To calculate the lateral load per foot at the wall-floor interface due to roof and wall inertia loads. Required Information: 1) Acceleration Factor applied to walls; by proportion $A.F. = \frac{0.6 + 2.6}{2} = 1.6$ 2) Height of wall (h), assume 7 feet 6 inches. 3) Wall unit weight, assume 3.25 PSF. 4) A.F. applied to the roof-- $A.F.\ roof = \frac{2.8 + 2.6}{2} = 2.7$ 5) Width of roof (w), assume 14 feet. 6) Roof unit weight, assume 3.6 PSF. Calculations: Wall inertia load = A.F. Wall x h x 3.25 PSF = 1.6 x 7.5 x 3.25 = 39.0 LBS/FT. Roof inertia load = A.F roof x $\frac{W}{2}$ x 3.6 PSF = 2.7 x $\frac{14}{2}$ x 3.6 = 68.0 LBS/FT. Therefore, total lateral load per foot at wall - floor interface = 39.0 + 68.0 = 107.0 LBS/FT.	

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)						(ii) Structural Attachments--The design of attachments shall be based on the loads and moments developed in paragraph (i) times a factor of 1.5.	Task III
						(iii) Transportable Integrated Structure--In order to effectively withstand the vibration and shock loads that occur during the transportation phase, the integrated structural assembly of the mobile home shall be designed to meet torsional and vertical bending stiffness criteria contained under 280.904(b)(3)(iii), Table I. The integrated design shall be capable of insuring rigidity and structural integrity of the complete mobile home structure and to insure against deformation of structural or finish members. The manufacturer shall by engineering analysis or by physical test, verify each mobile home design. The test procedure and resulting data shall be in compliance with Subpart E, "Testing," paragraph 280.406.	Task III

<table>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th></tr>
<tr><td>Section No.
Para No.</td><td>Current Language</td><td>*</td><td>†</td><td>**</td><td>††</td><td>Recommended Language</td><td>Justification for Change</td></tr>
<tr><td>280.904
Specific
requirements
(Cont'd)</td><td>TABLE I
REQUIRED MINIMUM STRUCTURAL STIFFNESS PROPERTIES
FOR MOBILE HOMES
<table><tr><th>PROPERTY</th><th>FRONT SECTION-MINIMUM</th><th>REAR SECTION-MINIMUM</th></tr><tr><td>$\overline{EI}$ (lb - in.^{2}) -
Vertical Bending</td><td>2.0×10^{10}</td><td>18.0×10^{10}</td></tr><tr><td>$\overline{GJ}$ (in.^{4}) -
Torsion</td><td>8.0×10^{8}</td><td>2.4×10^{8}</td></tr></table></td><td></td><td></td><td></td><td></td><td>The above table specifies the minimum $\overline{EI}$ and $\overline{GJ}$ values for the front and rear sections of both single- and multi-wide mobile homes. To comply with minimum stiffness requirements, temporary supporting structure will be required at the marriage wall of multi-wide units and a minimum equivalent of one interior shear wall in the front section and one interior shear wall in the rear section will be required. Minimum values shall be substantiated by calculation and/or by test verification (1. If calculations are used to substantiate the temporary structure, design moments and shears due to inertia loads shall be considered using the same methodology used to design the exterior sidewall and interior shear walls; 2. for testing procedures, refer to Subpart E, "Testing." Torsional stiffness, GJ, shall be calculated using the formula as listed in (5) CALCULATIONS OF TORSION TEST in Subpart E.)</td><td>Task III, Vol. I (Also, see "Rationale for Design Recommendations" in this volume.)</td></tr>
</table>

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)						Adequate fasteners must be installed to insure structural integrity during the transportation phase (see 280.904 b) (3)ii)). The manufacturer shall provide in his written instructions, information on how to reinstall these stiffeners for any subsequent relocation of the home. NOTE: Design loads resulting from the application of "acceleration factors" are considered to be impact loads. Therefore, design allowables (as listed in the NFPA "National Design Specification for Stress-Grade Lumber and its fastenings") are increased by 100 percent. (4) Fixed Equipment and Plumbing, Mechanical, and Electrical Systems Contained Within the Chassis: In order to withstand the vibration and shock loads during the transportation phase, the design of attachments to the mobile home structure of fixed service equipment, and critical plumbing, mechanical, and electrical components shall be based on the same "joint design factor" noted above (1.5 applied to the loads and moments of the component under consideration).	

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)	(4) Running gear assembly. (i) The running gear assembly, as part of the chassis, shall be designed to perform, as a balanced system, in order to effectively sustain the designed loads set forth in 280.904(b)(3) and to provide for durable dependable safe mobility of the mobile home. It shall be designed to accept shock and vibration, both from the highway and the towing vehicle and effectively dampen these forces so as to protect the mobile home structure from damage and fatigue. Its components shall be designed to facilitate routine maintenance, inspection, and replacement.		X	X		(5) Running gear assembly (i) The running gear assembly is part of the chassis and shall be designed as the supporting/rolling interface between the road surface and the body structure. The running gear must provide durable, dependable, and safe transportation for the mobile home during its design life. The mobile home weight as applicable to the design and/or selection of the running gear shall be as follows: • Static weight on running gear equals mobile home gross weight minus 12 percent for minimum tongue weight (hitch/coupler load). The loads used to select running gear components shall be based on the static weight on the running gear, as defined above, times a design factor as noted in each of the following sections applicable to specific components of the running gear.	Results of data from towing tests. Inspection of running gear assemblies for wear and degradation. Task III, Vol. I, Part II. (Also, see "Rationale for Design Recommendations" in this volume.)

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)	(ii) Location of the running gear assembly shall be determined by documented engineering analysis, taking into account the gross weight (including all contents), total length of the mobile home, the necessary coupling weight shall not be less than 12 percent nor more than 25 percent of the gross weight.		X			(ii) Location of the running gear assembly shall be determined by documented engineering analysis and supplemented by manufacturer's data taking into account the gross weight (including all contents), total length of the mobile home, maximum allowable weight per axle, tire size and rating, and the necessary coupling weight which shall be not less than 12 nor more than 25 percent of the static gross weight of the mobile home.	Results of Data from Towing Tests. Task III, Vol. I, Part II.
	(5) Spring assemblies. Spring assemblies (springs, hangers, shackles, bushings, and mounting bolts) shall be capable of withstanding all the design loads as outlined in 208.904(b)(3) without exceeding maximum allowable stresses for design spring assembly life as recommended by the spring assembly manufacturer. The capability of the spring system shall assure that under maximum operating conditions, sufficient clearance shall be maintained between the tire and mobile home frame or structure to permit unimpeded wheel movement and for changing tires.		X			(6) Spring Assemblies. Spring assemblies (springs, hangers, shackles, bushings, U-bolts, grease fittings, spacers, and pivot bolts) shall be capable of withstanding and transmitting to the running gear and mobile home structure all of the design loads outlined in 280.904(b)(5)(i) times a factor of 1.2 without exceeding the maximum allowable stresses and cyclic fatigue life for the spring assembly and attaching hardware as recommended by the spring assembly manufacturer. The capability of the spring system shall be designed such that under maximum operating dynamic load conditions, as specified in 280.904(b)(5)(i), times a factor of 1.2, sufficient clearance shall be maintained between the tire/wheel and the mobile home frame or structure to permit unimpeded wheel movement and for changing tires/wheels. Under conditions of maximum vertical deflection of	More specific design data required. Results of detailed inspection of spring assemblies for cracks and wear. Task III, Vol. I, Part II. (Also, see "Rationale for Design Recommendations" in this volume.) Detailed inspection of running gear components for wear and degradation. See Modification Report on "Transportation Safety Performance of the Axle/Spring/Spring Hanger/Wheel System."

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)						the spring (with axle) and shackle, adequate clearance will be maintained. Attachment of the spring hangers to the chassis shall be made for maximum integrity and rigidity. Continuous fillet welds are required around the perimeter of the hanger.	
	(6) Axles. Axles and their connecting hardware, shall be capable of withstanding all of the design loads outlined in 280.904 (b)(3) without exceeding maximum allowable stresses for design axle life as recommended by the axle manufacturer. The number of axles required to provide a safe tow and good ride characteristics shall be determined and documented by engineering analysis. Those alternatives listed in 280.903(c) may be accepted in place of such an analysis.					(7) Axles. Axles and attaching hardware shall be capable of withstanding and transmitting to the springs all of the design loads outlined in 280.904(b)(5)(i) times a factor of 1.0, without exceeding maximum allowable stresses for designed axle loads and fatigue life. The axle shall be permanently dated and identified with respect to manufacturer's specifications and design life.	More specific design data. (Task III, Vol. I, Part II.) Detailed inspection of running gear components for wear and degradation.
						Unless substantiated in the design to the satisfaction of the approval agency (DAPIA) by either engineering analysis, load tests, or documented evidence of actual transportation experience, there shall be no less than the following minimum number of 6000# rated axles with not less than the mobile home rated tires indicated in Table 1 and Table 2, on each mobile home or floor section of a multiple unit mobile home:	

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)	Table 1 Length of mobile home[1] — No. of 6,000 pound rated axles equipped with 7 x 14.5 Mobile Home 8-ply tires 12 foot wide: To 60 ft maximum ..... 2 Greater than 60 ft to 80 ft maximum ..... 3 14 foot wide: To 52 ft maximum ..... 2 To 76 ft maximum ..... 3 To 80 ft maximum ..... 4 Table 2 Length of mobile home[1] — No. of 6,000 pound rated axles equipped with 8 x 14.5 Mobile Home 8-ply or 10-ply rated tires 12 foot wide: To 65 ft maximum ..... 2 Greater than 65 ft to 80 ft maximum ..... 3 14 foot wide: To 56 ft maximum ..... 2 Greater than 56 ft to 80 ft maximum ..... 3 [1]Length of a mobile home is the "length" as defined in § 280.902(b).					Determination of the number of axles required by use of the above tables does not eliminate the requirement for each axle to be capable of withstanding the actual imposed dead load without exceeding the maximum allowable stresses for design axle life as recommended by the axle manufacturer, or the maximum tire load rating in § 280.904(b)(8). If a manufacturer had submitted documented evidence of transportation experience to meet the requirements of § 280.903(c)(2), the minimum number of axles required by the experience record may not be reduced by use of the above tables. (The number of axles must be consistent with and no less than the number and rating of the axles indicated in the experience record.)	

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)	(7) Hubs and bearings. Hubs and bearings shall meet the requirements of 280.904(b)(3) and good engineering practice. Both of these components shall be accessible for inspection, routine maintenance, and replacement of parts.					(8) Hubs and bearings. The hubs, seals, and bearings for the selected axle shall be matched to the axle and wheel/tire combination and shall meet the design life and associated loads noted in 280.904(b)(1), times a factor of 1.0, as well as the axle and/or running gear manufacturer's recommendations regarding loads, operation, design, maintenance, inspection, and parts replacement practices. Both components shall be readily accessible for routine inspection and maintenance and parts replacement.	Detailed inspection of running gear components for wear and degradation. Task III, Vol. I, Part II. (Also, see Modification Report on "Transportation Safety Performance of the Axle/Spring/Spring Hanger/Wheel System.")

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)	(8) Tires, wheels and rims. Tires, wheels and rims shall meet the requirements of 280.904(b)(3). Tires shall be selected for anticipated usage.		X	X		(9) Tires, wheels and rims. (i) The tires shall effectively withstand the requirements set forth in 280.904 (b)(5)(i), times a factor of 1.0. Tires shall be sized and fitted to axles in accordance with the gross axle weight rating determined by the mobile home manufacturer. The permissible tire loading may be increased by utilizing a service load factor not to exceed 50 percent of the mobile home tire load limits specified in MH-1 of the Tire and Rim Association Handbook (1975 edition), but the individual permissable tire loading may not exceed 3,000 lbs. For example, the maximum tire loading for a 7 x 14.5 mobile home 8 ply tire each 70 PSI cold inflation pressure would be 2,805 lbs (1,870 lbs (MH-1 rating) x 1.5 (service load factor)=2,805 lbs). The tire load limit specified in MH-1 shall be determined by the tire manufacturer in accordance with procedures described in 40 CFR 571.119. (ii) Used tires may also be sized in accordance with the above criteria whenever the tread depth is at least 2/32 of an inch as determined by a tread wear indicator. The determination as to whether a particular used tire is acceptable shall also include a visual inspection for thermal and structural defects (e.g., dry rotting, excessive tire sidewall splitting, etc.). Wheels and rims shall be sized in accordance with the tire manufacturer's recommendations as suitable for use with the tires selected. Wheels and rims shall effectively withstand the static requirements set forth in 280.904(b)(5)(i), times a factor of 1.0.	U.S. Federal Highway Adm. (DOT) Laboratory Tests on new mobile home tires performed for HUD (1976-1977).

* Acceptance
† Weak
** Ambiguous
†† Excessive

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)	(9) Brake assemblies. (i) The number, type size and design of brake assemblies required to assist the towing vehicle in providing the effective control and stopping of the mobile home shall be determined and documented by engineering analysis. Those alternatives listed in 280.903(c) may be accepted in place of such an analysis.		X	X		(10) Brake assemblies. (i) Unless substantiated in the design to the satisfaction of the approval agency by either engineering analysis of those alternatives listed in §280.903(c)(1) and (2), there shall be a minimum of two axles equipped with brake assemblies on each mobile home floor or unit. The number, size, type and design of brake assemblies required on the mobile home to assist the towing vehicle in providing effective control and stopping capability for the mobile home shall be determined by the mobile home manufacturer using data providided by the brake manufacturer. The effective control and stopping shall be determined by tests (refer to Subpart E) and documented by engineering analysis and supported by the brake manufacturer's data. The tests shall be made utilizing the actual combinations or running gear equipment to be used by the manufacturer in production. Regardless of the method of substantiation, any substitution of equipment by the manufacturer shall be approved by the DAPIA, and have a rating no less than the equipment being replaced. The brake assemblies shall be rated at an acceptable "percent efficiency" level to enable the mobile home to pass the 20/40 stop test required in the following section (ii). The wiring installation shall provide an equal voltage distribution to each brake. The voltage developed at the brakes shall not be less than the value specified in the brake manufacturers instructions. Aluminum wire installations shall utilize compatible terminations with protection against galvanic action between dissimilar metals.	Tow test data and 20-40 stop tests and detailed inspection of running gear components for wear and degradation. Task III, Vol. I, Part II and Modification Report on "Investigation of Aluminim and Copper Brake Wires."

* Acceptanc
† Weak
** Ambiguous
†† Excessive

TABLE I. COMPARATIVE PARAGRAPH ANALYSIS

SUBPART J - TRANSPORTATION

1	2	3	4	5	6	7	8
Section No. Para No.	Current Language	*	†	**	††	Recommended Language	Justification for Change
280.904 Specific requirements (Cont'd)	(ii) Brakes on the towing vehicle and the mobile home shall be capable of assuring that the maximum stopping distance from an initial velocity of 20 miles per hour does not exceed 40 feet (U.S. Department of Transportation Regulations).		X			(ii) The combined brakes on the towing vehicle and the mobile home shall be capable of assuring that the maximum stopping distance (on level road surface) for the combined units from an initial velocity of 20 miles per hour does not exceed 40 ft. During the stopping operation, the longitudinal axis of the mobile home and towing unit shall remain within ±1 foot tolerance. This test is to be performed according to 280.410(1).	Towing test data and 20-40 stop tests. (Task III, Vol. I, Part II.) Also, see Modification Report on "Investigation of Aluminum And Copper Brake Wire."
	(10) Lights and associated wiring. Highway safety electrical lights and associated wiring shall conform to applicable federal requirements in terms of location and performance. The manufacturer shall have the option of meeting this requirement by utilizing a temporary light/wiring harness provided by the mobile home transportation carrier.	X				Associated Wiring Federal Motor Vehicle Safety Standard No. 108 shall be deemed the applicable Federal standard to be used for location and performance of highway safety electrical lights and associated wiring for determining compliance with this section. The manufacturer shall have the option of meeting this requirement by utilizing a temporary light/wiring harness provided by the mobile home transportation carrier.	Regulation of "lights" does not fall under the authority of the Dept. of Housing & Urban Development.

* Acceptance
† Weak
** Ambiguous
†† Excessive

PART II

RATIONALE FOR DESIGN RECOMMENDATIONS

Design for Transportation Loads

1. Accelerations

In this study, design recommendations for transportation loads are based on measured accelerations incurred vertically, longitudinally, and laterally during transport of both single- and double-wide mobile homes. The variations in accelerations from front to rear during transportation do not remain constant. The variation depends, in part, on the road surface condition generating the vertical displacement in response to the weight and velocity of the test unit. Small surface waves on the road produce higher accelerations over the axle. Large distortions generate higher accelerations in the rear. Undulations can produce the higher acceleration at any one of the three locations depending on the wave shape, velocity, and number and period of oscillations. A sharp hole in the road will produce the higher acceleration over the axle. Road roughness also varies from run to run because the same track in each road cannot be duplicated each trip; the route is the same, the weight and velocity are the same, but the exact bump or hole that was hit the first trip may not have been hit the second. Varying accelerations also occur with respect to the location of walls, windows, doors, etc.

Since the accelerations vary at each of the three locations, in the vertical, lateral, and longitudinal directions, the differential between these accelerations is a key factor. For example, if the rear wall bends downward and generates a high acceleration because of its

cantilever design, the critical stresses caused by the rear wall acceleration will not occur at the rear wall, but over the axle at the point of maximum bending where a lower acceleration may have been recorded. Similarly, the lateral acceleration, during the majority of test conditions, will be higher at the rear wall than over the axle or at the front wall due to the "overhang" behind the running gear. This is indicated by the recorded data. Since the tow tractor stabilizes the front end, the predominant lateral motion at the axles is "side-sway" and roll due to the action of the springs/shackles/tires; this is amplified by the rear overhang.

Briefly then, accelerations are affected by several items including:

- Road conditions,
- Velocity of tractor/mobile home combination,
- Weights, including furnishings and fixed equipment,
- Weight distribution,
- Joints and fabrication tolerances or variations,
- Variations in towing vehicles.

In order to derive realistic design acceleration factors from the test data, the "average peak occurrence" data reduction technique was used, and then these average accelerations were modified to allow for inherent variables. The measured accelerations and modification of these accelerations are described later in this section.

2. Test Data

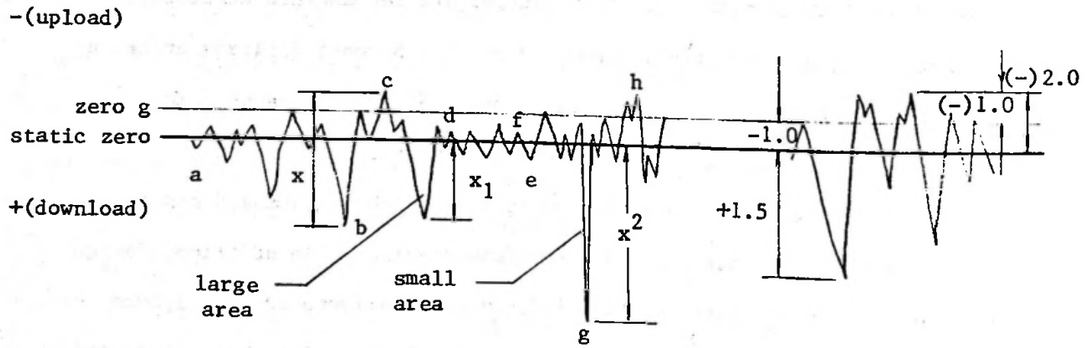
The test data included in this report cover the spectrum of tests from the "new" Condition I, to the "used" (secondary move) Condition II. These data reflect the maximum stiffness factor for each unit when new, resulting in higher vertical and lower lateral accelerations. The dynamic

response phenomenon occurs, in part, because the joints in the mobile home structure have not yet begun significant loosening from initial transportation. Based on data from tests on new and used test units, the greater the unit stiffness, the higher the vertical acceleration peaks; and conversely, the "softer" and more flexible the unit becomes, the lower the vertical acceleration peaks. Moreover, while the road test data generally reflect a reduction in vertical acceleration peaks as degradation increases, lateral accelerations may increase due to a "racking" mode (as demonstrated in Modification 2, Task II, which presents data tabulated in Table 1 from testing a unit with and without temporary stiffeners corresponding to new and degraded units, respectively).

Volume 3 consists of significant raw data traces reproduced during the test program by the playback method from magnetic tape to the Visicorder. Peak accelerations were measured from these traces. Tabulated summaries of maximum and minimum peak accelerations derived from the traces precede each set of traces. The data presented are particularly significant for use in the formulation of the recommended acceleration factors (AF) for inclusion in the revision to Subpart J "Transportation" of the Federal Mobile Home Construction and Safety Standards. These recommendations are to be based, in part, on average acceleration occurrences per mile that are considered related to the damage and degradation of the mobile home structure during transportation. In addition, design factors for mobile homes must include adequate allowances for minimum production quality, excessive transportation loads and on-site loads and vibrations as well as inconsistencies in production, transportation, predicted loads, etc.

3. Data Reduction Technique

In order to determine the occurrences per mile of the various levels of accelerations (peaks) generated by the varying road conditions, a "g" level intercept count for every 1/2 g of magnitude was made using the computer and the tape recorder with accelerometer data channels. The range of accelerations checked during the intercept analysis were from 6.0 g down to 0.5 g. This data reduction technique was applied to several recorded accelerometer signals in each direction that were generated over a 3.75 mile section of typical mobile home transport road. Tables 2, 3 and 4 present the results of the peak count measurements for the vertical accelerometer located on the floor over the axles of Test Units T-1, T-2A, and T-2B, one of each mobile home type. The three traces, Figures 1, 2, and 3, illustrate the typical signal patterns measured by these three transducers. A sketch follows to elucidate the method used in measuring and interpreting the acceleration traces generated by the mobile home road tests:



where

x = peak to peak measurement;

x_1 = peak measurement (from static zero);

x_2 = high "g" factor with minimum area (or energy);

a,e are minimum download positive peaks;

b,g are maximum download positive peaks;

c,h are maximum upload negative peaks;

d,f are minimum upload negative peaks;

Area under the curve relates to energy contained in the acceleration.

Note Example: +1.5 g measured plus 1.0 g static = 2.5 g's total positive (downward);

-1.5 g measured plus 1.0 g static = -.5 g total negative (upward)

The interpretation of "significant" peak traces is related to the degree of "damage-energy" each acceleration peak contains. Rather than the amplitude of an acceleration, the dwell time or duration of the acceleration seems to be the more significant cause of degradation in a mobile home. For example, 6-g peak acceleration that occurs in 2 msec contains practically no energy or dwell time (area under curve). However, a 3-g peak acceleration that occurs over a period of 85 msec contains significant energy, more energy than the 6-g peak. The range of 2 to 3 g's shown in Table 2, contains acceleration levels with significant area (duration of occurrence) under the curve, creating the damaging fatigue-like effect. Hence, a review of the tables containing acceleration occurrences per mile and a study of the degree of energy contained in various types of acceleration curves indicate that the higher "g" levels of 4, 5, and 6 would probably do less damage than those in the 1.5, 2.0, 2.5, and 3.0 g levels occurring per mile of travel. (See Tables 2, 3, and 4.) The 1.5 to 3-g levels occur 20 to 20,000 times as frequent as the high g's. This theory was one of the prime considerations in selecting the damaging g levels* for each axis for input into the design recommendations.

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* Data available from SwRI.

TABLE 2. T-1 FLOOR OVER AXLE VERTICAL ACCELEROMETER PEAK COUNTS ($\overline{RC}$=1.2)

"G"s*	RUN #3		RUN #6	
	(+) ct	(-) ct	(+) ct	(-) ct
6.0 - 5.5	1		1	1
5.5 - 5.0	1		1	1
5.0 - 4.5	2		1	4
4.5 - 4.0	1		1	5
4.0 - 3.5	1	1	4	5
3.5 - 3.0	8	2	6	10
3.0 - 2.5	18	6	3	10
2.5 - 2.0	31	3	13	18
2.0 - 1.5	** { 103	8	27	81
1.5 - 1.0	{ 2683	43	116	295
1.0 - 0.5	33,188	120	953	6095
0.5 - 0.1	2096	1012	20,775	33,538

* Measured 0 to peak from zero static reference line which is 1-g above static.
** Maximum damage area.

NOTE: (1) These peak occurrences were measured over a 3.75 mile section of typical mobile home transport road.
(2) The raw data traces indicate the comparative energy via the area under the acceleration curve.

TABLE 3. FLOOR OVER AXLE VERTICAL ACCELEROMETER PEAK COUNTS FOR T-2A AND T-2B ($\overline{RC}$=@1.0)

"G"s*	T-2A Run #1 $\overline{RC}$=1.1 to 1.0		T-2B Run #2 $\overline{RC}$=1.0	
	(+) count	(-) count	(+) count	(-) count
6.0 - 5.5				
5.5 - 5.0				
5.0 - 4.5				
4.5 - 4.0				
4.0 - 3.5	1	1		
3.5 - 3.0	1	1		
3.0 - 2.5	5			
2.5 - 2.0	11	3		
2.0 - 1.5	** { 30	10		1
1.5 - 1.0	{ 347	27	8	23
1.0 - 0.5	40,873	49	1156	2021
0.5 - 0.1	3797	534	29,235	28,029

* Measured 0 to peak from zero static reference line which is 1-g above static.
** Maximum damage area.

NOTE: (1) These peak occurrences were measured over a 3.75 mile section of typical mobile home transport road.
(2) The raw data traces indicate the comparative energy via the area under the acceleration curve.

TABLE 4. FLOOR OVER AXLE VERTICAL ACCELEROMETER PEAK COUNTS FOR T-2A AND T-2B ($\overline{RC}$=1.2)

"G"s*	T-2A Run #1		T-2B Run #2	
	(+) count	(-) count	(+) count	(-) count
6.0 - 5.5				
5.5 - 5.0				
5.0 - 4.5			1	
4.5 - 4.0	2	1	1	
4.0 - 3.5	4	3	3	1
3.5 - 3.0	7	1	3	2
3.0 - 2.5	15	5	13	3
2.5 - 2.0	47	9	42	7
2.0 - 1.5	** 131	9	101	11
1.5 - 1.0	** 3941	88	2957	109
1.0 - 0.5	49,333	341	38,416	777
0.5 - 0.1	5796	3729	21,839	28,123

* Measured 0 to peak from zero static reference line which is 1-g above static.

** Maximum damage area.

NOTE: (1) These peak occurrences were measured over a 3.75 mile section of typical mobile home transport road.

(2) The raw data traces indicate the comparative energy via the area under the acceleration curve.

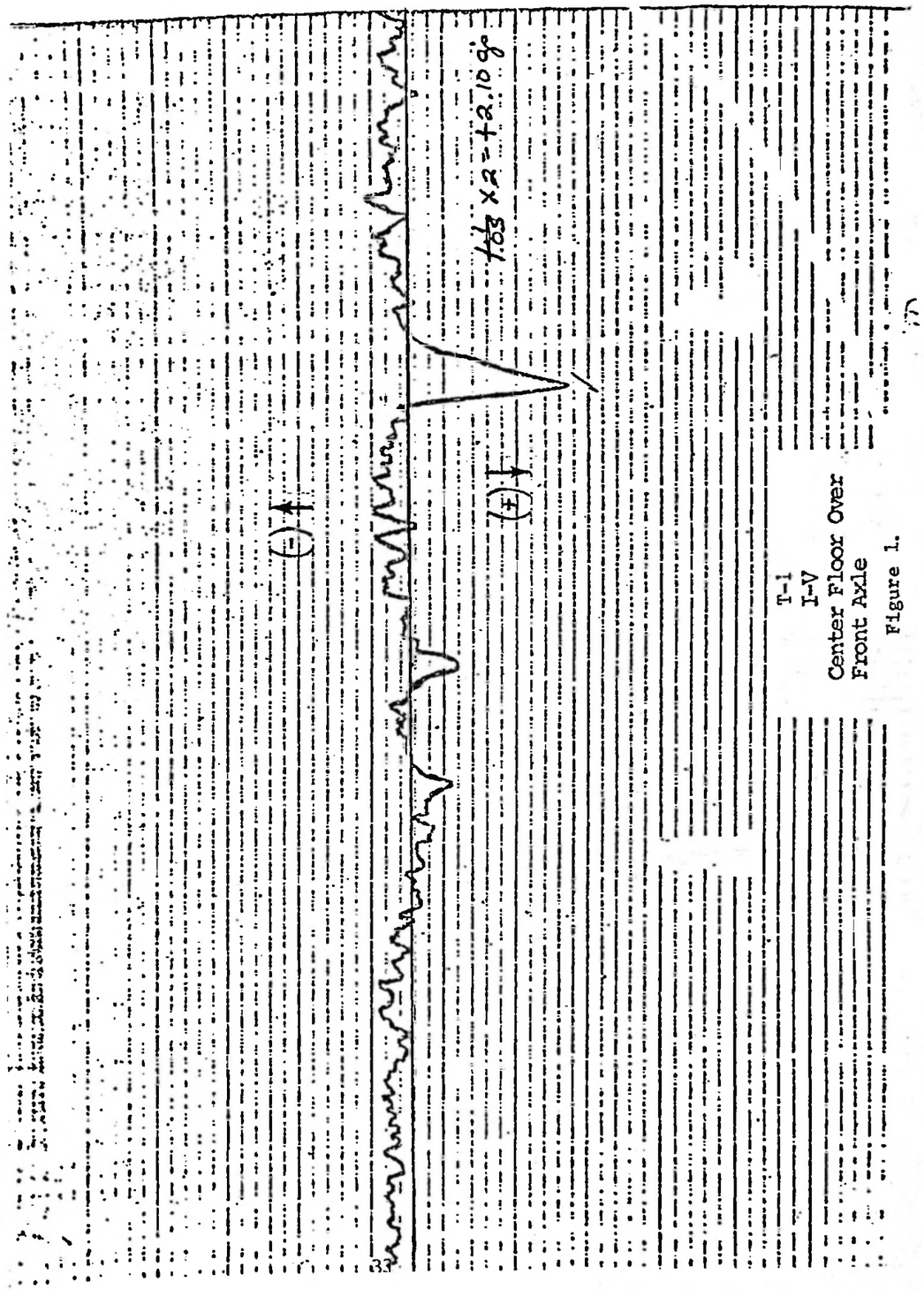


Figure 1.

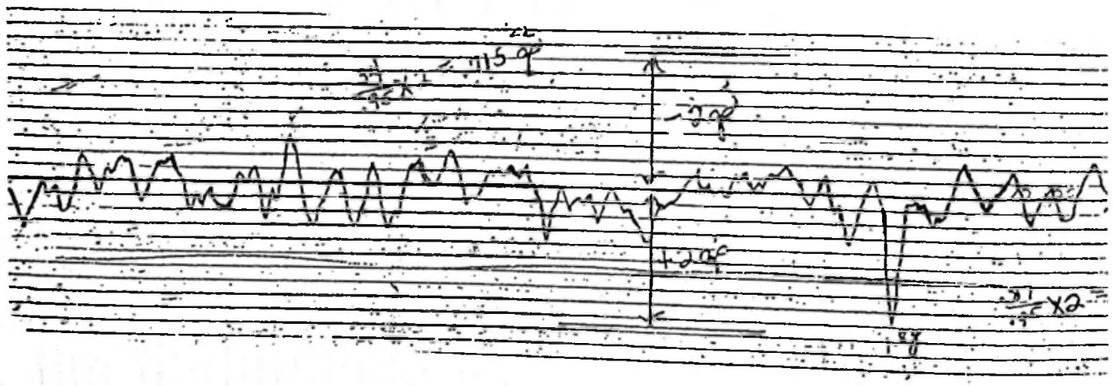
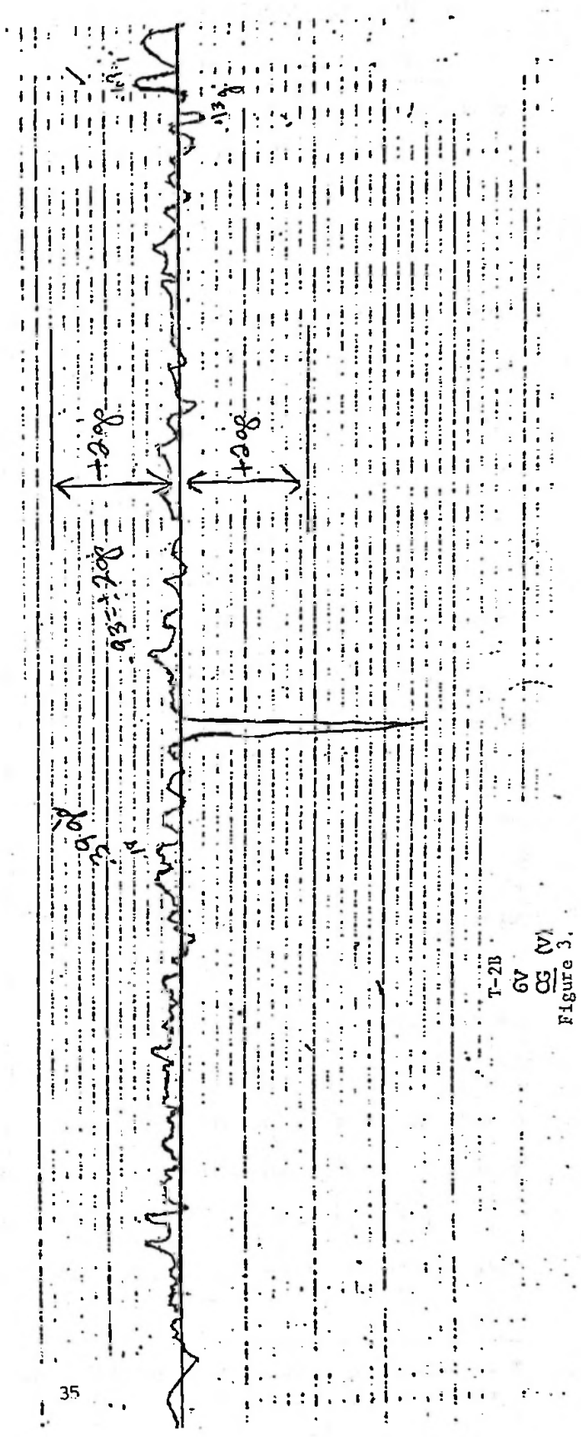


Figure 2

T-2A
4-V
CG (V)
34



T-2B
GV
CG (V)
Figure 3.

4. Measured Accelerations for Structural Box

The following are the average accelerations selected that relate to the structural box assembly.

Vertical Acceleration, g's = 2.50*

Longitudinal Acceleration, g's = 1.25

Lateral Acceleration, g's = 1.80 (at ceiling)

The selection of a single acceleration for each axis was based on a review of the accelerations generated along each of the three axes in the front, over the axle, and in the rear section of the mobile home test units. Accelerations among the units, single-wides, and each half of the double-wides were then compared to determine the relationship to model variations.

(a) Rationale for Selection of Single Acceleration for Each Axis Along the Length of the Mobile Home

- Vertical--Comparison of vertical accelerations for the three mobile home configurations appears in Table 5 , which presents data from a selected section of road (Culebra Road) with an RC of 1.0 to 1.1, over which each mobile home test unit was towed. These are not maximum accelerations.

The data in Table 5 indicate that the acceleration peaks generated by this stretch of road have a degree of commonality. The accelerations in general varied depending on the type of road condition causing the movement (accelerations over the axle were usually the highest); however, because of the minimal variation evidenced between the front, middle, and rear sections of the mobile home, one vertical acceleration was chosen for the entire structural box.

- Longitudinal--The following longitudinal accelerometer values were generated during sudden stops and starts of the tow tractor and

* Includes 1-g static (dead weight) load; negative (upward) loading equals 0.5 g's, usually not critical.

TABLE 5. VERTICAL ACCELERATIONS
(Acceleration Peaks)*
Difference Between Double-Wide and Single-Wide and Variations Along Length

LOCATION	Single-Wides		Wet Half--Double-Wides				Dry Half--Double-Wides			
	T-1		T-2A		T-4A		T-2B		T-4B	
	+	-	+	-	+	-	+	-	+	-
Rear	2.05	0.77	1.71	0.60	1.65	0.56	1.50	0.74	1.66	0.41
Middle	1.92	0.89	1.87	0.52	1.72	0.86	1.63	0.58	1.87	0.96
Front	1.67	0.96	1.52	0.83	1.59	0.86	1.50	0.90	1.77	0.70

LOCATION	Single-Wides	
	T-3	
	+	-
Rear	2.27	0.95
Middle	2.33	1.10
Front	1.95	0.86

*Refer to Appendix A for tabulated data and traces.

mobile home Test Unit T-1. Two accelerometers in the longitudinal direction were mounted along the centerline of the unit on the floor at the front wall. Stops and starts were made in both the forward and rearward directions denoted by F and R, respectively. Also, stops from speeds of 5 and 20 mph were recorded as indicated on the traces (See Volume 3). Table 6 summarizes the longitudinal accelerations experienced under each of these conditions.

TABLE 6. LONGITUDINAL ACCELERATION PEAKS FOR TEST UNIT T-1

Direction	Velocity (mph)	Acceleration (g's)*	
		−	+
Forward	start/stop	0.4	0.4
		0.4	0.36
		0.46	0.4
Rearward	start/stop	0.3	0.4
		0.28	0.4
Forward	5	0.48	-
		0.56	-
Rearward	5	-	0.4
		-	0.3
Forward	20	0.54	-
		0.54	-

* Positive longitudinal acceleration is toward the rear of the mobile home.

These longitudinal accelerations are consistent along the length of the mobile home because of the inherent stiffness of a unit in this direction. Therefore, a single longitudinal acceleration factor is applicable throughout the length of the unit.

Note that the acceleration values of Table 6 are low compared to what would be expected under normal transport conditions. These values are low because Test Unit T-1 was heavy and the SwRI tow tractor was considered light. Greater accelerations are generated by combinations

of lighter mobile homes and heavier tractors. Hence, the magnitude of accelerations is dependent upon the relative weights of the mobile home and tractor; however, since the particular tractor/mobile home combination to be used during transport is not known or controlled, a single longitudinal acceleration factor was considered for all units. The final design acceleration factor (discussed later in this section) reflects a conservative situation of a heavy tractor unit towing a light mobile home.

Also note that forward deceleration values from 5 and 20 mph differ little. This indicates that even at velocities as low as 5 mph, maximum decelerations occur.

- Lateral--The measured lateral accelerations were generally greater at the ceiling than the floor because of the greater radius of rotation at higher points. The values were assumed to vary linearly between the two vertical extremes of the structural box. This is a reasonable assumption since (1) the angular acceleration should be fairly constant along a vertical line at a point in time and (2) the tangential (or lateral) acceleration is the rate of change of the tangential velocity which varies linearly with the radius of rotation. Because of this vertical variation of the lateral accelerations, the recommended lateral acceleration factor of the structural box is actually a linear function which increases with height.

Although the lateral accelerations at the ceiling do vary somewhat from front to rear, a definite trend does seem to exist, as noted in Table 7, which summarizes the accelerations generated by the same section of road from which the vertical accelerations were selected. The trend indicates that the middle or over-the-axle lateral ceiling accelerometer readings are within the same general magnitude as the front and rear. As a result of a review covering several sections of road from $\overline{RC}$ = 1.0 to $\overline{RC}$ = 1.5, similar

TABLE 7. LATERAL ACCELERATIONS (at ceiling)
(Acceleration Peaks)*
Difference Between Double-Wide and Single-Wide and Variations Along Length

LOCATION	Single-Wides				Wet Half--Double-Wides				Dry Half--Double-Wides			
	T-1		T-3		T-2A		T-4A		T-2B		T-4B	
	-	+	-	+	-	+	-	+	-	+	-	+
Rear	0.95	0.47	0.82	0.35	1.35	0.67	0.82	0.49	1.22	0.51	1.07	0.41
Middle	0.62	0.53	0.56	0.42	0.87	0.55	0.37	0.45	0.33	0.49	0.89	0.47
Front	0.89	0.31	0.70	0.52	0.69	0.72	0.66	0.32	0.87	0.61	0.94	0.66

*Refer to Appendix A for tabulated data and traces.

results were indicated that would justify the use of a single lateral acceleration factor function for the entire length of the mobile home.

(b) Rationale for Selection of Same Accelerations or Acceleration Function for Both Single- and Double-Wide Units

A prime consideration in the selection of "g's" was the condition of the test mobile home following the road test program. As indicated by the data, T-1 performed adequately as did T-3 (although degradation did occur), while T-2A and T-4A and B did not withstand the test series within acceptable margins. The difference in degradation is not because input accelerations differed substantially among the units, but, rather, because the response to the accelerations differed, particularly in the lateral direction. The double-wides logically offer less resistance to vertical, lateral, and longitudinal acceleration than single-wides, which are inherently more stiff. If both single- and double-wides are designed to the same stiffness requirements (vertically, longitudinally, and laterally) and they both achieve the minimum required $\overline{EI}$ and $\overline{J}$ recommended in Subpart J, then they both should perform the same with respect to degradation. Since acceleration factor design requirements are related to stiffness, the same accelerations for single- and double-wide units were selected for design purposes. (Presently, only the vertical acceleration performance criteria are required by the Federal Standard.) Since the double-wides degraded at a rapid rate, then they should be assembled to generate a higher $\overline{EI}$ and $\overline{J}$, and if necessary, use temporary stiffeners to supplement stiffness during transportation.

5. Design for Joints and Attachments

Loosening of joints used in assembling the structure of the mobile home is the largest contributor to the degradation of mobile homes. The structural components of the unit do not fail; rather, the

joints and fasteners simply loosen to the point that the structural box then loses a large percentage of its original stiffness and integrity. The stud, header or plate do not fail, but the attachment of these items to other items works loose and permits large deflections resulting in high stresses and opening up of seams/joints.

In order to design for increased stiffness and margins of safety in the joints and attachments, a "joint design factor" of 1.5 times the loads and moments in the joint under consideration are recommended. The application of this factor is made by first determining the loads in the joint, multiplying these loads by the 1.5 factor, and then applying these loads to the detailed analysis for the joint stresses and fasteners. The 1.5 factor is introduced to increase the stiffness or integrity of the joints, which in turn, will increase the integrity of the mobile home. The 1.5 factor is also used to offset any inconsistencies in the joints during fabrication and assembly. This joint design factor is based upon road test measurements indicating a significant looseness of the joints, thereby requiring added integrity in the form of the 1.5 factor. Tests on the mobile home units also revealed a 5- to 10-Hz frequency throughout the mobile home structure causing the joints to degrade. The designer should also consider the structure, chassis, hitch/coupler, components, and appliances as subject to a vibration of: 0.3-g amplitude, 8-Hz frequency, and 540,000 cycles (total application equivalent to 825 miles).

6. Measured Accelerations for Hitch Coupler and A-frame

In addition to the accelerations for the structural box assembly, the following accelerations were selected from data applying to the

hitch coupler and A-frame:

Vertical Acceleration, g's = 2.50*

Longitudinal Acceleration, g's = 1.80

Lateral Acceleration, g's = 1.10

These accelerations represent the combined inputs from the mobile home running gear and the tow tractor.† Table 8 presents data used to support the selection of the aforementioned accelerations. The tabulated values are average peak accelerations in the vertical, lateral, and longitudinal directions experienced at the front wall of a mobile home which represent accelerations virtually identical to those at the A-frame and hitch coupler. These acceleration values are typical for both single- and double-wide units.

TABLE 8. AVERAGES OF T-1's FRONT ACCELEROMETER SIGNAL PEAKS (g's)*

	VERTICAL	LATERAL	LONGITUDINAL
POSITIVE	2.40	1.10	2.1 (0.5)†
NEGATIVE	1.73	1.03	1.4 (0.5)†

* Refer to Volume 3 for tabulated data and traces.
† Minimum g's with lightweight tow tractor.

The longitudinal minimum acceleration values in the parentheses were produced during normal test runs with the SwRI light tractor (about 8950 lb) compared to heavy diesel equipment weighing as much as 18,000 lb for use as a tow unit generating the higher g's. The acceleration peaks in the longitudinal direction reflect sudden starts,

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* Includes 1-g static load (dead weight); negative (upward) loading not critical.
† See Modification 2, Task IV.

and stops, the severity of which depend greatly upon the size, weight, and power of the tow tractor and the effectiveness of the brake system. Thus, in determining the longitudinal acceleration factor, the effect of heavy tractors was given more consideration since the majority of mobile homes are towed by these heavy rigs.

7. Measured Accelerations for Running Gear

The following are the accelerations selected from data applying to the running gear and its points of attachment to the mobile home chassis:

Vertical Acceleration, g's = 2.80*

Longitudinal Acceleration, g's = 1.25

Lateral Acceleration, g's = 1.80

As far as the mobile home manufacturer is concerned, these acceleration factors apply only to the attachment of the spring hangers and other connection points between frame and running gear, such as equalizer brackets and shackle brackets.

The recommended lateral and longitudinal acceleration factors for the running gear assembly are equal to those of the frame and structure of the mobile home. The lateral accelerations are the same because there is minimal damping in the lateral direction; the longitudinal accelerations because of the rigid attachment between the running gear, chassis, floor, and box structure. However, the determination of the vertical acceleration was based on the axle accelerometer that measured vertical accelerations with peaks averaging those presented in Table 9.

* Includes 1-g static load (dead weight); negative (upward) loading not critical.

TABLE 9. AXLE VERTICAL ACCELERATION PEAK AVERAGES (g's)*

MOBILE HOME	POSITIVE	NEGATIVE
T-1	4.22	4.76
T-2B	2.3	1.9

* Refer to Volume 3 for tabulated data and traces.

Higher g's peak were measured on the axle along with the frequency of accelerations, but these higher g values cannot be considered because of the action of the spring system; therefore, only frequency measurements were taken from these traces of vertical accelerations.

The axle (running gear) design is factored by the axle manufacturer for normal road dynamics using the spring as the absorbing media as well as acting as the damper between the road and box structure. The axle manufacturer will certify his axle, spring, wheel, shackle and hanger assembly to the designated static weight rating without any reference to the dynamic capabilities. The running gear will experience higher vertical accelerations than the box structure, and the interface spring will damp the inputs into the box structure resulting in lower inputs for the structure. The running gear on most mobile homes is classed as "limited life" which interprets to mean up to 2000 miles. However, concern is expressed for a set of limited life running gear that is delivered 800 miles to the first setup site where it is static for 2 or 3 years and then put back on the road in this condition for another 700 miles with rusty/sticking components.

8. Acceleration Factors: Modification of Accelerations for Structural Box, Hitch Coupler and A-frame and the Running Gear

The next analysis involved the modification of the aforementioned measured accelerations to reflect the nominal conditions applicable to the average transporting of a mobile home. SwRI believes the actual velocity generated by most transporters, the handling of the mobile homes, the road conditions, and the usual setup and takedown procedures vary significantly, and, frequently, may be much more severe than the conditions of the SwRI testing. The selection of the accelerations from the predictive analysis and tow test data covered controlled conditions at 45 mph and nominal weight. Therefore, in order to compensate for the potential difference between the controlled test conditions and those of actual operating modes, the test accelerations were increased by a factor of 1.45. The 1.45 factor was developed by application of the following ratio formulas to the critical rear section of the test units:

$$\frac{G_{\overline{RC}\ (norm)}}{G_{\overline{RC}\ (test)}} = \left(\frac{\left(V_{norm}\right)^{x}}{\left(V_{test}\right)^{x}}\right)\left(\frac{\overline{RC}\ (norm)}{\overline{RC}\ (test)}\right)$$

where,

V = velocity (45 mph for test and 55 mph for normal highway speeds);

x = 0.734 (Task III, Volume II);

$\overline{RC}$ (test) = 1.2. This is the RC factor of most SwRI test roads;

$\overline{RC}$ (norm) = 1.5. This is the RC factor to apply to many "back roads" over which mobile homes are being transported.

Therefore,

$$\frac{G_{1.5}}{G_{1.2}} = \left(\frac{(55)^{0.734}}{(45)^{0.734}}\right)\left(\frac{1.5}{1.2}\right) = 1.45$$

(Refer to Task III, Volume II.)

This ratio factor is considered realistic since correlation was established in this area between the predictive analysis and the test program. Moreover, it is a significant indicator of the contribution of speed and road conditions in the degradation cycle of mobile homes during the transportation mode.

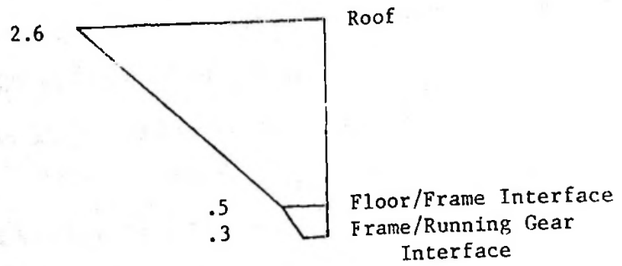
Using this modification factor of 1.45 produces the acceleration factors (AF) listed on the following page. These AF's are recommended to be incorporated in Subpart J "Transportation" of the Federal Mobile Home Construction and Safety Standards. See Task IV for recommended revisions to the existing standard. Considerable work has been accomplished on the correlation of data supporting these recommendations. Refer to the predictive analysis, test data, and correlative analysis. (Volumes 1 through 4.)

STRUCTURAL BOX

Axis	Measured Accelerations	Factor	Recommended AF
Vertical	2.50	1.45	3.6*
Longitudinal	1.25	1.45	1.8
Lateral	1.80	1.45	2.6(roof) .5(floor/frame interface) .3(frame/running gear interface)

* Includes 1-g static load (dead weight).

During the application of the AF's, it must be kept in mind that because of impact loads, the NFPA material design allowables can be increased by a factor of 2.0. Also, the lateral load is to be applied as uniformly distributed along the side of the mobile home. However, because of the vertically increasing acceleration, the lateral acceleration factor shall be as diagrammed on the following page.



The designer is to consider the AF's noted above as acting independently in order to simplify the analysis and eliminate the use of combined loading requirements.

HITCH COUPLER AND A-FRAME

Axis	Measured Accelerations	Factor	Recommended AF
Vertical	2.50	1.45	3.6*
Longitudinal	1.80	1.45	2.6
Lateral	1.10	1.45	1.6

The hitch coupler and A-frame AF's differ slightly than those of the structural box, especially in the longitudinal axis, because of the concentrated input point as well as the panic stops and sudden starts. These concentrated inputs are damped as they progress aft along the chassis and structural box.

* Includes 1-g static load (dead weight).

RUNNING GEAR

Axis	Measured Accelerations	Factor	Recommended AF
Vertical	2.80	1.45	4.0*
Longitudinal	1.25	1.45	1.8
Lateral	1.80	1.45	2.6

The above acceleration factors were developed for the running gear because of the detailed test data that was assembled. However, the designer normally would not use these data for purposes other than the attachment of the running gear to the chassis or I-beams. The manufacturer of the running gear has his own design criteria for certification of the axle assemblies. The designer of the mobile home simply uses the maximum weight of the mobile home and subtracts the 12 percent applicable to the tongue and divides the results by the axle rating to determine the number of certified axles required. Therefore, these AF's have minimum applicability for the mobile home designer.

Because the loads induced by these acceleration factors at the running gear are transmitted to the mobile home frame through the spring hangers and other attachment hardware, it is recommended that special attention be given this area by the designer. In particular, he should ensure that the weldment of the hangers is capable of withstanding these forces. Therefore, the recommended revisions of Subpart J include the requirement of 100% weld between hanger and frame.

* Includes 1-g static load (dead weight).

*U.S. GOVERNMENT PRINTING OFFICE : 1980 O-625-549/1955

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