NBSIR 73-224 (R)

Criteria for Testing Laboratories for Manufactured Building

One and Two Family Dwelling Systems and Components

J. O. Bryson, A. A. Camacho, F. M. Gavan,
J. L. Heldenbrand, M. A. Robinson, B. M. Vogel

Project LEAP
Office of Building Standards and Codes Services
Center for Building Technology, IAT
National Bureau of Standards
Washington, D. C. 20234

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Preliminary Report

Prepared for
National Conference of States on Building Codes and Standards

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This report is to be superseded by a future publication which will receive general distribution and should be cited as a reference. Please consult the NBS Office of Technical Information and Publications to obtain the paper citation.

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National Conference of States on Building Codes and Standards

U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary
NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

FOREWORD

Within the last decade, the emphasis has been changing in the housing industry from traditional stick-built construction to industrialized construction. To assure that industrialized housing units comply with the rules and regulations of the jurisdiction in which they will eventually be erected, an approval system must be established so that the units will be inspected during manufacture for compliance with these rules and regulations. This approval system is predicated on three specific certification functions: (1) design review and evaluation; (2) component and system testing; and (3) inspection for compliance during the production process. These certification functions are generally referred to as:

(1) Engineering Analysis

(2) Testing

(3) Compliance Assurance

For traditional stick-built construction at the site, the local building officials carry out these certification functions. However for industrialized construction, the local building official is faced with the problem of inspecting manufactured building during fabrication located in other jurisdictions, in some cases great distances away. In view of this and other associated problems, building officials have come together and decided that the best system to establish for the approval of industrialized building is one involving the used of qualified agencies or laboratories, public or private, to perform certification functions acceptable to all responsible parties concerned. Qualified agencies or laboratories will be identified by examining applicants against standard criteria.

The Center for Building Technology, NBS, nas been asked to develop this criteria and the examination methodology for each of the three "certification function categories."

This report describes criteria for testing laboratories and is based on requirements of the North Carolina Procedures and Regulations for Mobile Homes, Modular Dwelling Units and other Factory Built Structures - 1970 Edition, and the American National Standards Institute Standard for Mobile Homes, ANSI A119.1 - 1969.

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PART I GENERAL INFORMATION

INTRODUCTION

The scope of the criteria for laboratory evaluation developed in this study is limited to those technical resources of testing laboratories needed to perform certain tests. This report (1) identifies certain physical tests, both stipulated and implied, that are indicated in the North Carolina Procedures and Regulations for Mobile Homes, Modular Dwelling Units and Other Factory Built Structures - 1970 Edition, and the American National Standards Institute Standard for Mobile Homes, ANSI A119.1-1969, and (2) presents and explains the criteria by which testing laboratories can be judged for their capability to perform these identified tests.

The implied tests are those tests that are not specifically spelled out but are indicated in performance specification statements or statements of design requirements and the like.

This report is divided into four parts: General Information; Calibration Plan; Criteria by Building Systems Disciplines; and Laboratory Organization.

Part I General Information gives the scope of this report and provides definitions pertinent to factory built housing, building code terminology and the like. In addition it contains certain general requirements for personnel. These personnel requirements are supplemented where necessary in Part III under the particular building systems disciplines.

Part II Calibration Plan provides the essential elements of a calibration plan needed in order to assure and maintain the accuracy of all test instrumentation and laboratory standards.

Part III Criteria by Building Systems Disciplines relates to the technical requirements for the evaluation of a testing laboratory with respect to the various building systems disciplines to be evaluated such as, Structures, Heating Ventilating and Air Conditioning, Fire Safety, Electrical and Plumbing. Each discipline category is written as a complete entity, identifying those requirements needed by a laboratory for it to have the capability to perform the required testing. These requirements are related to Equipment, Instrumentation, Facilities, and Personnel. At the end of each discipline category a table is presented which lists the tests identified in the referenced standards. In addition the table lists the Standard Reference, Objective, Test Personnel Required, Test Instrumentation, Fixtures and Appliances Required, and Procedure.

Part IV Laboratory Management sets forth some generalized statements about the organization of a testing laboratory conducive to its proper and continuing operation.

DEFINITIONS

The definitions set forth hereinafter, are stipulated primarily for the purpose of providing uniformity in the statement of criteria for the various disciplines.

Accredited - Sanctioned by the building official or other authority having jurisdiction.

Analysis - Investigation; study; identification of constituents (i.e. related to conclusions drawn principally through study or computation).

Analysis Agency - An organization that investigates and/or evaluates building materials, components or assemblies through study and/or computation.

Approved - See "accredited".

Building - A roofed structure for the shelter, support, or enclosure of persons, animals, chattels, or moveable property of any kind.

Certification - The issuance of a legal-type of document (with liability to the certifier) stating that the goods referred to by the certificate possess the qualities stated in the certificate.

Competence - Requisite abilities or qualities, including such job-oriented requirements as training, experience, initiative, amount of supervision needed, team work, and communications skills.

Component - Any sub-system or sub-assembly designed for use as a part of a system.

Criterion - A standard on which a judgment or decision is based.

Dwelling Unit - One or more habitable rooms which are occupied or which are intended or designed to be occupied by one family with facilities for living, sleeping, cooking, and eating.

Facilities - The physical plant required to house and protect the laboratories, occupants, test equipment and instrumentation, and records against the elements and to provide a working area for such testing.

Factory Built Housing - A general term indicating the fabrication of housing modules or components in a factory through industrialized manufacturing methods; also, industrialized housing and manufactured housing.

Industrialized Building - A building assembly or system of building subassemblies, including the necessary electrical, plumbing, heating, ventilating and other service systems, manufactured in its entirety, or in substantial part, and transported to the point of use for installation or erection, with or without other specified components, as a finished building unit, and not designed for ready removal to, or installation or erection on another site.

Inspection - Examination of materials or systems for visual, dimensional and tactile characteristics (i.e. usually those attributes which are susceptible to physical measurement). The process of measuring, examining, gaging, or otherwise comparing the article of service with specified requirements.

Inspection Authority - That agency with the legal responsibility for administering and/or enforcing promulgated laws, codes and regulations.

Labeled - Components and systems of buildings bearing an inspection label of an approved listing agency.

Laboratory Personnel:

Engineer (E) - One who has general knowledge of the basic principles, theories, and practice in a given field of engineering such as may be acquired through completion of a full engineering curriculum leading to a

bachelor's degree from a accredited college or university or through training equivalent in type, scope and thoroughness.

Technician (T) - One who has knowledge of the basic principles, theories, and practice in a given field of engineering such as may be acquired through the completion of at least two years of engineering curriculum at an accredited engineering college or university, or has graduated from a specialized technical vocational institute appropriate to his field or through training equivalent in type, scope and thoroughness.

Aid (A) - One who has demonstrated ability to read and write the English language and to perform simple arithmatical computations and who performs certain routine laboratory tasks and procedures under direct supervision.

Listed - Equipment or materials included in a list published by a listing agency that maintains periodic inspection of current production of listed equipment or the materials and whose listing states that either the equipment or material complies with approved standards or has been tested and found suitable for use in a specified manner.

Performance Evaluation - The actual determination of the desired attributes of a material, component or system to fulfill certain specific requirements.

Personnel - Management, administrative, technical, clerical support workers.

Quality Assurance - A planned and systematic pattern of all actions necessary for acceptance and/or rejection of a service, process or product.

Quality Control - A management function whereby control of quality of raw or produced material or components is exercised for the purpose of preventing the production of defective items.

Test - The measurement of physical, chemical or functional characteristics of materials, systems or components.

Testing Laboratory - As used in this document, is an organization having the technical resources for performing, interpreting and reporting certain required physical tests.

PERSONNEL

Personnel considerations are covered in three different areas, for each of the building disciplines. First, the criteria for each particular test includes a "Personnel" subheading, giving the personnel requirements needed to conduct and interpret that specific test. The "Summary" section at the end of each building discipline also carries a "Personnel" subheading. A summary is given of the minimum number and type of personnel needed to conduct all the tests listed for that building discipline. Thirdly, the tables at the end of each building discipline tabulate the criteria covered under the specific tests, providing a quick reference to the level of competence needed for:

TEST--Actually conducting the test using prescribed methods and standards

INTERPRETATION--Providing technical supervision, technical interpretation and consultation in event of non-standard results; preparing written reports.

In addition to the technical personnel needed to conduct specific tests, each laboratory shall designate, as laboratory manager or technical director, an employee having overall responsibility for the testing and reporting by the laboratory. The laboratory manager or technical director should have suitable training and experience in technical and administrative disciplines. He may or may not be personally involved in the actual performance of testing.

PART II CALIBRATION PLAN

INTRODUCTION

This section sets forth requirements for a plan describing the laboratory's procedures for periodic calibration of test instruments and laboratory standards. Where applicable, testing machines or equipment may be considered as test instruments for the purposes of this document.

The calibration plan shall include the following basic elements, each of which is described in greater detail, below.

1) Instrument Inventory List - A list of those test instruments requiring periodic calibration.

2) Standards Inventory List - A list of the laboratory standards used in the calibration of test instruments.

3) Procedures - Procedures and required periods for in-house calibration of test instruments and for calibration of laboratory standards.

4) Environment - Environmental conditions required for the calibration room.

5) Procedure Check - Procedure for inspections between calibration periods to validate the calibration plan.

6) Instrument Labels - Procedure for assuring compliance with established calibration schedules and reflecting the calibration and operational status.

7) Calibration Records - Procedures for recording the calibration and repair history and for identifying the present calibration and operational status of individual instruments and laboratory standards.

1. INSTRUMENT INVENTORY

An inventory of test instruments requiring calibration shall be maintained. Inventory records shall include:

1) Manufacturer

2) Model number

3) Serial number

4) Operating range

5) Calibrated range

6) Calibration procedure reference

7) Effective period of calibration

8) Characteristic sensitivity to specific environmental elements

9) Characteristic accuracy

10) Data source for (8)

2. STANDARDS INVENTORY

An inventory list of the laboratory standards used to calibrate test instruments shall be maintained. If calibration of test instruments is done by an outside agency, the inventory of laboratory standards shall be maintained by that agency with a copy furnished to the laboratory.

2.1 RECORDS

The standards inventory records shall include applicable items listed in Instrument Inventory, Section 1.

2.2 TRACEABILITY

The inventory records shall trace laboratory standards to the National Bureau of Standards or to natural physical constants or through subcontractor calibration certificates traceable to NBS or to natural physical constants.

2.3 LABORATORY WORKING STANDARD

Under laboratory reference conditions the accuracy of a laboratory working standard shall be at least four times the required accuracy of the instruments to be calibrated.

2.4 PROOF

The laboratory shall establish written documentation proving that the laboratory standards together with the accuracy and stability characteristics of each calibrated instrument are adequate to assure attainment of the accuracy requirement.

3. PROCEDURES

Written procedures shall be provided for the calibration methods and periods to be used for in-house calibration of test instruments and for calibration of laboratory standards. The procedures shall be of sufficient detail to assure compliance by laboratory personnel.

4. ENVIRONMENT

Specify the control required of environmental elements in the instrument calibration facility.

5. PROCEDURE CHECK

A procedure shall be documented for conducting inspections between calibrations for the purpose of checking instrument stability and to provide for any necessary adjustment of calibration periods.

Calibration periods shall be adjusted as necessitated by results of the Procedure Checks.

6. INSTRUMENT LABELS

Record forms, such as labels, tags, or placards, and a written procedure for their use shall be provided in order to assure that required calibration intervals are adhered to and needed repairs are made.

6.1 VISIBILITY

The method of labeling shall include readily visible means of identifying the calibration status of each instrument and for drawing attention to out-of-calibration or malfunctioning instruments.

6.2 INTERVAL

The calibrated interval for all operational ranges shall be prominently displayed on the instrument.

7. CALIBRATION RECORDS

The laboratory shall maintain records on all calibrated instruments and laboratory standards. The records shall include:

1) Identification of instrument or standard being calibrated

2) Property being calibrated (where appropriate)

3) Trace path through reference or transfer standard to NBS or equivalent

4) Reference standard certificates

5) Required accuracy or other requirements

6) Current calibration data, including points or range

7) Calibration form

8) Calibration data history

9) Repair history

10) Procedure reference (See Procedures, Section 3)

11) Comments (instrument condition, limitations, disposition)

PART III CRITERIA, BY BUILDING SYSTEMS DISCIPLINES

STRUCTURES

This section covering structures, and structural testing, shall utilize general performance criteria.

The structure of a dwelling unit is the housing framing, support and attachments that form the total shelter system. Each item of this total system must be able to perform its functions with regard to normal contingencies over the life span of the system.

The raw materials, manufacturing process, installation and use affect the life of the components and must be accounted for in the design and structural testing. Minimum code requirements must be met, of course, but all areas of concern might not be encompassed in a code (legislation and standard). Professional judgment and expertise is called upon to further refine and impose those additional requirements as seen fit in order to meet the basic goals of Health and Safety.

In the course of design, certain areas are of particular concern. These areas are in need of further study to assure the structural integrity of the system. When the need is identified, structural testing is required to closely simulate the actual loading encountered. When, in the opinion of the certifying authority, it becomes apparent that compliance can only be assured by physical tests, such tests shall be identified as needed and the capability of the testing organization shall be sufficient to accomplish these tests.

Generally, a physical testing laboratory shall demonstrate the capability to perform the required tests (Table S-1). These required tests are classified, in this document, as either stipulated tests or implied tests.

1. STIPULATED TESTS

Where, in a code, a stipulated test is required the capability to perform this test shall exist. Methods detailed or referenced to specific procedures, will be followed for the purpose of evaluation. In all cases, capability to perform and interpret is a requisite and shall be fully demonstrated.

1.1 TEST OF ROOF RAFTERS OR TRUSSES

1.1.1 Equipment

The equipment required for loading shall be capable of exerting a load equivalent to sixty (60) pounds per square foot, in supported area, in increments of ten (10) pounds per square foot. These shall also be provided equipment capable of exerting an uplift equivalent to twenty-five (25) pounds per square foot. All loading devices used shall be capable of applying said loads within 5% accuracy.

COMMENTARY

Since the simplest forms of loading devices for this test could be bricks, concrete masonry units, sand bags, and the like, it is important that these or any other device be calibrated against a known standard. The most rudimentary equipment will suffice for conducting this test and as such, no great deal of sophistication is required.

1.1.2 Instrumentation

The resultant deflections occuring during this test shall be measured to within 1/16 inch. Mounting provisions and supporting fixtures shall be of sufficient rigidity so as not to influence test data.

1.1.3 Facilities

Refer to facilities required for Wall Test.

1.1.4 Personnel

Two Technicians to erect and load the test specimen with the lead Technician recording the data and an Engineer in charge, for checking results and interpretation.

1.2 FLOORING TEST

1.2.1 Equipment

The equipment used for the application of load shall be capable of 200 pounds maximum load with a repeat accuracy of 5%.

1.2.2 Instrumentation

A means of measuring resultant deflections shall be provided. The degree of precision needed shall be graduations of 0.001 inch with a full range of 1 inch with data recorded to tne nearest 0.01 inch. Mounting plates and support rods for instrumentation mounting shall be of sufficient rigidity, so as not to influence test data.

1.2.3 Facilities

Refer to facilities required for Wall Test.

1.2.4 Personnel

One Technician to load the weight and read and record the data.

2. IMPLIED TESTS (Table S-1)

The two classes of implied tests are:

1) Design Loads Assurance

Those areas of concern or questionable analytical approach where the means of assurance of structural integrity are the actual test and test data.

2) Application Assurance

Those areas of the actual construction where in order to assure compliance with plans and specs, or questionable areas of Workmanship/Materials, tests and test data are needed for proof.

A testing agency shall have the capability both for devising those tests where no standard method exists and for carrying out the devised test to meet the intent of the cognizant authority ordering such test. In all cases, capability to perform and interpret is a requisite and shall be fully demonstrable.

2.1 WALL TEST (Ref. ASTM E72)

2.1.1 Equipment

The loading equipment shall be capable of operating in each of three planes so as to produce compressive, transverse and racking load modes. This equipment shall have a means of applying the load to the wall with rate selectivity ranging from 0.03 in/min. to 0.25 in/min. In addition, it shall be capable of applying loading with 5% accuracy.

COMMENTARY

In order that various configurations and directions of loading may be accomplished, it is necessary that load applying devices be of sufficient adaptability so as to enable all combinations with a minimum of required equipment.

Section 3.3 of ASTM E72 suggests that the load rates vary from 0.03 in/min. for a compressive load on nailed wood construction to 0.20 in/min. for the racking load test.

2.1.2 Instrumentation

A means of measuring resultant deflections shall be provided. The degree of precision needed shall be graduations of 0.001 inches with a full range of 3 inches, with data recorded to the nearest 0.01 inches. Mounting plates and support rods for instrumentation mounting shall be of sufficient rigidity, so as not to influence test data.

COMMENTARY

All instrumentation, whether electronic or mechanical, should be calibrated against a traceable standard. They shall be in good working order and of sufficient range, as determined by pretest analysis, so as to include the entire test data spread.

Mounting plates, test stands, instrument racks, etc., should never adversely affect the test results. All collected data should be reasonable, reliable and repeatable.

2.1.3 Facilities

A testing area large enough to handle a full-size specimen, test stands, recording instruments, work stand, etc., shall be provided. The minimum size test area should be 150 square feet in order to accommodate a full size test specimen (wall) which is 8 feet by 8 feet. The geometry of the area shall provide sufficient clearance around the specimen.

Where temperature is a factor in any test, such temperature in the test area shall be controlled to the degree consistent with the desired test data accuracy.

Where humidity or specimen wetting is a factor in any test, such control of the humidity or wetting process shall be consistent with the degree of accuracy sought.

The temperature of the wetting solution shall be 75 ± 5°F (ASTM E72, Sec. 16.3). The temperature of the ambient air in the test area shall be controlled to 75 ± 5°F (ASTM E72, Sec. 16.3).

COMMENTARY

In general, testing facilities must take cognizance of the unique facility requirements of each test. In the above requirements, a "wetted racking test" requirement has been detailed to enable the laboratory to have an appreciation for the types of items that must be provided and demonstrated to establish their capability to perform as a complete (in any one test) structural physical testing laboratory.

2.1.4 Personnel

The minimum number of people needed to successfully accomplish the testing methods as detailed in ASTM E72 is three (3); two Technicians to accomplish the loading and data retrieval; and an Engineer, with education and experience in the field of structures analysis and structural physical testing, to take charge of the test. One of these Technicians shall have a minimum experience in structures testing of at

least one year under the supervision of an experienced (1 year or more) person, either Technician or Engineer. This Technician shall be designated the lead Technician.

COMMENTARY

To successfully meet the intent of any standard and specifically ASTM E72, a practical minimum of personnel experience has been detailed. This minimum, as detailed, should in no way preclude more personnel from being utilized for each test and in certain cases, less being used. Where fewer personnel are used, certain functions that normally would be considered technician level effort could be accomplished by the engineer-in-charge.

Minimum qualifications and detailed position descriptions are as previously presented.

2.2 ALL STRUCTURAL ASSEMBLY (Ref. ASTM E72)

2.2.1 Equipment

The equipment needed is detailed under the Wall Test and summarized in Table S-1. In addition, the approximate failure point shall be known beforehand as determined by pretest analysis. It is a requirement that safety measures and adequate protection, both for personnel and equipment, be provided. The capability must exist and be demonstrated for ascertaining failure and indicating such for all commonly used materials and combinations of materials.

COMMENTARY

In order to meet the premise of reliable, reasonable and repeatable data, prior analysis will assure adequate knowledge of anticipated failure points. Once approaching this point, care can be exercised such that the true failure point can be properly pin-pointed. Certain additional precautions as dictated by State law and/or insurance regulations shall not preclude the engineer-in-charge from exercising due precaution and forethought.

2.2.2 Instrumentation

In addition to those requirements as stated in Instrumentation Section 3.2, a means of protection against breakage and/or "over travel" shall exist. Damaged instruments shall be repaired and recalibrated against a traceable standard or discarded. No non-calibrated instruments shall be used for test purposes.

COMMENTARY

The use of non-calibrated instruments would be, of their very nature, not in keeping with the basic laboratory data premise of "reasonable, reliable and repeatable".

2.2.3 Facilities

Refer to Facilities required for Wall Test.

2.2.4 Personnel

Refer to Personnel required for Wall Test.

2.3 EXTERIOR JOINTS (Ref. ASTM B117, B287, B368)

2.3.1 Equipment

The equipment needed to conduct this test shall be:

1) A suitable chamber which is (a) temperature controlled to 95 ± 2°F and has a fine fog spray; (b) constructed of inert materials so as not to influence test results; and (c) of sufficient size to handle representative samples and sizes.

2) A camera capable of taking indoor color photographs.

3) Chemical analysis provisions sufficient so as to enable identification of corrosion products.

COMMENTARY

This test will be of great value during the prototype testing of any new or unusual usages of materials not commonly employed in the industrialized housing industry today. With the advent of different materials, tests such as this will be needed to further identify the possible long range maintenance problems that might exist. This test could also be used to verify commonly employed "rules of thumb" that exist today.

This test may be run using salt spray for accelerated life representation of actual conditions encountered in the field. However, whichever liquid is used, care must be exercised in interpretation. It is important to recognize the limitation of accelerated life testing which is; the results of such testing are a guide to selection of materials and are not hard data which can be used for analysis.

2.3.2 Instrumentation

None needed.

2.3.3 Facilities

Refer to facilities required for Wall Test.

2.3.4 Personnel

The personnel required for this test are:

1) An Engineer with experience and/or education in materials, chemical analysis and interpretation of results. One year of experience in this test with a four year college engineering degree is sufficient.

2) A Technician with one year of experience in preparing samples and conducting the test.

2.4 CHASSIS ASSEMBLY

COMMENTARY

At the present time, dynamic loading of a mobile home to test for in-transit conditions is beyond the capabilities of most structural testing laboratories. The analytical approach toward solution of the design requirement, must be fulfilled to meet the stated code requirement. (ANSI A119.1-1969, Sec. 5.3). (This capability will be covered in another document).

3. SUMMARY

3.1 EQUIPMENT

The minimum equipment required for accomplishment of the structural testing is that equipment summarized in Table S-1. It is the intent to assure the basic minimum conformance of these items when compared to standards as set forth in ASTM E4, E74, E83, E105, E122, E6, E72 and E73 as applicable. In general, all equipment shall be in good working order, with attachments and gages all in readable condition, sufficient so as to produce reasonable, reliable and repeatable data.

3.2 INSTRUMENTATION

Those means of measuring deflections, loads, reactions, temperatures, and strains are implied in the broad generic term, instrumentation.

Calibration of these instruments shall be on a routine basis against traceable standards with records available for inspection on frequency of calibration, standard use, etc. All instrumentation shall be of sufficient precision so as to produce a data read out accuracy of 5%. (Ref: ASTM E117) (Ref: NBS Special Publication SP250-1968)

3.3 FACILITIES

Where indicated, facilities shall have sufficient structural rigidity so as not to influence test results. All facilities shall be temperature and humidity controlled, where

indicated, so as not to influence test results. For ease in testing and maintaining quality results, cleanliness and order shall be of value to the evaluator.

3.3.1 References

A reference library, including all listed references from Table I, ANSI A119.1-1969, page 22, should be readily available to the laboratory personnel. In addition, those standard forms, past analyses, charts and graphs as deemed necessary shall be included in said reference library.

Provisions shall be made for maintaining this library current.

3.4 PERSONNEL

The minimum number of personnel required shall be two (2) individuals. One of these individuals must be an Engineer versed in structural physical testing, with experience and education as stated before. The second required individual shall, as a minimum, be a Technician who through a combination of training and experience can demonstrate his ability to perform such testing as is his responsibility.

Table S-1

STRUCTURAL TESTS

	ANSI A119.1 Reference 1969 Edition	Objective	Resources			Procedure
			Technical Personnel		Test Instrumentation, Fixtures & Appliances	
			Test	Interpretation		
1) Effective Flexural Rigidity	Appendix I p. 24-27	To determine effective $\overline{EI}$ of the composite coach assembly and attempt to classify as to its structural capability in a transportation mode.	T	E	*Listed in ANSI A119.1-1969, p.25 in addition, a test slab capable of carrying load and coach.	ANSI A119.1-1969, p. 24-27
2) Roof Rafters or Trusses	Appendix II p. 29-30	To determine the capability to withstand snow, wind, and live load requirements without failure. Failure is permanent set or excessive deflection.	T	E	*Suitable supports, steel rule (1/16" graduations) taut wire system, uniform loading units in 10 lb/ft^2 increments, time piece.	ANSI A119.1-1969, p. 29-30
3) Flooring	I-6-8 p. 13	To determine ability of sub-floor and floor finish to withstand service load.	T	E	*200 lb. wgt. 2 inch diameter disk or a 2 inch diameter base 200 lb. wgt., dial gage - 2 inch face graduated in .001 inches, clamp support and rods for attaching dial gage, straight edge and rule.	ANSI A119.1-1969, p. 13
4) Wall	I-6.6 p. 13	Implied test for vertical, horizontal and racking load requirements on walls.	T	E	*Load application device with 5% accuracy in application, 3 dial gages with 0 to 3 inch range, graduated to .001 inch, structure mount plates, attach clamps, strong back, etc.	ASTM E 72
5) All Structural Assembly	I-6.10 p. 14	Implied ultimate load test.	T	E	*Same as #1 above.	ASTM E 72

Table S-1 (continued)

STRUCTURAL TESTS

	ANSI A119.1 Reference 1969 Edition	Objective	Resources			Procedure
			Technical Personnel		Test Instrumentation, Fixtures & Appliances	
			Test	Interpretation		
6) Exterior Joints	I-7.1 p. 15	Implied test for corrosion resistance due to incursion of weather on exterior materials and fasteners.	T	E	*Camera, chemical analysis provisions, wet chamber.	ASTM Methods B 117, B 287, B 368
7) Chassis Assembly	I-10.1 p. 19	Implied testing for dead load, live load and dynamic loading.	T	E	*Calculation based on $\overline{EI}$ from Table S-1, Test 1	ANSI A119.1-1969, Section 10

*Load application devices can be weights, hydraulic cylinders, electromotive screw jacks, pulley systems, etc. Any device or combination of devices shall be capable of repeating the action required to within 1% (Ref: ASTM E 4).
Instrumentation such as dial gages, strain gages, linear potentiometers, etc., shall be calibrated against a traceable standard on a periodic basis to an approved plan. (Ref: ASTM E 4).

HEATING, VENTILATING AND AIR CONDITIONING (HVAC)

This section provides a listing of required HVAC tests, details where needed for clarification, and criteria for evaluating the ability of a laboratory to perform the tests listed. A summary of the detailed criteria is provided at the end of the section together with additional guide criteria pertaining to the evaluation of a laboratory's methods of operation.

The stipulated tests are listed in Table H-1 together with a summary of basic test objectives, personnel, and equipment resources needed to conduct the test. Table H-2 lists those stipulated test requirements in which the choice of testing or inspection is optional. The criteria applied depends on the option chosen. Only the testing option will be treated in this document.

The laboratory must also be capable of performing implied tests, which cover requirements stated in the reference standards, but for which no test procedure or specific result is stipulated. Implied tests are listed in Table H-3. Table H-4 lists those implied requirements for which the choice of testing, inspection or analysis is optional. Again, only the testing option will be covered here.

1. STIPULATED TESTS

The remarks which follow are intended to clarify certain of the test requirements listed in Table H-1, HVAC Stipulated Tests.

1.1 STATIC LEAK TEST - GAS PIPING SYSTEM

COMMENTARY

Loss of pressure equal to 0.06 inches Hg or greater shall be cause for rejection. Approximately 0.06 inches Hg shift in static pressure can be caused by 1°F change in gas temperature in the piping system. It is therefore necessary that the gas be in thermal equilibrium with the piping system before the test begins and that the temperature of the piping system remain essentially constant during the test.

1.1.1 Equipment

A source of compressed gas equal to 6 inches Hg minimum pressure is needed to perform this test. The gas source can be an air compressor, a bicycle tire pump, or a high pressure cylinder of nitrogen, air, etc. (avoid highly oxidizing or reducing gases) with appropriate regulators, connectors, hose, and valves. An LPG gas source could also be used with a special regulator.

Thermal equilibrium can be established by waiting for an appropriate period or by introducing the gas charge through a temperature tempering mass stabilized at room temperature (any substantial mass such as a tank of oil or water will serve). The compressed gas is passed first through the pressure regulator or other throttling means and thence through a coil of tubing (suggest 15 ft. copper or stainless tubing, diameter of 1/4 inches or less) submerged in the tank.

1.1.2 Instrumentation

Inclined mercury manometer 0-10 inches Hg or 0-5 psig, with scale increments of 0.1 inches Hg or less. Scale readability shall be enhanced by such measures as using 0.01 inch supplemental scale increments in the area of the reading, or by carefully aligning the surface of the liquid column with a mark on the scale. Ref. General Instrumentation Criteria, Section 5.2.2(11).

1.1.3 Facilities

During static leak testing of the gas piping system, the test floor or area shall provide essentially constant temperature; i.e. keep the rate of change of gas temperature in the piping system under 1°F/10 minutes. Temperature control should also be provided as necessary to maintain approximate shirt-sleeve working conditions (75 ± 15°F).

1.1.4 Personnel

Test -- One Aid, having the equivalent of ten years* of formal education and two test experiences.**

Interpretation -- One Technician having the equivalent of fourteen years of formal education.

1.2 BUBBLE LEAK TEST - APPLIANCE CONNECTIONS

1.2.1 Equipment

Thee same compressed gas source and piping connections as used for the Static Leak Test can be employed for leak testing of appliance connections. Possibly a finer bleed valve may be needed for better control of the 10 to 14 inches water column applied pressure. A supply of soapy water, a brush, an inspection mirror and a lamp complete the equipment requirements.

1.2.2 Instrumentation

Water manometer, 0-20 inches water column minimum.

1.2.3 Facilities

Test area approximating shirtsleeve working conditions.

1.2.4 Personnel

Test -- One Aid, having the equivalent of ten years of formal education and one test experience.

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*That is, an education equivalent to that of a graduate of the tenth grade. Where the equivalent of some secondary or college education is indicated in the personnel requirements, it should include industrial/vocational, pre-engineering or science courses.

**To qualify as a training experience, the test should be essentially identical to the subject test, include set-up and tear-down, and be conducted under the immediate and complete supervision of a qualified lead man or work director.

Interpretation -- One Technician, having the equivalent of fourteen years of formal education.

1.3 WET LEAK TEST - OIL TANK & PIPING SYSTEM

COMMENTARY

The surface of oil in the tank shall be adjusted to a height of 8 ± 1/4 feet above the orifice to simulate the maximum probable pressure head with the dwelling located on a sloping site.

1.3.1 Equipment

Oil tanks are not furnished as part of the dwelling unit. A suitable pressure head can be applied by connecting an elevated container to the oil line. Equipment needed includes the container, correct grade of fuel oil, connectors, hose, adjustable stand, lamp and inspection mirror.

1.3.2 Instrumentation

Twelve-foot steel measuring tape, or equivalent.

1.3.3 Facilities

Test area approximating shirtsleeve working conditions.

1.3.4 Personnel

Test -- One Aid, having the equivalent of eight years of formal education and one test experience.

Interpretation -- One Technician, having the equivalent of fourteen years of education.

1.4 SUPPLY DUCT LEAKS

1.4.1 Equipment

Tubing or hose and connectors for static pressure measurement.

1.4.2 Instrumentation

1) Static pressure pick-up, fabricated per UL 307(b) 1965, Paragraph 289.

2) Inclined water manometer, 0-5 inches water column.

1.4.3 Facilities

This test includes the measurement of furnace static discharge pressure with no heat energy input. The static pressure is not influenced by relatively small changes in ambient air temperature. A test space which is temperature controlled for a shirtsleeve working environment (say 75 ± 15°F) is deemed to be satisfactory for this test if room temperature drift is less than approximately 5°F during the period of test.

1.4.4 Personnel

Test -- Minumum of one Aid, having the equivalent of twelve years of formal education and three test experiences. It may be desirable to have one additional Aid, with equivalent of ten years education, to assist in set-up and teardown.

Interpretation -- One Technician, having the equivalent of fourteen years of formal education.

2. STIPULATED TESTS OR INSPECTIONS

Remarks in this section are intended to clarify the test option for specified requirements listed in Table H-2 wherein the laboratory has the option of either testing or inspection.

2.1 GAS PIPE SIZING

2.1.1 Equipment

The connectors and hose necessary to tee off from the gas supply and appliance connections and to hook up to the inclined manometer are required. These should be of such design and physical condition as to minimize opportunity for small leaks. Relatively small leaks in the connections will cause significant errors in low pressure measurements such as required for this test.

While flexible plastic tubing is often used for hook up of manometers, slight movement of the tubing does cause fluctuation in gage indication which could be avoided by using the less flexible types of hoses.

2.1.2 Instrumentation

Inclined manometer, 0-1 inches water column.

2.1.3 Facilities

Test area approximating shirtsleeve working conditions.

2.1.4 Personnel

Test -- One Aid, having the equivalent of twelve years of formal education and two test experiences.

Interpretation -- One Technician, having the equivalent of fourteen years of formal education.

3. IMPLIED TESTS

Remarks in this section are intended to clarify the requirements listed in Table H-3 HVAC Implied Tests.

3.1 REGULATED GAS PRESSURE

COMMENTARY

It is interpreted that the intention of this requirement is to assure provision of LPG vapor supply pressure, within the operating ranges of the appliances. The pressure shall be measured at the gas supply connection, under two different load conditions; a) with all appliance gas cocks closed, and b) with all gas appliances simultaneously operating at rated capacity. Under both conditions the measured pressure shall be within the range specified on the listing/label for each gas appliance.

3.1.1 Equipment

Connectors and hose necessary to hook up the water manometer.

3.1.2 Instrumentation

Water manometer, 0-20 inches water column.

3.1.3 Facilities

The test area and inside of the dwelling unit should be well ventilated to avoid the possibility of accumulating a hazardous quantity of combustible gas. This requirement also applies to other tests involving the possibility of leaking LPG or natural gas.

3.1.4 Personnel

Test -- One Aid having the equivalent of twelve years of formal education and one test experience.

Interpretation -- One Technician having the equivalent of fourteen years of formal education.

3.2 SIZING OF DUCTS

COMMENTARY

The purpose of this implied test is to assure adequate airflow by checking for a satisfactory match between the duct system and the furnace. Ordinarily this would necessitate checking the temperature rise across the furnace, measuring and adjusting the rate of energy to equal the manufacturer's rated input and firing the furnace at rated input until equilibrium temperature is achieved. However, the procedure outlined would entail resources typical of a furnace acceptance testing laboratory and this is not believed to be the original intent. In addition, no provision is made for the multi-speed fans.

It is therefore interpreted that the intent of this paragraph will be satisfied by operating the furnace at manufacturer's rated input ±5%, (Ref. ANSI 21.47-1968, paragraph

2.3.3), until equilibrium is achieved, with the fan adjusted to the speed (or motor terminal position) specified by the housing system producer. Attainment of equilibrium is indicated by changes in temperature of flue gas in the vent pipe of not more than ± 5°F between readings 15 minutes apart (Ref. ANSI 21.47-1968, paragraph 2.9.2). If no speed setting is specified by the housing system producer for an application using a multi-speed fan, the fan shall be set at its maximum speed for this test.

3.2.1 Equipment

Assuming that a labeled, forced-air furnace is furnished as part of the dwelling unit, with or without evaporator coil, the fixtures needed to perform this implied test are those required to set up the furnace for operation at rated input and the connections and hose to hook up the inclined manometer.

3.2.2 Instrumentation

1) Inclined manometer, 0-1 inches water column.

2) Means of measuring energy input -- for gaseous fuels, a laboratory wet test gas meter, 150 cfh; for oil vaporizing burners, a calibrated liquid graduate; for mechanical-atomizing oil burners, a scale accurate to 0.01 pounds or a burette capable of the same resultant accuracy; for electric furnaces, a wattmeter capable of reading up to about 40 KW at 120 and 240 V.

3) Stop watch.

4) Temperature indicating potentiometer or strip chart recorder.

5) Thermocouple probe for measuring gas temperature in the vent pipe, fabricated per UL 727-1970, paragraph 306, Figures 18 and 19 (Ref. also, ANSI Z96.1-1970).

6) Static pressure pickup, fabricated per UL 307 (b)-1965, paragraph 289, or UL 727.

3.3 PARTITION LOADING

COMMENTARY

This is an implied test of the structural integrity of the exposed vertical panel on alcove-installed appliances. Where the furnace panel takes the place of a wall, the panel must be capable of resisting the horizontal load test for interior surfaces (A119.1-1969, Part I, paragraph 7.3). The test criteria is -- that structural integrity necessary to resist permanent set which would be detrimental to function or appearance.

3.3.1 Equipment

One method of checking this requirement employs an air bag filled to 5 psf per applicable portions of ASTM E72, Transverse Load Test. Where the furnace faces across a hallway, the opposite wall can provide air bag reaction. In other situations, reaction must be provided by a special test fixture.

3.3.2 Instrumentation

Pressure gage for air bag, 0-1 inches water column per ASTM E72 and E4.

3.3.3 Facilities

Test area approximating shirtsleeve working conditions.

3.3.4 Personnel

Test -- One Aid having the equivalent of nine years of formal education and one test experience.

Interpretation -- One Engineer having the equivalent of sixteen years of formal education.

4. IMPLIED TESTS, INSPECTIONS, OR ANALYSIS

Remarks in this section are intended to clarify the test options applicable to the implied requirements listed in

Table H-4, wherein the laboratory has the option of either testing, inspecting or analyzing.

4.1 LPG CONTAINER RESTRAINT

COMMENTARY

The LPG Container Restraint components shall withstand the stipulated test loads with no degradation in performance of the restraint function. A load force equal to four times the filled weight of the container assembly shall be applied sequentially in each of six directions (i.e. three mutually perpendicular axes).

A test of rotational restraint may also be necessary to evaluate the effectiveness of the restraint system in preventing detrimental strain on the regulator and tubing connections. In this event, a suitable torque of, say, 25 lb.-ft. should be applied in each of three planes through the approximate center of the container. Moment arm should also be measured from the center of the container.

4.1.1 Equipment

If the installed clearance permits, testing of the container assembly restraint can be accomplished by using a webbed harness or shaped compression pad to apply the specified load. In event of insufficient clearances in the container cabinet, testing of a mock-up restraint system may be necessary.

A fixture will be necessary to incorporate the webbing attachment or compression pad, force measuring gage, and means of applying the force. The 0 to 600 pound force could be applied by means of a motor driven or manually operated screw jack, such as an automobile jack.

If it is necessary to test rotational restraint, a couple-applying fixture will be required.

4.1.2 Instrumentation

1) Force measuring gage or equivalent, 0-600 pounds.

2) Force measuring gage, 0-50 pounds.

4.1.3 Facilities

Test area approximating shirtsleeve working conditions.

4.1.4 Personnel

Test -- One Aid having the equivalent of 12 years of formal education and one test experience.

Interpretation -- One Engineer having the equivalent of sixteen years of formal education.

4.2 HEAT LOSS

COMMENTARY

ANSI A119.1-1969, paragraph I-9.3 and I-7.5, provides for either analysis or testing as alternate methods of determining heat loss for the total dwelling and for unit heat losses of floor, walls and ceiling. However, the wording of paragraph I-7.5 indicates that the analysis method was envisioned as the principal approach. The testing method of evaluation would involve considerable investment in a large, environmentally controlled test space and associated instrumentation. This criteria will therefore not include a description of requirements for determining heat loss by test.

5. SUMMARY

In this sub-section, a summary of the above criteria is provided relating to the specific test requirements. Additional guide criteria is given pertaining to a somewhat broader evaluation of the laboratory's methods of operation.

5.1 EQUIPMENT

5.1.1 Test Equipment

The minimum equipment required to conduct the HVAC tests includes:

1) Source of compressed gas with restrictions and bleed valves or other means of controlling the

applied pressure from 0 to 5 psig and to 0 - 14 inches water column.

2) Temperature tempering tank.

3) Miscellaneous regulators, connectors, hose and valves suitable for compressed gas.

4) Soap solution, method of application and means of inspecting for leaks.

5) Fuel oil of correct grade, container, connectors, hose and adjustable stand, suitable for fuel oil.

6) Tubing or hose and connectors for manometer hook-up to duct static pressure and to fuel gas supply and appliance connections.

7) Air bag (Ref. ASTM E72 Transverse Load Test).

8) Loading harness and/or compression pad (Ref. LPG Container Restraint).

5.1.2 General Equipment Criteria

Other criteria for evaluating test fixtures and equipment and practices related to such equipment include:

1. Complete library of instruction books covering setup and operation of test equipment, accessible to operating personnel.

2. Handbook or placards warning of common discrepancies or errors in utilizing test equipment.

5.2 INSTRUMENTATION

5.2.1 Test Instrumentation

The minimum instrumentation required to conduct the HVAC tests include:

1) Inclined mercury manometer, 0-10 inches Hg with scale increments of 0.1 inches Hg or less plus means of further enhancing scale readability; or alternatively, an equivalent calibration in psi.

2) Water manometer, 0-20 inches water column minimum.

3) Static pressure pickup.

4) Inclined water manometer, 0-1 inches water column.

5) Wet test gas meter, 150 cfh.

6) Calibrated liquid graduate, 0-10 ml. or equivalent.

7) Balance scale accurate to 0.01 pounds or burette capable of the same resultant accuracy.

8) Wattmeter, 120-240 V, approximately 40 KW range.

9) Stopwatch.

10) Temperature indicating potentiometer or strip chart recorder.

11) Thermocouple probe - vent pipe gas temperature.

12) Force measuring gage, 0-600 pounds, or equivalent.

13) Force measuring gage, 0-50 pounds, or equivalent.

5.2.2 General Instrumentation Criteria

General criteria for evaluating instruments and instrumentation practices include:

1) As a guide, the rate of furnace energy input should be adjusted to within ± 5% of manufacturer's specified rating. For acceptance tests, overall experimental error should be kept within ± 5% of true value*. Attainment of these objectives will generally require employment of instruments having an accuracy of ± 2 to 3% under laboratory reference conditions.

2) Tangible evidence of procedures for periodic calibration of those instruments which are subject to drift with time or usage, against traceable standards, in accordance with a calibration plan which includes the essential elements described in Part II of this document.

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*"True value" is defined here as an accepted reference level of a property, as employed in ASTM E177.

3) Security and protection of instruments from unauthorized use, as required to assure integrity of the calibration plan.

4) Ease of obtaining timely repair of malfunctioning instruments, e.g. blown or dirty manometers, so as to maintain accuracy of instrumentation when accidents occur between scheduled calibration periods.

5) Complete file of operating and instruction books provided by vendors, or written by laboratory personnel, for special instruments, accessible to operating personnel.

6) Handbook or placards warning of common discrepancies or errors in utilizing various types of instruments. Examples of typical error analysis, accessible to operating personnel.

7) Training program in use of instruments. To avoid misapplication, operating instructions and training programs should emphasize what variable the particular instrument responds to, as opposed to what units are on the indicator dial.

8) Facilities (carts, benches, racks, etc.) as necessary to provide secure mounting and appropriate orientation for accurate read-out.

9) For instruments whose accuracy is based on percent of full scale, a general guide for selecting the optimum scale to use is that the meter should have a scale range not more than one and one-half times the value to be measured. (Ref. UL 307(b)-1965 para. 286).

10) Where discrete measurements are to be taken, the smallest scale division should be not more than 1/50 of the maximum scale range. This is not applicable where "Go, No-go" readings falling on a major scale division are to be taken and no calibration correction is to be applied to the scale reading.

11) It is desirable that a uniform procedure be used for reading liquid manometers. For ordinary vertical manometers, the manometer should be read at the horizontal tangent to the "level" surface of the meniscus. For extraordinarily critical readings, corrections may be applied in accordance with NBS Monograph 8, "Mercury Barometers and

Manometers", 1964. Accepted practices should be employed in leveling the manometer and in taking "zero" readings or zeroing the scale. Zero readings should be taken before and after a pressure reading. For inclined manometers, the scale graduations should be normal to the axis of the liquid column. Improved readability is attained by reading the manometer at the tangent to the meniscus which is parallel to the scale graduations. The "zero" reading should be made in the same way.

5.2.3 Instrumentation References

In addition to the minimum instrumentation required to perform stipulated tests, more sophisticated, general purpose instrumentation may be employed which will require consideration by persons evaluating the laboratory. The characteristics of various instruments used in HVAC testing are described in many reference sources. Some of these include:

1) American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Handbook of Fundamentals*, latest Edition. (Note bibliography to Chapter 13 for further references on HVAC instrumentation).

2) Gas Engineers Handbook, American Gas Association, Sections 6 & 7, 1965, Industrial Press.

3) ASTM Part 33, Index and Glossary; Ref. accuracy, bias (systematic error), precision (repeatability, reproducibility), random error, and error.

4) Nondestructive Testing Handbook, Vol. 1 & 2, 1963, edited by R. C. McMaster, Ronald Press, Ref. Sections 1-19, 1-20, 54-3, 54-41.

5) American Society for Testing Materials (ASTM) STP 335, 1963, Manual for Conducting Interlaboratory Study of A Test Method.

6) Standards and Practices for Instrumentation, Third Edition, 1970, edited by G. F. Harvey, ISA.

7) ASHRAE Standard 41-66 Part 1, Standard Measurements Guide Section on Temperature Measurement.

8) Institute of Electrical and Electronic Engineers (IEEE) Standard No. 108 Electrical Voltmeter, No. 118 Resistance Measurement, No. 119

Temperature Measurement of Electrical Apparatus and No. 120 Electrical Measurements.

9) American National Standards Institute (ANSI) C42.30-1957, Electrical Meters.

10) Instrument Society of America (ISA) RP16.1-3 Rotameters.

11) National Electrical Manufacturers Association (NEMA) Automatic Temperature Controls.

12) Scientific Apparatus Makers Association (SAMA) SAMA II, 1 & 2 Load Cells (as well as others on thermometers, thermocouple temperature vs EMF, etc.).

13) International Standards Organization (ISO) ISO R541-1967 Measurement of Fluid Flow.

14) International Electrotechnical Commission (IEC) Various Standards on Electrical Measurements.

15) National Bureau of Standards Special Publication Series 300. Vol. 1 Statistical Concepts and Procedures, 1968, Vol. 2 Temperature, 1968; Vol. 3 Electricity - Low Frequency, 1968; Vol. 6 Heat, 1970; A collection of NBS papers, abstracts of other papers and bibliography of reference texts.

16) National Bureau of Standards Monograph 8, "Mercury Barometers and Manometers", Reprinted 1964; currently out of print.

17) Air-Conditioning and Refrigeration Institute, ARI Standards.

5.3 FACILITIES

5.3.1 Criteria for Test Facilities

The minimum required facilities in the way of shelter needed to conduct the HVAC tests include: Test floor or area sized to contain the largest dwelling unit; temperature controlled as required to maintain approximate shirtsleeve working conditions (75 ± 15°F) and restrict temperature drift of the gas in the piping system to less than 1°F/10 minutes; include vent pipe opening with protection from effects of wind gusts; provide good ventilation to remove

hazardous gases. Avoiding temperature extremes will help to assure that tests will be conducted in a workmanlike manner, prevent freeze-up of Bubble Leak Test solutions and manometer fluids and minimize the necessity for applying corrections for temperature variations.

5.3.2 Criteria for General Facilities

Laboratory space shall be provided which is suitable for general evaluation test activity; for preparation, storage and retrieval of test reports; and for calibration, protection and physical control of test instruments and fixtures.

The laboratory facilities shall include a reference library containing applicable product standards such as those listed in ANSI A119.1-1969, Part III Appendix, the ASHRAE Standards and Handbooks, and applicable testing standards and methods and reference texts such as those included in the Instrumentation References, Section 5.2.3.

5.4 PERSONNEL

5.4.1 Test Personnel

Assuming that all tests are done in sequential fashion and that personnel are trained and experienced in conducting each test, the minimum personnel needed to conduct the HVAC tests are as follows:

1) One Engineer, Mechanical, for HVAC interpretation or testing, having the equivalent of four years of engineering education including a one year course in statics and dynamics. See also General Personnel Criteria, Section 5.4.2.

2) One Technician, Mechanical, for interpretation or testing, having the equivalent of two years of engineering college. Alternatively, one Aid having the equivalent of 12 years of formal education.

5.4.2 General Personnel Criteria

The staff of the HVAC laboratory shall include at least one engineer, in either the work director or test engineer positions, who has a working knowledge of the testing of forced air, energy consuming devices, such as that obtained by at least one year of product development or acceptance

testing of furnaces or HVAC systems. Other qualifications for the Aid, Technician, and Engineer positions are included with the Criteria for the required tests and in the Part I Definitions under "Laboratory Personnel".

5.4.3 Written Procedures

The laboratory should employ standardized, written test procedures or equivalent documents, as necessary to communicate and interpret the basic objectives, the test requirements, the type of data and form of report desired and cautionary or advisory information. Where unusual or non-standard systems are to be tested, written test requests should be employed to convey the above information and to provide an engineering estimate of expected results.

Table H-1

HVAC - STIPULATED TESTS

Test	ANSI A119.1 Reference 1969 Edition	Objective	Resources			Procedures
			Technical Personnel		Test Instrumentation, Fixtures & Appliances	
			Test	Interpretation		
a) Static Leak Test-Gas Piping System	III-5.1.19.1 p. 75	::Convey gas from supply to consuming appliance. ::Conserve fuel gas energy. ::Preserve non-explosive atmosphere.	A	T	::Sheltered from solar incidence on coach to hold temperature drift rate of plumbing under 1°F/10 minutes. ::5 psig min. compressed air source and gas tempering tank. ::Hg manometer or inclined manometer (0-10" Hg or 0-5 psig).	ANSI A119.1 -1969
b) Bubble Leak Test - Appliance Conn.	III-5.1.19.2 p. 75	See item a).	A	T	::1 psig min. compressed gas source ::Water manometer or pressure gage (0-20 In. W.C.) ::Pressure control valves, connector, hoses.	ANSI A119.1-1969
c) Wet Leak Test - Oil Tank & Piping System	III-5.2.10 p. 76 and III-4.2.1 p.69	::Convey oil from supply to consuming appliance. ::Conserve oil. ::Prevent unsightly contamination and undersirable odors. ::Avoid creating potential fire hazard-fuel soaked combustible materials.	A	T	::Supply of fuel oil, all grades. ::Reservoir to simulate pressure head.	ANSI A119.1-1969
d) Supply Duct Leaks	III-6.10.4 p. 80	::Assure effective circulation of air throughout the system.	A	T	::Test-furnance. ::Test-plenum with static pickup and means of sealing off air outlet. ::Inclined water manometer, 0-1 Inches W.C.	ANSI A119.1-1969

Table H-2

HVAC - STIPULATED TESTS OR INSPECTIONS

Test or Inspections	ANSI A119.1 Reference 1969 Edition	Objective	Resources: Technical Personnel		Resources: Test Instrumentation, Fixtures & Appliances	Procedures
a) Gas Pipe Sizing	III-5.1.4	::Provide adequate supply of gas to assure satisfactory operation of all appliances.	A	T	::Inclined water manometer (0-1 In. W.C.) ::Conn. & Hose.	ANSI A119.1-1969

Table H-3

HVAC - IMPIED TESTS

Implied Test	ANSI A119.1 Reference 1969 Edition	Objectives	Resources: Technical Personnel: Test	Resources: Technical Personnel: Interpretation	Resources: Test Instrumentation, Fixtures & Appliances	Procedures
a) Regulated Gas Pressure	III-4.1.7.2 p. 68	::Maintain supply pressure within operating range of appliances.	A	T	::Water manometer (0-20 In. W.C.) ::Connectors and tubing.	Measure manifold pressure in service line (a) with all appliances gas cocks closed and (b) with all gas appliances operating at rated capacity.
b) Sizing of Ducts	III-6.10.2 p. 79	::Assure adequate air flow to: -achieve rated temperature rise, heating (avoid operating on limit) -achieve rated temperature drop, cooling (avoid icing evaporation coil) -avoid temperature stratification in living space -provide required heating or cooling capacity.	T	E	::Sheltered lab. space, temp. controlled to 75± 15°F. ::Provision for discharging flue gases outside lab (gust resistance). ::Test-furnace ::Test-evaporator coil or equivalent orifice restriction. ::Static pressure pickup tube. ::Inclined manometer (0 to 5 In. W.C.) ::Instrumentation to check rated input of furnace. ::For gaseous fuels, positive displacement volumetric flow meter 150 cfh. -for oil vaporizing burner, a liquid graduate. -for mechanical - atomizing oil burner a scale account to 0.01 pound or an equivalent burnett. -for electrical furnace, wattmeter, about 0-40 KW. ::Stop Watch. ::Means of changing orifices, and adjusting regulator setting. ::Temperature indicating potentiometer or multipoint strip chart recorder. ::Thermocouple probe - Flue Gas.	ANSI Z21.47 UL 727 NOTE: 1) Static pressure depends on fan design/rpm duct load, filter load and temperature rise through furnance. 2) Must be specified due to advent of multi-speed and variable speed fans.

Table H-3 (Continued)

HVAC - IMPLIED TESTS

Implied Test	ANSI A119.1 Reference 1969 Edition	Objectives	Resources: Technical Personnel: Test	Resources: Technical Personnel: Interpretation	Resources: Test Instrumentation, Fixtures & Appliances	Procedures
c) Partition Loading	I-7.3 p. 15	::Where a furnace panel takes the place of an interior wall, as in an alcove installation, the panel must resist horizontal loads per A119-1969, Part I, paragraph 7.3.	A	T	::Air bag.	Employ air bag test per applicable portions of ASTM E 72 transverse load test. Check for excessive residual deflection detrimental to function or appearance.

Table H-4

HVAC - IMPLIED TESTS OR ANALYSIS

Implied Tests or Analysis	ANSI A119.1 Reference 1969 Edition	Objective	Resources			Procedures
			Technical Personnel		Test Instrumentation, Fixtures & Appliances	
			Test	Interpretation		
a) LPG Container Restraint	III-4.1.3.3 p. 66	::Maintain integrity of LP gas system during transportation of coach.	A	E	::Tensometer, 0-600 lbs. ::Harness (Tension Test) ::Strap Wrench (Rotational Restraint).	::Visual inspection. ::Attempt incorrect installation ::Check vent design drawings.
b) Heat Loss	I-9.3 p. 19 and I-7.5 p. 15-18	::Conserve energy. ::Prevent surface moisture condensation. ::Tradeoff HVAC System capacity (ref. $70^{o}F$ at lowest design temp) vs cost of insulation. ::Communicate effect of storm sash to be used (placard) ::Enhance comfort by: -minimizing $(T_{db}-T_{mrt})$ -specifying minimum allowable insulation resistance for walls, floor, ceiling.	T	E	::Engineering office facilities. ::Alternatively. ::Low temperature test chamber large enough to accept coach and all instrumentation required under "Sizing of Ducts".	See Criteria. ::ASHRAE Handbook of Fundamentals. ::ANSI A119.1-1969.

FIRE SAFETY

In industrialized housing precaution must be taken against fire. In addition to the measures specified in NFPA 101-1967 Code for Safety to Life for Fire in Buildings and Structures, interior finishes and ducts must meet provisions specified by tests performed according to the ASTM Standard Method of Test for Surface Burning Characteristics of Building Materials, E84-67, (also referenced as UL723-1960, USAS 2.5-1963, and NFPA 255-1966).

This is a rather sophisticated test involving extensive conditioning and control equipment. There are only a few installations available and, as other agencies offer new testing facilities for consideration, it will be increasingly necessary to have all concerned in agreement as to the proper procedure and the meaning of the test results.

Surface flame spread test interpretation involves considerable judgment since laboratory tests afford only an indication of the behavior in a real fire. This is stressed in E84, which states, in part, that "it is the intent of this test method to register performance during the period of exposure and not to determine suitability for use after the test exposure".

This section on Fire Safety will set forth the requirements in the form of the equipment, instruments, facilities, and personnel required of a laboratory or agency to perform the stipulated test for fire safety.

1. STIPULATED TEST

1.1 THE TUNNEL TEST - ASTM E84-67

See Chart F-1.

COMMENTARY

This test has not been analyzed extensively, but one published study (ASTM MR&S May 1970 p. 19-20, 50-52) states that flame spread is most significantly affected by moisture content, brick temperature, preheat time, specimen thickness,

and related interactions. Good laboratory practice will include full consideration of all the variables plus standardization of the composition and flow of the gas supply, the use of reference standards in the area of from 50 to 75 and from 100 to 200 flame spread, and complete specifications and a stable source for the cement-asbestos board and the "select" red oak. Good laboratory practice shall also indicate the development of the assurance that 95% of the material rated by the test will be under prescribed limits. Each laboratory concerned should also pay careful attention to the methods of mounting test samples so that eventually standard methods can be developed for various classes of materials.

1.1.1 Equipment

The referenced standard (E84) sets specific requirements on the type of equipment necessary to conduct the test. The tunnel, fire test chamber, gas supply and burners are all detailed. The air conditioning equipment needed will depend on the size of the test room.

1.1.2 Instrumentation

Standard E84 specifies, in general terms, nearly all of the instruments necessary. All instruments employed must be calibrated, at least once yearly, against standards traceable to the National Bureau of Standards. All instruments should give readings accurate to 1%.

In addition, it should be specified that the thermocouples are of chromel-alumel and must be read with a potentiometer, preferably of the recording type. There should also be available a recording psychrometer to indicate continuously the temperature and relative humidity of the test room and of the air supply to the tunnel.

1.1.3 Facilities

The test room must be supplied with conditioned air at 70 ± 5°F (21 ± 2.8C) and a relative humidity between 35 and 40%. As stated before, the capacity of the air conditioning equipment must be good enough for the size room employed. This room must be large enough to house the tunnel, several operators and observers, some sample storage, and all the instruments (for easy reading).

Since ASTM E84-67 sets specific requirements for the apparatus and the environment, a copy of E84 should be available in the reference library of the laboratory or agency.

1.1.4 Personnel

Skilled Technicians (T), as defined in "Definitions", are a requisite for conducting this test. They are required to have specific training in conducting this test and to have specialized knowledge of the burning characteristics of various finish materials. An Engineer shall be in general charge of conducting the test, collecting and disseminating the data desired, and preparing and signing the report.

Two people can perform this test with duties as follows:

(1) Control Operator

(2) Flame Front Observer and Recorder.

2.0 IMPLIED TESTS

There are no implied tests for fire safety in ANSI A119.1-1969.

Table F-1

FIRE - THE TUNNEL TEST

Test	ANSI A119.1 Reference, 1969 Edition	Objective	Resources			Procedure
			Technical Personnel		Test Instrumentation, Fixtures & Appliances	
			Test	Interpretation		
Fire Tests of Interior Surfaces (Including non-metallic ducts, see III.6.10.1)	I.7.3	To ascertain that the flame spread ratings of materials used as interior surface finishes does not exceed 200.	T	E	25ft. long tunnel and appurtenant equipment as set forth in ASTM E 84-67.	ASTM E 84-67

ELECTRICAL

The objective of the development of the criteria suitable for judging the capabilities of laboratories to perform electrical testing is to ensure reliable test results.

Reliability of test findings depends on the instrumentation used, the test method employed and the experience of the personnel involved. Moreover, the precision and reliability of test instrumentation is highly dependent on the reference and working standards employed in checking and calibrating the instrumentation.

The laboratory must be able to conduct the stipulated and implied tests required by ANSI A119.1-1969. Table D-1 summarizes these tests. Inspections that could be considered functional tests, such as operation of light switches, etc., will be treated in a future quality control document.

1. STIPULATED TEST

1.1 DIELECTRIC STRENGTH TEST

The Dielectric Strength Test shall be performed by applying the test voltage (900V) for one minute between live parts (including neutral) and ground. Alternatively, the test may be performed at 1088 volts for one second.

COMMENTARY

The voltage should be applied from zero initially and it should rise gradually to the required voltage or until breakdown occurs.

1.1.1 Equipment

The Dielectric Strength Test, as stated in ANSI A119.1-1969, Section IV-24.1, can be performed with commercially available AC hypot tester.

1.1.2 Instrumentation

Refer to Instrumentation Section contained in Summary.

1.1.3 Facilities

Refer to Facilities Section contained in Summary.

1.1.4 Personnel

Refer to Personnel Section contained in Summary.

2. IMPLIED TEST

2.1 CONTINUITY OF SYSTEM GROUND

There shall be electrical continuity among the grounding terminals or enclosures of the distribution panel and all exposed metal parts, enclosures, frames, lamp fixture canopies, etc., and all exposed noncurrent-carrying metal parts that may become energized. The latter include water, gas and waste piping.

COMMENTARY

As is the case for the Dielectric Strength Test, the Continuity Test is performed to protect against fire and insure the personal safety of occupants.

2.1.1 Equipment

The continuity test, as implied in ANSI A119.1-1969, Section IV-23, can be performed using an ohmmeter or a continuity tester.

2.1.2 Instrumentation

Refer to Instrumentation Section contained in Summary.

2.1.3 Facilities

Refer to Facilities Section contained in Summary.

2.1.4 Personnel

Refer to Personnel Section contained in Summary.

3.0 SUMMARY

3.1. EQUIPMENT

The equipment listed under the stipulated and implied tests shall be required of a laboratory that performs electrical testing and inspection for factory built dwellings. An accredited laboratory should have additional equipment to perform related tasks involved in trouble-shooting investigations. Comments under Instrumentation shall also apply to this Section. A list of possible equipment and accessories could include the following:

1) Multi-range voltmeters
2) Multi-range ammeters of the conventional and tong-test types
3) Resistive electrical loads
4) Continuity equipment such as:

   (a) Magneto test set,
   (b) Head-telephone and dry battery testing set,
   (c) Electric-bell testing outfit, or
   (d) Continuity lamps or buzzers.

5) Receptacle circuit tester
6) Test-lamp set or Neon-glow lamp testers
7) Insulated fuse pliers
8) Meggers
9) Multi-range ohmmeters
10) Miscellaneous equipment such as:

   (a) Soldering iron and flux
   (b) Wire strippers, pliers, knives, hacksaw
   (c) Electrical insulation tape
   (d) Stopwatch

11) Transformers and power supplies
12) Circuit protective equipment and switchgear
13) AC hypot tester
14) Strip-chart recorders
15) Wattmeters

3.2. INSTRUMENTATION

When equipping a laboratory, reliability, safety and accuracy should be considered in the selection of instruments.

Reliability of the instruments implies that they shall be calibrated according to established reference standards and shall be in good working order so as to be able to repeat the same measurement.

Safety of the instruments implies that their handling and operation shall not constitute a hazard.

Accuracy of the equipment refers to the agreement of the instrument reading with the true value of the quantity measured. A ± 2 to 3% error shall be the maximum inaccuracy allowed for a calibrated electrical testing instrument. Then, for acceptance tests, overall error is kept within ± 5%.

In shipping the instruments from the laboratory to the test site, care shall be taken to ensure that calibrated instruments are moved without impairing their calibrations.

3.3. FACILITIES

3.3.1 Environment

The tests may be performed under the atmospheric conditions found in a housing system producer's plant.

3.3.2 Reference Standards

The laboratory should either have an electrical standards section where calibration and certification of precision measuring equipment is performed or it should subcontract to one who does.

The working standards used to calibrate its instruments should be periodically calibrated against reference standards traceable to NBS.

3.3.3 Reference Library

The laboratory should have a reference library containing applicable documents, such as the National Electrical Code, ANSI A119.1-1969, N.C. Regulations, National Electrical

Manufacturer Association (NEMA) Institute of Electrical and Electronics Engineers (IEEE) and American Society for Testing and Material (ASTM) Standards.

3.4. PERSONNEL

3.4.1 Requirements

The minimum number of competent personnel required to perform all of the electrical tests is as follows:

1) One Electrical Technicial able to conduct the test

2) One Electrical Engineer able to interpret test results

The qualifications of both the Technician and the Engineer are given the Definitions.

3.4.2 Training

The laboratory should conduct or sponsor, periodically, a training program to bring laboratory personnel to the "state-of-the-art" in electrical testing methodology, performance and quality standards.

Table E-1

ELECTRICAL TESTS

	ANSI A119.1 Reference 1969 Edition	Objective	Resources			Procedures
			Technical Personnel		Test Instrumentation, Fixtures & Appliances	
			Test	Interpretation		
1) Dielectric Strength	IV 24.1	Test electrical insulation of complete wiring. Check for improper terminal connections, dirty terminals or bad cable splices.	T	E	AC or DC HY-POT Tester	Connect tester between each of the phases and ground. Apply voltage per ANSI A119.1-1969.
2) Continuity of Ground*	IV 23	Safety - Protection against shocks.	T	E	Continuity tester or ohmmeter	ANSI A119.1-1969.

*This is an Implied Test.

PLUMBING

Testing performed on the various plumbing systems and appurtenances is of the "Go, No-go" type wherein the precision and reliability of the instrumentation is not critical. The objective of each of the tests is to ascertain whether or not the system leaks.

1. STIPULATED TESTS

There are no implied tests for plumbing systems. All tests are stipulated and are summarized in Table P-1.

1.1 WATER SYSTEM TEST

1.1.1 Equipment

The equipment and materials required for this test are as follows:

1) Potable water supply - 100 psi pressure.

2) Complete representation of prototype of water distribution system.

3) Bourdon type gage with 0 - 200 psi scale and with a maximum error of ± 2 psi @ a 100 psi reading.

4) Plugs and/or caps for closing all openings in system.

5) Timer.

1.1.2 Instrumentation

The only instrumentation requiring calibration is the Bourdon pressure gage. Its precision and calibrated range are indicated under "Equipment" above.

1.1.3 Facilities

A room of sufficient size to contain a dwelling unit or, alternatively, a full scale model of water distribution system

is required. A source of potable water having 100 psi pressure is to be provided. The room should have a drainage system for removal of water after the test and the room must be of sufficient area to contain units as large as 16 feet by 80 feet.

1.1.4 Personnel

This test can be conducted by one Technician.

1.2. DRAINAGE AND VENT SYSTEM WATER TEST

1.2.1 Equipment

The equipment and materials required for this test are as follows:

1) Dwelling unit or, alternatively, a full scale representation of prototype drainage and vent system.

2) Potable water supply.

3) Caps and/or plugs for closing all openings in the system, except the vent terminal.

4) Timer.

1.2.2 Instrumentation

None required.

1.2.3 Facilities

The same facilities specified for the Water System Test are required, except that the water supply need not be under a specified pressure.

1.2.4 Personnel

This test can be conducted by one Technician.

1.3 DRAINAGE AND VENT SYSTEM AIR TEST

1.3.1 Equipment

The equipment and materials required for this test are as follows:

1) Full scale representation of prototype drainage and vent system.

2) Potabble water supply.

3) Source of compressed air equivalent to 2 inches of water column, with valve cut-off and means of bleeding off the source pressure.

4) Water manometer, 0-4 inches water column, differential pressure range, graduated in 0.1 inch increments.

5) Caps and/or plugs for closing all openings in the system.

1.3.2 Instrumentation

Water manometer shall be graduated in 0.1 inch increments and shall have a calibrated accuracy of ± 0.05 inches.

1.3.3 Facilities

Same as required for Water System Test.

1.3.4 Personnel

This test can be conducted by one Technician.

1.4. FLOOD LEVEL TEST

1.4.1 Equipment

The equipment and materials required for this test are as follows:

1) Dwelling unit or, alternatively, a full scale representation of prototype drainage and vent system with all fixtures installed.

2) Plugs.

3) Potable water supply.

4) Timer.

1.4.2 Instrumentation

None required.

1.4.3 Facilities

Same as required for Water System Test.

1.4.4 Personnel

This test can be conducted by one Technician.

1.5. FIXTURE TEST

(See Table P-1).

1.5.1 Equipment

The equipment and materials required for this test are as follows:

1) Full scale representation of prototype drainage and vent system, with all fixtures installed.

2) Plugs.

3) Potable water supply.

1.5.2 Instrumentation

None required.

1.5.3 Facilities

Same as required for Water System Test, except potable water supply need not be under pressure.

1.5.4 Personnel

This test can be conducted by one Technician.

1.6. SHOWER STALL TEST

(See Table P-1).

1.6.1 Equipment

The equipment and materials required for this test are as follows:

1) Dwelling unit or, alternatively, a full scale representation of prototype drainage and vent system with shower stall pan installed. The shower stall pan must be tested prior to being covered by finish material.

2) Potable water supply.

3) Plug for shower stall drain.

4) Timer.

1.6.2 Instrumentation

None required.

1.6.3 Facilities

Same as required for Water System Test, except that the water supply need not be under pressure.

1.6.4 Personnel

This test can be conducted by one Aid.

1.7. FREEZE TEST

1.7.1 Equipment

The equipment and materials required for this test are as follows:

1) Full scale models of prototypes of both the water distribution, and the drainage and vent systems, complete with insulation and other weather protection as provided in the dwelling unit.

2) Method for lowering and maintaining the ambient temperature to the lowest design or capacity temperature specified on the mobile home certificate. (Ref: ANSI A119.1-1969, Figure 2).

3) Timer.

1.7.2 Instrumentation

1) Method for measuring the ambient temperature to within ± 1°F.

2) Method for measuring water or piping systems temperatures in areas most likely to freeze.

1.7.3 Facilities

A room of sufficient size to test a full scale model of both water distribution and drainage and vent systems, complete with insulation and other weather protection and designed to maintain the test temperature for a period of not less than 12 hours. There shall be a source of potable water and a drainage system for removal of water after completion of the test.

1.7.4 Personnel

This test can be conducted by one Technician.

2. SUMMARY

2.1 Equipment

The equipment required to conduct the plumbing tests is summarized as follows:

1) Dwelling unit or, alternatively, a full scale representation of prototype of water supply system.

2) Dwelling unit or, alternatively, a full scale representation of prototype of drainage and vent system with fixtures installed.

3) Bourdon pressure gage.

4) Water manometer, 0-4 inches water column, differential pressure range.

5) Potable water supply 100 psi pressure.

6) Compressed air supply equivalent to 2 inches of water column and cut-off valve.

7) Plugs and/or caps of the sizes required to seal off water supply piping, drainage and vent piping, tub drain and overflow, and shower drain.

8) Timer.

9) Method for lowering temperature in the test area.

10) Method for measuring water or piping systems temperatures in areas most likely to freeze.

2.2 Instrumentation

The Bourdon pressure gage shall be calibrated from 0 to 200 psi and shall have an accuracy of ± 2 psi at 100 psi pressure. Water manometer, 0-4 inches water column, differential pressure range, graduated in 0.1 inch increments and having a calibrated accuracy of ± 0.05 inches. A method for measuring the temperature within one degree Fahrenheit will be required for the Freeze Test.

2.3 Facilities

The room area where the plumbing tests are to be conducted shall be of sufficient size to accommodate the dwelling unit or a full scale representation of the prototype water distribution system and/or the dwelling unit or a full scale representation of the prototype drainage and vent system; this area will have to be of such construction as to maintain a specified temperature for a period of not less than 12 hours. The room shall have to accommodate those systems contained in a structure 16 feet wide by 80 feet long. There shall be available a source of potable water at a pressure of at least 100 psi, a source of compressed air capable of being accurately controlled to 2 inches of water column. The area in which the tests are to be conducted shall be equipped with a floor drainage system, supply water and drain. Waste and vent piping systems shall be maintained as separate, with no cross connections.

The laboratory shall maintain a reference library containing those standards for plumbing system components contained in Part II - Table II of ANSI A119.1-1969. The library shall also contain reference books on plumbing and hydraulic flow theory.

2.4 Personnel

Because of the nature of the plumbing testing, i.e. "Go, No-go", all testing can be conducted by one Technician with the exception of the Shower Stall Pan Test, which can be conducted by an Aid. An Engineer shall have overall responsibility for the laboratory and shall attest to all test reports. The Technician and Aid shall have at least 2 test experiences, under the direct supervision of an Engineer, for each of the test procedures he is assigned.

Table P-1

PLUMBING TESTS

Test	ANSI A119.1 Reference 1969 Edition	Objective	Resources: Technical Personnel: Test	Resources: Technical Personnel: Interpretation	Resources: Test Instrumentation, Fixtures & Appliances	Procedures
1) Water System	II-14.1	To determine whether water distribution system leaks.	T	T	a) Potable water supply of at least 100 psi pressure. b) Full scale mock-up of prototype water distribution system. c) Bourdon-type pressure gage, scale 0-200 psi accuracy ± 2 psi @ 100 psi. d) Caps and/or expandable plugs. e) Timer.	All openings on system are capped and/or plugged, pressure and/or plugged, pressure gage is installed in system. System charged with water having pressure of 100 psi air bled out of system. Pressure to hold at 100 psi for 15 minutes.
2) Drainage and Vent System	II-14.2	To determine whether drainage and vent system leaks. Several methods available as follows:				
Water Test	14.2.1		T	T	a) Potable water supply. b) Mock-up of prototype of entire drainage and vent system, including fixtures. c) Timer.	Before plumbing fixtures are connected, all openings are capped or plugged, system filled to top of highest vent opening, water level to hold for 15 minutes.
Air Test	14.2.2		T	T	a) Potable water supply. b) Air supply equivalent to 2 inches of water. c) Water manometer, 0-4 inches W.C. d) Caps or plugs. e) Mock-up of prototype of entire drainage and vent system, including fixtures.	After all fixtures are installed traps filled with potable water, remaining openings capped and/or plugged, air pressure equivalent to 2 In. W.C. applied to system. If system loses pressure, it is leaking.

Table P-1 (Continued)

PLUMBING TESTS

Test	ANSI A119.1 Reference 1969 Edition	Objective	Resources: Technical Personnel: Test	Resources: Technical Personnel: Interpretation	Resources: Test Instrumentation, Fixtures & Appliances	Procedures
Flood Level Test	14.2.3		T	T	a) Potable water supply. b) Mock-up of prototype of entire drainage and vent system including fixtures. c) Caps or plugs. d) Timer.	Mock-up to be erected so as to represent system in a leveled prefabricated unit. Tub and shower drains plugged. System filled with water to rim of water closet bowl. Trapped air bled off. Water level of water closet to be tested by filling high fixtures with water and simultaneously emptying system to obtain maximum flow in piping and checking for leaks.
Fixture Test	14.2.4	Check for leaks and retarded flow in fixtures.	T	T	See Flood Level Test.	Fill fixtures and connections with water and test for leaks and retarded flow while emptying.
3) Shower Stall Test	14.3	Check for leaks in shower stall linings (nonmetallic).	A	A	a) Nonmetallic linings b) Potable water c) Timer	Nonmetallic shower stall lining to be filled with water to top of dam. Water level to hold for 15 minutes.
4) Freeze Test	5.2.4	To assure that all piping and fixtures subject to freezing are insulated or protected to prevent freezing.	T	T	a) Potable water supply b) Mock-up of entire water supply, drainage and vent system, including all fixtures installed with insulation and protection. c) Caps and plugs. d) Method for lowering temperature to that specified for zone which unit is designed for. e) Thermometer. f) Timer.	Complete mock-up to be erected with water supply, drainage and vent piping in place, fixtures installed, lines filled with potable water, protection and/or insulation provided as per approved plans of unit. The entire assembly to be erected in a location where test temperature can be lowered to that required in the design of the heating system for the unit piping to withstand temperature without freezing for 12 hours.

PART IV LABORATORY ORGANIZATION

GENERAL

In Parts I and III, the general scope and technical resources of a laboratory have been emphasized. However, it is unrealistic to assess a laboratory's potential solely on these bases. Therefore, it is a necessity that a suitable management structure exist for the proper, productive, and successful operation of the laboratory. Each laboratory, regardless of its size, must have a management structure to coordinate and oversee the range of jobs and to prioritize this work in terms of defined policy and resources available. Specifically, there are three basic functions which are requisite for efficient operation of a laboratory:

1) allocation and coordination of physical resources;

2) allocation and coordination of personnel; and

3) allocation and coordination of finances.

It is realized that to establish specific criteria, applicable to every laboratory and covering these basic functions, would be most difficult. Therefore, it is incumbent upon the investigative and/or evaluative agency that these functions shall be taken into consideration when a laboratory is evaluated.

APPENDIX

SI CONVERSION UNITS

In view of present accepted practice in this country in this technological area, common U.S. units of measurement have been used throughout this paper. In recognition of the position of the USA as a signatory to the General Conference on Weights and Measures, which gave official status to the metric SI systems of units in 1960, we assist readers interested in making use of the coherent system of SI units, by giving conversion factors applicable to U.S. units used in this report.

Length

1 in = 0.0254* meter

1 ft = 0.3048* meter

Area

1 in^2 = 6.4516* x 10^{-4} $meter^2$

1 ft^2 = 0.09290 $meter^2$

Force

1 lb (lbf) = 4.448 newton

1 kip = 4448 newton

Pressure, Stress

1 psi = 6895 $newton/meter^2$

Mass/Volume

1 lb/ft^3 (lbm/ft^3) = 16.02 $kilogram/meter^3$

Temperature

°F (Fahrenheit) = 9/5 °C (celsius) + 32* .

*Exactly

FORM NBS-114A (1-71)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBSIR 73-224	2. Gov't Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE

Criteria for Testing Laboratories for Manufactured Building One and Two Family Dwelling Systems and Components

5. Publication Date: November 1972

6. Performing Organization Code

7. AUTHOR(S) James O. Bryson, Adolfo A. Camacho, Frank M. Gavan, Jim L. Heldenbrand, Morris A. Robinson, Bertram M. Vogel

8. Performing Organization: NBSIR 73-224

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

10. Project/Task/Work Unit No.: 4601131

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

National Bureau of Standards

13. Type of Report & Period Covered: Preliminary Report

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

This report presents and explains the criteria by which testing laboratories can be judged for their capability to perform tests identified in the North Carolina Procedures and Regulations for Mobile Homes, Modular Dwelling Units and Other Factory Built Structures-1970 Edition. This also includes the American National Standard for Mobile Homes, ANSI, A119.1-1969 which the code adopts by reference. Technical resources, in terms of facilities, equipment, instrumentation and personnel, necessary to perform each of these tests were subsequently identified after a thorough study of each test. The information is arranged in the report into four major parts (I) General Information, (II) Calibration Plan, (III) Criteria by Building Systems Disciplines and (IV) Laboratory Organization.

Each tests along with those technical resources required for its performance is further identified under one of the five building systems disciplines, namely, (1) Structures, (2) HVAC, (3) Fire Safety, (4) Electrical and (5) Plumbing. This criteria is found in Part III of this report.

17. KEY WORDS (Alphabetical order, separated by semicolons) Accreditation of laboratories; factory built houses; institutional examining agency; laboratory evaluation, building; methodology, examining laboratories; mobile homes; modular houses.

18. AVAILABILITY STATEMENT

[X] UNLIMITED.

[ ] FOR OFFICIAL DISTRIBUTION. DO NOT RELEASE TO NTIS.

19. SECURITY CLASS (THIS REPORT): UNCLASSIFIED

21. NO. OF PAGES

20. SECURITY CLASS (THIS PAGE): UNCLASSIFIED

22. Price

USCOMM-DC 66244-P71