Lawrence Livermore Laboratory

PROPOSED SAFETY STANDARDS FOR ERDA
TRAILERS AND OTHER PORTABLE STRUCTURES

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PROPOSED SAFETY STANDARDS FOR ERDA TRAILERS AND OTHER PORTABLE STRUCTURES

I. GENERAL CONSIDERATIONS

A. Introduction

The use of trailers, and other portable structures, has become wide-spread throughout the ERDA contractor installations. The low-cost and easily transportable temporary structures are prevalent, especially on installations whose growth rate is so high that it is economically not feasible to construct new permanent buildings at a comparable rate to accommodate the new employees and facilities. In spite of their advantages, some portable structures can create a greater safety problem for an installation than a permanent building. Such a problem can occur since the relatively stringent building and occupancy codes applicable to permanent buildings do not apply to commercially used mobile structures. It is not surprising then to find some trailers constructed with inferior products which render them less than safe. They are highly vulnerable to fire, windstorm, and other property damage.

Although on June 15, 1976 the Department of Housing and Urban Development had issued a new building code for mobile homes,¹ presently no comparable document exists for ERDA-owned portable structures. Each installation has its own safety standards which creates difficulty in monitoring the manufacturer's design plans and construction as well as in certifying by an authorized inspection agency that the trailer complies with the standard. One way to ameliorate this difficult situation is to establish a uniform ERDA Trailer Safety Standard. Such a standard should attempt to unify the presently used safety codes as well as to recommend additional safety measures to ensure protection of the lives and health of ERDA contractor employees and to minimize programmatic losses which could result from a fire or other accidents.

To prepare ourselves for the task of writing the standards, we visited a number of trailer manufacturers in California, surveyed ERDA contractor installations, and witnessed combustion tests performed at the LLL Testing Laboratory and the full-scale fire test facility for mobile homes at the National Bureau of Standards. To determine the major causes of fires, we studied fire incidents that had occurred in trailers used by ERDA contractors and privately owned mobile homes. Finally, we reviewed numerous State and Federal construction codes and building safety standards. These are presented in the Bibliography section of this report.

1. Mobile Home Construction and Safety Standards, HUD, June 15, 1976.

We learned from our visits to the trailer manufacturers that unless otherwise specified, the walls in an average trailer are panelled with 1/4-in. plywood veneer. This material delaminates quickly in a fire and burns fiercely, the varnish coating further enhances the flame spread. It was material such as this that caused the loss of life in the Boston Coconut Grove fire and other life-loss fires. The standard ceilings are combustibile fiberboard tile similar to Celotex, which has been prohibited for all AEC/ERDA permanent buildings since the early 1950's. The underfloor insulation is asphalt-impregnated fiberboard. This highly combustibile material can be readily ignited by firebrands, debris, or by discarded smoking material igniting wind-blown debris around or beneath the trailer. The electrical wiring in the average trailer is run in non-metallic sheathed cable (Romex). Although conduits are preferred by most Fire Chiefs, Romex is acceptable if it is hand-driven to wood with non-metallic sheathed cable staples or tied to metal with nylon cable ties. Unless otherwise specified, trailers intended for offices are not fireproofed, but have smoke detectors installed in them. Exits in typical office trailers are minimal and nonstandard. Some inside or screen doors do not open in the direction of exit travel, but open inward, contrary to the usual exit method in code-complying buildings. Such practices hamper egress in an emergency situation.

Our cross-country trailer survey shows the diversity in the end usage of the mobile structures. They are used for offices, laboratories, snack rooms, computer rooms, instrumentation small shops, storage, and dormitories. Perhaps one of the most salient points gleaned from this survey is the ease with which the mobile units can be filled with hundreds of thousands of dollars worth of material and equipment, mission critical or important programmatic activities, or occupancies posing life safety problems. Many of these units fail to meet the building and occupancy codes applicable to permanent structures, and in case of fire or other accidents, the material and programmatic losses could be much greater than we realize.

Some of the more evident safety problems associated with mobile units are in the following areas: wiring, structural, heating and air conditioning, spacing between trailers and permanent structures, life safety, and fire. Among these, fire is by far the greatest problem.

The following figures show examples of the different types of trailers that are presently used on the various installations. Figure 1 portrays one

Fig. 1. Office trailers.

of the older office trailer complexes. The individual trailers are connected by wooden walkways and stairs and are separated from each other anywhere from just a few inches to 15 feet, depending upon the code requirements of an installation. Most of the office trailers do not have any fire detection alarm systems, and the only means of primary fire suppression consists of portable fire extinguishers. The lack of automatic detection systems and the highly combustible nature of these trailers could result in a total loss within about 10 minutes should a fire occur. However, installation of a sprinkler system and an alarm system connected to the local Fire Department in such a complex would give the trailers a better chance for survival.

Figure 2 shows a wheel-chair lift that can be very easily incorporated into a trailer design. Ramps could also be used to accommodate the handicapped employees. Unfortunately, not too many installations have made provisions for their wheel-chair-confined employees.

Figures 3 and 4 show examples of instrumentation trailers. There are at least three types of mobile units that are used to house electronic equipment: magnesium trailers, aluminum-clad wood frame construction trailers, and modified commercial-type steel-sheathed vans. The fire detection and suppression systems in these high-value and/or programmatically important trailers varies from portable fire extinguishers to automatically activated detectors and extinguishing systems. In the automatic systems, the heat or smoke detectors are connected to the installation's Fire Department, and the suppression system is activated by the second alarm heat or smoke detectors.

Since the rate of flame spread is much faster in a trailer than in a permanent building, an automatic detection and suppression system should be mandatory when the trailers are loaded with high-value equipment. Had such a system been installed in the high-value instrumentation trailer complex at the Nevada Test Site, a loss of 1/2 million dollars worth of equipment might have been prevented. In December 1976, fire erupted in one of the trailers and went undetected until a passerby saw the smoke and alerted the Fire Department. Unfortunately, when firefighters arrived on the scene, the fire had developed to such an extent that the burning structure was beyond salvage and firefighters were concentrating on preventing further spread of the fire to nearby trailers.

Figure 5 shows an excellent way to protect an instrumentation trailer that is placed inside a permanent structure. This trailer is equipped with a smoke-detector-activated Halon system and sprinklers on top of the roof.

Fig. 2. Computer trailer with a wheel chair lift.

Fig. 3. Magnesium trailers used as an Instrumentation Facility.

Fig. 4. Modified commercial vans and aluminum-clad wood frame construction trailers used as Instrumentation Facilities.

Fig. 5. Fire protection for an Instrumentation trailer.

Figure 6 shows one type of dormitory trailer that is used out in the field. They are aluminum clad, or wood frame construction, separated from each other by less than 3.0 meters (10 feet). The fire protection consists only of portable fire extinguishers. Although the value of this cluster of structures is low, the trailer arrangement violates the Health and Safety Standards regarding trailer spacing, number of exits per unit housing eight people,* and maximum square footage of trailer complexes.

Figures 7(a) through (d) show the inside of a computer trailer and the second alarm smoke-detector-activated Halon 1301 suppression system. The first detector zone emits an audible sound to alert the trailer occupants and the Fire Department of possible trouble in the area. At the same time, the ventilation system is shut down. In the event of a false alarm, the occupants can manually disable the Halon system and prevent the unnecessary Halon discharge. In the event of fire, the second detector zone will go off and discharge the Halon into the area.

Our analysis of trailer accidents consisted of those involving both mobile homes and trailers used on ERDA-contractor installations. The mobile homes were included in this study since the construction materials used in mobile homes are frequently used in office, some dormitory, and some instrumentation trailers. We had learned that fire is the most prevalent hazard in both the mobile homes and in trailers used for technical purposes. Some of the characteristics of trailers and mobile homes which can contribute to fires and related injuries are:

- Numerous Ignition Sources — faulty wiring or aluminum wiring has been a cause of many fires. Another common ignition source is heaters which may have misaligned flues that can direct hot air at highly flammable paneling.
- Rapid Fire Spread — because of the low ceilings, narrow corridors, highly flammable thin, plywood paneling and combustible interior furnishings. Since plywood is used in most trailers instead of gypsum board, which is usually used in houses, flames can spread quickly down the corridor and throughout the trailer.

* Only one exit is provided per unit.

Fig. 6. Dormitory trailers.

(a)

(b)

Fig. 7. (a-b) Halon 1301 Suppression System used in a computer trailer.

(c)

(d)

Fig. 7. (c-d) Halon 1301 Suppression System used in a computer trailer.

- Difficulty in Getting Out — because of faulty or blocked exits. Some mobile homes and office trailers have small windows which cannot be used for emergency exit.

Another hazard associated with trailers is the danger of tip-over in high winds or a mild earthquake. There are tie-downs which can hold the trailer down and keep it from sliding sideways off its blocks. However, they are not very widely used because they have to be installed before the trailer is put on the site.

Table 1 shows examples of the accidents found in trailers on ERDA-contractor installations.

Table 2 condenses some accident experience from mobile homes. The data summarized here show how the above-mentioned trailer characteristics affect the fire build-up, and also the efficiency of countermeasures in reducing the fire losses.

The guidelines proposed in this study cover all materials and installations used in the design, construction, fire safety, plumbing, heat-producing and electrical systems, and insulation of trailers and other portable structures. In addition, these recommendations cover size of trailers and spacing between them, industrial safety and hygiene, and testing of the various materials used in the construction of trailers and other portable structures. The following examples illustrate just a few of the safety features that the standard covers.

In the area of fire safety, we suggest measures which will provide a reasonable degree of safety from fire to the occupants of the various types of trailers and to minimize programmatic losses which could result from a fire. We recommend that materials for various interior structures as well as carpets and drapes be noncombustible and able to pass certain standards for resisting flame spread. Trailer foundations shall be tightly enclosed to prevent accumulation of trash or storage of equipment beneath the trailer. A number of detection and suppression systems are suggested for various types of trailers as well as trailer complexes. For example, each trailer unit 3×16 m (10×52 ft) shall have a local audible alarm. Each office in such a unit shall have a smoke or heat detector which will be connected to a master box either at the trailer unit or at the nearest building. Unsprinklered office trailer complexes shall be divided by two-hour firewalls into areas not exceeding 465 m (5000 ft^2). Sprinklered office trailer complexes shall be divided by two-hour firewalls into areas not exceeding 1394 m ($15,000 \text{ ft}^2$).

Table 1. Analysis of accidents in trailers in ERDA-contractor installations.

Location	Occupancy	Date	Weather Conditions	Cause of Accident	Major Contributions to Accident	Extent of Injuries	Extent of Damage	Fire-Fighting Effort	Existing Counter Measures	Recommended Counter Measures	Additional Comments
LASL Kirtland Air Force Base	Electronics lab and office trailer.	March 1969	Not reported	Short in non-metallic sheathed cable.	Combustible acoustical tile.	None	\$67,900	Firefighters put out fire with <50 gal of water.	None	Automatic detection and alarm systems and self-contained extinguishment system should be used.	Interior construction should be non-combustible and/or fire-retardant material.
Brookhaven	Electronics Lab.	Oct. 1972	Not reported	Heaters heat-up overload protectors did not operate.	Faulty wiring in electrical terminal panel.	None	\$528	Burned itself out.	None	Smoke and heat detectors are being installed	
NTS	Change trailer	Jan. 1970 (early morning)	Cold	Heat from the propane water heater ignited enclosure around the water heater.	Combustible plywood enclosure around water heater.	None	\$2,000	1-inch booster line quickly extinguished the fire.	None	Installation of proper clearance and use of non-combustible material.	
NTS (remote location)	Restrooms	Oct. 1973 (early morning)	Not reported cold	Arson - small area ignited with a match.	Combustible plywood paneling.	None	\$120	Firefighters opened the wall and extinguished fire.	None	Smoke detectors.	
Argonne, Chicago	Fire control growth experimental lab.	Dec. 1974 (early morning)	Cold	Improper use of electrical wiring strung near ceiling.	Styrofoam plastic beneath electrical timer.	None	\$100	1-15 lb CO ₂ extinguisher ² used by firefighters to extinguish fire.	Smoke and heat detectors	None	
Lawrence Livermore Laboratory	Office-lab trailer	May 1970	Not reported	Monroe desk-type calculator failed internally.	Fire did not spread past the calculator.	None	\$650	Fire extinguisher	None	Disconnect business machines.	

Table 1. (Continued)

Location	Occupancy	Date	Weather Conditions	Cause of Accident	Major Contributions to Accident	Extent of Injuries	Extent of Damage	Fire-Fighting Effort	Existing Counter Measures	Recommended Counter Measures	Additional Comments
Idaho	Storage trailer	Dec. 1974 (early morning)	Snowy, cold, windy	Overhead heater ignited wooden support board.	Plywood shelf	None	\$96	Fire extinguisher used by fire-fighters extinguished fire.	Heat detectors only	Smoke detectors	
Rocky Flats	Office	Dec. 1975 (early morning)	Cold, windy	Winds in excess of 100 mph loosened cable.	Improperly tied down	None	\$6,000 side, top of the roof were destroyed.	NA	Tied down	Proper tie-down and placement.	
Nevada	Office & Electronics repair, and storage repair.	Dec. 1967 (afternoon)	Clear, extremely high velocity wind	Overhead heater overheated because fan stalled.	Combustible ceiling.	None	\$65,000	Firefighters extinguished fire with a booster pump.	None	Smoke and heat detectors; remove heaters and replace with thermostatically controlled heaters.	
Nevada	Portable office unit	Dec. 1971 (afternoon)	Cold, windy	Electric heater fan failed, wall paneling and ceiling ignited.	Combustible wall paneling.	None	\$200 - wall and ceiling only.	Extinguished with fire extinguisher by occupant.	None	Use mfg recommendation to install heaters.	
Nevada	Restroom housing-type trailer, remote area	March 1972 (evening)	Clear, cool	Could not be determined.	Thirty-minute response time from nearest fire station; combustible construction	None	Total loss \$2,500	Security inspector attempted to put out fire with portable fire extinguisher but failed.	Portable fire extinguisher		
Nevada	Six office trailers	Jan. 1976		Undetermined cause. Probable cause: electrical.	Inadequate spacing between trailers.		Loss of all six trailers.	Fire dept. response delayed approximately 5.0 min; people who saw smoke drove to complex instead of calling Fire Dept.	Automatic fire alarm system		Trailers were close together, connected with wood breezeway. Lack of H ₂ O in tank; trailers were set on wooden cribbing.
Nevada	Office trailer	April 1973 (morning)		Malfunction of a ceiling-mounted electric heater.	Combustible acoustical tile.	None	\$750	Fire controlled by employee with hand extinguisher; Fire Dept. completed extinguishment of fire.	Portable fire extinguisher	Take all improperly installed heaters out of service.	

Table 2. Analysis of accidents in mobile homes.

Location	Occupancy	Date	Weather Conditions	Cause of Accident	Major Contributions to Accident	Extent of Injuries	Extent of Damage	Fire-Fighting Effort	Existing Counter Measures	Recommended Counter Measures	Additional Comments
DaKota, Illinois	Mobile home	Jan. 1973 (early morning)	Very cold	Defective oil burner	Combustible plywood walls.	2 killed	Total loss	None	None		Fire spread rapidly from heater room into adjoining rooms.
Alden, New York	Mobile home	Jan. 1971 (night)	Not reported	Short in lamp cord.	Combustible fiberboard interior finish.	1 dead of smoke inhalation	\$7,000	Husband tried to fight fire with garden hose.	None	Smoke detector alarm system.	Fire spread from victim's bed to combustible fiberboard interior finish.
South Dakota	Mobile home	Jan. 1971	Not reported	Electrical tape wrapped on pipe caught insulation board on fire.	Combustible insulator board.	None	\$7,000	30-min. delay between time fire was discovered and Fire Dept. was alerted.	None		
Marshalltown, Iowa	Mobile home	June 1973	Not reported	Arcing in aluminum wiring.	Improper wiring.	None	Total loss	None	None	Do not use aluminum wiring.	
Boaz, Alabama	Mobile home	Feb. 1974 (afternoon)	Not reported	Air conditioner started fire due to faulty wiring.	Improper wiring, inferior materials.	None	Minimal	Fire confined to space of origin.	None		

Table 2. (Continued)

Location	Occupancy	Date	Weather Conditions	Cause of Accident	Major Contributions to Accident	Extent of Injuries	Extent of Damage	Fire-Fighting Effort	Existing Counter Measures	Recommended Counter Measures	Additional Comments
Merit Island, Florida	Mobile home	April 1974 (night)		Foam pillow was kicked on electric heater.	Combustible interior finish	1 killed 1 suffered 2nd degree burns over 40% of body.	Total loss	Not reported			Fire spread through combustible interior finish and the antique furniture it contained.
Portland, Oregon	Mobile home	Jan. 1971 (night)		Careless disposal of cigarette in one of the bedrooms.	Inadequate spacing in trailer court.	None	Total loss of 3 trailers.	Not reported		Install smoke detectors.	Inadequate spacing of trailers caused fire to spread to two adjoining trailers.
Great Falls, Montana	Mobile home	Nov. 1972		Electric wiring shorted by mail.	Plastic undercoating of the mobile home.	None	Damage to the entire floor area throughout the trailer.	Not reported	None		Fire ignited plastic undercoating of the mobile home, destroying the entire floor.
Pickaway, Ohio	Mobile home	Nov. 1973		Electrical lines to space heaters overheated.	Improper wiring.	None	\$10,000	Local Fire Dept.		House wiring should have been checked.	
Jerry City, Ohio	Mobile home	Oct. 1973 (early morning)		Spontaneous ignition in one corner in the kitchen.	Wood veneer plywood paneling.	Eight children died	Total loss	None	None	None	
Kawkawlin Twp., Mich.	Mobile home	Oct. 1974 (night)		Space heater overheated and ignited wall.	Poor housekeeping blocked exit.	1 man died	Total loss	None			

Individual trailers containing equipment values at \$100,000 or more shall be protected by an automatic fire extinguisher system. This system shall either be an automatic fire sprinkler system or Halon 1301. In addition to the automatic sprinkler system, high-value trailers shall have local visible and audible alarms mounted on the outside of the trailer. The trailer alarm circuit should be connected to the fire alarm circuit at the installation Fire Department.

In the area of construction, we point out that the body and frame must have adequate structural strength and rigidity and be protected against weather, corrosion, decay, and insects. The trailers must have provision for support and anchoring that can prevent it from sliding or overturning. Roof trusses, wall, floors, windows and doors must meet strength tests under various wind and snow conditions and while the unit is being hauled. Trailers to be located where hurricanes and heavy snows are prevalent must meet special tests. Walls, floors, and roofs must be insulated and a certificate provided to indicate the lowest outdoor temperature at which the heating equipment will maintain a 20.5°C (70°F) temperature inside. Data about central air conditioning must be provided.

In the area of plumbing we suggest that piping exposed to weather, water, mud, and road hazards must be protected from damage, deterioration, and freezing, and must not protrude where it could be easily damaged during transit.

Finally, in the heating and cooling systems we point out that fuel supply containers must have such things as accessible cutoff valves, automatic pressure regulation devices, and relief valves. Sturdy plates with information about safe fuel storage and handling should be attached permanently to an outside wall near each gas supply connection.

B. Definitions

The following definitions are common to all subparts, and are in addition to the terms that are defined in the individual subparts:

- *Combustible material* — materials made of or surfaced with, wood, compressed paper, plant or other substance that will ignite and burn. These materials shall be considered as combustible even though flameproofed, fire-retardant treated or plastered.
- *ERDA Manual* — prescribed standards as they appear in the manual.
- *Imminent safety hazard* — a hazard that presents an immediate and unreasonable risk of death or severe personal injury.
- *Installations* — all arrangements and methods of construction, as well as fire safety, plumbing, heat-producing, and electrical systems used in trailers.
- *Labeled* — identifying mark of a nationally recognized testing laboratory inspection agency or other organization concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials, and whose labeling indicates compliance with nationally recognized standards or tests to determine suitable usage in a specified manner.
- *Listed or certified* — included in a list published by a nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.
- *Manufacturer* — any person engaged in manufacturing or assembling movable structures.
- *Trailer or trailer unit* — a sectional unit of the complex transported on its own wheels and under carriage with its own towbar or a modular or sectional unit transported on a separate vehicle. It may or may not have wheels, and may be placed either inside or outside of fixed structures and buildings.

II. BODY AND FRAME DESIGN AND CONSTRUCTION REQUIREMENTS

A. Scope

This subpart covers the minimum requirements for materials, products, equipment and workmanship to assure that the trailer will provide:

- Structural strength and rigidity.
- Protection against erosion, decay, and insects.
- Protection against hazards of windstorm.
- Resistance to the elements.
- Durability and economy of maintenance.

B. Definitions

- *Anchoring equipment* — straps, cables, turnbuckles and chains, including tensioning devices, used with ties to secure a trailer to ground anchors.
- *Anchoring system* — a combination of ties, anchoring equipment and ground anchors that will, when properly designed and installed, resist overturning and lateral movement of the trailer from wind and seismic forces.
- *Tie* — strap, cable, or securing device used to connect the trailer to ground anchors.
 - Diagonal tie* — a tie intended to primarily resist horizontal forces, but which may be used to resist vertical forces.
 - Vertical tie* — a tie intended to resist the uplifting or overturning forces.
- *Footing* — portion of the support system that transmits loads directly to the soil.
- *Ground anchor* — any device at the trailer stand designed to transfer trailer anchoring loads to the ground.
- *Loads*
 - *Dead load* — the weight of all permanent construction including walls, floors, roof, partition, and fixed service equipment.
 - *Live load* — the weight superimposed by the use and occupancy of the trailer including wind load and snow load, but not including dead load.

- *seismic* - lateral movement of the portable structure due to an earthquake.
- *Windload* - The lateral or vertical pressure or uplift on the trailer due to wind blowing in any direction.
- *main frame* - structural component on which is mounted the body of a trailer.
- *pier* - that portion of the support system between the footing and the trailer exclusive of caps and shims.
- *sheathing* - material which is applied on the exterior side of a building frame under the exterior weather-resistant covering.
- *Stabilizing devices* - all components of the anchoring and support system such as piers, footings, ties, anchoring equipment, ground anchors, and any other equipment which supports the trailer and secures it to the ground.
- *Support system* - a combination of footings, piers, caps and shims that will, when properly installed, support the trailer.

C. General Requirements

Construction

All construction methods shall be in conformance with accepted engineering practices.

Structural Analysis

The strength and rigidity of the component parts and/or the integrated structure shall be determined by engineering analysis or by suitable load tests to simulate the actual loads and conditions of application that occur.

Allowable Design Stress

The design stresses of all materials shall conform to accepted engineering practice. The use of materials not identified as to strength or stress grade shall be limited to the minimum allowable stresses under accepted engineering practice.

Alternate Test Procedures

In the absence of listed and prescribed standards, the manufacturer shall develop or cause to be developed necessary tests to demonstrate the structural properties and the significant characteristics of the method employed. Such tests shall be witnessed by an independent licensed professional engineer or architect or by a recognized testing organization. Copies of the test results shall be kept on file by the manufacturer.

D. Materials

Dimensions and board lumber shall not exceed 19% moisture content at time of installation.

The materials used and methods of construction shall comply with the latest edition of the following standards:

- American Institute of Steel Construction (AISC).
- Application and Fastening Schedule HUD-FHA Bulletin UM-25C, ICC Regulations.
- National Design Specification for Stress Grade Lumber and Its Fastening (NFP).
- National Electrical Code.
- National Fire Codes.
- Standard for Mobile Homes (ANSI A119.1).
- Uniform Building Code (UBC).
- Uniform Mechanical Code.

E. Structural Design Requirements for All Occupancies

1. General Considerations

All construction methods shall be in conformance with accepted engineering practices to ensure durable and safe structure. Exposed metal structural members shall be protected to resist corrosion.

The strength and rigidity of component parts and/or the integrated structure shall be determined by engineering analysis or by suitable load tests to simulate the actual loads and conditions of application that occur on-site.

Trailer units shall be designed, constructed, installed, and blocked so as to withstand all dead loads plus live loads, as specified herein, including both vertical and lateral loads. The individual units of a trailer complex

shall be fastened to each other at roof, walls and floors in such a way as to make the entire structure respond to all loads and force as a unit rather than as individual units.

2. Design Loads

Design Dead Loads — design dead loads shall be the actual dead load supported by the structural assembly under consideration.

Design Live Loads — the roof live load or snow load shall not be considered as acting simultaneously with the wind load, and the roof live or snow load and floor live loads shall not be considered as resisting the overturning moment due to wind.

3. Wind, Snow and Roof Loads

Standard Wind Loads (Zone I) — Trailers and other portable structures in the standard wind zone shall be designed to withstand the following wind loads:

- Horizontal — 718 Pa (15 lb/ft²)
- Vertical upward — 575 Pa (12 lb/ft²)

Hurricane Wind (Zone II) — Trailers and other portable structures designated "Hurricane-and windstorm-resistive" shall be designed for the following wind loads:

- Horizontal — 1200 Pa (25 lb/ft²)
- Vertical upward — 718 Pa (15 lb/ft²)

Roof Loads — Roofs shall be designed to resist the following live loads, applied downward on the horizontal projection:

- North Zone — 1915 Pa (40 lb/ft²)
- Middle Zone — 1435 Pa (30 lb/ft²)
- Hurricane Zone — 955 Pa (20 lb/ft²)

The three wind zones and roof load zones are shown in Figs. 8 and 9.

Seismic — The seismic load shall be $0.133 \times (\text{dead load} + 25\% \text{ of floor live load})$.

STANDARD WIND ZONE I 15 PSF HORIZONTAL 9 PSF UPLIFT
 HURRICANE ZONE II 25 PSF HORIZONTAL 15 PSF UPLIFT

Fig. 8. Wind zone map.

North 40 PSF (Snow)
 Middle 30 PSF (Snow)
 South 20 PSF (Minimum)

Fig. 9. Roof load zone map.

4. Fastening of Structural Systems

Roof framing shall be securely fastened to wall framing, walls to floor structure, and floor structure to chassis, so as to resist wind overturning and sliding as imposed by design loads mentioned in section E-3.

5. Walls

The walls shall be of sufficient strength to withstand the load requirements as defined in section E-3. The connections between the bearing walls, floor, and roof framework members shall be fabricated in such a manner as to provide support for the material used to enclose the trailer, and to provide for transfer of all lateral and vertical loads to the floor and chassis.

6. Floors

Floors in individual trailers should be designed to withstand a minimum uniform live load of 2400 Pa (50 lb/ft²) plus the dead load of materials. In addition, floors shall be able to support a 91.kg (200-lb) concentrated load on a 50 mm (2-in) diameter disc at the mostly critical location with a maximum deflection not to exceed 0.3 mm (1/8-in) relative to floor framing. Perimeter joists of more than 150 mm (6 in.) depth shall be stabilized against overturning from superimposed loads as follows: (1) at ends by solid blocking of not less than 50 mm (2-in.) thickness by full depth of joist, or by connecting to a continuous header of not less than 50-mm (2-in) thickness and not less than the depth of the joist with connecting device; and (2) at (2-44 mm) (8-ft) maximum intermediate spacing by solid blocking or by wood cross-bridging of not less than 25 × 75-mm (1 × 3-in.) metal cross-bridging of equal strength.

7. Roofs

Roofs shall be strong enough to withstand the load requirement as mentioned in section E-3. The connections between roof framework members and bearing walls shall be fabricated in such a manner as to provide for the transfer of design vertical and horizontal loads to the bearing walls, and to resist uplift forces.

Roofing membranes shall be rigid enough to prevent deflection which would permit ponding of water or separation of seams due to wind, snow, ice, or transportation forces.

All roof penetrations for electrical, plumbing, or mechanical systems shall be properly flashed and sealed. Where a metal roof membrane is penetrated,

a wood backer shall be installed. The backer plate shall be not less than 7.9-mm (5/16-in.) plywood, with exterior glues, secured to the roof framing system beneath the metal roof, and shall be of a size to assure that all screws securing the flashing are held by the backer plate.

8. Ceilings

Ceilings shall consist of fiberglass or mineral fiber panels having a Class A Fire Rating, noncombustible, with flame spread of 25.

F. Windstorm Protection

Each trailer shall have provisions for support and anchoring systems which, when properly designed and installed, will resist overturning and lateral movement of the trailer as imposed by the respective design loads. The design wind loads to be utilized for calculating resistance to overturning and lateral movement shall be the wind loads indicated in Section E-3.

The maximum allowable surface soil bearing pressure for pier design is 1.03 MPa (1,500 psi).

Vertical and Lateral Stability

Provisions for vertical and lateral stability can be either at least two rows of standard wood cribbing, or other means such as metal piers with soil anchor or concrete block piers with frame tie-downs. Units may be supported by treated wood plates anchored to the ground surface.

Ties shall be as evenly spaced as practical along the length of the trailer with not more than 2.43 m (8 ft.) open-end spacing on each end.

When continuous straps are provided as vertical ties, such ties shall be positioned at rafters and studs. Where a vertical and diagonal tie are located at the same place, both ties may be connected to a single ground anchor, provided that the anchor used is capable of carrying both loadings.

Double-wide trailers shall require only diagonal ties. These shall be placed along the main frame and below the outer side walls.

The individual units of multiple trailer assemblies shall be fastened to each other at roof, walls, and floors by positive means to make the entire structure respond to loads as a unit rather than as individual units.

Protection shall be provided at sharp corners where the anchoring system requires the use of external cables or straps. Protection shall also be provided to minimize damage to roofing or sliding caused by the cable or strap.

Anchoring equipment shall be capable of resisting an allowable working load equal to or exceeding 1432 kg (3150 lb) and shall be capable of withstanding a 50% overload, i.e. 2148 kg (4725 lb) total or without failure of either the anchoring equipment or the attachment point on the trailer.

G. Resistance to Elements and Use

Exterior coverings shall be of moisture-and weather-resistive materials attached with corrosion-resistant fasteners to resist wind, snow, and rain. Metal coverings and exposed metal structural members shall be of corrosion-resistant materials, or shall be protected to resist corrosion. All joints between portions of the exterior covering shall be designed and assembled to protect against the infiltration of air and water, except for any designed ventilation of wall or roof cavity.

Joints between dissimilar materials and joints between exterior coverings and frames of openings shall be protected with a compatible sealant suitable to resist infiltration of air or water.

The trailer foundation shall be tightly enclosed to prevent accumulation of trash or storage of equipment beneath the trailer. A rodent and insect barrier shall be constructed of 15.9-mm (5/8-in.) fire-rated gypsum board which meets the UL listing. The widely used barrier in trailers is a highly flammable, asphalt-impregnated polyethylene.

H. Structural Design Requirements for Specific Occupancies

The following requirements are additional to provisions specified in the earlier sections.

1. Computer Trailers

All materials used in the fabrication and installation of the computer complex shall be noncombustible.

All construction shall be capable of supporting the live loads and resisting the lateral forces mentioned in Section E, and shall be capable of supporting a steel subfloor load of 7.18 kPa (150 lb/ft²).

Structural Components

Underpinning — Shall be designed and constructed to withstand vertical loads and lateral forces due to wind and/or seismic loads as mentioned in Section E.

Floor System — The main support girder of the floor system shall consist of rolled or formed steel sections with welded connections. Floor beams of steel and the steel subfloor above shall be securely bolted or welded together and fastened to the main supporters. The subfloor top surface shall be smooth and free of cracks, joints, etc., and shall provide a smooth surface to receive raised computer flooring. All joints in the structural subfloor deck shall be sealed with non-flammable mastic or sealer to make the subfloor air-tight. In computer complexes, joints at subfloor between trailer units shall be sealed with nonflammable gasket to maintain the air tightness of the subfloor as a unit.

Exterior Walls — Shall be constructed of metal studs of adequate size, and spacing shall not exceed 41 mm (16 in.) O.C., to support the design loads and to resist lateral forces specified.

Roofs — The roof structures should be supported only on exterior end walls. There shall be no intermediate free-standing supports such as pipe columns. The roof shall be supported by trusses which span approximately 15.6 mm (52 ft) and are supported only on the end walls.

2. Instrumentation Trailers

A commercial-type van shall be modified to accommodate electronic equipment. The modifications shall consist of the following:

- The wood floor shall be covered with sheet metal, and a metal raised floor shall be installed.
- A false ceiling of fibrous-glass or mineral-fiber panels having a Fire Rating Class 25 Type A noncombustible, in a steel or aluminum-tee-bar grid system shall be installed.

III. PLANNING CONSIDERATIONS

A. Scope

This section covers the following architectural considerations:

- Floor areas of individual structures and complexes
- Separation distances between temporary structures and permanent buildings

- Ceiling heights
- Glass and glazed openings
- Exit facilities.

B. Definitions

- *Floor area* — all space, wall-to-wall, including recessed entries which are not to exceed 0.46 m^2 (5 ft^2).
- *Exposure* — the heat effect from an external fire which might cause ignition of or damage to an exposed building or its contents.
 - *Exposure to Radiant heat* — that might pass through windows or other openings in the facade of a burning building, from the flames issuing from the windows of a burning building, or from flames issuing from the burning facade of a building.
 - *Exposure to flames* — issuing from the roof or top of a burning building in cases where the exposed building is higher than the burning building.
- *Pilot ignition* — the radiant ignition of a material by thermal radiation where a local, high-temperature igniting source is located in the stream of gases and volatiles issuing from the exposed material. In practice, a glowing ember or a flash of flame might constitute the high-temperature ignition source which merely serves to ignite the flammable gases and volatiles.
- *Noncombustible materials* — materials, no part of which will ignite and burn when subjected to fire.
- *Monetary value* — value of the structure plus the value of its contents. This shall be grouped as follows:
 - *Low value* — less than \$100,000.
 - *Moderate value* — \$100,000 to less than \$1 million
 - *High value* — \$1 million to \$25 million

C. Requirements for All Occupancies

1. Floor Areas of Individual Structures and Complexes

Floor areas of complexes shall not exceed 465 m^2 (5000 ft^2) by more than 10%.

Larger complexes (unsprinklered) shall be divided by two hour firewalls and automatic door closures activated by ionization smoke detectors into areas not exceeding 465 m^2 (5000 ft^2) by 10% as per ERDA Manual 6301 Appendix I3C. An ordinary Hazard NFPA #13 STD sprinkler system will increase the maximum area to 1394 m^2 ($15,000 \text{ ft}^2$) which is not to be exceeded by 10% before firewalls are required.

2. Spacing

Parameters Affecting the Distances Between Structures -

The following parameters are taken from NFPA 80A "Recommended Practice for Protection of Buildings from Exterior Fire Exposure" (1975).

- *Width of Exposing Fire (w)* — the length of the exposing wall between exterior end walls where no separations exist.
- *Height of Exposing Fire (h)* — the height in feet of the number of stories involved in the exposing fire, considering such factors as building construction, closure of vertical openings, and fire resistance of floors.
- *Percent of Opening in Exposing Wall Area* — the percentage of the exposing wall made up of doors, windows, or other openings within assumed height and width of the exposing fire. Walls without the ability to withstand fire penetration for more than 20 minutes should be treated as having 100% opening. Walls having the ability to withstand fire penetration for more than 20 minutes, but less than the expected duration of the fire, should be treated as having 75% openings.
- *Severity* — three levels of exposure severity are assumed: light, moderate, and severe. Two of the important properties influencing fire severity are:
 - The average combustible load per unit floor area.
 - The characteristics and average flame spread ratings of the interior wall and ceiling finishes.

Table 3 serves as a guide in assessing severity on the basis of these properties. In using this table, the more severe of the two classifications should govern.

Table 3. Levels of exposure severity.

Classification of severity ^a	<u>Fire loading of Floor Area</u>		Average flame spread rating of interior wall and finish ^c
	psi	Pascals	
Light	1-7 ^b	0-335 Pa	0-25
Moderate	7-15	335-720	26-75
Severe	15 +	720 +	75-up

^aWhere only a portion of the exposing building has combustible interior finish (i.e. some rooms only, ceiling only, some walls only, etc) this factor is considered in judging severity classification inasmuch as it reduces the average flame spread rating.

^bExcluding any appreciable quantities of rapidly burning materials such as certain foamed plastics, excelsiors, or flammable liquids. Where these materials are found in substantial quantities, the severity should be classed as moderate or severe.

^cSee NFPA No. 255-1972, Methods of Test of Surface Burning Characteristics of Building Materials.

Guide Numbers for Minimum Separation Distance — Table 4 gives the guide numbers for minimum separation distances. The guide numbers are a function of exposure severity, percent openings, and the ratio of w/h or h/w (the higher dimension always becomes the numerator). The separation distances are then computed by multiplying the lesser dimension of width (w) or height (h) by the guide number and adding 1.52 m (5 ft) to the result. Suggested separation distances contemplate Fire Department response. Where no organized firefighting facilities are available, the distances derived from guide numbers should be increased by a factor of up to 3.

Separation Adjustments — The separation distances can be reduced by applying various means of protection, as shown in Table 5.

Table 4. Guide numbers for minimum separation distances.

Severity			Width/Height or Height/Width																
Light	Moderate	Severe	1.0	1.3	1.6	2.0	2.5	3.2	4.	5.	6.	8.	10.	13.	16.	20.	25.	32.	40.
Percent openings ^a			Guide number (multiply by lesser dimension, add 5 feet, (1.52 m) to get building-to-building separation)																
L	M	S																	
20	10	5	0.36	0.40	0.44	0.46	0.46	0.49	0.50	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
30	15	7.5	0.60	0.66	0.73	0.79	0.84	0.88	0.90	0.92	0.93	0.94	0.94	0.95	0.95	0.95	0.95	0.95	0.95
40	20	10	0.76	0.85	0.94	1.02	1.10	1.17	1.23	1.27	1.30	1.32	1.33	1.33	1.34	1.34	1.34	1.34	1.34
50	25	12.5	0.90	1.00	1.11	1.22	1.33	1.42	1.51	1.58	1.63	1.66	1.69	1.70	1.71	1.71	1.71	1.71	1.71
60	30	15	1.02	1.14	1.26	1.39	1.52	1.64	1.76	1.85	1.93	1.99	2.03	2.05	2.07	2.08	2.08	2.08	2.08
80	40	20	1.22	1.37	1.52	1.68	1.85	2.02	2.18	2.34	2.48	2.59	2.67	2.73	2.77	2.79	2.80	2.81	2.81
100	50	25	1.39	1.56	1.74	1.93	2.13	2.34	2.55	2.76	2.95	3.12	3.26	3.36	3.43	3.48	3.51	3.52	3.53
—	60	30	1.55	1.73	1.94	2.15	2.38	2.63	2.88	3.13	3.37	3.60	3.79	3.95	4.07	4.15	4.20	4.22	4.24
—	80	40	1.82	2.04	2.28	2.54	2.82	3.12	3.44	3.77	4.11	4.43	4.74	5.01	5.24	5.41	5.52	5.60	5.64
—	100	50	2.05	2.30	2.57	2.87	3.20	3.55	3.93	4.33	4.74	5.16	5.56	5.95	6.29	6.56	6.77	6.92	7.01
—	—	60	2.26	2.54	2.84	3.17	3.54	3.93	4.36	4.82	5.30	5.80	6.30	6.78	7.23	7.63	7.94	8.18	8.34
—	—	80	2.63	2.95	3.31	3.70	4.12	4.61	5.12	5.68	6.28	6.91	7.57	8.24	8.89	9.51	10.05	10.50	10.84
—	—	100	2.96	3.32	3.72	4.16	4.65	5.19	5.78	6.43	7.13	7.88	8.67	9.50	10.33	11.15	11.91	12.59	13.59

^a Trailers shall be treated as combustible with 100% openings.

Table 5. Separation adjustments.

Means of protection	Separation distance adjustment
<u>A. Frame or combustible exterior wall</u>	
1. Replace with blank fire-resistive wall (3-hr minimum).....	reduce to 0 m (ft)
2. Install automatic deluge water curtain over entire wall with no windows or with wired glass windows or with windows closed by 3/4 hr protection.....	reduce to 1.52 m (5 ft)
3. Install automatic deluge water curtain over entire wall with ordinary glass windows.....	reduce 50%
<u>B. Noncombustible exposed exterior wall (fire resistance less than 3 hr.)</u>	
1. Replace wall with blank fire-resistive wall (3-hr minimum).....	reduce to 0 m (ft)
2. Close all wall openings with material equivalent to wall, or with 3/4-hr protection and eliminate combustible projections.....	reduce 50%
3. Install automatic deluge water cur- tain over entire wall with no windows or with windows closed by 3/4-hr protection.....	reduce to 1.52 m (5 ft)
4. Install automatic deluge water curtain on all wall openings equipped with or- dinary glass and on combustible project- ions.....	reduce 50%
<u>C. Veneered exposed exterior wall (combustible construction covered by a minimum of 100 mm (4 in) of masonry):</u>	
1. Replace wall with blank fire-resistive wall (3-hr minimum).....	reduce to 0 m (ft)

Table 5 (cont.)

Means of protection	Separation distance adjustment
2. Close all wall openings with 3/4-hr protection and eliminate combustible projections.....	reduce 50%
3. Close all wall openings with material equivalent to wall construction and eliminate combustible projections.....	reduce 1.52 m (5 ft)
4. Install automatic deluge water curtain over windows equipped with wired glass or over 3/4-hr closed openings and on combustible projections.....	reduce 1.52 m (5 ft)
5. Install automatic deluge water curtain over windows equipped with ordinary glass and on combustible projections.....	reduce 50%
<u>D. Fire-resistive exposed exterior wall</u>	
1. Close all openings with material equivalent to wall or protect all wall openings with 3-hr protection.....	reduce to 0 m (ft).
2. Protect all openings with 1-1/2-hour protection.....	reduce by 75% (maximum req'd = 3.0 m (10 ft))
3. Protect all wall openings with 3/4-hr protection.....	reduce by 50% (maximum req'd = 6.0 m (20 ft))
4. Install automatic deluge water curtain on all wall openings with wired glass or with 3/4- or 1-1/2-hr protection.....	reduce to 1.5 m (5 ft)
5. Install automatic deluge water curtain on all wall openings equipped with ordinary glass.....	reduce 50%

Practical Examples -- The following practical examples will illustrate the use of the concepts found in NFPA 80 A:

Example 1. Determine the distance between two unsprinklered one-story trailers assessed monetary value at \$300-\$500/m² (\$50/ft²)

- width of exposing fire (w) = 30 m (100 ft)
- height of exposing fire (h) = 6 m (20 ft)
- percent openings = 100%
- severity = moderate
- width vs height 30/6 (100/20) = 5
- guide number from table = 4.33
- separation distance $6 \text{ m} \times 4.33 + 1.5 \text{ m}$
(20 ft $\times$ 4.33 + 5 ft) = 28 m (91.60 ft)

Example 2. Determine the separation distance between an unsprinklered trailer and a sprinklered trailer complex of 1500 m² (16129 ft²) assessed monetary value at \$300-\$500/m² (\$50/ft²).

- one story
- width of exposing fire (w) = 18 m (60 ft)
- height of exposing fire (h) = 6 m (20 ft)
- percent openings = 100%
- severity = light
- width vs height 18/6 (60/20) = 3
- guide number from table = 2.28 (by interpolation)
- Separation distance $6 \text{ m} \times 2.28 +$
(20 ft $\times$ 2.28 + 5) = 50.60 ft. (15 m)

The distances will of course be reduced by an appropriate factor if any of the protective measures listed in Table 5 are incorporated in the temporary structures.

It is suggested that a distance of at least 15 m (50 ft) be maintained between:

- Two sprinklered trailer complexes each having an area of 1500 m² (16,000 ft²).
- Two non-sprinklered trailer complexes each having an area of 465 m² (5,000 ft²).
- Between a sprinklered complex of 1500 m² (16,000 ft²) and a wood frame building.

The concepts discussed are illustrated in Fig. 10.

Fig. 10. Separation distances between structures.

Location — All trailers shall have direct access from a street, or shall be suitably located as to permit fire apparatus to be operated within 30 m (100 ft).

All complexes shall be located so that firefighting equipment is not blocked from access to adjacent structures.

3. Ceiling Heights

All portable structures shall have a minimum ceiling height of 2.13 m (7 ft).

4. Glass and Glazed Openings —

- All windows shall meet the requirements of 280.403, the "Standard for Windows and Sliding Glass Doors Used in Mobile Homes."
- Safety glazing materials, where used, shall meet ANSI Z 97.1 (1972).
- Tempered glass, where used, shall also meet FS DD-G1403A.
- Insulated glass, where used, shall meet or exceed the requirements of Sealed Insulating Glass Manufacturers Association (SIGMA), and shall be permanently identified with the name of the insulating glass manufacturer.

5. Exit Facilities

General Provisions — Each trailer shall have at least two exits which are remote and accessible from any point in a trailer within a minimum travel distance. This distance shall not exceed 60 m (200 ft). There shall be no dead-end corridors in excess of 6 m (20 ft).

All exits shall discharge directly to a street, yard, or open area with the open corridor of travel not to be within 7.6 m (25 ft) of any fence or structure.

All access routes to exits shall have separate circuit with separate power emergency power to lights, spaced a maximum of 7.6 m (25 ft).

Interior and Exterior Doors --

- Exterior doors shall be a minimum of 3° × 6⁸ (0.91 m × 2.03 m) of Standard Trailer design.
- All doors used for emergency exit shall swing with the exit travel direction.
- Latches or other releasing devices to open exit doors or doors in the path of travel to reach exits shall be of the safety type which shall permit opening the door and exit from inside by the simple operation of a single knob or lever.
- Doors leading through wall paneling which harmonize in appearance with the rest of the walls shall be clearly marked as exits.
- All exit doors designed to be kept normally closed shall bear signs indicating, NOTICE EXIT, EMERGENCY USE ONLY.
- All exit doors designed to be kept normally closed shall be provided with a self-closing mechanism.

Stairs -- Portable stairs of wood or metal shall be provided for each exterior door. Stair platform landings shall be minimum 5° × 5° (1.53 m × 1.53 m) and level with trailer floor. Stairs and platform shall be provided with handrails and securely fastened to the structure. Stairs and platform shall meet OSHA 1910.24 requirements. The first step shall be 16 in. minimum from door edge.

The stair assembly shall be inspected at least twice per year and repaired as required to meet OSHA requirements.

Provisions for Handicapped -- Ramps shall be provided in trailers or trailer complexes that are planned to be occupied by handicapped employees.

The ramps shall conform to the general requirements of Section 5-1 and 5-6 in the NFPA NO. 101 Lift Safety Code.

D. Requirements for Specific Occupancies

1. Dormitory trailers

Every sleeping room shall have at least one outside window. Such windows shall be operable from the inside, without the use of tools, to provide a clear opening of not less than 56 mm (22 in.) in least dimension and 0.46 m^2 (5 sq ft) in area. The bottom of the opening shall be not more than 1.22 m (4 ft.) above the floor.

IV. THERMAL PROTECTION

A. Scope

This section sets forth the requirements for condensation control, air infiltration, and insulation. The following provisions are recommended for all occupancies. There are no additional provisions for specific occupancies.

B. Definitions

- *Pressure envelope* — primary air barrier surrounding the living space which serves to limit air leakage. In construction using ventilated cavities, the pressure envelope is the interior skin.
- *Thermal Envelope Area* — the sum of the surface areas of outside walls, ceiling and floor, including all openings. The wall area is measured by multiplying outside wall lengths by the inside wall height from floor to ceiling. The floor and ceiling areas are considered as horizontal surfaces using exterior width and length.

C. Materials

Materials used for insulation shall be of proven effectiveness and adequate durability to assure that required design conditions concerning thermal transmission are attained.

D. Condensation Control (vapor barriers)

1. Ceilings

Ceilings shall have a vapor barrier having a permeance not greater than 1 perm (dry cup method) installed on the living space side of the roof cavity.

2. Exterior walls

Exterior walls shall have a vapor barrier not greater than 1 perm (dry cup method) installed on the living space side of the wall.

Unventilated wall cavities shall have an external covering and/or sheathing which forms the pressure envelope. The covering and/or sheathing shall have a combined permeance of not less than 5.0 perms. In the absence of test data, combined permeance may be computed using the formula $P_{\text{total}} = 1 / [(1/P_1) + (1/P_2)]$ where P_1 and P_2 are the permeance values of the exterior covering and sheathing in perms. Formed exterior siding applied in sections with joints not caulked or sealed shall not be considered to restrict water vapor transmission.

Wall cavities shall be constructed so that ventilation is provided to dissipate any condensation occurring in these cavities.

E. Air Infiltration

- Envelope air infiltration — the opaque envelope shall be designed and constructed to limit air infiltration to the interior of the trailer. Any design, material, method, or combination thereof which accomplishes this goal may be used.
- Envelope penetrations — installations of window and door frames shall be constructed or treated to limit air infiltration.
- Joints between major envelop elements — Joints not designed to limit air infiltration between wall-to-wall, wall-to-ceiling and wall-to-floor connections shall be caulked or otherwise sealed.

F. Heat Loss

Transmission Heat Coefficient: The overall coefficient of heat transmission of portable structures for the respective zones and an indoor design temperature of 20.5°C (70°F), including internal and external ducts, and excluding infiltration ventilation and condensation control, shall not exceed the $\text{W.m}^{-2}.\text{K}^{-1}$ BTU/(hr) (sq ft) (F) of the trailer envelope area as tabulated below:

Zone:	Maximum transmission coefficient:
I	$0.89 \text{ W.m}^{-2}.\text{K}^{-1}$ [0.157 BTU/(hr)(sq ft) (F)]
II	$0.72 \text{ W.m}^{-2}.\text{K}^{-1}$ [0.126 BTU/(hr)(sq ft)(F)]
III	$0.59 \text{ W.m}^{-2}.\text{K}^{-1}$ [0.104 BTU/(hr) (sq ft) (F)]

To assure uniform heat transmission, cavities in exterior floors and ceilings shall be provided with thermal insulation. The insulation shall be of fibrous glass with an aluminum foil vapor barrier on the interior side to eliminate sweating.

G. Heat Loss, Heat Gain and Cooling Loading Calculations

Information, values and data necessary for heat loss and heat gain determinations shall be taken from the 1972 ASHRAE Handbook of Fundamentals:

- Infiltration and Ventilation — Chapter 19
- Determination "R" and "U" Value — Chapter 20
- Heating Load — Chapter 21
- Cooling Load Calculations — Chapter 22
- Outdoor Winter Design Temperatures (Use 97-1/2 percent values)
Chapter 33
- Outdoor Summer Design Temperatures (Use 2-1/2 percent values)
Chapter 33

H. Criteria in Absence of Specific Data

The following criteria are taken from HUD's "Mobile Home Construction and Safety Standards," December 1975. In the absence of specific data, these shall be used for purposes of heat loss/gain calculations.

1. Infiltration Heat Loss

In the absence of measured infiltration heat loss data, the following formula shall be used to calculate heat loss due to infiltration and intermittently operated fans exhausting to the outdoors. The perimeter calculations shall be based on the dimensions of the pressure envelope.

Infiltration Heat Loss = $0.7 (T) \text{ ft of perimeter) BTU/hr}$ where
 $T = 70$ minus the heating system capacity certification temperature stipulated in the Heating Certificate, in F.

2. Framing Area

- Wall — 15% of wall area less windows and doors.
- Floor and Ceiling — 10% of the area.

3. Insulation Compression

Insulation compressed to less than nominal thickness shall have its nominal R-values reduced for that area which is compressed in accordance with Fig. 11.

When insulation is installed over the framing members, the thermal performance of the insulation is reduced to compression at the framing member. The resistance value of the insulation between the framing members is reduced by 12.5% for framing members 450 mm (18 in.) O.C., 8.5% for framing members 610 mm (24 in.) O.C., and 4% for framing members 1.22 m (48 in.) O.C.

4. Air Supply Ducts Within Floor Cavity

Air supply ducts located within a floor cavity shall be assumed to be heating or cooling the floor cavity to working space temperatures unless the duct is structurally isolated by the framing system or thermally insulated from the rest of the floor cavity with thermal insulation at least to R-4.

5. Air Supply Ducts Within Ceiling Cavity

Where supply ducts are located in ceiling cavities, the influence of the duct on cavity temperatures shall be considered in calculating envelop heat loss or heat gain.

6. Supply Duct Loss and/or Heat Gain

The supply loss or heat gain shall be calculated using the actual duct surface area and the actual thickness of insulation between the duct and outside of the trailer. If there is an air space of at least 12.7 mm (1/2 in.) between the duct and the insulation, heat loss/gain need not be calculated if the cavity in which the duct is located is assumed to be at working space temperature. The average temperature inside the supply duct, including ducts installed outside the trailer, shall be assumed to be 53.5°C (130°F) for purposes of calculation of heat loss and 15°C (60°F) for heat gain.

7. Return Air Cavities

Cavities used as return air plenums shall be considered to be at working space temperature.

Fig. 11. Insulation compression.

V. HEATING AND COOLING SYSTEMS

A. Scope

This section covers the heating, cooling and fuel-burning equipment installed in portable structures. Most of the information presented in this section is taken from NFPA 501 B, NFPA 501 C and HUD's Dec. 18, 1975 "Mobile Home Construction and Safety Standards."

B. Definitions

- *Accessoible* - when applied to fixture, connection appliance of equipment, means having access to, but which may require the removal of an access panel, door, or similar obstruction.
- *Air duct* - conduits or passageways for conveying air to or from heating, cooling, air conditioning or ventilation equipment, but not including the plenum.
- *Class 0 air ducts* - ducts of materials and connectors having a fire hazard classification of zero.
- *Class 1 air ducts* - ducts of materials and connectors having a flame spread rating of not over 25 without evidence of continued progressive combustion and a smoke-developed rating of not over 50.
- *External combination heating /cooling system* - comfort conditioning system placed external to the trailer with connecting ducts to the trailer for the supply and return air systems.
- *Fuel gas piping system* - the arrangement of piping, tubing, fittings, connectors, valves and devices designed and intended to supply or control the flow of fuel gas to the appliance.
- *Plenum* - an air compartment which is part of an air-distributing system, to which one or more ducts or outlets are connected.
- *Readily accessible* - direct access without the necessity of removing any panel, door, or similar obstruction.

C. Requirements for all Occupancies

1. Fuel Supply Systems

The following conditions shall be met whenever gas is used for heating or cooling portable structures:

LP-Gas systems shall be of the vapor-withdrawal type. Gas, at a pressure not over 3500 Pa (14 in.) water column, or 1/2 psi shall be delivered from the system into the gas supply connection.

Containers shall be constructed and marked in accordance with the specifications for LP-Gas containers of the U.S. Department of Transportation (DOT) or the Rules for Construction of Unfired Pressure Vessels, Section VIII, Division 1, ASME Boiler and Pressure Vessel Code. ASME containers shall have a design pressure of at least 2.15 MPa (312.5 psig).

LP Gas containers shall be located at least 7.62 m (25 ft) away from the portable structure.

Valves in the assembly of a two-cylinder LP-Gas container system shall be arranged so that replacement of containers can be made without shutting off the flow of gas to the appliance.

DOT containers shall be provided with safety relief devices as required by the regulations of the U.S. Department of Transportation. ASME containers shall be provided with relief valves in accordance with Subsection 221 of the Standard for the Storage and Handling of Liquefied Petroleum Gases (NFPA No. 58-1974; ANSI Z 106. 1 - 1974).

A readily accessible, approved manual shutoff valve shall be installed at the outlet of a gas supply tank. The valve shall be installed to close against the supply.

2. Gas Piping Systems

All materials used for the installation, extension, alteration, or repair of any gas piping system shall be new and free from defects or internal obstructions. Inferior or defective materials shall be removed and replaced with acceptable material. Materials used shall comply with ANSI Standard B 36.10 (1970) for Wrought-Steel and Wrought-Iron Pipe; ASTM B 43-66 for standard sizes and specifications for Seamless Red Brass Pipe; ASTM A 539-73 Steel Tubing for Gas and Fuel Oil Lines.

Gas pipe sizing, joints for gas pipes, and joints for tubing shall comply with provisions in the HUD's "Mobile Home Construction and Safety Standards," Dec. 1975.

Tubing shall not be run inside walls, floors, partitions, or roofs. Where tubing passes through walls, floors, partitions, roofs or similar installations, such tubing shall be protected by the use of weather-resistant grommets that shall snugly fit both the tubing and the hole through which the tubing passes.

D. Heating and Air Conditioning Units

Every air-conditioning unit or a combination air-conditioning and heating unit shall be listed or certified by a nationally recognized testing agency for the application for which the unit is intended, and installed in accordance with the terms of its listing.

The air-conditioning unit or the combination air-conditioning/heating unit will comply with HUD's subsection 280.714 of the "Mobile Home Construction and Safety Standards," Dec. 18, 1975.

There shall be one exterior-mounted, thermostatically controlled temperature control unit per each temporary structure 3 x 16 m (10 x 52 ft) with a minimum of four ceiling supply and return diffusers. For a larger structure, an appropriately engineered HAVAC should be installed.

The supply ducts shall be concealed in ceiling space and shall be installed with 12.7 mm (1/2 in.) thick interior insulation, or prefabricated insulated section. All ductwood materials shall be of gauge comparable to the duct size.

Diffusers — A minimum of four supply units shall be provided for each temporary structure 3 x 16 m (10 x 52 ft) and so arranged that four equally spaced areas can be partitioned internally.

Ventilators — Each office unit without air conditioning within a 3 x 16 m (10 x 52 ft) temporary structure shall have a two-speed, low-silhouette type roof ventilator. Each unit shall be equipped with bird screen manual Hi-Low-Off switch, roof disconnect, back draft damper, and ceiling intake grille. Fans shall be sized to provide a 5-min air change against 9.5 mm (3/8 in) wg external static pressure at high speed.

E. Requirements for Specific Occupancies

1. Dormitory trailers

The following additional provisions are for dormitory trailers, and they shall comply with HUD's "Mobile Home Construction and Safety Standards," Dec. 18, 1975.

a. Heat Producing Appliances

Heat-producing appliances and vents, roof jacks, and chimneys necessary for their installation in dormitory trailers shall be listed or certified by a nationally recognized testing agency for use.

Fuel-burning heat-producing appliances and refrigeration appliances, except ranges and ovens, shall be of the vented type and vented to the outside.

b. Clothes Dryers

These shall comply with provisions of subsection 280.708 of HUD "Mobile Home Construction and Safety Standards." Clothes dryers shall be exhausted to the outside by a moisture-lint exhaust duct and termination fitting. Such termination fittings for gas dryers shall be listed or certified as components of the dryer.

c. Installation of Appliances

The installation of each appliance shall conform to the terms of its listing and the manufacturer's instructions, and comply with subsection 280.709 of HUD "Mobile Home Construction and Safety Standards."

d. Operating Instructions of Appliances

Operating instructions shall be provided with each appliance. These instructions shall include directions and information covering the proper use and efficient operation of the appliance and its proper maintenance.

e. Marking of Appliances

Information on clearances, input rating, lighting and shutdown shall be attached to the appliances with the same permanence as the nameplate, and so located that it is easily readable when the appliance is properly installed or shut down for transporting of the dormitory trailer.

Each fuel-burning appliance shall bear permanent marking designating the type(s) of fuel for which it is listed.

f. Accessibility

Every appliance shall be accessible for inspection, service, repair, and replacement without removing permanent construction. Sufficient room shall be available to enable the operator to observe the burner, control, and ignition means while starting the appliance.

g. Venting

The venting shall be accomplished by either: (1) an integral vent system listed or certified as part of the appliance, or (2) a venting system consisting entirely of listed components, including roof jack, installed in accordance with the term of the appliance listing and the appliance manufacture's instructions.

Venting systems shall not terminate underneath a mobile home. Venting system terminations shall be not less than 0.9 m (3 ft) from any motor-driven air intake discharging into habitable areas.

The area in which cooking appliances are located shall be ventilated by a metal duct which may be single wall, not less than 0.008 m^2 (12.5 in.^2) in cross-sectional area (minimum dimension shall be 51 mm (2 in.) located above the appliance(s) and terminating outside the dormitory trailer, or by listed mechanical ventilating equipment discharging outside the dormitory that has been installed in accordance with the terms of listing and manufacturer's instructions. Gravity or mechanical ventilation shall be installed within a horizontal distance of not more than 3 m (10 ft.) from the vertical front of the appliance.

VI. PLUMBING SYSTEMS

A. Scope

This section refers to plumbing fixtures that might be found in large trailer complexes or self-contained dormitory trailers. The plumbing fixtures shall conform with the latest requirements of HUD's "Mobile Home Construction and Safety Standards," Section 280.6.

B. General Requirements

The plumbing system shall be of durable material, free from defective workmanship, and so designed and constructed as to give satisfactory service for a reasonable life expectancy.

1. Components

Plumbing materials, devices, fixtures, fittings, equipment, appliances, and accessories shall be listed or certified by ANSI, ASTM, FS, NSF, IAPNO or, specifically approved by the Dept. of HUD.

2. Exposed Piping

All exposed piping, pipe threads, hangers, and support shall be painted, coated, wrapped, or otherwise protected from deterioration.

3. Freezing

All piping and fixtures subject to freezing temperatures shall be insulated or protected to prevent freezing.

4. Rodent Resistance

All exterior openings around piping and equipment shall be sealed to resist the entrance of rodents. Piping and electrical wiring shall not pass through the same holes in walls, floors or roofs. Plastic piping shall not be exposed to heat in excess of manufacturer's recommendation or radiation from heat-producing appliance.

C. Piping Systems

All hot water piping shall be covered with 12.7-mm (1/2 in.) glass fiber insulation.

1. Joints and Connections

Joints and connections in the plumbing system shall be gas-tight and water-tight for the pressures required under testing procedures. Plastic pipe and fittings shall be joined by installation methods recommended by the manufacturer or in accordance with the provisions of a recognized, approved, or listed standard.

2. Traps

Material and design — Each trap shall be self-cleaning with a smooth and uniform interior waterway. Traps shall be manufactured of cast iron, cast brass, or drawn brass tubing of not less than No. 20 Brown and Sharpe gage, or other approved or listed material. Union joints for a trap shall be beaded to

provide a shoulder for the union nut. Each trap shall have the manufacturer's name stamped or cast in the body of the trap, and each tubing trap shall show the gage of the tubing.

Traps shall not be less than 32-mm (1-1/4 in.) in diameter. A trap shall not be larger than the waste pipe to which it is connected.

Each trap shall be located as close to its vent and to its fixture outlet as structural conditions will permit.

All traps shall be effectively vented.

3. Supports and Hangers

Strains and Stresses — Piping in a plumbing system shall be installed without undue strains and stresses, and provisions shall be made for expansion, contraction, and structural settlement.

Piping shall be secured at close enough intervals to keep the pipe in alignment and carry the weight of the pipe and contents. Plastic drainage piping shall be supported at intervals not to exceed 1.2-m (4 ft.) and plastic water piping shall be supported at intervals not to exceed 0.9-m (3 ft).

Hangers and Anchors — Hangers and anchors shall be strong enough to support their proportional share of the pipe alignments and prevent rattling.

Hangers and straps supporting plastic pipe shall not compress, distort, cut or abrade the piping, and shall allow free movement of the pipe.

4. Vents

Each plumbing fixture trap shall be protected against siphonage and back pressure, and air circulation shall be ensured throughout all parts of the drainage system by means of vents.

Materials — Vent piping shall be standard-weight steel, wrought iron, brass, copper-tube DWV, listed plastic, cast iron or other approved or listed materials.

Each individually vented fixture with 38-mm (1/2 in.) or smaller trap shall be provided with a vent pipe equivalent in area to a 32-mm (1 1/4-in.) nominal pipe size.

Vent Terminal —

Roof extension — each vent pipe shall extend through its flashing and terminate vertically, undiminished in size, not less than 51 mm (2 in.) above the roof.

Flashing — the opening around each vent pipe shall be made watertight by an adequate flashing or flashing material.

D. Fixtures

1. Shower Compartments

Dormitories equipped with showers shall comply with provisions of HUD's "Mobile Home Construction and Safety Standards," subsection 280.607.

2. Toilet Units

Toilets shall be designed and manufactured according to approved or listed standards, and shall be equipped with a water flushing device capable of adequately flushing and cleaning bowl at each operation of the flushing mechanism. Toilet flushing devices shall be designed to replace the water seal in the bowl after each operation.

Flush tanks shall be fitted with an overflow pipe large enough to prevent flooding at the maximum flow rate of the ball cock. Overflow pipes shall discharge into the toilet, through the tank.

Floor connection — toilets shall be securely bolted to an approved flange or other approved fitting which is secured to the floor by means of corrosion resistant screws. The bolts shall be of solid brass or other corrosion-resistant material, and shall be not less than 6.4 mm (1/4 in.) in diameter. A watertight seal shall be made between the toilet and flange or other approved fitting by use of a gasket or sealing compound.

E. Water Distribution System

The water distribution system in trailer complexes equipped with bathroom facilities and showers (as in the case of dormitories) shall comply with provisions of subsection 280.607 of HUD's "Mobile Home Construction and Safety Standards, "Dec. 18, 1975.

F. Drainage Systems

1. General

Each fixture directly connected to the drainage system shall be installed with a water-seal trap.

2. Drain Outlets

The drain outlet shall be provided with a minimum clearance of 76 mm (3 in.) in any direction from all parts of the structure or appurtenances, and with not less than 460 mm (18 in.) unrestricted clearance directly in front of the drain outlet.

The drain connector shall not be smaller than the piping to which it is connected, and shall be equipped with a water tight-cap or plug matching the drain outlet. The cap or plug shall be permanently attached to the drain outlet.

The drain outlet and drain connector shall not be less than 76 mm (3 in.) inside diameter.

The drain connection for each toilet shall be 76 mm (3 in.) minimum inside diameter, and shall be fitted with an iron, brass, or listed plastic floor flange adaptor ring securely screwed, soldered, or otherwise permanently attached to the drain piping in an approved manner and securely fastened to the floor.

G. Test

All water piping in the water distribution system shall be subjected to a pressure test. The test shall conform with the latest requirements of the National Plumbing Codes as related to Trailer Coach Standards.

1. Drainage and Vent System and Plumbing Fixtures

Water Test — Before plumbing fixtures are connected all of the openings into the piping shall be plugged and the entire piping system subjected to a static water test for 15 min. by filling it with water to the top of the highest vent opening. There shall be no evidence of leakage.

Fixture Test — The plumbing fixtures and connections shall be subjected to a flow test by filling them with water and checking for leaks and retarded flow while they are being emptied.

2. Shower Compartments

Shower compartments and receptors shall be tested for leaks prior to being covered by finish material. Each pan shall be filled with water to the top of the dam for not less than 15 min.

VII. ELECTRICAL SYSTEMS

A. Scope

This section covers the requirements for materials and workmanship in the installation of electrical systems. The provisions of this section apply to office trailers, dormitory trailers, instrumentation trailers, laboratory trailers, and computer trailers.

B. Definitions

The following definitions are common to all occupancies.

- *Appliances* — portable utilization equipment such as electric space heaters, coffee pots, hot plates.
- *Bonding* — permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.
- *Branch circuit* — the circuit conductors between the final over-current device protecting the circuit and the outlet(s).
- *Circuit breaker* — a device designed to open and close a circuit by nonautomatic means, and to open the circuit automatically on a predetermined overload of current without injury to itself when properly applied within its rating.
- *Externally operable* — capable of being operated without exposing the operator to contact with live parts.
- *Ground* — a conducting connection between an electric circuit and earth, or to some conducting body that serves in place of the earth.
- *Guarded* — covered, shielded, fenced, enclosed or otherwise protected by means of suitable covers, casing, barriers, rails,

screens, mats or platforms to prevent contact by persons or objects to a point of danger.

- *Panelboard* — a single panel or group of panel units designed for assembly in the form of a single panel, including buses, automatic overcurrent protective devices, and with or without switches for the control of light, heat, or power circuits. Designed to be accessible from the front.
- *Raceway* — any channel for holding wires, cables, or busbars that is designed expressly for, and used solely for, this purpose.
- *Rain-tight* — so constructed or protected that exposure to a beating rain will not result in the entrance of water.
- *Receptacle* — a contact device installed at an outlet for the connection of a single attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is a single device containing two or more receptacles.
- *Utilization equipment* — equipment which utilizes electric energy for mechanical, chemical, heating, lighting, or similar purposes.
- *Weatherproof* — so constructed or protected that exposure to the weather will not interfere with successful operation.

C. Electrical Requirements for all Occupancies

1. General

All work and materials shall be equal to or better than the requirements of the latest editions of the National Electrical Code, Division of Industrial Safety, Title 8, Electrical Safety Orders, and HUD's latest edition of "Mobile Home Construction and Safety Standards." In addition, all electrical material and equipment shall bear the inspection label of the Underwriter's Laboratories, Inc., or shall show evidence of approval by an acceptable independent testing laboratory.

Aluminum conductors shall not be acceptable in branch circuit wiring.

2. Identification

All panelboards shall be identified with panel numbers, voltage, and phase.

All receptacles and lighting switches shall be identified by the circuit number.

All motors, starters, disconnect switches, and control devices shall be identified by circuit number.

All panelboards shall be furnished with a complete typewritten schedule mounted in the inner door.

3. Materials

Rigid Steel Conduit — Rigid steel conduit shall be full-weight pipe, hot-dipped galvanized or sheradized with threaded ends, protected both inside and out. All couplings and fittings shall be the threaded type, and shall be subject to the same requirements as the rigid conduit.

Electrical Metallic Tubing — Thinwall conduit (EMT) shall be lightweight rigid steel, electrogalvanized.

Flexible Metal Conduit —

Indoor use and fixture connections — Flexible metal conduit, shall be of galvanized steel, and shall meet in all respects Underwriters Laboratories Standard for Flexible Steel Conduit, ULI or any subsequent revision thereof.

Outdoor Use and Motor Connections — Flexible metal conduit shall be liquid-tight, interlocking single strip type with overall moulded jacket to exclude moisture. All fittings shall be clamp or screw-in type.

Non-Metallic, Sheathed Cable (ROMEX) — Shall be code type NM or type NMC, all copper conductors including all insulated or bare copper equipment grounding conductor. Minimum size shall be No. 12 AWG for all conductors. Support shall be with approved non-metallic sheathed cable staples hand-driven to wood, or tied to metal with nylon cable ties.

Wire — Branch circuit wire in raceways shall be 600-volt, single-conductor copper, minimum size No. 12 AWG, Type TW, of a standard manufacture approved and labeled by the Underwriters' Laboratories, Inc.

Feeder conductors shall be the same as above.

Color Code — All conductors shall be color coded as follows: phase A-black; phase B-red; phase C-blue; Neutral-white or grey; equipment ground-green or bare copper.

Boxes — Outlet boxes shall be standard galvanized steel knock-out type. Minimum size shall be 100-mm (4 in.) square or octagon by 38-mm (1-1/2 in.) deep. Outlet boxes shall be mounted flush with wall or ceiling finish.

Junction boxes shall be code gauge steel with screw-mounted cover.

4. Installation

Rigid metal conduit shall be used underground or in contact with earth.

Bending — Field bends in rigid conduit or EMT shall be made with standard tools and equipment manufactured especially for the purpose, and shall have a radius not less than allowed by code. The bends shall be free of kinks, indentations, or flattened areas. The heating of conduits for any purpose is prohibited.

ROMEX shall be stapled or strapped at intervals not exceeding 1.37 m (4-1/2 ft) and within 0.305 m (12 in.) from every box or cabinet.

Wire — Splicing of conductors will be permitted only in outlet boxes, junction boxes, pull boxes, gutters, and in panelboard gutters, by the following methods:

- No. 10 AWG conductors or smaller shall be joined together with pre-insulated spring pressure connectors.
- No. 8 AWG conductors or larger shall be joined together by approved pressure connectors or by compression connectors. Split-bolt-type connectors shall not be used. Pressure type connectors shall be retightened after initial tightening.

- Uninsulated splices, joints and free ends of conductors shall be covered with an insulation equivalent to that of the conductors by application of any of the following:
 - Plastic tape, high dielectric strength 0.18-mm (0.007-in.) thick.
 - Plastic insulating caps for use with companion splicing caps, provided they rated from temperatures to which they will be subjected.
 - Splices in conductors with insulation rated higher than 75°C shall be insulated with self-adhesive thermosetting glass tape.

Termination of conductors No. 8 AWG and larger shall be by use of pressure-type solderless lugs. Multiple lugs shall be provided where parallel conductors are used.

Marking — In addition to color coding, all signal and control wires shall be numbered at all termination points in cabinets, terminal boxes, equipment racks, and control panels in accordance with approved schedules prepared by the equipment manufacturer.

5. Equipment Grounding

A bare, soft drawn copper wire, securely connected and sized, shall be installed from each current-consuming device, panelboard, cabinet, motor controller, switch, etc., to the equipment grounding block located in its panelboard, to form a continuous grounding system. These bare equipment grounding wires may be spliced or interconnected to serve common units, and shall be installed with their respective power conductors.

All metallic cable (cope) trays shall be installed and grounded to conform with ART 3/8-6 at the NEC.

6. Panelboards and Circuit Breakers

Branch circuit panelboards shall meet or exceed the requirements of Underwriters Laboratories, Inc. Panelboards shall be flush-mounted and shall be complete with a factory-installed copper ground bus and all branch circuit hardware and busses in each breaker space, including space only spaces.

7. Lighting Fixtures

All fixtures shall be wired with wire of a type approved by the NEC as fixture wire.

All fixtures shall have a suitable interior means of attaching the grounding wire to the fixture enclosure.

Exterior area lighting fixtures shall be wall-mounted, complete with 175-watt mogul base mercury vapor lamp and pre-wired, internally mounted, photoelectric control.

Fluorescent lights — Fluorescent lights may be flush-mounted on class A ceilings.

Flourescent light ballasts shall be of the series-sequence start, high-power factory type, manufactured by a Certified Ballast Manufacturer, approved by an independent electrical testing laboratory, and shall be listed as "class P" by the Underwriters' Laboratories, Inc. All ballasts shall have approved thermal cutouts to limit the temperature of the ballast cast to 90°C under the all conditions of fault.

8. Emergency Light and Battery Unit

Shall have a solid-state battery charger and two sealed beam lights. Battery shall be maintenance free and have a 10 year minimum warranty. The unit shall meet National Electric Code, Life Safety Code, and OSHA requirements.

Emergency Page System — Paging outlet boxes shall consist of (102 mm × 38 mm) (4 in. × 1-1/2 in.) deep outlet box with appropriate ring to finish flush with ceiling surface.

Paging cable shall be installed continuous with no splices between outlet and/or junction boxes.

Cable shall be 2-conductor-stranded 20 AWG minimum, 350-volt, color-coded, and with a 0.63 mm (0.025-in.) minimum outer jacket.

D. Electrical Requirements for Specific Occupancies

1. Computer Trailers

Supply Circuits and Interconnecting Cables — The branch circuit conductors to which one or more units of a data processing system are connected to a source of supply shall have an ampacity not less than 125% of the total connected load.

The data processing system may be connected by means of computer cable or flexible cord and attachment plug cap or cord set assembly specifically approved as a part of the data processing system. Separate units may be interconnected by means of flexible cords and cables specifically approved as part of the data processing system. When run on the surface of the floor, they shall be protected against physical damage.

The power and communication supply cables and interconnecting cables may be installed under a raised floor provided that:

- The raised floor's construction complies with NFPA No. 75;
- The branch-circuit supply conductors to receptacles are in rigid conduit, electrical metallic tubing, flexible metal conduit, Type MI mineral-insulated metal sheathed cable, or Type ALS aluminum-sheathed cable.

Disconnecting Means — In addition to any integral individual disconnect switches for components or other units of the data processing system, disconnecting means shall be as follows:

- In Data Processing Areas — The disconnecting means shall disconnect the ventilation system serving that area and the power to all electrical equipment in the area except lighting, and shall be controlled from locations readily accessible to the operator and at designated exit doors from that data processing area.
- In General Trailer Complex Areas — The disconnecting means shall disconnect all interconnected data processing equipment in the area and shall be controlled from a location readily accessible to the operator.

Grounding — All exposed noncurrent-carrying metal parts of a data processing system shall be grounded.

Marking — Each unit of a data processing system which is intended to be supplied by a branch circuit shall be provided with a manufacturer's nameplate, which shall also include the rating in volts, the operating frequency, and the total load in amperes. All machine tools shall have a lockable power disconnect for protection of personnel during maintenance or repair of machines.

VIII. FIRE SAFETY

A. Scope

The purpose of this section is to suggest measures which will provide a reasonable degree of safety from fire to the occupants of the various types of trailers, and to minimize programmatic losses which could result from a fire.

B. Definitions

The following definitions are applicable to Section VIII only.

- *Flame spread* — the propagation of flame over a surface.
- *Interior finish* — the surface material of walls, fixed or movable partitions, ceilings and other exposed interior surfaces affixed to the trailer structure including any material such as paint and the substrate to which it is applied. Interior finish does not include windows and doors or their frames, trim and moldings which are not affixed to the trailer structure.
- *Single Station Alarm Device* — an assembly incorporating the smoke detector sensor, the electrical control equipment requirement and the alarm-sounding device in one unit.
- *Smoke Detector* — wall or ceiling-mounted detector of the ionization chamber or photoelectric type which detects visible or invisible particles of pyrolysis or combustion and operates from 120-V source of electrical power supply.

C. Requirements for all Occupancies

1. Flame Spread Limitations

All interior-finish walls and partitions, ceilings, floors, and insulation shall be of noncombustible materials having a flame spread rating of not over 25, as measured by the ASTM E 84 test.

Walls and partitions shall preferably be of inert material such as plasterboard. Fire-retardant paint is not an acceptable substitute for noncombustible sheathing, but it may be used in existing on-site trailers where alterations cannot be made.

Ceiling shall be of acoustical tile, noncombustible mineral board, fibrous glass or equal.

The underfloor layment found in most trailers is a highly combustible asphalt-impregnated fiberboard, shall be either replaced with a noncombustible material, or be sheathed with a noncombustible material. If sheathed, there shall be no air space between the sheathing and the fiberboard.

Insulation shall be of fiberglass with aluminum foil vapor barrier on the interior side to eliminate sweating. Insulation shall be installed in attic or ceiling, walls, and floor.

2. Electrical Wiring

Aluminum conductors will not be acceptable in branch circuit wiring.

Preferably, wiring shall be run in conduits. However, non-metallic sheathed cable (ROMEX) shall be acceptable if it is hand-driven to wood with non-metallic sheathed cable staples or tied to metal with nylon cable ties.

3. Good Housekeeping

Trailer foundations shall be tightly enclosed to prevent accumulation of trash or storage of equipment beneath the trailer.

The amount of combustibles shall be kept to a minimum, and all trash shall be removed daily.

4. Furnishings

Drapes and Curtains — Fabric shall be noncombustible or treated with approved flame retardant.

Carpets — All carpets shall have a minimum flame spread under 50 and smoke rating density under 200.

5. Heat-Producing Appliances

Coffee pots and hot plates shall be of UL approved type and shall require a Fire Safety Permit prior to installation. Coffee pots connected to a timer shall have the timers installed by qualified technician.

Portable electric space heaters shall be of an approved type and be located in an open area in such a way as to be visible at all times to inspection or checking by security patrols.

Heat-producing appliances shall be so located that no door, drape, or other combustible material shall come in contact with the appliance. They shall be installed in noncombustible shielding holders that will maintain the required clearance from combustible material.

6. Fire Detection & Suppression Systems

The following systems are recommended for office trailers and trailer complexes under 465 m^2 (5000 ft^2). Fire detection and suppression systems for large office complexes (1344 m^2) ($15,000 \text{ ft}^2$) computer trailers, storage trailers, dormitory trailers and laboratory trailers appear in part VIII D; requirements for specific occupancies.

Products of combustion detectors or thermal detectors shall be installed in office trailers and connected to a master box either at the trailer unit or at the nearest building. A local audible alarm shall be installed in each trailer unit ($3 \times 16 \text{ m}$) ($10 \times 52 \text{ ft}$); when such a unit is used for dormitories. A strobe or beacon light may be installed in each unit when the detection is connected to the nearest building. Fire extinguishers shall be installed in each office unit as required by the NFPA 10.

D. Requirements for Specific Occupancies

The following fire protection and fire suppression measures are suggested, in addition to those mentioned in part VIII C.

1. Office Trailer Complexes

Unsprinklered office trailer complexes shall be divided by 2-hr firewalls into areas not exceeding 465 m^2 (5000 ft^2).

Sprinklered office trailer complexes shall be divided by 2-hr firewalls into areas not exceeding 1394 m^2 ($15,000 \text{ ft}^2$). An ordinary Hazard NFPA #13 STD sprinkler system shall be acceptable.

2. Trailers Housing Computers or Electronic Equipment

All furniture used in trailers housing computers and electronic equipment must be noncombustible. No wooden or plastic furniture shall be allowed.

Metal waste cans with self-closing lids shall be used for trash and rubbish.

All combustible supplies shall be stored in totally enclosed metal files or cabinets, and only the amount of combustible supplies necessary for one day's operation shall be allowed outside of the files or cabinet.

Computer or electronic trailers shall not be used for the storage of flammable liquids. If flammable liquids are required for the operations housed in a trailer, up to 3.8 l (1 gal) of the liquid may be kept in an approved safety can.

Trailers containing equipment valued at \$100,000 or more shall be protected by an automatic fire-extinguishing system. This system shall either be an automatic fire sprinkler system or HALON 1301.

Fire Sprinkler System — The fire sprinkler system shall be of the Light Hazard Group 1, and shall conform to the latest edition of all applicable codes and regulations and to the NFPA Code No. 13, "Standard for the Installation of Sprinkler Systems." Other piping systems may be evaluated and if found equal shall be accepted.

In addition to the automatic sprinkler system, high-value trailers shall have local visible and audible alarms mounted on the outside of the trailer. The trailer alarm circuit should be connected to the fire alarm circuit at the installation Fire Department.

Testing — The sprinkler piping system shall be tested hydrostatically at 1.38 MPa (200) for a period of 24 hours without a loss of pressure or visible signs of any leaks. All ceiling panels under the piping shall be removed during this test. Should any material fail in this test, the material shall be replaced and the test repeated until a satisfactory test is obtained. Faulty, welded joints shall be replaced, not remade.

Stock of extra sprinklers — The trailer shall be provided with extra sprinklers corresponding to the type and temperature ratings of the sprinklers installed. Any special sprinkler wrenches shall also be provided.

Underfloor drainage — The underfloor shall be provided with drains.

Painting — The sprinkler riser, including drain and test piping, shall be painted from grade to the top fitting of the riser as follows:

- One coat DuPont Metal Primer, Rustoleum, or equal.
- One coat red color DuPont Metal Protective Paint, Rustoleum, or equal.
- In a room, the exposed piping may be painted the same color as the room if the piping is clearly marked.

Halon 1301 Discharge System — The Halon 1301 discharge system shall comply with the newest edition of NFPA 12A. A concentration of about 6-7% by volume should be used.

The Halon 1301 discharge system shall be activated by a fixed-temperature/rate-of-rise device, backed by a product of combustion detector.

The fire detection system should have the capability to shut down the power, ventilation and alarm systems, but shutdown functions should be capable of being by-passed.

A 30 to 45-second delay shall be provided before ventilation shutdown, to get good mixing of Halon 1301 and air. The status of by-passes and disabling devices must be apparent either by pilot light indications or the position of switches at the installation Fire Department.

The automatic extinguishing system shall have a capability for disablement to protect from shocks during movement of the trailer.

The trailer alarm circuit and the Halon automatic discharge circuit should be connected to the fire alarm circuit at the installation's Fire Department.

3. Trailers Housing Laboratories

The use of trailers and other portable structures to house laboratories shall be discouraged.

Trailers housing biological or chemical laboratories shall comply with the newest edition of NFPA-45 "Fire Protection for Laboratories Using Chemicals, 1975.

- All flammable or combustible chemicals shall be stored outside the trailer in cabinets for flammable and combustible chemicals. The storage cabinets shall comply with provisions of NFPA-30. "Flammable and Combustible Liquids Code," 1973.
- If flammable liquids are required for experimental endeavors, up to 37.85 l (1 gal) of the liquid may be kept in an approved safety can.

Furniture —

- All furniture in the biological and chemical laboratories shall be noncombustible. No wooden or plastic furniture shall be allowed.
- Furniture and laboratory equipment in laboratories shall be so arranged that means of access to an exit may be reached easily from any point.
- Each laboratory shall have a portable fire extinguisher installed, located, and maintained in accordance with the newest edition of NFPA-10 "Standard for the Installation of Portable Fire Extinguishers."
- In addition to the portable fire extinguishers, the laboratory trailers shall be protected by either one of the automatic fire extinguishing systems described earlier in Part VIII-D-2.

IX. INDUSTRIAL SAFETY AND HYGIENE

A. Scope

This section outlines occupational safety and health standards applicable to the various types of trailer occupancies.

B. General Requirements for Occupancies

1. Lighting

Work stations, work areas and nonwork areas shall meet the 50-30-10 foot candle criteria.

Where higher levels of illumination are determined to be necessary for specialized tasks, personnel safety, or facility security reasons, they shall be provided but shall not exceed the recommended levels contained in ANSI A 11.1-1973.

Where such higher illumination levels are judged necessary, special consideration shall be given to providing local or task supplemental lighting to minimize general overhead lighting requirements.

2. Ventilation

Provisions shall be made for adequate ventilation in accordance with part 280.103 of HUD "Mobile Home Construction and Safety Standards." This portion of the recommendations excludes the ventilation requirements for the laboratory areas. Part 280.103 states that "an area equivalent to not less than 4% of the gross floor area shall be available for unobstructed ventilation. Glazed areas need not be openable where a mechanical ventilation system is provided and is capable of producing a change of air in the room every 30 minutes, with not less than one-fifth of the air supply taken from outside the trailer. Windows and doors used for ventilation shall open directly to the outside of the trailer."

Each toilet compartment shall be provided with artificial light, and in addition, be provided with external windows or doors having not less than 0.139 m^2 (1.5 ft^2) of fully openable glazed area, except where a mechanical ventilation system is provided that is capable of producing a change of air every 12 minutes. Any mechanical ventilation system shall exhaust directly to the outside.

3. Potable Water Supply

Drinking water shall be made available within 61 m (200 ft) of any location in a trailer complex.

Sanitary drinking fountains shall be of a type and construction in accordance with the Standard Specification for Drinking Fountains, ANSI Z 4.2.

C. Requirements for Specific Occupancies

The following additional requirements are addressed to trailers housing biological or chemical laboratories.

1. Ventilating Systems

Duct systems for laboratory heating and ventilating, including warm air heating systems, general ventilating systems, air cooling systems, and laboratory exhaust and hood exhaust systems, air cooling systems, and laboratory exhaust and hood exhaust systems, shall comply with provisions contained in the newest editions of NFPA 45 and NFPA 90 A.

In addition, each ventilation system designed to control irritating or toxic airborne material must provide reliable control to prevent exceeding the protection guide values stated in the Threshold Limit Values published by the American Conference of Governmental Industrial Hygienists.

Each ventilation system shall include fire cut-offs, be constructed of fire-resistant materials, and be installed an adequate distance from combustible material.

2. Exposure to Toxic or Irritating Constituents

All exposure to irritants or toxic biological and chemical constituents shall be below the established ERDA Health and Safety Limits.

3. Sanitation

Toxic or flammable chemicals must not be released into the sanitary sewer system or the storm sewer system; they must be placed promptly in a designated and labelled metal container.

All garbage and trash shall be accumulated outside of the trailer in closed containers and removed from the premises promptly.

X. IDENTIFICATION OF PORTABLE STRUCTURES

To properly provide an address in the event of fire, accident, injury, or other emergency, all movable structures shall have painted metal placards placed on them as follows.

- To the right of the main entrance of the movable structure.

- On the side that faces most heavily troubled path of personnel and/or vehicle traffic.
- The placard shall state the trailer number as designated by the Plant Manager, and identify the trailer's position in or near a permanent Laboratory facility.

XI. TESTING

A. Structural Load Tests

Every structural assembly tested shall be capable of meeting the Proof Load Test or the Ultimate Load Test as follows:

1. Proof Load Test

Every structural assembly tested shall be capable of sustaining its dead load plus superimposed live loads equal 1.75 times the required live loads for a period of 12 hours without failure.

Tests shall be conducted with loads applied and deflections recorded in 1/4 design live-load increments at 10-minute intervals until 1.25 times design live load plus dead load has been reached. Additional load shall then be applied continuously until 1.75 times design live load plus dead load has been reached. Assembly failure shall be considered as design live load deflection (or residual deflection measured 12 hours after live load removal), rupture, fracture or excessive yielding.

An assembly to be tested shall be of the minimum quality of materials and workmanship of the production. Each test assembly, component or sub-assembly shall be identified as to type and quality or grade of material.

2. Ultimate Load Test

Ultimate load tests shall be performed on a minimum of the three assemblies to generally evaluate the structural design. Every structure tested shall be capable of sustaining its total dead load plus live loads increased by a factor of safety consistent with the material being tested. Tests shall be conducted with loads applied and deflections recorded in 1/4 design live-load increments at 10-minute intervals until 1.25 times design live load plus dead load has been reached. Additional loading shall then be applied continuously until failure occurs or 1.5 times the factor of safety times the design

live load plus the dead load is reached. Assembly failure shall be considered as design live-load deflection greater than the limits set in Section 208.305 of HUD's "Mobile Home Construction and Safety Standards."

B. Test Procedure for Roof Trusses

Trusses may be tested in pairs or singly in a suitable test facility. When tested singly, simulated lateral support of the test assembly may be provided, but in no case shall this lateral support exceed that which is specified for the completed trailer. When tested in pairs, the trusses shall be spaced at the design spacing and shall be mounted on solid support accurately positioned to give the required clear span distance (L) as specified in the design. The top and bottom chords shall be braced and covered with the material, with connections or method of attachments, as specified by the completed trailers. The procedures for the various tests specified in Subpart 280.402 of the latest edition of HUD's "Mobile Home Construction and Safety Standards."

C. Tests for Windows

Structural Performance test, air infiltration test, and water resistance test shall be performed according to provision of 280.403 of HUD's "Mobile Home Construction and Safety Standards."

D. Tests for Swinging Exterior Passage Doors

The size of the test specimen, structural performance test, and water resistance test shall be performed according to specifications in Subpart 280.405 of HUD's "Mobile Home Construction and Safety Standards."

E. Flammability Tests for Ceilings, Wall and Floor Materials

The surface flame spread rating for the interior finish of all walls and ceilings shall not exceed 25, as measured by the ASTM E 84 test or the ASTM E 162-68 Radiant Panel Test.

Carpet intended to be used in any of the trailer facilities shall at least have passed the DOC FF 1-70 (Pill Test). This test was designed to eliminate from commerce those carpets that can be easily ignited by small ignition sources such as cigarettes, matches, glowing embers from fireplaces or minor electrical short circuits. The test is simple, reproducible, and

effective in screening out easily ignitable materials, however, it does not measure the hazard potential of the material. A test method that relates to actual hazard is currently being developed at the National Bureau of Standards and once completed, it should become a mandatory test for floor coverings.

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