UL 307B

STANDARD FOR SAFETY

Gas-Burning Heating Appliances for Manufactured Homes and Recreational Vehicles

UL Standard for Safety for Gas-Burning Heating Appliances for Manufactured Homes and Recreational Vehicles, UL 307B

Fifth Edition, Dated October 31, 2006

Summary of Topics

This revision to UL 307B is being issued to remove the reference to the withdrawal date of UL 873 and to address universal upkeep of UL Standards for Safety. These revisions are considered to be non-substantive and not subject to UL's STP process.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

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UL 307B

Standard for Gas-Burning Heating Appliances For Manufactured Homes and Recreational Vehicles

The First edition was titled ″Gas- and Oil-Fired Heating Appliances for Trailer Coaches″ and numbered UL 307. The Second edition was titled ″Gas-Heating Appliances for Mobile Homes and Travel Trailers.″ The Third Edition was titled ″Gas-Burning Heating Appliances for Mobile Homes and Recreational Vehicles.″

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This UL Standard for Safety consists of the Fifth Edition including revisions through September 17, 2013.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements apply to the following gas fuel-burning heating appliances:

a) Direct-vent system appliances for manufactured homes and recreational vehicles; and

b) Vented appliances for manufactured homes other than the direct-vent system type that provide for separation of the combustion system from the atmosphere of the manufactured home by an installation method.

1.2 Requirements for the installation and use of heating appliances in manufactured homes and recreational vehicles are included in:

a) The Department of Housing and Urban Development Manufactured Home Construction and Safety Standards, Chapter II of 24 CFR, Part 3280-1994; and

b) The Standard for Recreational Vehicles, NFPA 501C-1993.

1.3 An appliance designed to burn either oil or gas, and a gas appliance designed to be converted to burn oil by the installation of an optional factory-furnished burner, shall also comply with the requirements in the Standard for Liquid Fuel-Burning Heating Appliances for Manufactured Homes and Recreational Vehicles, UL 307A.

1.4 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this Standard, and that involve a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this Standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this Standard cannot be judged to comply with this Standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this Standard.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

2.1.2 A component need not comply with a specific requirement that:

a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard; or

b) Is superseded by a requirement in this standard.

2.1.3 A component shall be used in accordance with its recognized rating established for the intended conditions of use.

2.1.4 Specific components are recognized as being incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits and shall be used only under those specific conditions for which they have been recognized.

2.2 Units of measurement

2.2.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

2.2.2 Unless indicated otherwise, all voltage and current values mentioned in this standard are rms.

2.3 Terminology

2.3.1 The term ″appliance″ as used in this standard refers to any heating appliance covered by this standard, such as a warm air central furnace, a wall furnace, a heating boiler, and a water heater.

3 Glossary

3.1 For the purpose of this standard, the following definitions apply.

3.2 AIR SHUTTER – An adjustable device for varying the size of the air inlet or inlets regulating primary or secondary air.

3.3 APPLIANCE FLUE – The flue passages within the appliance.

3.4 AUTOMATICALLY LIGHTED APPLIANCE – An appliance in which fuel to the main burner is intended to be turned on and ignited automatically.

3.5 BOILER – A closed vessel in which water or some other liquid is heated or steam is generated or superheated, under pressure or vacuum, by direct application of heat.

3.6 BOILER, LOW PRESSURE HOT WATER – A boiler that furnishes hot water at a pressure not exceeding 160 psig (1103 kPa) and at a temperature not exceeding 250°F (121°C).

3.7 BOILER, LOW PRESSURE STEAM – A boiler in which steam is generated at a pressure not exceeding 15 psig (103 kPa).

3.8 BURNER – A device for the final conveyance of fuel or a mixture of fuel and air to the combustion zone.

a) Forced-Draft – (See Power Burner, (e)).

b) Induced-Draft – A burner that depends on the draft induced by a fan beyond the appliance for its proper operation.

c) Injection (Bunsen) Type – A burner employing the energy of a jet of gas to inject air for combustion into the burner and mix it with the gas.

1) Atmospheric Injection Type – A burner in which the air at atmospheric pressure is injected into the burner by a jet of gas.

d) Luminous or Yellow-Flame – A burner in which secondary air only is depended on for combustion of the gas.

e) Power – A burner in which either gas or air or both are supplied at pressure exceeding, for gas, the gas line pressure, and for air, atmospheric pressure; this added pressure being applied at the burner. A burner for which air for combustion is supplied by a fan ahead of the appliance is commonly designated as a forced-draft burner.

f) Premixing – A power burner in which all or nearly all of the air for combustion is mixed with the gas as primary air.

g) Pressure Burner – A burner that is supplied with an air-gas mixture under pressure [usually from 0.5 to 14.0 inches water column (124 – 4032 Pa) and occasionally higher].

3.9 BURNER HEAD – That portion of a burner beyond the outlet end of the mixer tube which contains the ports.

3.10 CENTRAL FURNACE – A self-contained appliance for heating air by transfer of heat of combustion through metal to the air, and designed to supply heated air through ducts to spaces remote from or adjacent to the appliance location.

3.11 COMBUSTIBLE MATERIAL – As pertaining to materials adjacent to or in contact with heat-producing appliances, chimney and vent connectors, steam pipes, and warm-air ducts, combustible material is that material made of or surfaced with wood, compressed paper, plant fibers, or other material that will ignite and burn. Such material is considered to be combustible even though flame-proofed, fire-retardant treated, or plastered.

3.12 CONDENSATE – The liquid which separates from the combustion by-products of a fuel (flue gases) due to a reduction in temperature below dew point.

3.13 CONTROL –

a) Fan – An automatic control intended to control the operation of the fan on forced air appliances.

b) Limit – An automatic safety control responsive to changes in liquid level, pressure, or temperature and intended to be set beyond the operating range for limiting the operation of the controlled equipment.

c) Low Water – A control that automatically cuts off the fuel supply when the surface of the water falls to the lowest safe water level. This point should not be lower than the bottom of the water glass.

d) Operating – A control, other than a safety control or interlock, to start or regulate burner firing according to demand and to stop or regulate firing on satisfaction of demand or upon reaching intended temperature or pressure in the appliance being fired.

e) Primary Safety – An automatic control that monitors the operation of a gas-fired or an oil-fired burner that is responsive directly to flame properties, sensing the presence or absence of flame and, in event of ignition failure or unintentional flame extinguishment, causes safety shutdown (lockout).

f) Safety – Automatic controls (including relays, switches, and other auxiliary equipment used in conjunction therewith to form a safety control system) which are intended to prevent operation of the controlled equipment that could cause a risk of fire, explosion, or injury to persons.

3.14 DIRECT VENT SYSTEM APPLIANCE – An appliance which by its inherent design is constructed so that:

a) All air supplied for combustion;

b) The combustion system of the appliance; and

c) All products of combustion are isolated from the atmosphere of the space in which the appliance is installed.

3.15 DRAFT HOOD – A device built into a gas appliance, or made a part of the vent connector from a gas appliance, which is intended to:

a) Provide for the ready escape of the products of combustion in the event of no draft, backdraft, or stoppage beyond the draft hood;

b) Prevent a backdraft from entering the appliance; and

c) Neutralize the effect of stack action of the flue or vent upon the operation of the appliance.

3.16 ELECTRICAL CIRCUITS –

a) High-Voltage Circuit – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage or an isolated-limited-secondary circuit.

b) Low-Voltage Circuit – A circuit involving a potential of not more than 30 volts alternating current (42.4 volts peak or direct current) and supplied by a primary battery or by a standard Class 2 transformer, or by a combination of transformer and fixed impedance that, as a unit, complies with all the performance requirements for a Class 2 transformer. A circuit derived from a source of supply classified as a high-voltage circuit using resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low-voltage circuit nor an isolated limited secondary circuit.

c) Safety Control Circuit – A circuit involving one or more safety controls, in which failure due to grounding, opening, or shorting of any part of the circuit can cause operation of the controlled equipment that can cause a risk of fire, explosion, or injury to persons.

3.17 EXCESS AIR – Air that passes through the combustion chamber and the appliance flues in excess of that theoretically required for complete combustion.

3.18 HEAT EXCHANGER –

a) Direct – A heat exchanger in which heat generated in the combustion chamber of the appliance is transferred directly through walls of the appliance to the heating medium (such as air, steam, or water) held in close contact with the combustion chamber walls. It is a self-contained combustion and heat-transfer device, hence a direct heat-transfer device.

b) Indirect – A heat exchanger that encloses or contains a heating medium (such as air, steam, or water), the heat from which is transferred to another heating medium separately contained in close contact with or directed through the heat exchanger.

3.19 HEATING SURFACES – All surfaces that transmit heat directly from flame or flue gases to the medium to be heated.

3.20 HEATING VALUE, GAS – The (Total) number of British Thermal Units produced by the combustion at constant pressure of 1 cubic foot of gas when the products of combustion are cooled to the initial temperature of the gas and air, when the water vapor formed during combustion is condensed, and when all the necessary corrections have been applied.

3.21 IGNITION SOURCE –

a) Continuous – An ignition source that, once placed in operation, is intended to remain ignited or energized continuously until manually interrupted.

b) Intermittent – An ignition source that is automatically ignited or energized when an appliance is called on to operate and that remains continuously ignited or energized during each period of main burner operation. The ignition source is automatically extinguished or de-energized when each main burner operating cycle is completed.

c) Interrupted – An ignition source that is automatically ignited or energized when an appliance is called on to operate and that remains ignited or energized during the main burner flame-establishing period. The ignition source is automatically extinguished or de-energized when each main burner flame-establishing period is completed.

3.22 LINING – Those interior surfaces of a combustion chamber exposed to combustion during use of the appliance.

3.23 LIQUEFIED-PETROLEUM (LP) GAS – Fuel gases, including commercial propane, predominantly propane or propylene, or commercial butane, predominantly butane, isobutane, and/or butylene.

3.24 LP-GAS-AIR MIXTURE – Liquefied-petroleum gases distributed at relatively low pressures and normal atmospheric temperatures that have been diluted with air to produce desired heating value and utilization characteristic.

3.25 MANIFOLD – The conduit of an appliance that supplies gas to the individual burner.

3.26 MANUFACTURED HOME – A manufactured or mobile home, or other housing factory-built in accordance with The Department of Housing and Urban Development Manufactured Home Construction and Safety Standards.

3.27 MIXER, GAS – The combination of mixer head, mixer throat, and mixer tube.

a) Mixer Head – That portion of an injection (Bunsen) type burner, usually enlarged, into which primary air flows to mix with the gas stream.

b) Mixer Throat – That portion of the mixer that has the smallest cross-sectional area and that lies between the mixer head and the mixer tube.

c) Mixer Tube – That portion of the mixer that lies between the throat and the burner head.

3.28 ORIFICE – The opening in a cap, spud, or other device whereby the flow of gas is limited and through which the gas is discharged to the burner.

3.29 ORIFICE CAP (HOOD) – A movable fitting having an orifice that permits adjustment of the flow of gas by the changing of its position with respect to a fixed needle or other device.

3.30 ORIFICE SPUD – A removable plug or cap that contains an orifice and that permits adjustment of the flow of gas either by substitution of a spud with a different sized orifice or by the motion of a needle with respect to it.

3.31 PILOT – A small flame utilized to ignite the fuel at the main burner or burners.

a) Continuous – A pilot that burns without turndown throughout the entire time the burner is in service, whether the main burner is firing or not.

b) Proved – A pilot flame supervised by a primary safety control that senses the presence of the pilot flame prior to permitting the main burner fuel to be delivered for combustion.

3.32 PIPING – Either pipe or tubing or both.

a) Pipe – Refers to rigid metal pipe.

b) Tubing – Refers to semirigid metal tubing.

3.33 PLENUM – An air compartment, part of a distributing system, to which one or more ducts are connected.

a) Furnace Supply – A furnace plenum attached directly to, or an integral part of, the supply outlet of the furnace.

b) Furnace Return – A furnace plenum attached directly to, or an integral part of, the return inlet of the furnace.

3.34 PORT – Any opening in a burner head through which fuel or an air-fuel mixture is discharged for ignition.

3.35 PRIMARY AIR – The air introduced into a burner that mixes with the fuel before it reaches the ignition zone.

3.36 RADIATION SHIELD – A separate panel or panels interposed between heating surfaces and adjacent objects to reduce heat transmission by radiation.

3.37 RECREATIONAL VEHICLE – A vehicular type unit primarily designed as temporary living quarters for recreational, camping, or travel use, which either has its own motive power or is mounted on or drawn by another vehicle. The basic entities are:

a) Camping Trailer – A vehicular portable unit mounted on wheels and constructed with collapsible partial side walls which fold for towing by another vehicle and unfold at the camp site to provide temporary living quarters for recreational, camping, or travel use.

b) Motor Home – A vehicular unit designed to provide temporary living quarters for recreational, camping or travel use built on or permanently attached to a self-propelled motor vehicle chassis or on a chassis cab or van which is an integral part of the completed vehicle.

c) Travel Trailer – A vehicular unit, mounted on wheels, designed to provide temporary living quarters for recreational, camping, or travel use and of such size or weight as not to require special highway movement permits when towed by a motorized vehicle, and of gross trailer area less than 320 square feet (29.7 m^2).

d) Truck Camper – A portable unit consisting of a roof, floor, and sides, designed to be loaded onto and unloaded from the bed of a pickup truck.

3.38 SECONDARY AIR – The air externally supplied to the flame at or beyond the point of ignition.

3.39 THERMOELECTRIC CIRCUIT – A circuit which receives its electrical energy by a conversion of heat to electricity by means of a thermocouple or thermopile.

3.40 VALVES –

a) Automatic – A device consisting essentially of a valve and operator that controls the fuel supply to the burner or burners during intended operation of the appliance. The operator may be actuated by application of fuel pressure on a flexible diaphragm, by electrical, mechanical, or other means.

b) Burner-Input Control – An automatic-control valve for regulating burner input.

c) Lubricated-Plug Type – A valve of the plug and barrel type designed to maintain a lubricant between the bearing surfaces.

d) Manual Gas Shutoff – A manually operated valve in the fuel line for completely turning on or shutting off the fuel supply to the appliance.

e) Safety Shutoff – A valve that is automatically closed by the safety control system or by an emergency device. This type of valve may be of the automatic or manually opened type.

3.41 VENT/AIR INTAKE TERMINAL – The device used with a direct vent system appliance which is located on the outside of the building through which the air for combustion is taken from the outside atmosphere and from which products of combustion are discharged.

a) Air Intake Terminal – The fitting at the inlet of the air intake pipe that allows entrance of the outside atmosphere to the air intake pipe.

b) Vent Terminal – The fitting at the end of the vent pipe that directs the flue products into the outside atmosphere.

3.42 VENTED APPLIANCE – An indirect-fired appliance provided with means to accommodate a chimney or a roof-jack connector.

3.43 VENT LIMITER – A means that limits the flow of air from the atmospheric diaphragm chamber of a gas pressure regulator to the atmosphere. This may be either a limiting orifice or a limiting device.

3.44 WALL FURNACE – A self-contained appliance, complete with grills or equivalent, intended for incorporation or permanent attachment to the structure of a manufactured home or recreational vehicle in furnishing heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing. Such appliances are not provided with duct extensions beyond the vertical and horizontal limits of the casing, except that boots not to exceed 10 inches (254 mm) beyond the horizontal limits of the casing for extensions through walls of nominal thicknesses may be permitted. When such boots are provided, they are supplied by the manufacturer as an integral part of the appliance and tested as such in accordance with these requirements.

3.45 WATER HEATER – An appliance for supplying hot water for domestic or commercial purposes other than for space heating. Categories of water heaters are:

a) Domestic Storage Water Heater – A water heater that heats and stores water at a thermostatically controlled temperature for delivery on demand. Input rating may not exceed 75,000 Btu per hour (22 kW).

b) Counter Type –

1) Concealed Type – A vented automatic storage heater which is for flush installation beneath a counter top 36 inches high, wherein the entire heater is concealed.

2) Flush Type – A vented automatic storage water heater with flat sides, top, front and back, and which is primarily for flush installation in conjunction with or adjacent to a counter 36 inches (0.9 m) high; wherein the front and top of the heater casing are exposed.

3) Recessed Type – A vented automatic storage water heater with flat sides, top, front, and back, which is for flush installation beneath a counter 36 inches high; wherein the front of the heater casing is exposed.

CONSTRUCTION

GENERAL

4 Assembly

4.1 An appliance shall be factory-built as a group assembly and shall include all the essential parts necessary for its intended function when installed as intended. An appliance may be shipped as two or more subassemblies.

4.2 An appliance that provides for separation of the combustion system from the indoor atmosphere of the manufactured home by an installation method shall be provided with an air-intake assembly conforming to these requirements. See 104.1.6.

4.3 A direct vent system appliance shall be constructed so that:

a) All air supplied for combustion;

b) The combustion system of the appliance; and

c) All products of combustion are isolated from the atmosphere of the manufactured home or recreational vehicle.

Doors, panels, and any other access openings serving an enclosure required for such isolation of a fuel-burning appliance are to communicate only to the outdoors.

4.4 Compliance with 4.3 is not intended to preclude constructions including parts which, when opened or removed, may permit the combustion system to communicate with the atmosphere of the manufactured home or recreational vehicle, provided:

a) The appliance is not operable when such part is opened or removed;

b) Compartment doors or access panels are hinged to the compartment in a manner not likely to permit or invite their removal, and an interlock switch is provided that will automatically open the circuit when the door or panel is opened and that will automatically close the circuit when the door or panel is closed – the construction of the interlock switch is such that a serviceman can manually close the circuit for servicing but the switch will automatically return to its normal position when the door or panel is closed, that is, be in a position to automatically open the circuit when the door or panel is reopened – and the interlock switch is wired in the power circuit to the appliance or in the combustion-detector circuit of the primary safety control; or

c) A combination of two or more compartment doors or access panels and interlock switches that provide equivalent protection to the preceding are furnished, in which case only one of the doors or panels need be hinged to the compartment.

4.5 A boiler shall be constructed, equipped, inspected, tested, and marked in accordance with the ASME Boiler Pressure Vessel Code, Section IV, Heating Boilers.

4.6 An appliance may include an opening, communicating with the combustion system, needed for the user to light or start the appliance, provided that the opening does not exceed a 28 square inch (181 cm^2) cross-sectional area and has an attached cover plate. The cover plate shall be self-closing and equipped with a means, such as a latch or spring, to hold it firmly in the closed position. The cover plate shall be marked as described 101.17

4.7 Air-intake assemblies and flue-gas outlet assemblies for appliances of direct vent system construction shall be an integral part of the appliance, or each assembly shall be constructed for direct attachment to the appliance.

4.8 If an appliance is not assembled by the manufacturer as a unit, it shall be arranged in as few subassemblies as practicable. Each subassembly shall be capable of being incorporated readily into the final assembly without requiring alteration, such as cutting, drilling, threading, welding, or similar tasks, by the installer. Two or more subassemblies, that must bear a definite relationship to each other for the intended installation or operation of the appliance, shall be arranged and constructed to permit them to be incorporated into the complete assembly, without need for alteration or alignment, only in the intended relationship with each other; or such subassemblies shall be assembled, tested, and shipped from the factory as one element.

4.9 A radiation shield or baffle employed to prevent excessive temperature shall be:

a) Assembled as part of the appliance;

b) Part of a subassembly that must be attached to the appliance for its intended operation; or

c) Constructed so that the appliance cannot be assembled for operation without first attaching a required shield or baffle in its intended position.

4.10 The construction of an appliance shall not, for any intended installation, require the alteration or removal of a baffle, insulation, or a radiation shield needed to prevent temperatures that can cause risk of fire or injury to persons.

4.11 The inherent construction of an appliance for recessed, alcove, or closet installation shall provide for maintaining the minimum clearance required between the bottom, sides, and back of the appliance and between concealed surfaces of the wall or partition in which or to which the appliance is to be installed. Spacers shall have the strength and bearing surface necessary to maintain required clearance from such constructions.

4.12 Appliances for alcove or closet installation, such as upflow and downflow furnaces, boilers, and the like, are considered to comply with the requirements of 4.11, if spacers are located at no less than one level to provide essentially continuous interference with adjoining construction as provided, for example, by an extended base or support. Appliances for recessed installation in an interior wall under a cabinet, or through an outside wall may require spacers at more than one level, or more than one spacer on each surface of the appliance, to maintain the required clearance.

4.13 Integral spacers, where required on the appliance, shall be of such strength and bearing surface as to maintain the required clearance. A sheet steel spacer shall have a minimum thickness of 0.032 inch (0.81 mm) unless equivalent strength and rigidity are obtained with lesser thickness. A spacer shall be attached to the appliance by welding, riveting, or equally permanent means.

4.14 An appliance for recessed, alcove, or closet installation shall permit no portion of the products of combustion nor any portion of the heated circulating air or air from the space being heated to be discharged into spaces within walls, floor, or ceiling. Openings in the jacket, top, or sides through which the chimney or vent connector extend shall be sufficiently close-fitting to comply with this requirement.

4.15 Adjustable or movable parts shall be provided with locking devices to prevent unintentional shifting.

4.16 Screws or bolts used to attach parts that are detached during normal care or servicing of the appliance shall function as intended upon the application of the torques indicated in Table 4.1 after removal and replacement.

Table 4.1
Maximum torque requirements for screws

Screw size	Torque, pound-inches
No. 8	20
No. 10	25
1/4 inch	100
5/16 inch	200
3/8 inch	350
7/16 inch	550
1/2 inch	800
9/16 inch	1200

4.17 An appliance shall afford convenient operation by the user of those parts requiring attention or manipulation by him in intended usage.

4.18 Bolts, nuts, screws, except sheet-metal screws, and other threaded parts used in the general assembly of the appliance shall have threads in accordance with the requirements for Unified Inch Screw Threads, ANSI/ASME B1.1-1989.

4.19 The construction of an appliance shall be such to prevent products of combustion from coming in contact with thermal insulation.

4.20 Sheet steel parts of the appliance, except where otherwise specified in these requirements, shall be at least thick of 0.021 inch (0.53 mm) if uncoated or 0.016 inch (0.41 mm) if galvanized. This applies to parts such as radiation shields and liners not exposed to combustion products, and intake tubes, and the like, unless greater strength and rigidity are required for the application.

4.21 A removable cover for an access opening that maintains, with the cover closed, required separation between the combustion system and the atmosphere of the manufactured home or recreational vehicle, and a removable flue collector box, shall fit tightly and shall, together with any gasket material:

a) Be made of a material rated for the temperature to which it is exposed;

b) Show no evidence of deterioration or damage as a result of tests of the appliance; and

c) Be formed and cut to prevent parts from blocking air openings of a burner or pilot.

4.22 The construction of an appliance for furnishing heated air, circulated by gravity or by a fan, directly into the space to be heated through openings in the casing shall provide continuous circulation of heated air at all times during intended operation. Such an appliance having a single warm-air register shall not be equipped with a shutter to restrict the flow of warm air from the appliance. Such an appliance having more than one warm-air register may be equipped with a shutter, if the construction of the appliance permits at least one warm-air register to be open at any position of the shutter.

4.23 A horizontal furnace intended for suspended installation shall be provided with brackets or hangers to support the furnace from its basic frame or structure.

4.24 Neither gas piping nor gas controls shall be located within circulating air passageways, except on an appliance for recreational vehicle installation without provision for connecting return air ducts. No filters shall be permitted and service accessibility of gas piping and gas controls shall be accomplished without disrupting the integrity of the direct vent system.

5 Accessibility for Servicing

5.1 An appliance shall be constructed so that parts and controls requiring attention, manipulation, or adjustment in usage are accessible.

5.2 An appliance shall be constructed to allow cleaning of parts such as interior surfaces of burners, heating surfaces in contact with combustion products, without major dismantling of the appliance or removal of parts required by 4.8 to be factory assembled.

5.3 The removal of access panels, burners, caps, manifold assemblies, and the like, specifically constructed to permit ready removal and replacement for servicing, are not considered major dismantling as defined by 5.2.

5.4 Accessibility achieved with the use of simple tools shall be afforded for cleaning, inspection, repair, and replacement of all burners, controls, and safety devices when the appliance is installed as recommended by the manufacturer. The arrangement of parts in the assembly removed for servicing shall be such that their restoration, following removal, will not necessitate realignment to secure their intended relationship with other parts of the assembly. Special equipment that may be required for servicing to be done by the operator shall accompany the appliance to the user.

5.5 The heads and nuts of bolts, and the threads of screws, which must be removed to permit the removal of clean-out plates shall not be placed where they are in contact with flue-gases.

Exception: Bolts made of Type 430 stainless steel or material equally resistant to heat and corrosion and brass nuts need not comply with this requirement.

5.6 The flue-gas passageways of an air-heating appliance shall be accessible for cleaning if:

a) The products of combustion are drawn below the level of the burner;

b) The temperature of the combustion products is less than 250°F (121°C) when the appliance is operated within ±2 percent of the manufacturer's Btu per hour (W) input rating; or

c) The width of any flue-gas passage is less than 1-1/2 inches (38.1 mm).

5.7 A forced air heating appliance intended to be connected to a supply duct or ducts shall include means for measuring static pressure developed within the appliance casing. Such connection shall consist of a pipe or tubing connector fitting with a removable cap or plug and shall be located in the warm air outlet end of the appliance and be accessible after the appliance is installed in accordance with the manufacturer's instructions.

Exception: The cap or plug need not be provided if the orifice in the appliance casing is 0.040 inch (1.02 mm) in diameter or less. See Figure 51.1.

5.8 A forced air heating appliance shall be constructed to permit:

a) Replacement of each filter and blower belt, when provided;

b) Removal of the blower assembly; and

c) Oiling the motor, blower or fan bearings, which require that lubricant be added, without dismantling or removing any portion of the vent/air intake system, unless the construction is such that removal and replacement can be accomplished without the necessity of resealing the vent/air intake system.

6 Air-Intake Assemblies

6.1 An appliance shall be provided with a combustion air intake. The intake for an appliance equipped with a draft hood shall also provide air for draft hood dilution. An intake shall communicate with the outdoors.

6.2 If two intakes are employed to provide air as required by 6.1, both shall be designed for location in the same floor, roof, or wall of the manufactured home or recreational vehicle, or both shall terminate in the same pressure zone in an appliance enclosure inside the manufactured (mobile) home or recreational vehicle.

6.3 An air-intake assembly to the underside of a manufactured home or recreational vehicle shall extend at least 7 inches (177.8 mm) below the upper surface of the floor. An air-intake assembly through the roof of a manufactured home or recreational vehicle shall be constructed so that, when the assembly is installed as intended, the air entrance will be at least 6 inches (152.4 mm) above the top surface of the roof and the exit at least 6 inches below the top surface of the roof.

6.4 An air intake assembly for installation through an outside wall of a manufactured home shall be capable of being extended from at least 2 to 4-3/4 inches (50.8 to 121 mm) beyond the inside face of the wall and shall not project more than 3 inches (76.2 mm) beyond the outside wall.

6.5 An air-intake assembly for an appliance intended only for installation through an outside wall of a recreational vehicle shall be capable of being extended at least 2 inches (50.8 mm) beyond the inside face of the wall and shall not project more than 3 inches (76.2 mm) beyond the outside wall. The appliance shall be marked as specified in 101.31.

6.6 If a telescoping slip-fit connection is used in the air-intake tube to provide for installation in walls of varying thickness, the overlap shall be at least 1-1/4 inches (31.8 mm).

6.7 If a slip-fit is used at the connection of an air-intake tube with the appliance, the minimum overlap shall be 1/2 inch (12.7 mm), and means shall be provided to position the tube with respect to the wall structure.

6.8 The air entrance of an air-intake assembly shall be guarded, shielded, or located to exclude rain, snow, debris, and birds. A screen, if used, shall have a mesh of not less than 1/4 inch (6.4 mm).

6.9 An air entrance located beneath the floor and having a free area of at least 10 square inches (65 cm^2) with no cross-sectional dimension less than 1-1/2 inches (38.1 mm) is considered as complying with 6.8 without additional guarding or shielding.

6.10 The construction of an air intake and the path of intake air shall provide adequate combustion air to burners and adequate dilution air to any draft hood.

6.11 The free area of openings to the outdoors in combustion air and dilution air-intake assemblies to be installed in the wall of an enclosure in which an appliance, other than a direct vent system appliance, is to be installed shall not be less than 1 square inch (645 mm^2) for each 5000 Btu per hour (14.64 W) of the total input rating of all appliances to be in the enclosure.

6.12 The minimum cross-sectional dimension of an internal air passage in an air-intake assembly shall be at least 1/2 inch (12.7 mm).

6.13 The top or plane of any concealed combustion air or ventilation opening shall be at least 2 inches (50.8 mm) above the floor level. The bottom of such openings shall be at least 1 inch (25.4 mm) above the floor level unless all performance provisions can be met with the bottom of the opening blocked to a distance 1 inch (25.4 mm) above the floor.

6.14 Openings in perforated or expanded metal panels, provided over combustion air, circulating air, or draft relief openings shall not be less than 1/4 inch (6.4 mm) diameter. If the openings in such panels are other than circular in shape, they shall be of such size that will permit entrance of a No. 3 DMS (drill mean size) (5.4102 mm) drill.

7 Base

7.1 General

7.1.1 The base or frame of an appliance shall be constructed to provide for the support of the appliance. A base or frame shall be constructed of noncombustible material in a manner to provide strength and durability.

7.1.2 An appliance shall be provided with facilities to permit secure and ready attachment to the floor or structure of the manufactured home or recreational vehicle. If special bolts, screws, or other parts are needed for that purpose, they shall be furnished with each appliance.

7.1.3 Means for leveling and alignment, if required, shall be included.

7.1.4 A subbase, if furnished as a separate assembly, shall be marked to indicate the correct position of the appliance with respect to the subbase. A separate subbase that cannot be assembled incorrectly with respect to the appliance need not be marked.

7.2 Warm air appliances

7.2.1 The base, subbase, or duct connector of a downflow appliance shall be acceptable for installation on a combustible floor and shall establish and maintain not less than the required clearance between vertical surfaces of the plenum or duct to be attached thereto and the floor construction. A spacer shall extend at least 3/4 inch (19.1 mm) below the upper surface of the floor on which the appliance is to be installed.

7.2.2 The use of spacers in the form of separate blocks, shims, and the like, is not considered to be in accordance with 7.2.1.

8 Casing

8.1 The outer casing or jacket shall be made of steel or equivalent material, reinforced or formed if necessary, so that it is not likely to be damaged through handling in shipment, installation, and use.

8.2 A sheet-metal casing made of steel having a minimum thickness of 0.021 inch (0.53 mm) if uncoated, or 0.023 inch (0.58 mm) if galvanized, or of nonferrous sheet metal having an average thickness of 0.029 inch (0.74 mm) is considered to comply with 8.1 thinner materials may be used if adequate reinforcement is provided.

8.3 Access panels which need to be removed for intended service and accessibility shall be constructed to permit ready removal and replacement repeatedly without causing damage or impairing any required insulating value.

8.4 A removable panel through which air is drawn for combustion shall be constructed so as to prevent it from being attached in a manner that may result in performance of the appliance that could cause a risk of fire or injury to persons.

8.5 A removable panel shall be constructed so that it is not interchangeable with another panel on the same appliance if operation of the appliance with the panel interchanged could cause a risk of fire or injury to persons.

8.6 The casing shall completely close the bottom or be constructed to provide an effective radiation barrier between the heat exchanger and the floor except for an opening intended to be permanently connected to a circulating air distribution duct.

8.7 The casing shall be provided with an opening for the installation of a gas supply line. The edges of the opening against which the connected supply line is likely to bear, including any internal parts of the appliance, shall be free of sharp edges.

8.8 With reference to 8.7, protection of sharp edges may be provided by hemming or forming the edges of the opening, or by providing a grommet of metal or other material having the necessary aging properties, temperature and strength characteristics, and durability for the purpose.

9 Radiation Shields

9.1 A radiation shield or liner shall be constructed, formed, and supported for intended positioning and to prevent distortion or sagging in service. A shield or liner shall be protected against corrosion if its deterioration may cause excessive temperature when the appliance is tested in accordance with these requirements. Any finish provided to obtain the required resistance to corrosion shall not be damaged by heat when the appliance is tested as specified in this standard.

10 Combustion Chamber

10.1 A combustion chamber and flueway shall be constructed of sheet steel, or other equivalent material that has the strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to AISI C1010 sheet steel having a minimum thickness of 0.026 inch (0.66 mm) for an appliance having a maximum rated input not in excess of 50,000 Btu per hour (14.6 kW) and of 0.032 inch (0.81 mm) for all other sizes.

10.2 Combustion chamber (fire box) lining material, if used, shall be durable, supported in place, and accessible for replacement with equivalent material.

11 Radiator

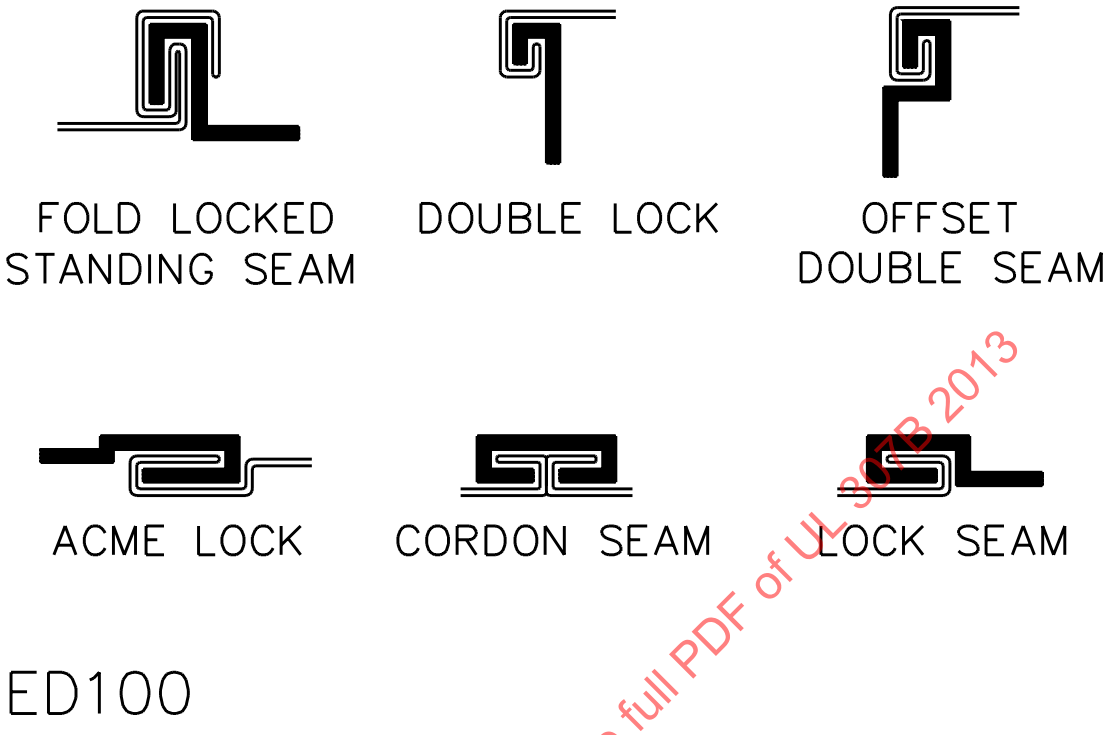
11.1 A radiator of an air heating appliance shall be made of material not lighter than that designated in 10.1 for a combustion chamber.

12 Heating-Surface Joints

12.1 Joints in heating surfaces shall be substantial and reasonably tight, as attained by being welded, lock-seamed, machined and bolted, or riveted. A joint shall not depend primarily on cement for tightness. A slip or lap joint shall not depend solely upon friction of the joint for strength.

12.2 Examples of some acceptable lock seams are illustrated in Figure 12.1.

Figure 12.1
Types of acceptable lock seams



13 Baffles

13.1 General

13.1.1 A flue baffle shall be fixed in position and shall be accessible for cleaning. A flue baffle that is removable for cleaning shall be of such construction as will facilitate its removal and permit replacement only in its intended position. It shall be made of material not lighter than that designated in 10.1 for a combustion chamber.

13.1.2 A baffle in a flue-gas passage or otherwise exposed to combustion products, whose malfunction would not cause a risk of fire or injury to persons and if considered replaceable, shall be observable and replaceable without dismantling the appliance.

13.2 Water heaters

13.2.1 If it is necessary to remove a flue baffle to clean the flueway, the flue baffle of an internal-flue-type water heater shall be constructed for removal within a clearance of 6-1/2 feet (2.0 m) above the floor, or 2 feet (610 mm) above the flue collar on a heater taller than 4-1/2 feet (1.3 m).

14 Flue Collar

14.1 A flue collar shall be arranged to permit secure attachment of a vent connector or draft hood, as required for the type of appliance.

14.2 A flue collar, or flue connector parts within the air handling compartment of a warm air appliance, shall have the rigidity, heat, and corrosion resistance at least equivalent to that of sheet steel having a thickness of not less than 0.032 inches (0.81 mm).

15 Flue-Gas Outlet Assembly

15.1 A flue-gas outlet assembly intended to convey flue gases to the outdoors shall be furnished with each appliance. A connector shall be furnished, if required, to connect the flue collar of the appliance to the flue-gas inlet of the outlet assembly.

15.2 A connector to a roof jack shall be of adequate length for the purpose when the appliance is installed in a manufactured home having at least a 7 foot (2.1 m) ceiling height.

15.3 A flue-gas outlet for an appliance shall not terminate beneath a manufactured home or recreational vehicle.

15.4 The flue-gas conveying conduit of a flue-gas outlet assembly for a gas-fired appliance exhausting flue gases at a temperature of 500°F (260°C) or less measured at the inlet to the flue-gas outlet assembly during the continuous operation test, and that is not constructed to be converted to utilize oil fuel, shall be made of material having durability and resistance to corrosion, fire, and heat equivalent to that of No. 1100 aluminum alloy, 0.016 inch (0.41 mm) thick.

15.5 The flue-gas conveying conduit of a flue-gas outlet assembly for appliances exhausting flue gases at a temperature greater than 550°F (260°C) but not greater than 1000°F (538°C) measured at the inlet to the flue-gas outlet assembly during the continuous operation test, shall be made of material having durability and resistance to corrosion, fire, and heat equivalent to that of Type 430 stainless steel, 0.012 inch (0.305 mm) thick.

15.6 A flue-gas conveying conduit of a connector, if shielded or encased or otherwise hidden when the appliance is installed, shall be made of material equivalent to that required on the flue-gas conveying conduit of the flue-gas outlet assemblies.

15.7 Type B gas-vent pipe is considered acceptable for a vent connector of a draft hood equipped gas appliance exhausting flue gases at a temperature not in excess of 500°F (260°C).

15.8 An outer casing or other structural part of a flue-gas outlet assembly or connector exposed to the weather (exclusive of flue-gas conveying conduit) shall be made of material having durability and resistance to corrosion, fire, and heat equivalent to that of galvanized steel, 0.018 inch (0.46 mm) thick. The material shall have a coating of zinc conforming with the coating Designation G90 in Table I of ASTM A653/A653M, Specifically for Sheet Steel, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM Designation. The weight of zinc coating may be determined by any acceptable method; however, in case of question, the weight of coating shall be established in accordance with the test method of ASTM A90-81(1991), Test Method for Weight of Coating. Such parts that are always inside the structure shall comply with the requirements in 9.1.

15.8 revised March 16, 2010

15.9 Parts of flueways shall be joined in a manner to prevent disengagement and shall be tight when tested in accordance with these requirements.

15.10 If a slip-fit is used at the connection of a connector with the appliance, the overlap shall be at least 1-1/4 inches (31.8 mm), and the construction at the outer ends of the connector shall result in a secure and gas-tight connection at the time of installation.

15.11 The assembly shall be provided with a cap to prevent the entrance of debris or rain into the flue-gas conveying pipe and into any air passages terminating exterior to the manufactured home or recreational vehicle.

15.12 A cap shall be constructed so that flue-gas or air passages are not likely to be obstructed by soot accumulation, by leaves or debris falling or blown onto it, or by birds.

15.13 A flue-gas outlet assembly intended for installation through the outside wall of a manufactured home or recreational vehicle shall be acceptable for varying thicknesses of wall construction as specified in 6.4 and 6.5.

16 Draft Hoods

16.1 A draft hood shall be furnished with each appliance except:

a) When the appliance is supplied with a power burner.

b) With a direct vent appliance which operates under forced or induced draft.

16.2 A detachable draft hood, when provided, shall comply with the applicable construction requirements of the Standard for Draft Hoods, ANSI Z21.12-1990.

16.3 A detachable draft hood shall be designed so that removal and replacement in normal use will not permanently deform any part or alter the relative position of any part with respect to another.

16.4 All parts of a nondetachable or built-in draft hood, if constructed of sheet steel, shall have a minimum thickness not less than the combustion chamber.

16.5 A built-in draft hood shall be constructed to provide adequate support for a vent connector or the flue outlet of the appliance. A collar on a horizontal outlet shall be at least 1 inch (25.4 mm) for outlets, 5 inches (127 mm) diameter or less, and a minimum 1-1/4 inches (31.8 mm) for outlets greater than 5 inches (127 mm) diameter.

17 Warm Air Appliance Air Handling System

17.1 An appliance and its return-air system shall be constructed so the negative pressure created by an air-circulating fan cannot affect the combustion air supply or cannot act to draw products of combustion into the circulating air.

17.2 The warm-air outlet of an appliance for alcove or closet installation shall extend to the exterior of the alcove or closet. The warm air outlet of an appliance for recessed installation shall extend to the interior of the counter or structure.

17.3 An integral plenum of an appliance for alcove or closet installation shall have no more than one outlet-air opening unless each additional opening is provided with a means supplied at the factory to close the openings in the casing and in any insulation or liner.

18 Warm Air Handling System for Installation Downstream From a Cooling System

18.1 A furnace intended for installation in the cooled-air path, downstream from a cooling coil, shall conform to the following:

a) All interior surfaces of the heat exchanger, combustion chamber including its bottom, radiators, and flues shall be resistant to corrosion by moisture.

b) The fire-box liner shall resist deterioration from moisture condensation.

c) Condensation shall not drip on burner parts or other corrodible parts if corrosion of any such parts is likely to cause hazardous operation.

d) The heat exchanger and appliance flue shall contain no traps or pockets in which condensation may collect.

18.2 A furnace containing a cooling coil parallel to the heating section shall have dampers or other means to prevent chilled air from entering the furnace section. If the dampers are manually operated, means shall be provided to prevent operation of either the furnace or the cooling unit unless the damper is in the full heat or cool position. Means shall be provided for disposal of condensate and to prevent dripping of condensate on the heating element.

18.3 Connections between the heat exchanger and the casing which encloses circulating air shall be constructed to prevent leakage of combustion products into the circulating air.

19 Materials In Air Handling Compartments of Warm Air Appliance

19.1 General

19.1.1 Materials in a compartment handling air for circulation through a duct system shall not have a flame spread rating of more than 25 nor a smoke developed rating of more than 50 when tested in accordance with the test method for fire hazard classification of building materials in the Standard for Tests for Surface Burning Characteristics of Building Materials, UL 723.

Exception: This requirement does not apply to the following:

a) Air filters, drive belts, wire insulation, and paint as applied for corrosion protection.

b) Gaskets forming air or water seals between metal parts.

c) Miscellaneous small parts such as resilient or vibration mounts, wire ties, clamps, or labels.

d) An adhesive which, when tested in combination with the specific insulating material, complies with the requirement.

e) Molded or formed components made of polymeric materials, not liners, in such quantity that the total surface area of such materials in the compartment does not exceed 10 square feet (0.9 m^2). See 19.1.7.

19.1.2 Exposed unimpregnated asbestos material shall not be used in an air handling compartment. The unprotected edge of a gasket sandwiched between two parts is considered to be exposed.

19.1.3 The supporting surface to be used in the fire hazard classification test of adhesives is to be of asbestos-cement board or metal. Other materials requiring support may be supported using metal rods or bars or 2-inch (50.8-mm) hexagonal mesh-wire with metal bars or rods.

19.1.4 Thermal or acoustic insulating material shall be securely positioned if loosening:

a) May reduce or block air flow to cause temperatures in excess of those acceptable in the temperature tests; or

b) Will result in reduction of electrical spacings below the required values, short-circuiting, or grounding.

Leading edges of insulation shall be protected against damage from the effects of the velocity of the moving air.

19.1.5 A mechanical fastener for each square foot (929 cm^2) of exposed surface is considered to securely position insulating liners. Mechanical fasteners may be bolts, metal clamps, wire rods, or the equivalent. Butting edges of insulation against bulkheads may be used to provide protection for leading edges against damage from effects of the velocity of moving air. Rigid or semirigid sheets of insulating material may not require fastening to the extent needed for less rigid material or protection of leading edges if the material possesses inherent resistance to damage.

19.1.6 An adhesive required for securing insulation shall retain its adhesive qualities at any temperature attained by the adhesive when the unit is tested under the performance requirements of this standard and at minus 17.8°C (0°F), or for outdoor-use equipment at minus 29°C (minus 20°F).

19.1.7 Polymeric materials exempted by 19.1(e) shall have a flame spread rating of not more than 25 or shall comply with the requirements of the Vertical Burning Test for Classifying Materials 5V in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

19.1.7 revised September 17, 2013

19.2 Air filters

19.2.1 An air filter shall be of a type acceptable for the purpose.

19.2.2 The temperature of any portion of a filter shall not exceed the maximum values specified in this standard when the appliance is tested as specified in this standard.

19.2.3 A filter, if supplied as a part of the appliance, shall be accessible for inspection or replacement without the use of special tools and without dismantling the appliance.

19.2.4 Means shall be provided to retain and support an air filter in the intended position in or on the appliance.

20 Water Heater Storage Vessels

20.1 A nonmetallic material in contact with water shall comply with the requirements in the National Sanitation Foundation Standard for Plastic Piping System Components and Related Materials, NSF No. 14-1990, with regard to toxicity, taste, color, solubility, and odor.

20.2 The water vessel storage tank shall withstand a hydrostatic test pressure of 300 psig (2.1 MPa), or its rated hydrostatic test pressure, whichever is greater, without developing leakage or visible permanent distortion, or the tank shall carry the symbol of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. The working pressure shall be not more than 50 percent of the hydrostatic test pressure. If the vessel is of steel, the inside surfaces shall be protected against corrosion by galvanizing, porcelain enameling, or the equivalent.

20.3 A storage tank shall be equipped with a valve to facilitate emptying the tank.

20.4 Hot and cold water connections shall be clearly identified.

20.5 A storage tank shall have an opening for installation of a temperature-and-pressure relief valve. The opening:

a) Shall be located:

1) In the top of the tank; or

2) With its centerline in the upper 6 inches (152.4 mm) of the side.

b) Shall be separate from the openings for water connections.

c) Shall be threaded in conformity with the Standard for Pipe Threads, General Purpose (Inch), ANSI/ASME B1.20.1-1983(R1992).

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d) Shall accommodate a 3/4-inch or larger trade-size pipe. See ANSI/ASME B1.20.1-1983(R1992).

20.6 Water heater outlet connections of 3/4 inch trade size pipe shall have a minimum internal diameter of 5/8 inch (15.9 mm).

20.7 Aluminum piping, tubing, or fittings shall not be used for water connections.

20.8 A storage-tank type water heater shall be equipped with a pressure relief valve or a combination temperature-pressure relief valve of appropriate capacity. The relieving pressure shall be not higher than 60 percent of the hydrostatic test pressure of the storage vessel. The relieving temperature of a combination valve shall be 210°F (98.9°C).

21 Water Heater Dip Tubes

21.1 A dip tube shall be provided with an antisiphoning hole so located that after the dip tube is installed, the hole is within 6 inches (152.4 mm) of the top of the tank.

21.2 A dip tube having a specific gravity less than 1.0 shall be held in place by a positive means that limits any vertical displacement to not more than 1/4 inch (6.4 mm).

21.3 Nonmetallic material for a dip tube shall have a specific gravity greater than 0.94 and comply with 20.1 for toxicity.

21.4 A nonmetallic dip tube shall be investigated for acceptability, particularly with respect to solubility, brittleness, and resistance to deformation, collapse, and sagging at temperatures likely to be encountered in service. Specific tests are described in Section 95, Nonmetallic Dip Tube Tests.

21.5 Nonmetallic dip tubes shall be permanently marked with the manufacturer's name or trademark and the lot number.

BURNER EQUIPMENT AND CONTROLS

22 General

22.1 A gas appliance shall be designed to use natural gas and LP-Gas interchangeably or LP-Gas only. The conversion from one gas to another shall be accomplished readily without the use of special tools.

22.2 If a change of orifices is required for a change in gas, each orifice shall be correctly and clearly identified. One set of orifices shall be in place when the appliance is shipped. The other orifices shall be attached to the appliance. An orifice shall be readily accessible, and the assembly shall be arranged so that a change can be made readily from one gas to another. An assembly removed for that purpose shall be removable without breaking splices in wiring or disconnecting conduit and shall be capable of being restored in accordance with 5.4 and without the possibility of transposal of electric connections that could cause risk of fire or electric shock.

23 Gas Piping, Tubing, And Fittings

23.1 Fuel-confining parts or operating parts shall be made of metal having a melting point (solidus temperature) of not less than 950°F (510°C) and tensile strength of not less than 10,000 psi (68.9 MPa) at 400°F (204°C) or equivalent, if failure of any of the part could cause a risk of fire, explosion, or injury to persons, such as leakage of fuel, or preventing a safety device from functioning. Parts shall not sag, distort, melt, or show leakage of fuel during any of the tests specified in this standard. Piping shall be made of iron, steel, copper, aluminum, or brass.

23.2 Aluminum piping and tubing shall not be:

a) Exposed to temperatures in excess of 700°F (371°C);

b) Exposed to condensate;

c) Acceptable when it passes through insulating material of other than neutral reaction, unless the tubing is protected from the insulation; nor

d) Acceptable for use on appliances for recreational vehicle installation, except for pilot lines 1/4 inch (6.4 mm) outside diameter or smaller.

23.3 Copper tubing or tubing with internal copper surfaces, when used for conveying gas, shall be internally tinned or equivalently treated to resist sulfur corrosion.

23.4 Compounds used on threaded joints of gas piping shall be resistant to the action of liquefied petroleum gases.

23.5 Unions in gas lines shall be of the ground-joint or flanged-joint type including a gasket resistant to the action of liquefied petroleum gases and suitable for the temperature to which it is exposed.

23.6 If the pilot gas supply line is taken from a horizontal line, the connection shall be made either on the side or top. If taken from a vertical line, it shall be above the main burner supply line.

Exception: A pilot supply line may be taken from the bottom of a horizontal line if means are provided to prevent condensate from entering the pilot line.

23.7 Steel gas supply piping employed on an appliance shall be in accordance with the Standard for Welded and Seamless Wrought Steel Pipe, ANSI/ASME B36.10M-1985.

23.8 Gas supply piping shall be firmly supported.

23.9 Main burner manifold assemblies shall be firmly supported to prevent turning or displacement while making connections to the service piping.

23.10 Formed supply piping shall:

a) Have all bends smoothly made without any appreciable reduction in the cross-sectional area;

b) Reveal no imperfections occasioned by the forming process;

c) Be annealed if necessary to remove internal stresses; and

d) Be thoroughly cleaned inside to remove loose particles.

23.11 Ends of piping and tubing shall be carefully reamed to remove obstructions or burrs.

23.12 Tapped holes for gas valves, pilots, or other branch supply lines shall have not less than 3-1/2 taper pipe threads.

23.13 A 1/8-inch NPT plugged tapping, accessible for test gauge connection, shall be furnished downstream from the last main line gas control for measuring gas pressure at the burner. The plug used shall not be of the slotted head type.

23.14 When steel pipe is used, its trade size shall not be less than 1/4 inch (6.4 mm) for pilot burner manifolds and 1/8 inch (3.2 mm) for individual pilot lines.

23.15 Nonferrous tubing employed as gas conduit shall have a wall thickness in accordance with Table 23.1.

Table 23.1
Minimum acceptable wall thickness for nonferrous tubing

Outside diameter		Minimum acceptable wall thickness	
Inch	(mm)	inch	(mm)
1/4	(6.4)	0.029	(0.74)
5/16	(7.9)	0.029	(0.74)
3/8	(9.5)	0.032	(0.81)
7/16	(11.1)	0.032	(0.81)
1/2	(12.7)	0.038	(0.97)
9/16	(14.3)	0.038	(0.97)
5/8	(15.9)	0.038	(0.97)
3/4	(19.0)	0.045	(1.14)
7/8	(22.2)	0.045	(1.14)

24 Main Burner and Flame Spreaders

24.1 Bodies or burners including mixer head, mixer tube, and burner head shall be made of materials having a melting point above 1450°F (788°C).

24.2 A burner shall be secured so it will not twist, slide, or drop out of position.

24.3 Burners shall be constructed of corrosion-resistant material or have a corrosion-resistant finish to resist corrosion by condensate. Steels with coatings, such as paint suitable to the temperature to which exposed, and cast iron are considered corrosion resistant.

24.4 Steel pipe, when tapped or threaded and used in the construction of the burner shall be in accordance with the Standard for Wrought-Steel Pipe, ANSI/ASME B36.10M-1985.

24.5 Joints, when used in the pressure zone or in the burner head of a burner assembly, shall be gas tight and shall not depend for mechanical strength, or primarily for tightness, on cement or other sealing material, except where such joints form part of the port area. Joints shall be securely bolted, threaded, machined, welded, brazed, or be of equivalent construction.

24.6 Ribbon burners shall be constructed so that they form an assembly that can be easily removed, cleaned, and replaced in the field without the use of special tools.

24.7 Main burners and mixer tubes shall be properly placed and securely positioned without the use of set screws in the heat zone so they will not twist, slide, or drop out of position. The construction shall be such that a burner cannot be installed in the appliance in other than the correct position.

24.8 If interchange of burners within an appliance can result in unsatisfactory ignition or combustion, the burners and their supporting means shall be so constructed that this interchange of burners is not possible.

24.9 Burner parts requiring field assembly shall be constructed so that they cannot be incorrectly fitted together within the appliance, or they shall be marked to indicate the correct method of assembly.

24.10 Provisions shall be made to permit observation of main burner flames during adjustment and under operating conditions. Flame observation ports shall be constructed of heat-resistant material and, unless located within the cabinet casing, shall be protected from mechanical damage. Glass, if used, shall be framed and be at least 1/8 inch (3.2 mm) thick.

24.11 Sheet-metal burner parts shall be at least 0.0304 inch (0.772 mm) thick AISI C1010 steel or equivalent.

24.12 Flame spreaders and flame spreader supports shall be constructed so they cannot be incorrectly fitted together, or they shall be marked to indicate the correct method of assembly. If it is necessary to remove the flame spreader for service or assembly, it shall not be threaded to its support unless the support is readily removable.

24.13 Flame spreader supports shall be constructed so that the flame spreader cannot be supported at other than the correct distance from the burner.

25 Combustion Air Supply and Control

25.1 General

25.1.1 Primary air adjustment means, when provided, shall be constructed so that the flow of primary air can be controlled to provide proper flame characteristics.

25.1.2 Provisions shall be made for fixing adjustable pilot and main burner primary air adjustment means accurately in position. Primary air adjustment means shall not change position by the action of gravity when the means for locking the adjustment is loosened sufficiently to permit adjustment.

25.1.3 The main burner primary air adjustment means shall be accessible with the burner in operation.

25.2 Air shutters

25.2.1 Air shutters shall be constructed of a corrosion-resistant material, or have a corrosion-resistant finish, except when the type of material or construction employed will prevent sticking or corroding in position. Cast-iron air shutters are considered acceptable.

25.2.2 Sheet-metal air shutters shall be at least 0.0254 inch (0.645 mm) thick. If sheet-metal air shutters are less than 0.0508 inch (1.29 mm) thick, they shall have the outer edges turned at right angles or be otherwise reinforced.

25.2.3 When air shutters are used, constructional clearances, such as between air mixer and air shutter faces and around orifice holders, shall be reduced to a practical minimum so as to have no appreciable effect on the flame characteristics when stopped by lint or are otherwise blocked.

25.3 Combustion air dampers

25.3.1 If a separate automatic combustion air door is provided, the door shall open by gravity if the automatic controlling means becomes inoperative.

Exception: If an automatic combustion air door is directly connected to an automatic valve, the air door need not open should the automatic valve fail to open.

25.3.2 Manipulation of an automatic combustion air door shall not cause the automatic valve connected to it to open.

25.3.3 An appliance equipped to change the firing rate automatically shall automatically proportion the air supply with the fuel, if necessary, to produce stable and complete combustion at all fire rates.

26 Orifice Spuds and Orifice Fittings

26.1 A threaded hexagon head or equivalent fixed orifice spud shall be provided for each main burner. Each orifice spud shall be readily accessible after the burner and mixer tube have been removed.

26.2 Readily removable fixed orifice spuds shall be provided, independent of the operation of the pilot gas valve, for limiting the amount of gas consumed by the pilot.

26.3 Main burner orifice spuds shall engage at least 3-1/2 full threads with their holders.

26.4 Main burner orifice spuds and orifice spud holders shall be made of materials having melting points of at least 1450°F (788°C).

27 Manual Valves

27.1 When a selector valve is provided on an appliance for use with natural gas or liquefied petroleum gases to convert the appliance from one fuel to another, it shall be arranged so that gas cannot enter two sets of orifices simultaneously nor flow through the appliance regulator and bypass simultaneously.

27.2 When the manual gas valve is exposed to view, lever or tee handles shall be at right angles to the line of flow when in the off position and parallel when in the on position. If this cannot be done, or if the valve handle only is exposed to view, the on and off positions or directions of rotation to open and close shall be clearly indicated.

27.3 A removable handle on a manual gas valve shall be constructed so that it cannot be attached to confuse the on and off positions.

27.4 Gas burner valves shall be located or constructed so that they will not be likely to unintentional change of setting.

27.5 Adjusting screws for regulating the gas admitted to the burner or pilot shall be concealed, protected, or enclosed.

27.6 Lubricants used on valves shall be resistant to the action of liquefied petroleum gases.

28 Gas Appliance Pressure Regulators

28.1 A gas appliance shall be equipped with a gas-pressure regulator to regulate the gas to be supplied to the appliance. An appliance for use with natural and LP-Gas interchangeably shall be equipped with a regulator arranged so that the change from one regulated pressure to the other may be accomplished readily, such as by inverting or transposing a part; it shall not be necessary to add or delete parts from the assembly to accomplish pressure regulation of either fuel.

28.2 Each appliance shall be provided with a gas appliance pressure regulator. The regulator shall be leak resistant to excessive pressure in accordance with the requirements for Gas Appliance Pressure Regulators, ANSI Z21.18-1993.

28.3 A gas-pressure regulator shall be constructed for main burner load application and for pilot load application if the appliance is so equipped. The regulator shall be installed within the casing so that when the appliance is tested as described in the Continuous Operation Temperature Test, Section 65, the regulator will not be subjected to temperatures in excess of 150°F (66°C) unless the gas-pressure regulator has been investigated for use at a higher temperature.

28.4 If a single regulator is used to control the pressure of both the main burner and pilot burner gas, it shall be of the type suitable for main burner and pilot burner load application as designated by the following symbol adjacent to the regulator model number:

a) Ⓟ for an appliance having a pilot gas flow rate less than 0.50 but not less than 0.15 cubic foot per hour (less than 3.93 but not less than 1.18 cm^3/s); or

b) Ⓟ or ▲ for an appliance having a pilot gas flow rate of 0.50 cubic foot per hour (3.94 cm^3/s) or greater.

28.5 An appliance convertible for use with natural gas and liquefied petroleum gases shall be provided with either a convertible gas pressure regulator or, when the outlet pressures for both gases are the same, with a regulator not convertible but suitable for use with both gases.

28.6 A gas appliance pressure regulator provided on a appliance not convertible for use with natural gas and liquefied petroleum gases shall be of either the adjustable or nonadjustable type.

29 Gas Bleeds and Vents

29.1 A gas appliance pressure regulator requiring access to the atmosphere for intended operation shall be vented as specified in 29.3 or it shall be provided with a vent-limiting means to limit the escape of gas from the vent opening in the event of diaphragm rupture as specified in 29.2.

29.2 The vent limiting means on pressure regulators that are not vented as specified in 29.3 shall limit the flow rate to:

a) Not more than 2.5 cubic feet (0.07 m^3) per hour of natural, manufactured, mixed gases, and LP-Gas-air mixtures of specific gravity of 0.64; and

b) Not more than 1.0 cubic foot (0.03 m^2) per hour of LP-Gas of specific gravity of 1.53 when tested at 21 inches of water column (5.2 kPa).

29.3 Gas bleed lines from diaphragm valves or controls and vent lines from gas-pressure regulators, when required, shall be furnished and shall be vented. A bleed line from a diaphragm valve shall terminate outside or in a burner located adjacent to the main burner or the constant-burning pilot if a constant-burning pilot is employed. Other bleed lines and a vent line from a gas pressure regulator shall terminate outside or, if a constant burner pilot is used, they may be terminated in a burner adjacent to a constant-burning pilot. Outside termination shall be such that the exit is not likely to be clogged with debris, ice, or snow. If termination is beneath the structure, the vent line shall include an internal vent-limiting device as specified in 29.2 for pressure regulators and as specified in 29.4 for diaphragm valves.

29.4 Diaphragm valves having termination of bleed lines beneath the structure shall include vent limiting means that will limit the flow of gas through the bleed lines, including the event of diaphragm rupture, to not more than 0.5 cubic foot (0.01 m^3) per hour of gas of specific gravity of 1.53 when tested at 11.0 inches water column (2.7 kPa).

29.5 If there is a continuous-burning pilot a bleed line or vent line shall terminate in a suitable burner tip constructed of metal having a melting point of at least 1450°F (788°C). The tip shall be secured in a fixed position relative to the pilot burner and located so that the escaping gas will be readily ignited by the pilot and the heat liberated thereby will not adversely affect the normal operation of the automatic ignition system.

29.6 When a vent line is provided for a gas pressure regulator, a U.S.A. Standard 375 micron (40 mesh) brass, aluminum or equivalent wire screen sufficient in size to provide free area equal to the area of the escapement orifice, shall be installed in and made a part of the connecting fitting for installation at the regulator vent tapping. The fitting, when tightened against the screen, shall provide no opening larger than the mesh of the screen specified. This provision is only applicable to gas pressure regulators having escapement orifices larger than 0.0165 inch (0.419 mm) in diameter.

30 Pilot Gas Filters

30.1 Pilot gas filter shall be provided for each pilot. Each pilot gas filter shall be in accordance with the Standard for Gas Filters on Appliances, ANSI Z21.35-1989.

30.2 The manufacturer's specified capacity of a pilot gas filter shall not be less than the rated capacity of the pilot burner with which it is used.

30.3 A pilot gas filter shall be installed at the point of pilot gas take-off from the main gas supply line. When the pilot valve is combined with another control and does not constitute the pilot flow adjustment means, the gas filter may be installed in the pilot line take off from the combination control.

31 Control Circuits

31.1 A safety control circuit shall be wired by the manufacturer as required for high-voltage circuits. The safety control circuit shall be two-wire, one side grounded, 120 volts maximum, 60 hertz, single phase.

31.2 A safety control or protective device shall interrupt the ungrounded conductors.

31.3 The requirement of 31.2 does not apply to a circuit within a safety control or to the extension of a circuit to a separate element of the control, such as a flame-sensing device.

31.4 A control circuit shall be arranged so that it may be connected to a power-supply branch circuit that can be fused at no more than the value appropriate for the rating of any control included in the circuit.

31.5 A safety limit control that functions to interrupt or reduce the delivery of fuel for combustion by opening an electrical circuit shall be arranged to effect the direct opening of that circuit, whether the switching mechanism is integral with or remote from the sensing element.

31.6 The requirement of 31.5 is intended to avoid interposing in the limit-control circuit other controls, the malfunction of which may create a risk of fire or injury to persons that the limit control is intended to prevent.

32 Controls

32.1 General

32.1.1 All safety controls shall be accessible.

32.1.2 A heating appliance shall be equipped with a primary safety control that conforms to the requirements for Automatic Gas Ignition Systems, Section 34.

32.1.3 No control shall be furnished on an appliance that would allow, by manual operation, gas flow to the main burner when there is no power available.

32.1.4 A safety control shall be supported so that both the control and its sensing element will remain in the intended position. It shall be possible to determine by observation or test whether or not each control is in its intended location.

32.1.5 Nothing shall be provided for the purpose of permitting any safety control to be rendered ineffective or allowing firing of the appliance without the protection of each of the required safety controls.

32.1.6 An appliance not equipped to provide automatic restarting as intended shall be arranged to require manual restart after any control functions to cause the fuel supply to be shut off and following restoration of an interrupted power supply.

32.1.7 An appliance shall be equipped with a limit control. The limit control shall be in addition to and shall function at a higher value than any operating control or thermostat.

32.1.8 The limit control or controls shall be factory-located on the appliance.

32.1.9 On an appliance provided with induced draft or power burners, construction shall be such as to prevent gas flow to the main burner or burners in the event the blower providing the draft is not rotating. A properly applied centrifugal, sail, or air pressure switch, or equivalent device suitable for safety control duty, meets the intent of this provision. If a centrifugal mechanism is used, the blower shall be secured to the shaft on which the centrifugal switch is located by means of a set screw on a flatted shaft, or equivalent.

32.1.10 A manual reset control shall be resettable without dismantling the appliance or removing any part of it if such dismantling or removal nullifies the separation of the combustion system from the atmosphere of the manufactured home or recreational vehicle.

32.2 Warm air appliance limit control

32.2.1 At the maximum setting allowed by a fixed stop, the limit control for a warm-air heating appliance shall not permit an outlet-air temperature in excess of the maximum permitted temperature as determined by the tests specified in 71.1 – 71.6.

32.2.2 The limit control of a warm-air heating appliance shall be a recycling-type control, except that the limit control for a wall furnace and an auxiliary limit control on a central furnace may be a manual-reset type.

32.3 Warm air appliance fan control

32.3.1 A temperature sensing fan control shall be provided with a fixed stop at the upper temperature limit for ″fan on″ operation.

32.3.2 When a temperature sensing fan control is not supplied, either the furnace shall be equipped with a device which will provide for blower operation to prevent abnormal air temperatures, or the blower shall operate continuously.

32.3.3 A device to provide for blower operation to prevent abnormal air temperatures, as permitted in 32.3.2, shall not be capable of adjustment without the use of special tools, which would allow longer blower off periods than recommended by the manufacturer at the start of operational cycles.

32.4 Boiler limit control

32.4.1 At the maximum setting allowed by a fixed stop, the limit control for a heating boiler shall not permit a steam pressure of more than 15 psig (103 kPa) in a steam boiler, or a water temperature of more than 250°F (121°C) in a hot-water boiler. Such boilers are stamped with the ASME Code Symbol H.

32.4.2 A steam boiler shall be equipped also with a safety control to prevent firing of the main burner or burners when the water in the boiler is at a low level that could cause a risk of fire, explosion, or injury to persons as determined by the test specified in 83.1 and 83.2.

32.5 Water heater limit control

32.5.1 A water heater shall be provided with an automatic fuel shutoff system, for example, a temperature limit control, actuated by high-water temperature as an integral part of the heater. The shutoff system shall be of the manual reset type and shall be arranged to interrupt all fuel supplied to the heater when the water in the storage tank has attained a temperature of not more than 210°F (936°C).

32.5.2 The limit control for a water heater shall shut off the gas supply to the main burner or burners. It shall be of the manual reset or of the single use type.

32.5.3 A manual-reset mechanism shall be accessible for resetting. A location behind an access cover in the jacket of the water heater is acceptable.

32.5.4 The automatic fuel shutoff system shall have no operating parts in common with the temperature-regulating control mentioned in 32.6.1, but a common mounting bracket or a common enclosure may be employed for both devices.

32.5.5 Immersion-type, temperature-limiting, devices shall be located so that the temperature-sensitive element is immersed in the water within the tank and controls the temperature of the water within the top 6 inches (152.4 mm) of the tank.

32.5.6 Surface-mounted limit controls shall be mounted and located so that the temperature-sensitive element senses the water temperature within the top 6 inches (152.4 mm) of the tank. Such surface-mounted temperature-sensitive elements shall be insulated or located so as to isolate them from flue gas heat or other ambient conditions that are not indicative of stored water temperature.

32.6 Water heater temperature regulating control

32.6.1 A water heater shall be controlled by means of a temperature-regulating control.

32.6.2 At the maximum setting allowed by a fixed stop, the temperature regulating control of a water heater shall limit the water temperature to not more than 194°F (90°C) except that a maximum water temperature of 200°F (93.3°C) may be accepted if the temperature-regulating control or controls and limit control have cutout temperature tolerances not greater than ±5°F (±2.8°C).

32.6.3 A temperature-regulating control shall be capable of operation under rated or actual electrical load for 30,000 cycles of operation without any mechanical or electrical failure, impairment of operation, or apparent damage. Any change in calibration as a result of the operation test shall not exceed ±10°F (±5.6°C).

32.6.4 An adjustable temperature regulating control shall be set at the factory to a control position corresponding to a 120°F (49°C) or lower setting. This setting is approximate in the case of a marking that reads ″Low-Medium-High″ or the equivalent, instead of directly in degrees Fahrenheit or Celsius.

32.6.5 A water heater equipped with a nonadjustable temperature-regulating control shall be set at 120°F (49°C) or lower.

Exception: A water heater equipped with a nonadjustable temperature-regulating control that is set above 120°F (49°C) at the factory shall be provided with the Scald Hazard Label Marking described in 103.3 and shown in Figure 103.1.

33 Automatic Gas Valves

33.1 Electrically operated main gas-control valves shall be of a type that will close upon current failure.

33.2 All gas to the main burner or burners shall pass through at least two safety shutoff valves in series which may or may not be in a single control body. These valves shall be either:

a) At least two automatic valves, each of which serve as both operating valves and safety shutoff valves.

b) At least one automatic valve and one safety shutoff valve. The automatic valve shall serve as an operating valve and a safety shutoff valve. The safety shutoff valve shall serve only as a safety shutoff valve, control any pilot gas as well as main burner gas, comply with 34.4, and shall be controlled only by the automatic gas ignition system and a secondary temperature limit control. This secondary temperature limit control shall be of the single use or manual reset type and have a temperature sensing element separate from that of the primary temperature limit control. An appliance equipped as specified in this shall comply with 66.1.5 and 66.2.1.

34 Automatic Gas Ignition Systems

34.1 Each appliance shall be equipped with an automatic gas ignition system or systems. This system or systems shall be constructed to function in either of the following manners:

a) Provide for ignition of main burner gas by means of a proved igniter or pilot. If the presence of the ignition source is not proved, provide:

1) For automatic shutoff of main burner and pilot burner gas; or

2) A system having an interrupted ignition source, shall provide for supervision if the main burner flame only following the main burner flame establishing period. If the presence of the main burner flame is not provided with the flame establishing period, the system shall provide for automatic shutoff of main burner.

b) Provide for ignition of main burner gas by means of a direct ignition device. If the presence of the main burner flame is not proved, provide for automatic shutoff of main burner gas. In the event of main burner flame outage during an operating cycle, provide for automatic shutoff of main burner gas without reenergizing the direct ignition device or provide for safe reignition of main burner gas by reenergizing the direct ignition device as specified in 64.3.1 and 64.3.2.

34.2 An automatic ignition device shall be placed so as to be easily seen or, if concealed in intended operation, shall be capable of being reached by the simple removal of an access cover. The use of tools to remove the access cover is acceptable.

34.3 A manually lighted pilot burner shall be located so as to be capable of being lighted without burning the hand. If a pilot burner ignition device or lighter rod is necessary for safe and convenient pilot ignition, it shall be provided. If a lighter rod is used, it shall not exceed 12 inches (305 mm) in length, and means shall be provided for permanently attaching it to the appliance.

34.4 If a manually lighted pilot is provided, the construction of each control shall be such that main burner gas flow cannot occur while the pilot is being lighted. The interruption of main burner gas flow shall not depend on the operation of a manual valve which is not mechanically interlocked with the pilot gas control, nor on the thermostat or a separate switch. After the pilot has been established and the safety shutoff device remains in a position that would permit main burner gas flow, an additional manual operation of a control shall be necessary to permit main burner gas flow.

34.5 A pilot burner shall be placed to permit visual observation (direct or indirect) of its flames during adjustment and under operating conditions. Such observation shall be accomplished without dismantling or removing any part of the direct vent system with the main burner or burners off and, unless other means are available for checking operation, with the main burner or burners on.

34.6 When an automatic relight pilot system is used, it shall be of a type that will act to reestablish the ignition means in 0.8 second or less, or a mechanical or electrical interlocking means shall be provided to prevent the flow of gas to the main burner or burners when the automatic relight pilot system is energized.

34.7 Slotted ports connecting ignition and thermal element ports of pilot burners shall be milled or otherwise accurately formed.

34.8 Automatic ignition devices, safety shutoff device assemblies, and bleed assemblies, when used, shall be made secure against unintentional displacement.

34.9 Automatic ignition devices shall be positively positioned with respect to the main burner ports.

34.10 Automatic gas ignition system components shall be installed so that the operation of these devices and main burner ignition will not be affected by falling scale and dirt during intended operation.

34.11 A control constructed for two or more fuel flow rates shall be equipped with either:

a) A readily accessible leakproof adjustment means for regulating all rates other than the full open rate. The adjustment for the lowest flow condition shall not be capable of adjustment in the field to a rate lower than the manufacturer's specified minimum input rating; or

b) A means, not adjustable in the field, for setting the lowest specified flow condition. Nonadjustable types shall be set by the manufacturer so the low-flow condition is not lower than the manufacturer's specified minimum input rating.

In the case of a power burner, the control shall be constructed so that no adjustment of the rate of gas flow can be made, unless the burner system is such that adjustment of the control will not adversely affect the proportion of air and gas supplied to the burner.

WIRING METHODS

35 Field Wiring

35.1 General

35.1.1 Provision shall be made for connection of a wiring system that, in compliance with the National Electrical Code, ANSI/NFPA 70-1993, will provide for connection of fixed equipment.

35.1.2 The location of an outlet box or compartment in which field-wiring connections are to be made shall permit these connections to be inspected after the equipment is installed as intended.

35.1.3 The connections are to be accessible without removing parts other than a service cover or panel and the cover of the outlet box or compartment in which the connections are made. A component intended for such use may serve as a cover.

35.1.4 The size of a junction box in which field-installed conductors are to be connected by splicing shall be not less than that specified in Table 35.1. A conductor passing through the box is to be considered as one conductor, and each conductor terminating in the box is also counted as one conductor. A field-furnished conductor for high-voltage circuits is considered to be not smaller than 14 AWG (2.1 mm^2).

35.1.4 revised February 2, 2009

Table 35.1
Size of junction boxes

Size of conductor, AWG	Free space within box for each conductor, cubic	
	inches	(cm^3)
16 or smaller	1.5	(24.6)
14	2.0	(32.8)
12	2.25	(36.9)
10	2.5	(41.0)
8	3.0	(49.2)

35.1.5 Wiring terminals or leads not less than 6 inches (152.4 mm) long shall be provided for connection of field-wiring conductors of at least the size required by the National Electrical Code, ANSI/NFPA 70-1993, corresponding to the marked rating of the assembly.

35.1.6 Leads may be less than 6 inches (152.4 mm) in length if it is evident that the use of a longer lead may result in damage to the lead insulation.

35.1.7 Leads intended for connection to an external circuit shall be provided with strain relief if stress on the lead may be transmitted to terminals, splices, or to internal wiring if such stress may cause the lead to separate from its termination or may result in damage to the lead from sharp edges. See Field Wiring Strain Relief Test, Section 68.

35.1.8 An identified (grounded) terminal or lead shall not be electrically connected to a single-pole manual switching device which has an off position or to a single-pole overcurrent (not inherent overheating) protective device.

35.1.9 Stranded conductors at terminals shall be prevented from contacting other uninsulated live parts and from contacting dead metal parts, such as by use of pressure-terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or equivalent means. Open slot-type connectors shall not be used unless they are designed to prevent disconnection resulting from loosening of the clamping means. The shanks of terminal connectors shall be protected by insulating tubing, or the equivalent, if the required spacings may be reduced as a result of loosening of the clamping means. The thickness of the insulation on the shanks shall be at least 0.028 inch (0.71 mm).

35.1.10 Leads provided for spliced connections to an external high-voltage circuit shall not be connected to wire-binding screws or pressure terminal connectors located in the same compartment as the splice or shall not be visible to the installer unless the screws or connectors are rendered unusable for field-wiring connections or the leads are insulated at the unconnected ends.

35.1.11 Terminal parts by which field-wiring connections are made shall consist of soldering lugs or pressure terminal connectors, except that for 10 AWG (5.3 mm^2) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire-binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to hold the wire in position.

35.1.11 revised February 2, 2009

35.1.12 A wire-binding screw at a high-voltage wiring terminal for field connection shall be not smaller than No. 10 (4.8 mm diameter) except that a No. 8 (4.2 mm diameter) screw may be used for the connection of a conductor not larger than 14 AWG (2.1 mm^2) and a No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) control circuit conductor.

35.1.12 revised February 2, 2009

35.1.13 A terminal plate for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) in thickness for a 14 AWG (2.1 mm^2) or smaller wire, and not less than 0.050 inch (1.27 mm) in thickness for a wire larger than 14 AWG; and in either case, there shall be not less than two full threads in the metal.

35.1.13 revised February 2, 2009

35.1.14 A terminal plate formed from stock having the required thickness may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads.

35.1.15 A wire-binding screw shall thread into metal.

35.1.16 Field-wiring terminals shall be secured to their supporting surfaces by methods other than friction between surfaces so that they will be prevented from turning or shifting in position if such motion may result in reduction of spacings to less than those required. This may be accomplished by two screws or rivets; by square shoulders or mortises; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by some other equivalent method.

35.1.17 Conductors intended for connection to a grounded neutral line shall be finished in a white or gray color. All other current-carrying conductors shall be finished in colors other than white, gray, or green. A terminal for connection of a grounded conductor shall be identified by a metallic-plated coating, substantially white in color and shall be readily distinguishable from other terminals, or it shall be identified in some other manner, such as on an attached wiring diagram.

35.1.17 revised February 2, 2009

35.1.18 A box or enclosure included as part of the assembly and in which a branch circuit supplying power to the appliance is to be connected shall not require that it be moved for intended servicing of the appliance. This requirement does not apply to limit controls and stack switches to which metal-clad cable or flexible metallic conduit is to be directly attached.

35.1.19 A box or enclosure in which field-installated conductors are to be connected as indicated in 35.1.18 and 35.1.20 shall be located so that the temperature of conductors within the box or surfaces of the box likely to be in contact with the conductors will not exceed that specified for Type T wire when the appliance is tested in compliance with these requirements.

35.1.20 Wiring to be done in the field, where permitted, between the appliance and devices not attached to the appliance, or between separate devices that are field-installed and located, shall comply with these requirements when done with Type T wire enclosed in conduit or with metal-clad cable.

35.1.21 A knockout or opening for connection of a field-wiring system to a terminal box or compartment shall accommodate conduit of the trade size determined by applying Table 35.2.

Table 35.2
Trade size of conduit in inches[a]

Wire size		Number of wires				
AWG	(mm^2)	2	3	4	5	6
14	(2.1)	1/2	1/2	1/2	1/2	1/2
12	(3.3)	1/2	1/2	1/2	3/4	3/4
10	(5.3)	1/2	1/2	1/2	3/4	3/4
8	(8.4)	3/4	3/4	1	1	1-1/4
6	(13.3)	3/4	1	1	1-1/4	1-1/4
4	(21.2)	1	1	1-1/4	1-1/4	1-1/2
3	(26.7)	1	1-1/4	1-1/4	1-1/4	1-1/2
2	(33.6)	1	1-1/4	1-1/4	1-1/2	2
1	(42.4)	1-1/4	1-1/4	1-1/2	2	2
1/0	(54.0)	1-1/4	1-1/2	2	2	2-1/2
2/0	(67.0)	1-1/2	1-1/2	2	2	2-1/2
3/0	(85.0)	1-1/2	2	2	2-1/2	2-1/2
4/0	(107.0)	2	2	2-1/2	2-1/2	3
MCM						
250	(127)	2	2-1/2	2-1/2	3	3
300	(152)	2	2-1/2	3	3	3
350	(177)	2-1/2	2-1/2	3	3-1/2	3-1/2
400	(203)	2-1/2	3	3	3-1/2	4
500	(253)	3	3	3-1/2	4	4

[a] This table is based on the assumption that all conductors will be of the same size and there will be no more than 6 conductors in the conduit. If more than 6 conductors will be involved or if all of them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires, based on the cross-sectional area of Type THW wire.

35.2 Grounding

35.2.1 The equipment grounding terminal or lead shall be located in the field wiring compartment and shall be suitable for connection of an equipment-grounding conductor of at least the size required by the National Electrical Code, ANSI/NFPA 70-1993, for the rating of the power supply circuit to be connected.

35.2.2 A soldering lug, a push-in (screwless) connector, or a quick-connect or similar friction fit connector shall not be used for the terminal for the field-installed grounding conductor.

35.2.3 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green colored head that is hexagonal, slotted, or both. At a wire-binding screw, upturned lugs, or the equivalent, shall be provided to retain the conductor. A pressure wire connector intended for connection of such a conductor shall be identified by being marked ″G,″ ″GR,″ ″Ground,″ ″Grounding,″ or by a marking on a wiring diagram provided on the equipment. The wire-binding screw or pressure wire connector shall be secured to the frame or enclosure and shall be located so that it is unlikely to be removed during servicing. If a pressure connector is used adjacent to the connectors intended for the supply conductors and if it could be mistaken for the neutral of a grounded supply, it shall be marked in accordance with 101.15.

35.2.4 The surface of an insulated lead intended for the connection of an equipment-grounding conductor shall be finished a continuous green color or a continuous green color with one or more yellow stripes, and no other lead visible to the installer shall be so identified.

35.3 Cord-connected appliances

35.3.1 An appliance intended for cord connection to the power supply shall be provided with a flexible cord and attachment plug of the grounding type, and of the type, voltage rating, ampacity, and current rating consistent with the rating and intended operation of the appliance.

35.3.2 The marked current rating of a cord-connected appliance shall not exceed 80 percent of the current rating of the attachment plug.

35.3.3 A cord-connected appliance shall employ a grounding-type attachment plug that complies with the ANSI/NEMA designations in Table 35.3.

Table 35.3
Attachment plugs

Attachment plug rating,		ANSI/NEMA designation[a]
Amperes	Volts	
15	125	5-15P
20	125	5-20P
15	250	6-15P
20	250	6-20P

[a] As part of the Standard for Wiring Devices – Dimensional Requirements, ANSI/NEMA WD6-1988.

35.3.4 A cord-connected appliance shall employ a Type SJ, SJO, SJT, or SJTO power-supply cord rated for use at a voltage not less than the rated voltage of the appliance. The ampacity of the cord as specified in the National Electrical Code, ANSI/NFPA 70-1993 shall not be less than what is required by the appliance.

35.3.5 The length of a power-supply cord shall not be less than 6 feet (1.82 m) and not more than 7 feet (2.13 m). The length is to be measured between the point at which the cord exits the appliance and the attachment plug.

35.3.6 The power-supply cord shall be provided with a strain relief means so that a stress of the cord will not be transmitted to terminals, splices, or internal wiring. If a metallic cord rip is provided, it shall not contact uninsulated live parts or reduce spacings within the enclosure if the cord is moved inward. The cord shall not be subject to damage by moving parts if it can be moved inward. See Strain Relief Test, Section 97.

35.3.7 The edges of the entry hole for the power-supply cord, including the cord entry hole in a bushing, shall be smooth and rounded, and without burrs, fins or sharp edges that may damage the cord insulation. The power-supply cord shall be routed to reduce the risk of damage to the cord insulation.

35.3.8 The power-supply cord shall be attached to the appliance in a manner and location where it cannot be run through holes in walls, ceilings, and floors when it is connected to the manufactured home or recreational vehicle's power supply outlet.

35.3.9 The power-supply cord shall be attached to the appliance in a manner and location where it cannot be concealed behind the walls, ceilings, and floors when it is connected to the manufactured home or recreational vehicle's power supply outlet.

36 Factory Wiring

36.1 The wiring of high-voltage and safety-control circuits shall comply with this section.

36.2 Wiring shall be insulated conductors having current-carrying capacity, voltage and temperature ratings acceptable for the intended use. Conductors for line-voltage circuits shall be rated for use at potentials up to 600 volts. A conductor, other than an integral part of a component, shall be not smaller than 18 AWG (0.82 mm^2).

36.2 revised February 2, 2009

36.3 The wiring of all circuits shall be furnished by the manufacturer as part of the appliance. If the appliance is not assembled and wired at the factory, such wiring shall:

a) Be furnished as a wiring harness with each appliance and be arranged to facilitate attachment when the appliance is assembled; and

b) A pictorial diagram showing the exact arrangement of the wiring shall be included with each appliance.

36.4 Electrical wiring to a part that must be moved for maintenance and servicing shall be arranged so that the part may be moved without breaking soldered connections or disconnecting conduit. Conductors to be disconnected from terminals of such a part shall terminate in eyelets or connectors. If the wiring to a part that functions also as an access plate or cover (for example, a transformer closing the access to the nozzle assembly) is not readily detachable, the assembly shall include provision for support of that part by means other than the wiring when the part is moved for servicing. Any allowable movement of such part shall not unduly twist, bend, or pull the wiring.

36.5 Conductors shall be enclosed within a metal conduit, electrical metallic tubing, metal raceway, metal-clad cable, or an electrical enclosure, except as indicated in 36.4.

Exception: Neoprene or thermoplastic insulated wiring material in Group A of Table 36.1 need not be enclosed as indicated above, if all of the following conditions are met:

a) Wiring is not subject to movement by air or vibration.

b) Where practicable, individual leads are bunched together to form a cable.

c) Wiring is secured to fixed panels or other surfaces at intervals to provide proper routing and to reduce the likelihood of hooking of slack during service, such as replacing air filters, operating reset mechanisms, oiling motors, replacing fuses, adjusting the settings of controls, or the like.

d) Wiring is located in a compartment which is provided with a complete base pan or similar bottom closure.

e) Wiring cannot be contacted through openings in the outer enclosure or cabinet by the probe illustrated in Figure 41.1.

f) Wiring is not located in a compartment where field connections are made at the point of installation.

Table 36.1
Typical wiring materials

Table 36.1 revised February 2, 2009

Group	Type of wire, cord cable or appliance wiring material with insulation thickness corresponding to wire sizes specified	Wire size		Insulation thickness	
		AWG	mm^2	Inch	mm
A	FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RHW, RUH, RUW, T, THW, XHHW, MTW, THW-MTW, THWN, TW, or thermoplastic appliance wiring material.	10 and smaller	5.3	2/64	0.8
		8	8.4	3/64	1.2
		6-2	13.3 – 33.6	4/64	1.6
		1	42.4	5/64	2.0
		1/0	53.5	5/64	2.0
		2/0	67.4	5/64	2.0
		3/0	85.0	5/64	2.0
		4/0	107.2	5/64	2.0
B	SO, ST, SJO, SJT, or appliance wiring material with thermoplastic or neoprene insulation.	18	0.82	4/64	1.6
		16	1.3	4/64	1.6
		14	2.1	5/64	2.0
		12	3.3	5/64	2.0
		10	5.3	5/64	2.0
		8	8.4	6/64	2.4
		6	13.3	8/64	3.2
Thermoplastic wiring materials, as specified in Group A, with insulation thickness of 2/64 inch (0.3 mm) for 16 or 18 AWG (1.3 or 0.82 mm^2) and 3/64 inch (1.2 mm) for 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3 or 8.4 mm^2), are considered equivalent to the wiring material specified in Group B, when the conductors are covered with 1/32 inch (0.8 mm) wall thickness thermoplastic insulating tubing of a type recognized for the purpose from the standpoint of dielectric properties, heat resistance, moisture resistance, and flammability.					

36.6 Flexible metal conduit shall be not smaller than 3/8-inch (9.5-mm) electrical trade size. This does not apply to parts of components, such as conduit protecting flame sensor leads.

36.7 Flexible metal conduit shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.4 m) and within 12 inches (305 mm) on each side of every junction box except for lengths not over 36 inches (0.91 m) where flexibility is necessary.

36.8 All splices and connections shall be mechanically secure and bonded electrically. A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection may result in the risk of fire or electric shock.

36.9 A splice shall be provided with insulation equivalent to that required for the wires involved if the spacing between the splice and other metal parts may not be maintained.

36.10 Splicing devices, such as fixture-type splicing connectors, pressure wire connectors, and the like, may be employed if they have insulation equivalent to that required for the voltage to which they are subjected.

36.11 A splice is to be enclosed by being installed in a junction box, control box, or other compartment in which high-voltage wiring materials may be employed as specified in Group A of Table 36.1.

36.12 Splices shall be located, enclosed, and supported so that they are not subject to damage, flexing, motion, or vibration.

36.13 At all points where conduit or metal tubing terminates, the conductors shall be protected from abrasion. If metal-clad cable is used, an insulating bushing or its equivalent shall be provided between the conductors and the metal tubing and the connector or clamp shall be such that the insulating bushing or its equivalent will be visible for inspection.

36.14 A wireway shall provide for the interconnection of sections and fittings that will provide a rigid mechanical assembly and electrical conductivity. The interior of the wireway shall be free from burrs and sharp corners or edges that might cause damage to the insulation on wires. Screws and bolts, however used, shall not project into the wireway unless sharp ends and threaded sections, other than the threaded sections of machine screws or bolts that do not project into the wireway more than 1/32 inch (0.79 mm), are covered or otherwise prevented from coming in contact with wires.

36.15 Wiring shall be supported and routed to reduce the likelihood of damage due to sharp edges or moving parts.

36.16 Factory wiring involving a potential of not more than 300 volts between parts attached to the same assembly with a predetermined fixed relationship one to the other may be done with Type SO or ST cord, provided all of the following conditions are fulfilled:

a) It is not practical to do the wiring in accordance with 31.6.

b) The cord is not required to be bent, twisted, or otherwise displaced to render maintenance and service.

c) The length of cord exterior to the assembly is not more than 4 inches (101.6 mm) and strain relief is provided.

36.17 Cords or appliance wiring material as referenced in Group B of Table 36.1 may be employed if the wiring is enclosed by an appliance casing conforming to all of the following:

a) There are no openings in the bottom, unless a U-shaped channel or trough is located under the wiring and the wires do not project through the plane of the top of the trough or channel.

b) Openings in other than the bottom will not permit entrance of a rod having a diameter of 1/2 inch (12.7 mm), and openings for such items as pipe or conduit are not more than 1/2 inch (12.7 mm) in diameter larger than the object that will be installed through the opening.

c) Openings are not closer than 6 inches (152.4 mm) to the wiring unless metallic barriers or baffles are placed between the wiring and the openings. Louvered openings of a kind which serve to protect the wiring from mechanical damage from outside the compartment and which

are so formed as to assist in confining an electrical disturbance to within the compartment are exempt from this requirement. To conform with these requirements the louvers should be of a drawn metal of a form to completely obscure viewing of the wiring within the compartment when viewed from the horizontal outside the compartment, and the openings shall be located so an object falling vertically cannot enter the compartment through the louvered openings.

d) Where flammable material other than electrical insulation is located within the compartment the wiring is separated from such material and the material will not sustain combustion upon removal of the ignition source. An air filter may be employed within the enclosure.

36.18 In applying the requirement of 36.17, an opening that is always intended to be connected to an air duct may be considered as closed.

36.19 Cords and other wiring material permitted in accordance with 36.17 and 36.24 shall be supported and arranged to avoid being physically damaged, such as by closely following surfaces. Strain relief, where required, shall be provided.

36.20 Holes in walls or partitions through which insulated wires or cords pass shall be provided with smoothly rounded bushings or shall have smooth, rounded surfaces, upon which the wires or cords may bear to prevent abrasion of the insulation. Bushings, if required, shall be ceramic, phenolic, cold-molded composition, fiber, or equivalent material.

36.21 A fiber bushing shall be not less than 3/64 inch (1.2 mm) thick, shall be so located that it will not be exposed to moisture, and shall not be employed where it will be subjected to a temperature higher than 90°C (194°F) under normal operating conditions.

36.22 A hole in porcelain, phenolic, phenolic composition, or other acceptable nonconducting material and having a smooth rounded surface is considered to be the equivalent of a bushing.

36.23 To provide an acceptable unbushed opening in sheet metal usually requires rolling, extrusion, or both, of the metal around the opening, or the insertion of an acceptable grommet.

36.24 Factory wiring of a low-voltage safety circuit may be Type SP-2 cord having all-neoprene insulation, Type SPT-2 cord or appliance wiring material having neoprene, thermoplastic, or equally durable insulation of equivalent thickness, or low-energy safety-control wire, if such wiring is located in a cavity or compartment of an appliance and is shielded from damage.

37 Electrical Systems Rated 12 Volt DC

37.1 Appliances for recreational vehicle use only may be equipped for operation on 120 volt ac and 12 volt dc, or 12 volt dc only power sources.

37.2 If the appliance includes a converter for 120 volt ac to 12 volt dc, the converter shall comply with the Standard for Power Units Other Than Class 2, UL 1012.

37.3 Wiring used in direct current circuits shall be of stranded copper not less than 18 AWG (0.82 mm^2), be provided with insulation as required for line-voltage ac circuit, and have adequate current-carrying capacity.

37.3 revised February 2, 2009

37.4 The electrical circuitry on a direct current appliance shall be of the two-wire type. The body of the appliance shall not be used as the return leg of the circuitry.

37.5 An appliance for connection to a 12 volt dc power source shall comply with the field wiring requirements in 35.1.1 – 35.1.21 if it is permanently connected, or Section 35.3 if it is cord connected.

37.6 Appliances intended for operation on a 120 volt ac and a 12 volt dc power source shall be provided with a selector switch. Such appliances may be permanently connected to each power source.

37.7 An appliance intended to be connected only to a 12 volt dc power supply does not need provisions for equipment grounding.

38 Separation of Circuits

38.1 Unless supplied with insulation for the highest voltage involved, insulated conductors of different circuits (internal wiring, including wires in a junction box or compartment) except subdivided circuits or branch circuits of the same voltage from the same feeder, shall be separated by barriers or shall be segregated; and shall, in any case, be so separated or segregated from uninsulated current-carrying parts connected to circuits of another voltage.

38.2 Segregation of insulated conductors from uninsulated live metal parts or another circuit may be accomplished by clamping, routing, or equivalent means that provides for permanent separation.

38.3 Field-installed conductors of any circuit shall be segregated or separated by barriers from:

a) Field-installed and factory-installed conductors connected to any other circuit, unless the conductors of both circuits are insulated for the maximum voltage of either circuit.

b) Uninsulated live parts of any other circuit.

c) Any uninsulated live parts whose short-circuiting may result in the risk of fire, electric shock, or injury to persons, except that a construction in which field-installed conductors may make contact with wiring terminals is acceptable, provided that Type T or equivalent conductors are or will be installed when wired in accordance with the National Electrical Code, ANSI/NFPA 70-1993.

38.4 Segregation of field-installed conductors from other field-installed conductors and from uninsulated live parts connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors, with respect to the terminals or other uninsulated live parts, so that there is no likelihood of the intermingling of the conductors or parts of different circuits.

a) If the number of openings in the enclosure does not exceed the minimum required for intended wiring and if each opening is located opposite a set of terminals, it is to be assumed for the purpose of determining compliance with 38.3, that the conductors entering each opening will be connected to the terminals opposite the opening.

b) If more than the minimum number of openings are provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit is to be considered.

38.5 To determine if a device complies with the requirements of 38.3, it is to be wired as it would be in service and in doing so slack is to be left in each conductor, within the enclosure, and no more than average care is to be exercised in stowing this slack into the wiring compartment.

38.6 If a barrier is used to provide separation between the wiring of different circuits or between operating parts and field-installed conductors, it shall be of metal or insulating material and shall be held in place.

38.7 A metal barrier shall have a thickness at least as great as that specified by Tables 41.1 and 41.2, based on the size of the barrier. A barrier of insulating material shall be not less than 0.028 inch (0.71 mm) thick and shall be of greater thickness if its deformation may be accomplished so as to defeat its purpose. Any clearance at the edges of a barrier shall be not more than 1/16 inch (1.6 mm) wide.

38.8 Openings in a barrier for the passage of conductors shall be not larger than 1/4 inch (6.4 mm) in diameter and shall not exceed in number, on the basis of one opening per conductor, the number of wires which will need to pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire may be in contact with it; and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the necessary wires.

38.9 The output of a transformer device supplying a Class 2 low-voltage circuit shall not be interconnected with the output of another such transformer device provided as a part of the equipment unless the voltage and current measurements at the output terminals of the interconnected devices are within the values allowed for a single, Class 2 transformer device of 30 volts or less.

38.10 Two or more transformer devices supplying circuits classified as Class 2 low-voltage circuits provided as a part of the appliance shall be treated as separate circuits. If more than one such circuit is intended to be field-wired, the several circuits shall be segregated or separated by barriers as specified in 38.6, and the transformer output of each circuit shall be marked to warn that the separation shall be maintained.

39 Bonding for Grounding

39.1 Exposed or accessible noncurrent-carrying metal parts, which are likely to become energized and which may be contacted by the user or by service personnel during service operations performed when the equipment is energized, shall be electrically connected to the point of connection of an equipment grounding terminal or lead.

39.2 Uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing, and piping valves, and the like shall be bonded for grounding if they may be contacted by the user or service personnel.

Exception: The following metal parts need not be grounded:

a) Adhesive-attached metal-foil markings, screws, handles, and the like, which are located on the outside of enclosures or cabinets and isolated from electrical components or wiring by grounded metal parts.

b) Isolated metal parts, such as magnet frames and armatures, and small assembly screws which are separated from wiring and uninsulated live parts.

c) Panels and covers which do not enclose uninsulated live parts if insulated parts and wiring are separated from the panel or cover.

d) Panels and covers which are insulated from electrical components and wiring by an attached insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 1/32 inch (0.8 mm) thick.

39.3 A component, such as a switch, likely to become separated from its intended grounding means for purposes of testing or adjustment while the appliance is energized, shall be provided with a grounding conductor not requiring removal for such service.

39.4 Splices shall not be employed in wire conductors used for bonding.

39.5 Metal-to-metal hinge bearing members are considered as a means for bonding a door for grounding.

39.6 A separate bonding conductor shall be of material rated for use as an electrical conductor. Ferrous-metal parts in the grounding path shall be protected against corrosion by enameling, galvanizing, plating, or equivalent means. A separate bonding conductor or strap shall:

a) Be protected from mechanical damage, such as by being located within the confines of the outer enclosure or frame, and

b) Not be secured by a removable fastener used for any purpose other than bonding for grounding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

39.7 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, or by welding, soldering, or brazing with materials having a softening or melting point greater than 454°C (849°F). The bonding connection shall penetrate nonconductive coatings such as paint or vitreous enamel.

39.8 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 39.10 under any degree of compression permitted by a variable clamping device and if the results are still acceptable after exposure to the effects of oil, grease, moisture, and thermal degradation which are likely to occur in service. The effect of assembling and disassembling, for maintenance purposes, such a clamping device is to be considered with respect to the likelihood of the clamping device being reassembled in its intended position.

39.9 If bonding depends on screw threads, two or more screws or two full threads of a single screw shall engage the metal.

39.10 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than specified by 39.11 – 39.13, it shall be acceptable if the connecting means does not open:

a) When carrying for the time indicated in Table 39.1 twice the current equal to the rating of the branch circuit overcurrent device required to protect the equipment, and

b) During a short circuit test when in series with a fuse of proper rating. See Short-Circuit Test, Section 69.

Table 39.1
Duration of current flow, bonding-conductor test

Rating of overcurrent device, amperes	Minimum duration of current flow, minute
30 or less	2
31 – 60	4

39.11 The size of a conductor or strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device to which the equipment will be connected. Except as specified in 39.10, the size of the conductor or strap shall be in compliance with Table 39.2.

Table 39.2
Bonding wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire		Aluminum wire	
	AWG	(mm^2)	AWG	(mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.4)

[a] Or equivalent cross-sectional area.

39.12 A bonding conductor to a component or electrical enclosure is not required to be larger than the size of the conductors supplying power to the component or components within the enclosure.

39.13 If more than one size of branch-circuit overcurrent devices is involved, the size of each bonding conductor is to be based on the rating of the overcurrent device intended to provide ground-fault protection for the component bonded by the conductor. For example, if a motor is individually protected by a branch-circuit overcurrent device smaller than other overcurrent devices used with the equipment, a bonding conductor for that motor is to be sized on the basis of the overcurrent device intended for ground-fault protection of the motor.

ELECTRICAL COMPONENTS

40 General

40.1 Electrical components and wiring shall be arranged:

a) To avoid oil or water dripping or running on them during intended use or from a connection required to be uncoupled for servicing the appliance; and

b) To avoid contact with water from humidifiers.

40.2 Attachment plugs or separable connectors shall not be used in a circuit if the breaking or making of the circuit by such devices may allow operation of the appliance in a manner that can cause risk of fire, electric shock, or injury to persons.

40.3 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to prevent it from turning except as specified in 40.4 and 40.5.

40.4 The requirement that a switch is to be prevented from turning may be waived if all of the following conditions are met:

a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during operation of the switch.

b) The means for mounting the switch makes it unlikely that operation of the switch will loosen it.

c) The spacings are not reduced below the required values if the switch rotates.

d) The operation of the switch is by mechanical means rather than by direct contact by persons.

40.5 A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation cannot reduce spacings below the required values.

40.6 The means for preventing turning shall consist of more than friction between surfaces. A toothed lock washer which provides both spring takeup and an interference lock is acceptable as the means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

40.7 Uninsulated live parts shall be so secured to the base or mounting surface that they will be prevented from turning or shifting in position if such motion may result in a reduction of spacings below the acceptable values.

40.8 Control equipment located within the plenum or return-air compartment of a furnace shall be so constructed, enclosed, and/or protected that dense smoke will not be generated or flame emitted under any conditions which may occur in service.

41 Electrical Enclosures

41.1 General

41.1.1 Uninsulated live high-voltage parts shall be enclosed, guarded, or located to reduce the risk of unintentional contact by persons during intended use of the appliance. This applies also to such parts located in a compartment into which access is required for servicing of the equipment, such as resetting controls, replacing filters, lubrication, cleaning, and the like.

41.1.2 Among the factors that are to be taken into consideration when evaluating the acceptability of a nonmetallic enclosure are resistance to:

a) Mechanical damage;

b) Impact;

c) Moisture-absorption;

d) Combustion;

e) Corrosion; and

f) Distortion at temperatures to which the enclosure may be subjected under conditions of anticipated use.

A polymeric material shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

41.1.3 The enclosure shall prevent the emission of molten metal, burning insulation, flaming particles, or the like through openings onto flammable material, including the surface on which the equipment is mounted.

41.1.4 Sheet metal complying with Tables 41.1 and 41.2 is considered acceptable for the enclosure of electrical components.

Table 41.1
Minimum thickness of sheet metal for electrical enclosures – carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated		Metal coated	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	(MSG)		(GSG)	
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	(24)		(24)	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	25.4)	12.5	(31.8)	(22)		(22)	
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	(20)		(20)	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	(18)		(18)	
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	73.7)	36.0	(91.4)	(16)		(16)	
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	88.9)	43.0	(109.2)	(15)		(15)	
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	(14)		(14)	
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
35.0	(88.9)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)	(13)		(13)	
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	(12)		(12)	
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	(11)		(11)	
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	(10)		(10)	

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidity attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Equivalent reinforcing may be accomplished by construction that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

1) Single sheet with single formed flanges (formed edges);

2) A single sheet which is corrugated or ribbed; and

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

Table 41.2
Minimum thickness of sheet metal for electrical enclosures – aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	(0.58)
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029
5.0	(12.7)	6.0	(5.2)	10.5	(26.7)	13.5	(34.3)	(0.74)
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	(0.91)
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	(1.14)
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	(1.47)
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075
20.0	(50.8)	25.0	(63.5)	45.0	(114.3)	55.0	(139.7)	(1.91)
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited		0.095
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	(2.41)
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	(3.10)
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	(3.89)

[a] See note a of Table 41.1.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

41.1.5 If the construction and location of the component and the strength and rigidity of the outer cabinet warrant, an individual enclosure thinner than specified in Tables 41.1 and 41.2 may be employed.

41.1.6 Terminal housings of motors, to which connections are to be made in the field, shall be of metal and shall be sized in accordance with the National Electrical Code, ANSI/NFPA 70-1993.

41.1.7 Steel enclosures shall be protected against corrosion by painting, plating, or other equivalent means.

41.1.8 If insulating material other than electrical insulation is provided within the enclosure, consideration is to be given to the burning characteristics and combustibility of the material, and the proximity of an ignition source.

41.1.9 All intended mounting positions of the unit are to be considered when determining if it complies with the requirement of 41.1.3.

41.1.10 A junction box which is formed in part by another part such as a fan scroll or a motor casing is to fit such that:

a) An opening between the box and motor frame having a dimension exceeding 1/2 inch (12.7 mm) does not permit a flat feeler gauge, 5/64 by 1/2 inch (2.0 by 12.7 mm) wide to enter.

b) An opening between the box and motor frame having no dimension exceeding 1/2 inch (12.7 mm) does not permit the entrance of a 13/64 inch (5.2 mm) diameter rod.

41.1.11 An overall enclosure for uninsulated live parts shall have no openings that are not closed when the appliance is installed.

Exception: An enclosure for parts other than a fuse or thermal cutout may have openings necessary for ventilation or for the device to function provided they comply with the following:

a) An opening that will not permit entrance of a 3/4-inch (19.1-mm) diameter rod is acceptable if:

1) A probe as illustrated in Figure 41.1 cannot be made to touch any uninsulated live part when inserted through the opening; and

2) A probe as illustrated in Figure 41.2 cannot be made to touch film coated wire when inserted through the opening.

b) An opening that will permit entrance of a 3/4-inch (19.1 mm) diameter rod is acceptable under the conditions described in Figure 41.3.

Figure 41.1
Probe for uninsulated live parts

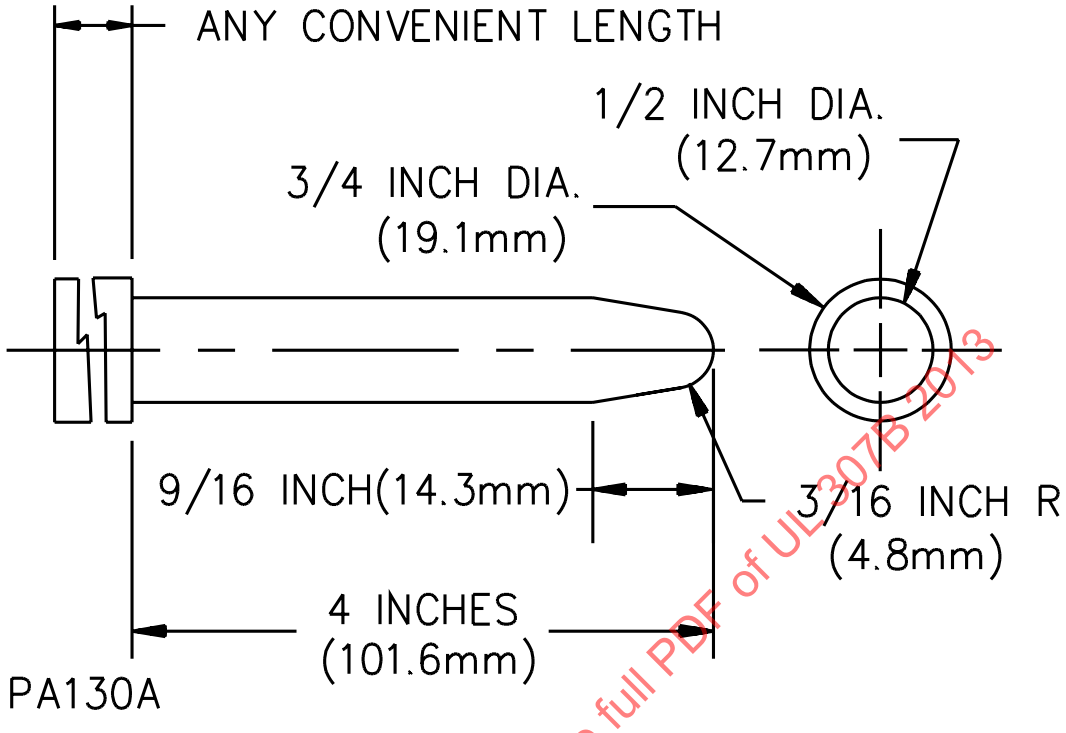


Figure 41.2
Probe for film coated wire

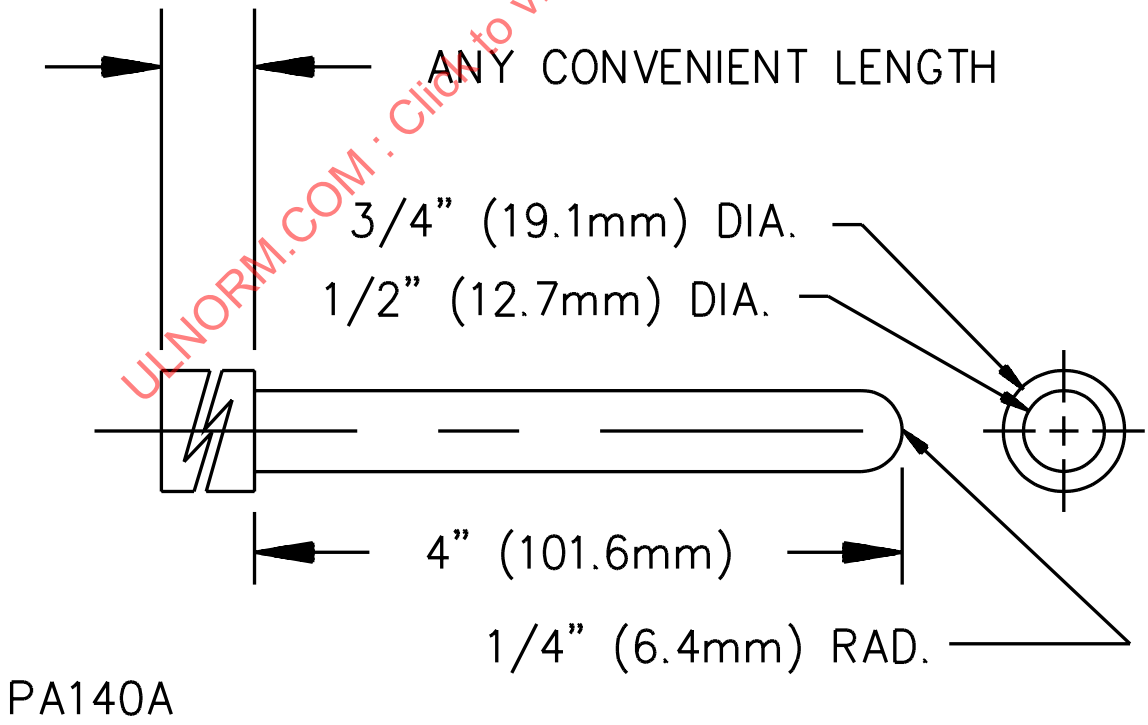
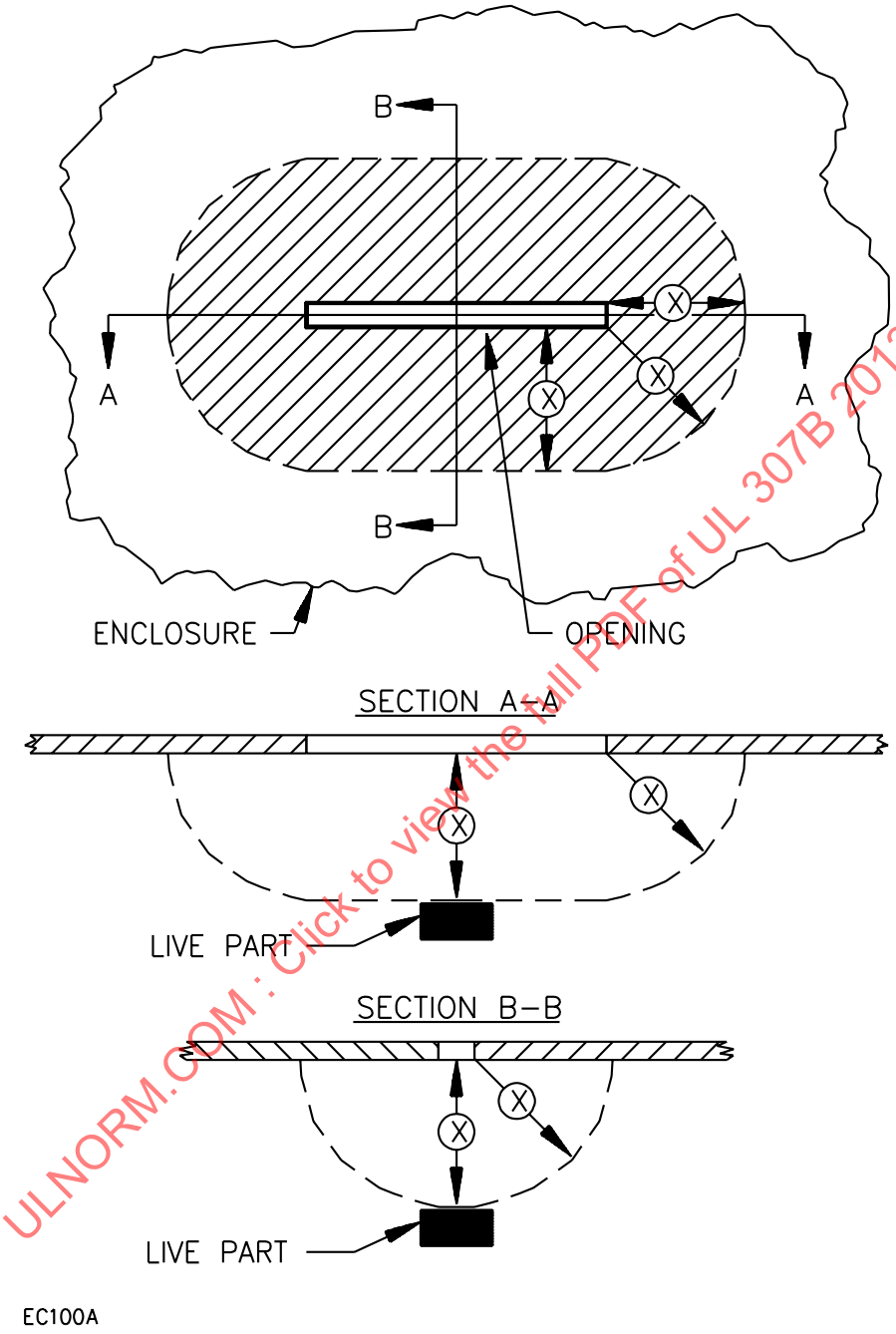


Figure 41.3
Opening in enclosure



The opening is acceptable if, within the enclosure, there is no uninsulated live part or enamel-insulated wire:

a) Less than X inches (mm) from the perimeter of the opening, as well as;

b) Within the volume generated by projecting the perimeter X inches (mm) normal to its plane. X equals five times the diameter of the largest diameter rod which can be inserted through the opening, but not less than 4 inches (101.6 mm).

41.1.12 During the examination for conformance with the requirements of 41.1.11, a part of the enclosure, including air filters, which may be removed without the use of tools, is to be removed.

41.2 Doors and covers

41.2.1 A cover or access panel of an enclosure for uninsulated live parts shall be provided with means for firmly securing it in place.

41.2.2 A hinged or pivoted panel or cover shall be positioned or arranged so that gravity or vibration incidental to operation of the product does not cause the panel or cover to fall or swing from the open position if this may cause injury to persons or expose persons to uninsulated live parts or to other moving parts that may cause injury.

41.2.3 The appliance shall be so arranged that an overcurrent protective device, such as a fuse, the intended functioning of which requires renewal, can be replaced and manual-reset devices can be reset without removing parts other than a service cover or panel, and a cover or door enclosing the device. See 41.2.4.

41.2.4 A required protective device shall be wholly inaccessible from outside the appliance without opening a door or cover, except that the operating handle of a circuit breaker, the reset button of a manually resettable motor protector, the reset button of a manually resettable limit control, and similar parts may project outside the appliance enclosure.

41.2.5 An opening in an enclosure to provide clearance around a dial, knob, lever, or handle shall not allow the entrance of a rod having a diameter of 9/64 inch (3.6 mm) at any setting or position of such part.

41.2.6 A fuseholder shall be so constructed, installed, or protected that adjacent uninsulated high-voltage live parts within 4 inches (101.6 mm), other than the screw shell of a plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder, will not be exposed to contact by persons removing or replacing fuses. An insulating barrier of vulcanized fiber or similar material employed for this purpose shall be not less than 0.028 inch (0.71 mm) thick.

41.2.7 The door or cover of an enclosure shall be hinged if it gives access to fuses or any motor overload protective device, the functioning of which requires renewal, or if it is necessary to open the cover in connection with the intended operation of the protective device such as resetting a manual reset overload protective device.

Exception: A hinged cover is not required for a device in which the only fuses enclosed are:

a) Control-circuit fuses of 2 amperes or less, provided the fuses and control-circuit loads, other than a fixed control-circuit load, such as a pilot lamp, are within the same enclosure;

b) Extractor-type fuses, each with its own enclosure; or

c) Fuses in low-voltage circuits.

41.2.8 Hinged covers, where required, shall not depend solely upon screws, or other similar means requiring the use of tools, to hold them closed, but shall be provided with a catch or spring latch.

41.2.9 A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the door in place and require some effort on the user's part to open it is considered to be an acceptable means for holding the door in place as required in 41.2.8.

41.2.10 A door or cover giving direct access to fuses in other than low-voltage circuits shall shut closely against a 1/4-inch (6.4-mm) rabbet or the equivalent, or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the wall of the box proper and shall overlap the edges of the box not less than 1/2 inch (12.7 mm). A construction which affords equivalent protection, such as a fuse enclosure within an outer enclosure, or a combination of flange and rabbet, is acceptable.

41.2.11 Strips used to provide rabbets, or angle strips fastened to the edges of a door, shall be secured at not less than two points, not more than 1-1/2 inches (38.1 mm) from each end of each strip and at points between these end fastenings not more than 6 inches (152.4 mm) apart.

41.2.12 Terminals of a low-voltage safety device within an appliance compartment or cavity to which factory wiring is connected need not be otherwise enclosed if such terminals are recessed and located so that the terminals are shielded from accidental shorting or damage.

41.3 Field wiring system connections

41.3.1 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 inch (0.81 mm) if uncoated steel, not less than 0.034 inch (0.86 mm) if galvanized steel, and not less than 0.045 inch (1.14 mm) if nonferrous.

41.3.2 If threads for the connection of conduit are tapped through a hole in an enclosure wall, or if an equivalent construction is employed, there shall be not less than three nor more than five threads in the metal, and the construction of the device shall be such that a conduit bushing can be attached. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall be not less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors that shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and that shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

41.3.3 An enclosure threaded for support by rigid conduit shall provide at least five full threads for engaging with the conduit.

41.3.4 A knockout in a sheet-metal enclosure shall be secured but shall be capable of being removed without deformation of the enclosure.

41.3.5 A knockout shall be provided with a flat surrounding surface for seating of a conduit bushing, and shall be so located that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those required.

41.3.6 A plate or plug for an unused conduit opening or other hole in the enclosure shall have a thickness not less than:

a) 0.014 inch (0.36 mm) for steel or 0.019 inch (0.48 mm) for nonferrous metal for a hole having a 1/4-inch (6.4-mm) maximum dimension; and

b) 0.027 inch (0.69 mm) steel or 0.032 inch (0.81 mm) nonferrous metal for a hole having a 1-3/8-inch (34.9-mm) maximum dimension.

A closure for a larger hole shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

42 Motors and Motor Overload Protection

42.1 Overload protection shall be provided for each motor on the appliance by one of the following:

a) Thermal or impedance protection complying with the requirements in the Standard for Overheating Protection for Motors, UL 2111.

b) Other protection that tests indicate is equivalent to the protection mentioned in (a).

c) Overcurrent protective devices as described in 42.2.

Exception: Motors, such as direct-drive fan motors, that are not normally subjected to overloads, and that are determined to be adequately protected against overheating due to locked-rotor current by a thermal or overcurrent protective device, are satisfactory when it is determined that the motor does not overheat under actual conditions of use.

42.2 ″Overcurrent protective devices,″ as referred to in 42.1, means overcurrent protective devices complying with the requirements of the National Electrical Code, ANSI/NFPA 70-1993, as follows:

a) A separate overcurrent device that is responsive to motor current. This device shall be rated or selected to trip at no more than the following percent of the motor full-load current rating:

Motors with a marked service factor not less than 1.15	125 percent
Motors with a marked temperature rise not over 72°F (40°C)	125 percent
All other motors	115 percent

(Each winding of a multispeed motor is to be considered separately and the motor is to be protected at all speeds.)

b) If the values specified for motor-running overcurrent protection do not correspond to the standard sizes or ratings of fuses, magnetic or thermal protective devices, the next higher size or rating may be used, but not higher than the following percent of motor full-load current rating:

Motors with a marked service factor not less than 1.15	140 percent
Motors with a marked temperature rise not over 72°F (40°C)	140 percent
All other motors	130 percent

42.3 Separate overcurrent devices, except when included as part of a magnetic motor controller, shall be assembled as part of the appliance and be readily identifiable as such after assembly to the appliance. Such protection shall not include means for manually interrupting the motor circuit if such interruption may create the risk of fire or electric shock.

42.4 Impedance protection is acceptable for motors that are determined to be adequately protected against overheating due to locked-rotor current, if it is determined that the motor will not overheat under actual conditions of use; except that impedance protection is not to be accepted where the motors are installed in compartments handling air for circulation to the conditioned space.

42.5 Fuses shall not be used as motor overload protective devices unless the motor is adequately protected by the largest size fuse that can be inserted in the fuseholder.

42.6 Overcurrent protective devices and thermal protective devices for motors shall comply with the requirements of the Short Circuit Test, Section 69.

42.7 In no case shall interruption of the circuit to a motor by the overcurrent or thermal protective device result in operation of the equipment or the discharge of fuel that could cause risk of fire, explosion, or injury to persons. If a burner depends solely upon an electric valve to stop the flow of fuel to the burner, the interruption of the circuit to the combustion air motor by the protective device shall also cause the interruption of the circuit to the valve. The device that interrupts the circuit to the valve may be independent of the motor circuit.

42.8 Automatic-reset type protective devices shall not be used if the automatic reclosing of the circuit to the motor by the device could cause risk of fire, explosion, or injury to persons.

42.9 A motor shall have no openings permitting a drop of liquid, or a particle falling vertically onto the motor, to enter the motor as applied to the appliance.

42.10 Compliance with the requirement in 42.9 may be provided by the motor frame or by other enclosure, structure, or shield, or by a combination of two or more such items, and is to be determined with the motor applied to the assembled appliance.

42.11 The requirements specified in 42.9 will necessitate the use of a barrier of noncombustible material under an open type motor unless:

a) The structural parts of the motor or the appliance such as the bottom closure provide the equivalent of such a barrier;

b) The motor overload protection device provided with a single-phase motor is to be such that no burning insulation or molten material falls to the surface that supports the appliance when the motor is energized under each of the following fault conditions, as applicable to the particular type of motor:

1) Open main winding;

2) Opening starting winding;

3) Starting switch short-circuited; and

4) Capacitor shorted, permanent split capacitor type;

c) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) that will prevent the temperature of the motor windings from exceeding 125°C (257°F) under the maximum load under which the motor will run without causing the protector to cycle, and from exceeding 150°C (302°F) with the rotor of the motor locked; or

d) The motor complies with the requirements for impedance-protected motors, and the temperature of the motor winding does not exceed 150°C (302°F) during the first 72 hours of operation with the rotor of the motor locked.

42.12 The barrier specified in 42.11 shall:

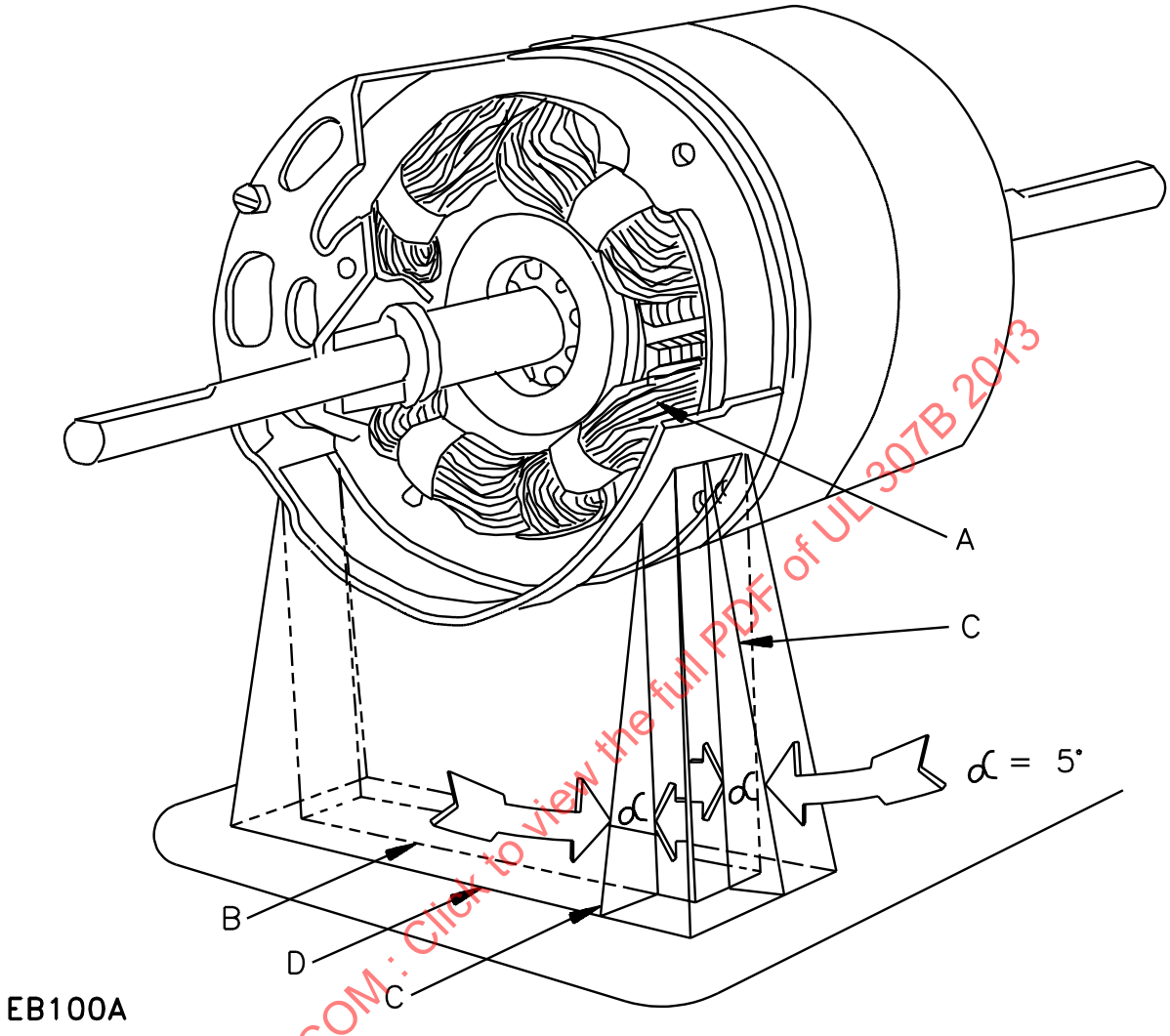
a) Be horizontal;

b) Be located as specified in Figure 42.1; and

c) Have an area not less than that specified in Figure 42.1.

Openings for drainage, ventilation, and the like, may be employed in the barrier, provided that such openings do not permit molten metal, burning insulation, or the like to fall on combustible material.

Figure 42.1
Location and extent of barrier



A – Motor winding to be shielded by barrier. This is to consist of the entire motor winding if it is not otherwise shielded, and is to consist of the unshielded portion of a motor winding which is partially shielded by the motor enclosure or equivalent.

B – Projection of outline of motor winding on horizontal plane.

C – Inclined line which traces out minimum area of the barrier. When moving, the line is to be always:

a) Tangent to the motor winding;

b) 5 degrees from the vertical; and

c) So oriented that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area is to be that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

43 Capacitors

43.1 A motor starting or running capacitor shall be housed within an enclosure or container that will protect the plates against mechanical damage and that will prevent the emission of flame or molten material resulting from malfunction of the capacitor. Except as noted in 43.2 and 43.3, the container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm).

43.2 The individual container of a capacitor may be of sheet metal thinner than specified in 43.1 or material other than metal if the capacitor is mounted in an enclosure that houses other parts of the appliance and provided that such box, case, and the like is acceptable for the enclosure of current-carrying parts.

43.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead metal parts by moisture-resistant insulation not less than 0.028 inch (0.71 mm) thick, except as indicated in 46.6; or it shall be separated from dead metal parts by spacings in accordance with Table 46.1.

43.4 A capacitor employing a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including faulted overcurrent conditions based on the circuit in which it is used. See Short Circuit Test, Section 69.

Exception: If the available fault current is limited by other components in the circuit, such as a motor start winding, the capacitor may be tested using a fault current less than the test current specified in Table 69.1 but not less than the current established by dividing the circuit voltage by the impedance of the other component or components.

44 Electrical Insulating Material

44.1 Material for the mounting of current-carrying parts shall be of moisture resisting material such as porcelain, phenolic composition, or cold-molded composition.

44.2 Vulcanized fiber may be used for the insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts of other than low-voltage circuits.

45 Switches and Controllers

45.1 Except as indicated in 45.2, a controller or controllers for controlling the loads involved shall be provided for all assemblies incorporating more than one motor intended for connection to the same power supply.

45.2 A controller is not required for an assembly having more than one motor if the marked maximum fuse size does not exceed 20 amperes at 125 volts or less, or 15 amperes at 600 volts or less, and with not more than 6 amperes full-load current for each motor.

45.3 A single controller may control more than one motor if the controller is rated for the combined load controlled.

45.4 A controller or switch shall be rated for the load that it controls.

45.5 The load controlled is to include any load external to the assembly for which connections in the controller or switch circuit are provided.

45.6 A controller that may be called upon to break a motor lead under locked rotor conditions shall have a current-interrupting capacity not less than the locked rotor load of the motor controlled. The locked rotor load of a motor is based on six times the full-load current rating of the motor if alternating current and ten times the full-load current rating if direct current.

45.7 If the controller is cycled by the operation of an automatic-reset overload device, it shall withstand an endurance test under locked-rotor conditions without failure. The endurance test is to be conducted for a duration equivalent to that required for the overload device and at an equivalent rate.

45.8 Motor controllers shall be arranged so that they will simultaneously open a sufficient number of ungrounded conductors to interrupt current flow to the motor.

SPACINGS

46 High-Voltage Circuits

46.1 Unless otherwise specified, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall be not less than the values indicated in Table 46.1.

Table 46.1
Minimum spacings

Ratings		Minimum spacings[d]					
Volt-amperes	Volts	Through air		Over surface		To enclosure[c]	
		Inch	mm	Inch	mm	Inch	mm
0 – 2000	0 – 300[a]	1/8[b]	3.2	1/4	6.4	1/4	6.4
More	0 – 150	1/8[b]	3.2	1/4	6.4	1/2	12.7
than	151 – 300	1/4	6.4	3/8	9.5	1/2	12.7
2000	301 – 600	3/8	9.5	1/2[c]	12.7	1/2	12.7

[a] If over 300 volts, spacings in last line of table apply.

[b] The spacings between wiring terminals of opposite polarity, or between a wiring terminal and grounded metal, shall be not less than 1/4 inch (6.4 mm), except that if short circuiting or grounding of such terminals will not result from rejecting strands of wire, the spacing need not be greater than that given in the above table. Wiring terminals are those connected in the field and not factory wired. Measurements are to be made with solid wire of adequate ampacity for the load connected to each terminal.

[c] Includes metal fittings for conduit or cable which are factory installed or which may be field installed.

[d] The spacings at wiring terminals of a motor shall be 1/4 inch (6.4 mm) for a motor rated 250 volts or less and 3/8 inch (9.5 mm) for a motor rated more than 250 volts. See 46.3.

46.2 The through air and over surface spacings at an individual component part are to be evaluated on the basis of the total volt-ampere consumption of the load or loads which the component controls. However, the spacing from the component to the enclosure is to be evaluated on the basis of the total load on all components in the enclosure. For example, the through air and over surface spacings at a component which controls only a motor are judged on the basis of the volt-amperes of the motor. A component which controls loads in addition to the motor is similarly judged on the basis of the sum of the volt-amperes of the loads so controlled, except that a component which independently controls separate loads is evaluated on the basis of the volt-amperes of the larger load. The volt-ampere values for the load referred to above are to be determined by the measured input.

46.3 For circuits not exceeding 300 volts, the over surface spacings for glass-insulated terminals of motors may be 1/8 inch (3.2 mm) where 1/4 inch (6.4 mm) is specified in the table, and may be 1/4 inch (6.4 mm) where 3/8 inch (9.5 mm) is specified.

46.4 The spacing requirements in Table 46.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component which is evaluated on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component, including clearances to dead metal or enclosures, are to be those indicated in the table.

46.5 All uninsulated live parts connected to different circuits, except subdivided circuits or branch circuits of the same voltage from the same feeder, shall be spaced from one another as though they were parts of opposite polarity in accordance with the requirements indicated above and shall be evaluated on the basis of the highest voltage involved.

46.6 An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material employed where spacings would otherwise be insufficient, shall not be less than 0.028 inch (0.71 mm) thick, except that a liner or barrier not less than 0.013 inch (0.33 mm) thick may be used in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it will not be damaged by arcing. Material having a lesser thickness may be used if it has equivalent insulating, mechanical, and flammability properties.

47 Low-Voltage Circuits

47.1 The spacings for low-voltage electrical components that are installed in a circuit that includes a motor overload protective device, or other protective device, where a short or grounded circuit may result in a risk of fire or electric shock shall comply with 47.2 – 47.5.

47.2 The spacing between an insulated live part and the wall of a metal enclosure including fittings for the connection of conduit or metal-clad cable shall be not less than 1/8 inch (3.2 mm). See 46.5.

47.3 The spacing between wiring terminals regardless of polarity, and between the wiring terminal and a dead metal part, including the enclosure, and fittings for the connection of conduit, which may be grounded when the device is installed shall be not less than 1/4 inch (6.4 mm).

47.4 The spacing between uninsulated live parts, regardless of polarity, and between an uninsulated live part and a dead metal part, other than the enclosure, which may be grounded when the appliance is installed shall be not less than 1/32 inch (0.8 mm), provided that the construction of the parts is such that spacings will be definitely maintained.

47.5 The spacing in low-voltage circuits that do not contain devices such as indicated in 47.1 are not specified.

PROTECTION OF USERS AND SERVICE PERSONNEL

48 General

48.1 An uninsulated high-voltage live part and moving parts shall be located, guarded, or enclosed so as to minimize the likelihood of unintentional contact by personnel performing service functions that may have to be performed with the appliance energized.

48.2 Service functions which may have to be performed with the equipment energized include:

a) Adjusting the setting of temperature controls with or without marked dial settings;

b) Resetting control trip mechanism;

c) Operating manual switches; or

d) Adjusting air-flow dampers.

A factory set and sealed control is not considered to be adjustable.

48.3 The requirements of 48.1 are not applicable to mechanical service functions that are not performed with the equipment energized.

48.4 Adjustable or resettable electrical control or manual switching devices shall be located or oriented with respect to uninsulated high-voltage live parts so that manipulation of the mechanism for adjustment, resetting, or operation can be accomplished in the intended direction of access and uninsulated high-voltage live parts or moving parts are:

a) Not located in front, in the direction of access of the mechanism; and

b) Not located within 6 inches (152.4 mm) on any side or behind the mechanism, unless guarded.

48.5 An electrical control component that may require examination, adjustment, servicing, or maintenance while energized, not including voltage measurements, shall be located and mounted with respect to other components and with respect to grounded metal parts so that it is accessible for electrical service functions without subjecting the serviceman to the risk of shock from adjacent uninsulated live parts or to injury from adjacent moving parts.

48.6 Accessibility and protection from electric shock and unintentional contact may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through an access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement. See Figure 48.1.

a) The components are located with respect to the access opening in the outer cabinet so that the farthest component in the control assembly is not more than 14 inches (356 mm) from the plane of the access opening.

b) Uninsulated live parts outside the control assembly projected clear space, except for live parts within a control panel, or unguarded moving parts are located not closer than 6 inches (152.4 mm) from any side of the access area. The projected clear space is considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or control enclosure when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure.

c) The volume generated by the projected clear space of the control assembly to the access opening in the outer cabinet, within the access area, is completely free of obstructions, including wiring.

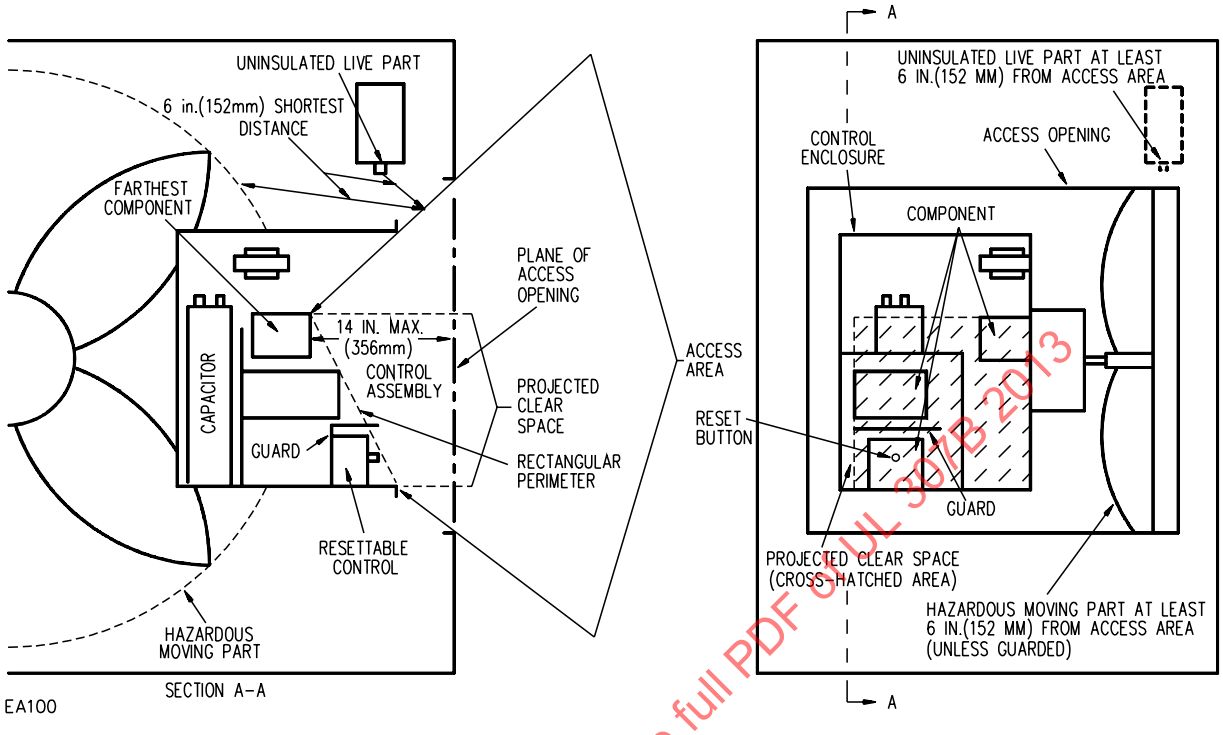
d) Access to the components in the control assembly is not impeded in the direction of access by other components or by wiring in this assembly.

e) Extractor-type fuseholders and snap switches mounted through the control assembly enclosure are to be located so that:

1) There is unimpeded access to those components through the access opening in the outer cabinet; and

2) They are not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless guarded.

Figure 48.1
Accessibility and protection



48.7 Components in a low-voltage circuit shall comply with the requirements of 48.5 in their relation to uninsulated live parts in a high-voltage circuit and to moving parts.

48.8 The following are not considered to be uninsulated live parts:

a) Coils of controllers;

b) Relays and solenoids;

c) Transformer windings, if the coils and windings are provided with insulating overwraps;

d) Enclosed motor windings;

e) Insulated terminals and splices; and

f) Insulated wire.

48.9 Moving parts such as blades, blower wheels, pulleys, or belts that may cause injury, shall be enclosed or guarded.

48.10 If the removal of doors, panels, or shields will expose moving parts that may cause injury:

a) The opening or removal of the door, panel, or shield shall require the use of tools;

b) An interlocking device shall shut off the mechanism; or

c) A warning marking shall be displayed which reads essentially as specified in 101.16.

48.11 The distance from an opening in a required guard or enclosure to the moving part mentioned in 48.9 shall be in accordance with Table 48.1, but the minor dimension of the opening shall not in any case exceed 3 inches (76.2 mm). For an opening having a minor dimension intermediate between two of the values included in the table, the distance from the opening to the moving part shall be not less than that found by appropriate interpolation between the corresponding values in the right-hand column of the table. The minor dimension of the opening is determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22 N).

Table 48.1
Dimensions of openings in enclosure

Minor dimensions of opening[a]		Minimum distance from opening to moving part	
Inches	**mm**	**Inches**	**mm**
1/4	6.4	1/2	12.7
3/8	9.5	1-1/2	38.1
1/2	12.7	2-1/2	63.5
3/4	19.1	4-1/2	114.0
1	25.4	6-1/2	165.0
1-1/2	38.1	10-1/2	267.0
2	50.8	14-1/2	368.0
over 2-1/2	(over 50.8)	30	762.0

[a] Openings less than 1/4 inch (6.4 mm) are not to be considered.

48.12 A moving part is not to be considered when evaluating compliance with 48.1 and 48.9 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

48.13 Any exposed part that might reasonably be brought into contact with the hand during normal use and care of the appliance shall be smooth and rounded. Examples of such parts are screw tips and threads, sharp points and sheared edges on sheet metal and the like.

PERFORMANCE

GENERAL

49 General

49.1 An appliance shall comply with the applicable requirements for performance as described herein, using any grade or type of fuel recommended by the manufacturer of the appliance. Each size and type of appliance, or a sufficient number of sizes and types to be representative of the entire range of sizes and types submitted, are to be subjected to all or part of the tests prescribed herein. An appliance is to be tested with each optional accessory recommended for use by the manufacturer which affects the performance of the appliance.

49.2 An appliance of a type not described specifically in these requirements is to be tested in accordance with the intent of these requirements. If any indications are observed during the tests prescribed that an appliance will not continue to meet the requirements in normal usage, such supplementary tests shall be conducted as deemed necessary for intended service.

49.3 An appliance is to be tested for installation on combustible floors and with the indicated clearances to combustible walls and ceilings.

50 Instrumentation

50.1 Draft measurement

50.1.1 Draft is to be measured by a draft gauge that may be read directly to 0.005 inch (or 0.10 mm) water column and that has an accuracy of plus or minus 0.0025 inch (or 0.05 mm). A gauge is to be checked for zero reading at the beginning and at the end of each test.

50.2 Fuel input measurement

50.2.1 The fuel input to a gas burner during a test is to be determined by a suitably sized laboratory-type gas meter.

50.3 Power measurement

50.3.1 The total electrical input to an appliance is to be measured in amperes.

50.3.2 An electrical meter is to have a maximum scale range of not more than 1-1/2 times the value to be measured. The smallest scale division is to be not more than 1/50 of the maximum scale range.

50.4 Speed measurement

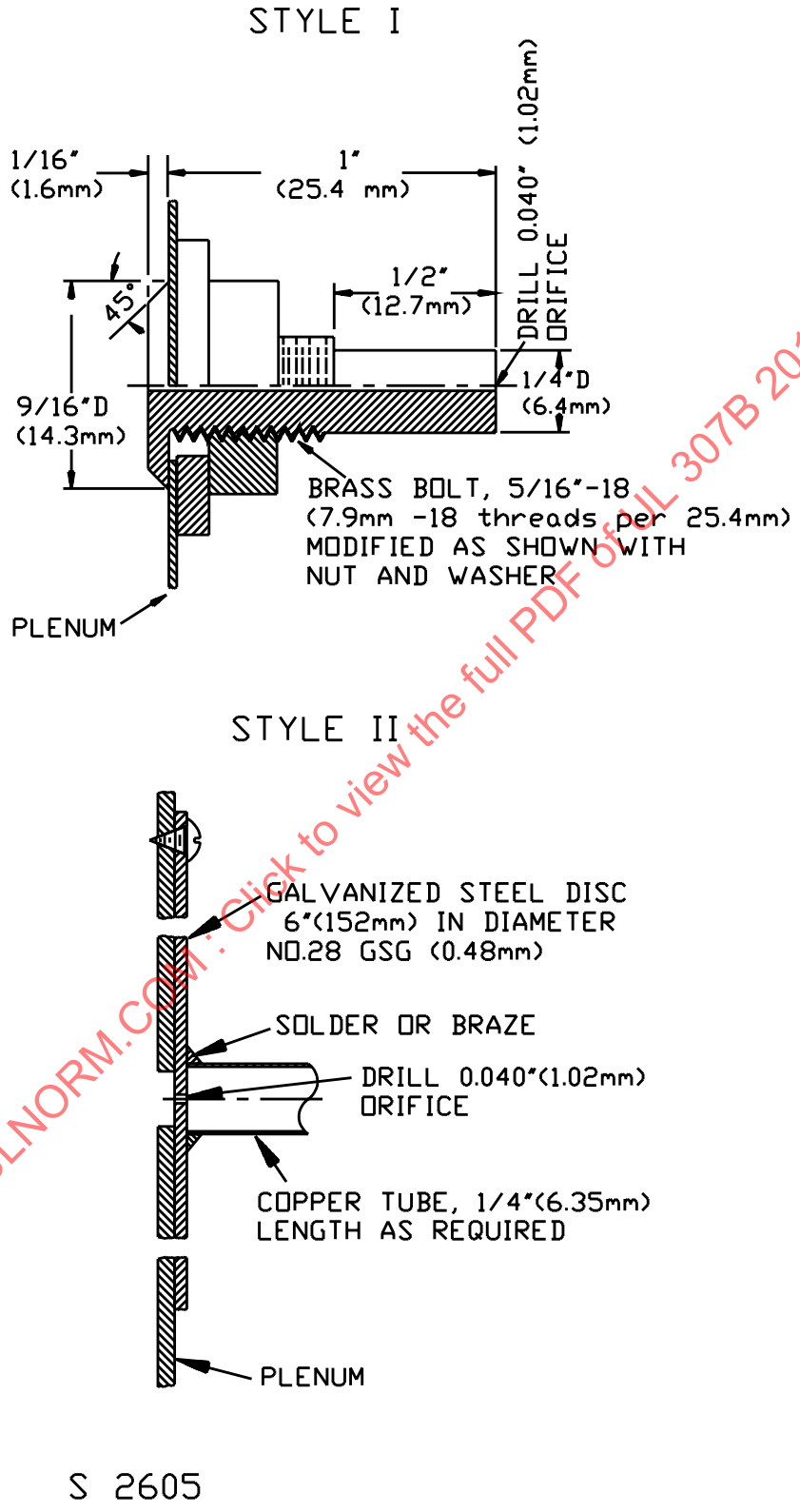
50.4.1 Mechanical or electronic means are to be used to measure the speed of a motor or of the mechanism driven by it. The load imposed by the counter is not to affect motor speed. A stroboscope is recommended for measuring speed of a motor under 1/8 horsepower (93 W) output.

50.5 Static pressure measurement

50.5.1 An inclined draft gauge is to be used to measure external static pressure in the outlet plenum. The gauge is to have an accuracy of ±0.0025 inch (±0.064 mm) and is to be capable of being read directly to 0.005 inch (0.10 mm). Unless otherwise specified, all references to static pressure measurements herein refer to static pressure in the outlet plenum.

50.5.2 The static pressure connection in the outlet plenum is to consist of one of the arrangements shown in Figure 50.1. An additional static pressure connection as described in 104.2.2 is furnished as a permanent part of the appliance.

Figure 50.1
Static pressure pickup arrangements



50.6 Temperature measurement

50.6.1 Temperatures are to be determined by means of a suitable measuring instrument and bead-type thermocouples. Unless otherwise indicated, a thermocouple is to be made of wires not larger than 24 AWG (0.21 mm^2).

50.6.1 revised February 2, 2009

50.6.2 Thermocouples are to be placed on surfaces of the test enclosure at various locations as may be required to observe maximum temperatures during tests. Temperatures on the surface of the flue-gas outlet assembly at points of contact with ceiling material are to be determined. Thermocouples are to be attached to other pertinent materials and parts such as those mentioned in Table 65.1.

50.6.3 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in good thermal contact with the surface of the material on which the temperature is being measured. In most cases, adequate thermal contact will result from securely taping or cementing the thermocouple in place, but where a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

50.6.4 Thermocouples are to be secured to wood surfaces by staples over the insulated portion of the wire and with the tip held in a good thermal contact with the surface by pressure-sensitive tape.

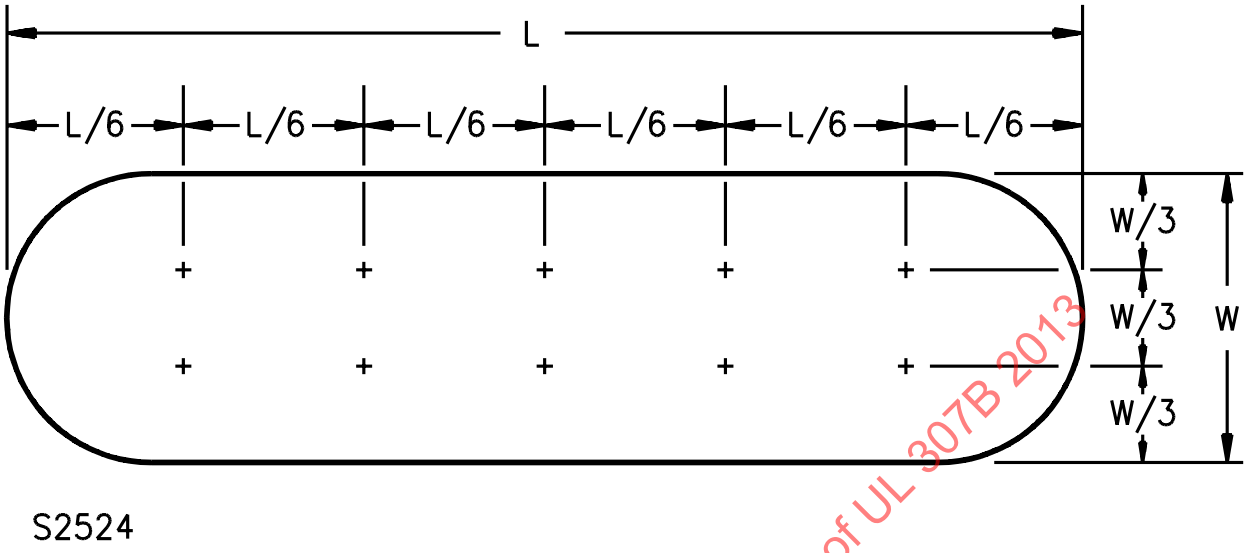
Exception: For zero clearance, the thermocouples are to be applied to surfaces of the appliance at points of zero clearance.

50.6.5 Thermocouples are to be attached to surfaces, other than as described above, by being cemented or taped to the surface in a manner to assure good thermal contact with the surface.

50.6.6 The flue-gas temperature of a gas-fired appliance is to be measured by a grid of parallel-connected thermocouples located in the flue-gas passage not more than 3 inches (76.2 mm) downstream from the flue-gas outlet of the appliance or the outlet of a draft hood if furnished as part of the appliance. The thermocouple grid is to be placed in a plane perpendicular to the axis of the passageway. For a round pipe, five thermocouples are to be supported by two taut wires intersecting at right angles in the plane of measurement and are to be arranged with one at the center and the remaining four symmetrically located at points one-half of the distance from the center to the inside wall of the pipe. For an oval pipe, ten thermocouples are to be supported by two taut parallel wires and are to be arranged in the pattern shown in Figure 50.2.

Exception: For the determination of stack losses according to 60.2, the thermocouple grid is to be located as described in 60.8.

Figure 50.2
Thermocouple grid pattern for measurement of flue-gas temperature of appliance with oval vent connector



50.7 Warm air appliances

50.7.1 The outlet-air temperature in rectangular ducts connected to forced-air heating appliances is to be measured by nine thermocouples having leads of identical length and wire size wired in parallel. The test duct cross section is to be divided into three equal horizontal and three equal vertical areas, with a thermocouple located centrally in each of the nine areas thus obtained. The outlet-air temperature in round ducts connected to forced-air heating appliances is to be measured by five thermocouples of identical wire length and wire size wired in parallel. The thermocouples are to be supported by two taut wires intersecting at right angles in the plane of measurement and are to be arranged with one at the center and the remaining four symmetrically located at points one-half of the distance from the center to the inside wall of the duct.

50.7.2 The outlet-air temperature of a wall furnace is to be determined by exploration with parallel-connected bead-type thermocouples, not larger than 24 AWG (0.21 mm^2), located 1 inch (25.4 mm) from the outer face of the warm-air grille or register.

50.7.2 revised February 2, 2009

50.7.3 For wall furnaces having warm-air outlets substantially in a vertical plane, the thermocouples are to be arranged in two horizontal rows located 2 inches (50.8 mm) apart vertically.

50.7.4 For warm-air outlets not more than 12 inches (305 mm) in width, six thermocouples are to be in each horizontal row. For warm-air outlets more than 12 inches (305 mm) in width, one additional thermocouple is to be added to each row for each additional 2 inches (50.8 mm) or fraction thereof of opening width.

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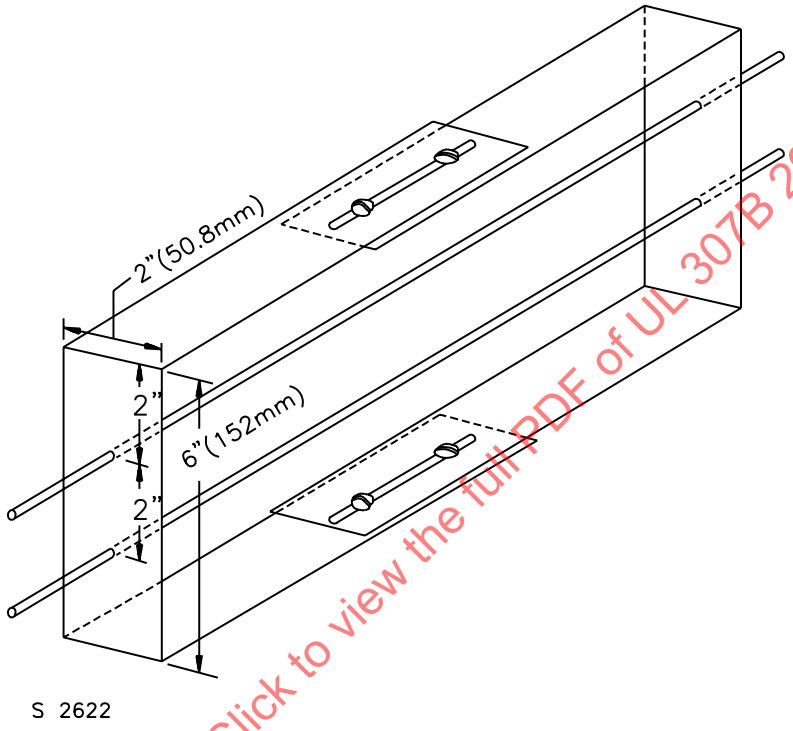
50.7.5 The outer thermocouples in each row are to be 1 inch (25.4 mm) inside the boundary of the opening, and the other thermocouples are to be evenly spaced between the outer thermocouples.

50.7.6 The thermocouples are to be supported in a rectangular shield as illustrated in Figure 50.3. The length of the shield is to correspond to the width of the warm-air outlet opening.

Figure 50.3
Thermocouple shield for outlet-air temperature of wall furnaces



50.7.7 The thermocouple assembly is to be moved vertically over the face of the outlet opening to determine the maximum indicated temperature.

50.7.8 For heating appliances having warm-air outlets arranged other than as described in 51.16, the temperature is to be measured in a similar manner, using 12 or more parallel-connected thermocouples spaced approximately on 2-inch (50.8-mm) centers in a shield similar to that illustrated in Figure 50.3.

50.8 Boilers

50.8.1 The outlet water temperature of a boiler is to be measured by a thermocouple located in the boiler so that the water temperature 1 inch (25.4 mm) below the outlet connection of a hot-water boiler and 1 inch (25.4 mm) below the surface of the water in a steam boiler may be determined.

50.9 Water heater

50.9.1 The outlet water temperature of a water heater is to be measured by a thermocouple placed in the storage vessel so that the water temperature 1 inch (25.4 mm) from the outlet connection may be determined.

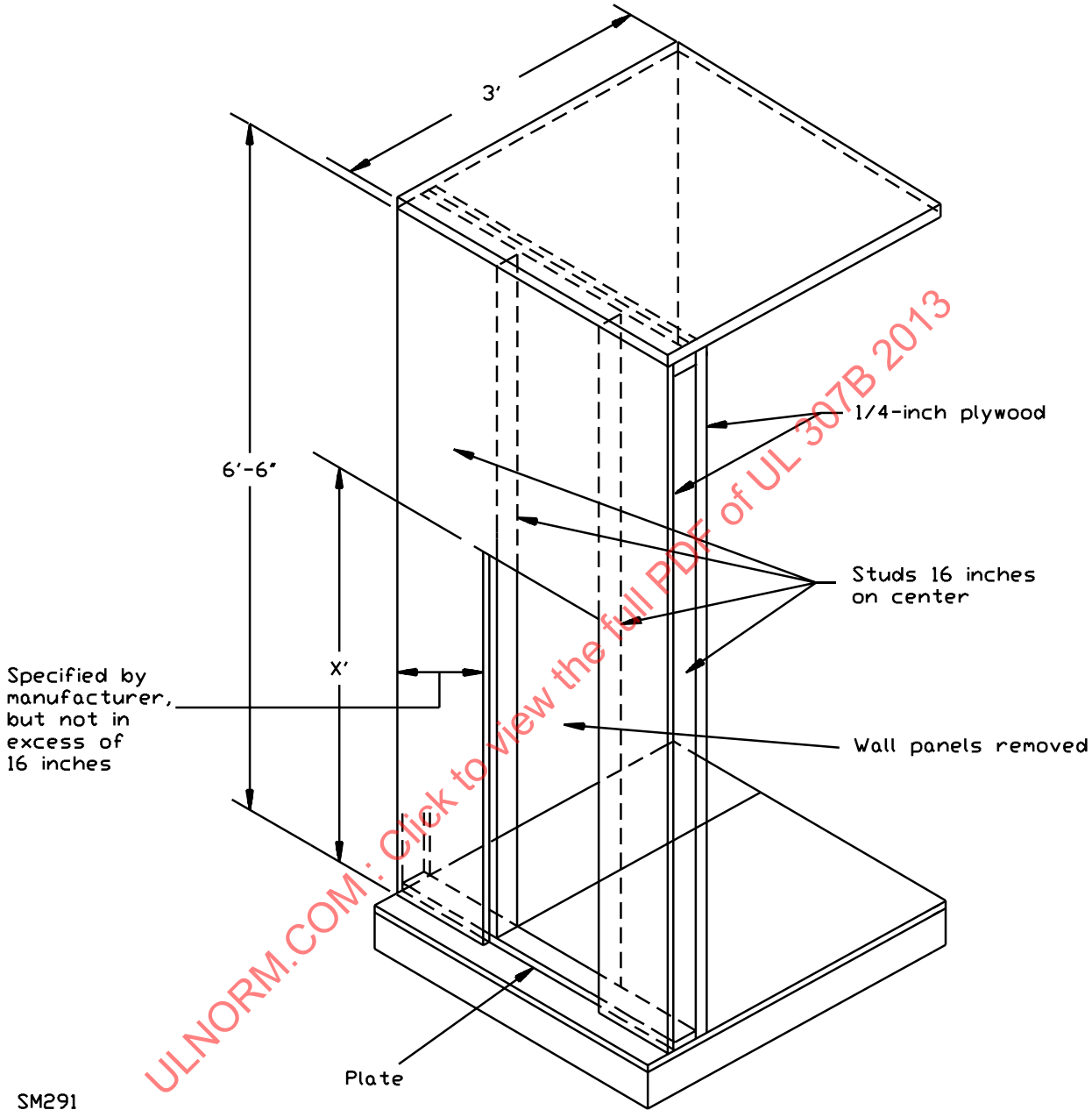
DUCT-CONNECTED APPLIANCE TEST INSTALLATION

51 General

51.1 Unless the supply plenum is an integral part of the appliance, the appliance is to be tested with a metal plenum having the same dimensions as the discharge opening of the appliance.

51.2 The height or depth of a separate plenum is to be such that the clearance from the plenum and warm-air duct to surface of the test enclosure will be in accordance with 4.2 and 53.2. See Figures 51.1 and 52.1.

Figure 51.1
Test structure for wall furnaces



Note – Ceiling and side wall are of 3/4 inch (19.1 mm) plywood.

51.3 Any opening through which a warm-air duct passes from the enclosure is to be of such size that the edges of the opening will clear the duct by 5/16 inch (7.9 mm), and this space is to be filled with insulating material and sealed.

51.4 The size of the outlet duct is to be calculated for approximately 900 feet per minute (275 m/minute) of standard air, 0.075 pound per cubic foot (1.2 kg/m^3) with the designed temperature rise through the appliance and based on an outlet equivalent to 75 percent of the rated input [Btu per hour (0.293 x W)]. Specific heat of air is to be taken as 0.243 Btu per pound (565 J/kg).

51.5 The outlet duct area may be calculated by means of the following formula:

$$A_1 = (Btu/h)\ input \times \frac{0.11}{T_F} \quad or \quad A_2 = W \times \frac{1.05954}{T_c}$$

Where:

A_1 = area in square inch; A_2 = area in cm^2.

T_F = 85°F or the designed temperature rise.

T_c = 47.2°C or the designed temperature rise.

$(Btu/h)_i$ = Rated input in Btu/h

W = Rated input in watts

The area for an 85°F (47.2°C) temperature rise may be used in tests for other temperature rises.

51.6 The test duct is to be rectangular in shape, with a width approximately equivalent to the corresponding dimension of the plenum or plenum collar, but the aspect ratio is not to exceed four to one.

51.7 The warm-air duct outlet is to be arranged to discharge away from the cold-air inlet of the appliance; also away from the air inlet to the test enclosure for closet installation. The inlet and outlet ducts should be positioned from 90 to 180 degrees apart.

51.8 A horizontal heating appliance is to be tested with the outlet duct arranged as indicated in Figure 53.3.

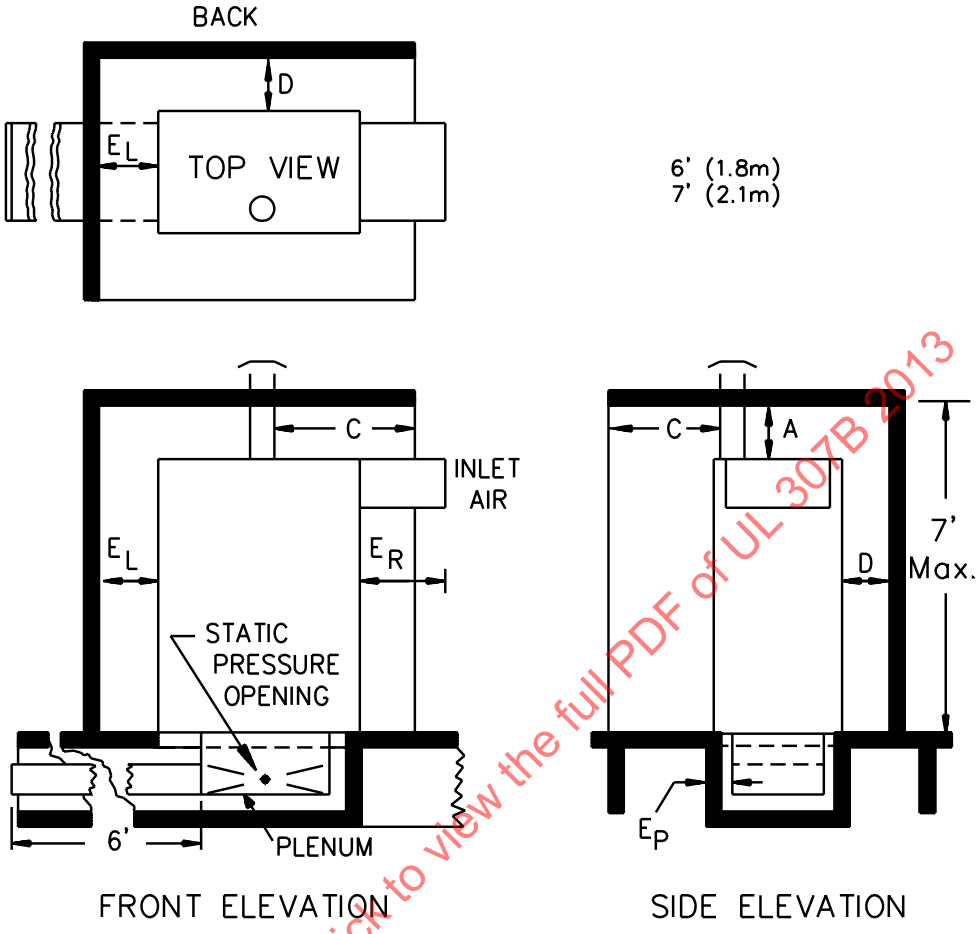
51.9 A thermocouple grid (see 50.7.1) is to be located in each warm-air outlet duct in a plane within 6 inches (152.4 mm) downstream from the position closest to the plenum where any thermocouple will not see any surface of the heat exchanger. The duct is to extend at least 6 inches (152.4 mm) beyond the thermocouple grid.

51.10 The cross-sectional area and shape of an air-inlet duct are to be equivalent to the cold-air inlet of the appliance. If a central heating appliance is of the direct vent type, the return-air inlet of the heating appliance need not be extended to the exterior of the alcove or closet, provided that compliance with 17.2 is obtained.

52 Corner Installation For Central Furnaces

52.1 A nonrecessed appliance of a construction inherently providing separation of the combustion system from the atmosphere of the manufactured home or recreational vehicle may be tested for installation in a room corner. The appliance is to be placed in a partial enclosure in the as-received condition. The distance from the chimney or vent connector and the distance from the back, side, and top of the appliance to the walls and ceiling of the enclosure are to be as indicated in Figure 52.1. If integral spacers are provided, the clearance may be other than specified, but not more than 2 inches (50.8 mm). When one side of the appliance may create a higher wall temperature than the other, that side of the appliance is to be directly opposite one wall.

Figure 52.1
Test enclosure – downflow furnace corner location clearances



A – From top of appliance.

C – From flue-gas outlet assembly.

D – From back of appliance, 0, 1, or 2 inches (0, 25, or 51 mm).

E_L – From left side of appliance 0, 1, or 2 inches (0, 25, or 51 mm) for left-hand corner installation, otherwise 24 inches (610 mm) or less.

E_P – Clearance from any side of supply plenum and warm-air duct within 3 feet (0.9 m) of appliance to be 0, 1/4, 1/2, 3/4, or 1 inch (0, 6.4, 12.7, 19.1, or 25.4 mm).

E_R – From right side of appliance, 0, 1, or 2 inches (0, 25 or 51 mm) for right-hand corner installation, otherwise 24 inches (610 mm) or less.

52.2 The ceiling height of the enclosure is to be that required to obtain the clearance from the top of the appliance to the ceiling specified by the manufacturer, but the ceiling height is to be not more than 7 feet (2.1 m).

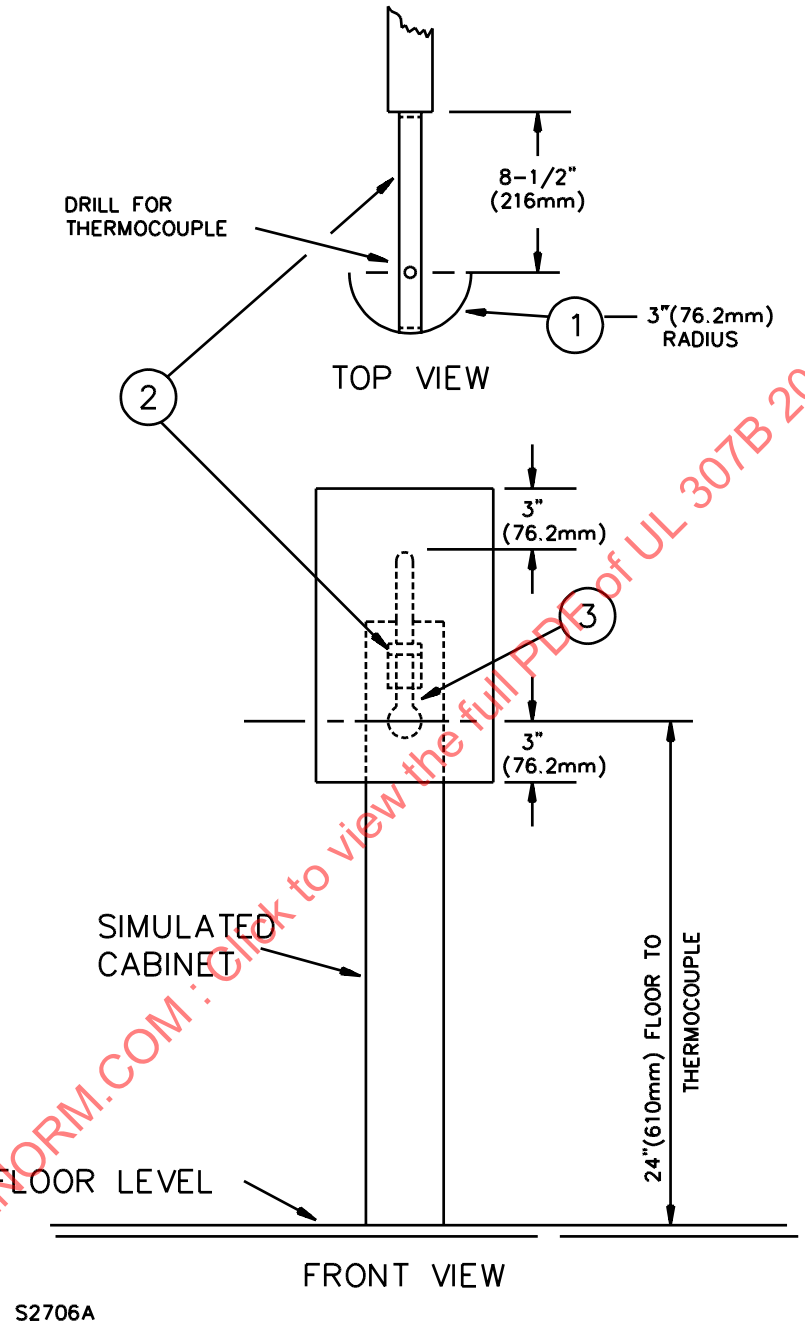
52.3 The partial enclosure is to be formed by walls of 1-inch wood boards (3/4 inch thick) or 3/4-inch (19.1-mm) thick plywood, set at right angles and finished in flat black. A ceiling and floor of equivalent construction are to be placed above and below the partial enclosure. The height of the walls is to be as shown. All joints are to be tight and sealed. The walls of the partial enclosure are to extend as shown.

52.4 For a downflow furnace, a structure made of 1-inch trade size lumber (3/4 inch thick) or 3/4-inch (19.1-mm) thick plywood representing a floor and joist structure is to be placed around the warm-air outlet plenum and duct. The clearance, between the plenum and duct and the enclosure is to be 0 or 1/4, 1/2, 3/4, or 1 inch (6.4, 12.7, 19.1, or 25.4 mm), as specified by the manufacturer. The structure is to extend the full length of the duct. See Figure 52.1.

52.5 A thermocouple is to be placed centrally 15 inches (381 mm) in front of the appliance and 24 inches (610 mm) above the floor of the test enclosure as indicated in Figure 52.2.

Exception: For horizontal furnaces, the thermocouple is to be located midway between the floor and ceiling of the test enclosure, for measuring room temperature.

Figure 52.2
Room temperature thermocouple



1. Bright aluminum baffle [No. 24 MSG or 0.020 inch (0.51 mm) minimum thick), 6 inches (152 mm) longer than (3).

2. Bracket material, 1/8- by 1-inch (3.18 by 25.4 mm) strap iron.

3. Thermocouple, supported by bracket.

52.6 The appliance is to be level. Leveling means, when provided, are to be removed if detachable; or, if not detachable, are to be adjusted to place the base of the appliance the minimum allowable distance above the floor.

53 Alcove or Closet Installation for Appliance Furnaces

53.1 An appliance of a construction inherently providing separation of the combustion system from the atmosphere of the manufactured home or recreational vehicle may be tested for installation in an alcove or closet. Other appliances may be tested only in a simulated closet arranged to isolate the appliance from the manufactured (mobile) home or recreational vehicle atmosphere.

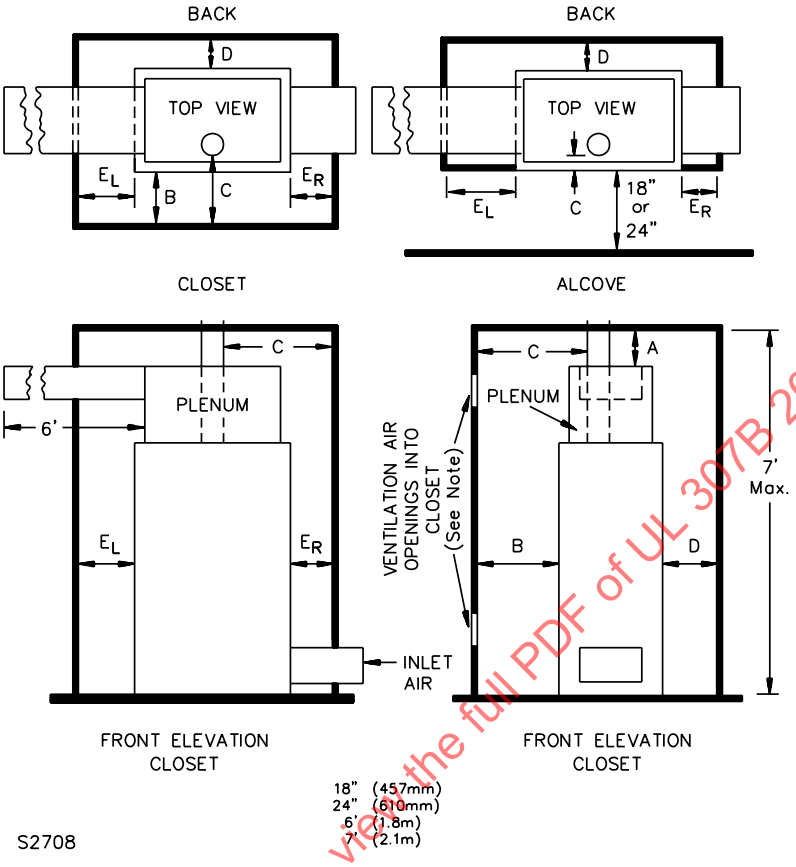
53.2 The appliance is to be installed in an enclosure, as described below, in the as-received condition, with clearances as specified by the manufacturer, to walls and ceiling of the test enclosure. Clearances to back and side walls are to be not more than 2 inches (50.8 mm). The specified clearances are to be maintained when the appliance is placed in the enclosure as close to such vertical walls as the construction of the appliance will permit. The ceiling height of the enclosure is to be that required to obtain the specified clearance from the top of the appliance to the ceiling, but in no case is the ceiling height to be more than 7 feet (2.1 m). See:

a) Figure 53.1 – Upflow appliances.

b) Figure 53.2 – Downflow appliances.

c) Figure 53.3 – Horizontal appliances.

Figure 53.1
Test enclosure for alcove or closet installations



NOTES

Description of dimension symbols and abbreviations for heating appliances.

A – Clearance above top of appliance.

B – From front of appliance. Prefix ″C″ to numeral indicates suitability for installation in closet only; prefix ″A,″ suitability for installation in alcove only; no prefix indicates installation to be in a room only.

C – From flue gas outlet assembly.

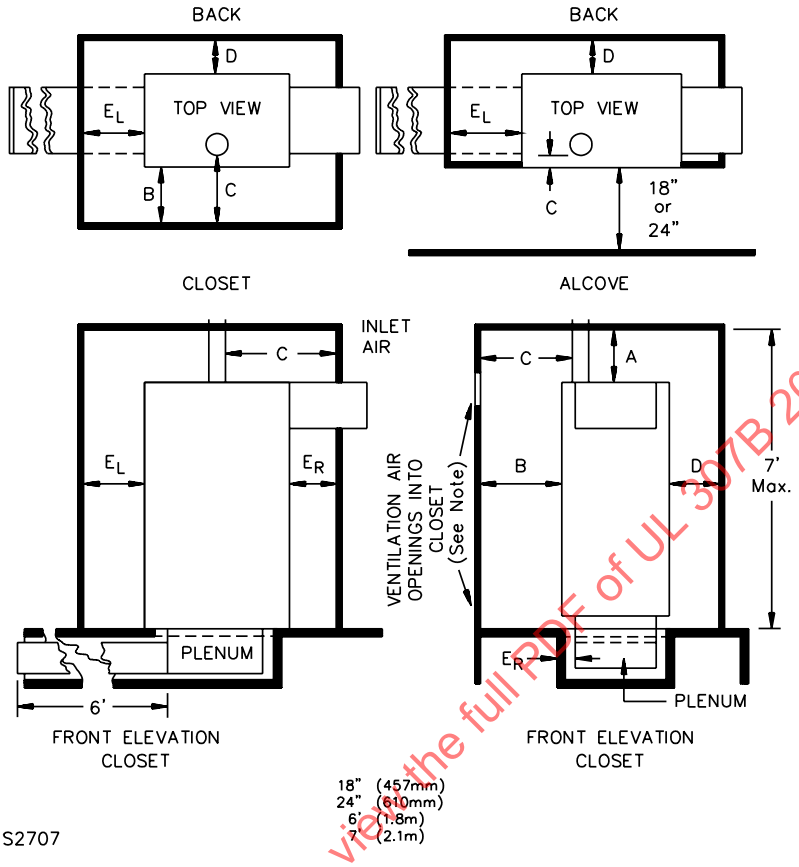
D – From back of appliance.

E^L – From left side of appliance.

E^R – From right side of appliance.

E^P – From any side of appliance plenum (downflow appliances have plenum beneath). ″E^P″ is only specified for appliances to be equipped with external plenums for connection to duct systems; its omission when A^D is specified indicates appliance equipped with integral plenum and if appliance is otherwise installed, clearances specified are not valid.

Figure 53.2
Test enclosure for alcove or closet installations



NOTES

Description of dimension symbols and abbreviations for heating appliances.

A – Clearance above top of appliance.

B – From front of appliance. Prefix "C" to numeral indicates suitability for installation in closet only; prefix "A," suitability for installation in alcove only; no prefix indicates installation to be in a room only.

C – From flue gas outlet assembly.

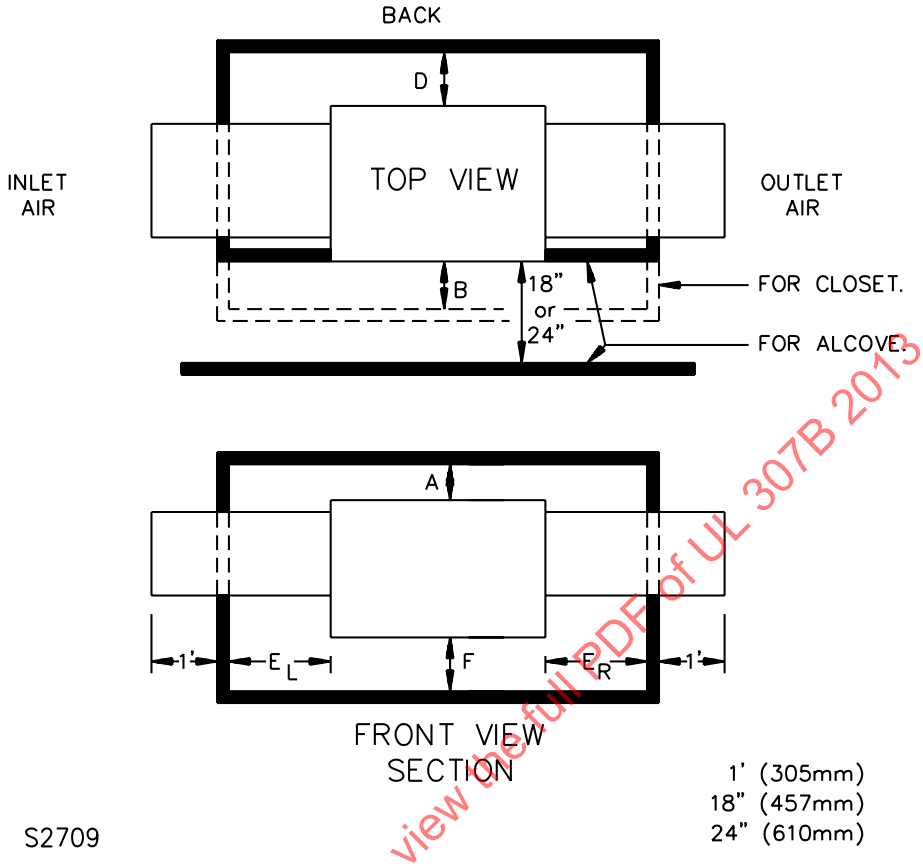
D – From back of appliance.

E^L – From left side of appliance.

E^R – From right side of appliance.

E^P – From any side of appliance pienum (downflow appliances have plenum beneath). "E^P" is only specified for appliances to be equipped with external plenums for connection to duct systems; its omission when A^D is specified indicates appliance equipped with integral plenum and if appliance is otherwise installed, clearances specified are not valid.

Figure 53.3
Test enclosure for alcove or closet installations



NOTES

Description of dimension symbols and abbreviations for heating appliances.

A – Clearance above top of appliance.

B – From front of appliance. Prefix ″C″ to numeral indicates suitability for installation in closet only; prefix ″A,″ suitability for installation in alcove only; no prefix indicates installation to be in a room only.

C – From flue gas outlet assembly.

D – From back of appliance.

E^L – From left side of appliance.

E^R – From right side of appliance.

E^P – From any side of appliance pienum (downflow appliances have plenum beneath). ″E^P″ is only specified for appliances to be equipped with external plenums for connection to duct systems; its omission when A^D is specified indicates appliance equipped with integral plenum and if appliance is otherwise installed, clearances specified are not valid.

53.3 The walls, floor, and ceiling of the enclosure are to be made of 1-inch trade size wood boards (3/4 inch thick) or 3/4-inch (19.1-mm) thick plywood. The walls are to be vertical and at right angles. The interior surfaces of the walls, floor, and ceiling are to be finished in flat black. All joints in the enclosure are to be sealed.

53.4 For alcove installation test, the enclosure is to be three-sided, leaving the front side of the appliance casing exposed. Any remaining opening around the casing from side to side and from floor to ceiling is to be closed with 3/4-inch (19.1 mm) plywood if the appliance is not provided with a frame or panel for this purpose. The side walls are to terminate flush with the front of the appliance, and a wall is to be placed opposite the open side of the enclosure at a distance of 18 or 24 inches (467 or 610 mm), as specified by the manufacturer for testing purposes. If it is evaluated that such an installation may create higher temperatures at some locations, an appliance may also be tested with one side wall of the enclosure extended 18 inches (457 mm) beyond the front of the appliance, in which case there is to be no wall placed opposite the front of the appliance.

53.5 For closet installation test, a simulated door is to be provided for the enclosure. Such door is to be made of 3/4-inch (19.1-mm) thick plywood, the interior surfaces of which are to be finished in flat black. If the door is to be provided with openings, they are to be placed at locations with respect to the appliance in accordance with the manufacturer's installation instructions.

53.6 For a downflow appliance, a structure made of nominal 1-inch trade size lumber (3/4 inch thick) or 3/4-inch (19.1-mm) plywood representing a floor and joist structure is to be placed around the warm-air outlet plenum and duct. The clearance between the plenum and duct and the enclosure is to be 0 or 1/4, 1/2, 3/4, or 1 inch (6.4, 12.7, 19.1, or 25.4 mm), as specified by the manufacturer. The structure is to extend the full length of the duct. See Figure 53.2.

53.7 The room temperature is to be measured by a thermocouple not larger than 24 AWG (0.21 mm^2), suitably shielded from direct radiation. For alcove installation, the thermocouple is to be placed centrally 15 inches (381 mm) in front of the appliance and 24 inches (610 mm) above the floor of the test enclosure, except that for a horizontal heating appliance, the thermocouple is to be located midway between the floor and ceiling of the test enclosure. For closet installation, the thermocouple is to be placed in the center of the lower ventilating opening into the closet when the manufacturer's instructions recommend that such openings be provided; otherwise the thermocouple is to be placed as specified above for alcove installation.

53.7 revised February 2, 2009

53.8 The appliance is to be level. Leveling means, when provided, are to be removed if detachable; or, if not detachable, are to be adjusted to place the base of the appliance the minimum allowable distance above the floor.

54 Wall Furnace Installation

54.1 A wall furnace is to be installed in or on a test wall as intended in accordance with the manufacturer's published instructions furnished with the furnace and with commonly observed practice. The height of the test wall is to be 6 feet, 6 inches (2.0 m) and the front and back panels are to be of 1/4-inch (6.4-mm) thick plywood. The wall studs are to be of a depth to accommodate the required spacing between panels and are to be placed to accommodate the width of the wall furnace. Additional studs of appropriate width and extending from the floor plate to the ceiling plate are to be placed 16 inches (406 mm) (on center) outside the studs forming the space in which the appliance is installed. A side wall and ceiling of 3/4-inch (19.1-mm) plywood are to be provided. See Figure 51.1.

54.2 The room temperature is to be the arithmetic average as measured by two thermocouples shielded against radiation, each to be at an elevation 24 inches (610 mm) above the floor of the test structure and located in the test structure so as not to be affected by other than room temperature.

55 Recessed Furnace Installation

55.1 An appliance of a construction inherently providing separation of the combustion system from the atmosphere of the manufactured home or recreational vehicle may be tested for recessed installation in a wall or under a cabinet counter top. The installation is to be at the clearances recommended by the appliance manufacturer.

55.2 For installation of a central furnace, a return air opening shall be provided in the test enclosure. The location and minimum area of the opening shall be as recommended by the manufacturer of the appliance.

BOILER AND WATER HEATER TEST INSTALLATION

56 General

56.1 A boiler or a water heater is to be tested for installation in a corner, alcove or closet or recessed location in a manner similar to that prescribed for warm air appliances or at manufacturer's recommended clearances if less than standard clearances.

56.2 The room temperature is to be measured by a thermocouple placed centrally 15 inches (381 mm) in front of the appliance and 24 inches (610 mm) above the floor of the test structure, as indicated in Figure 52.2.

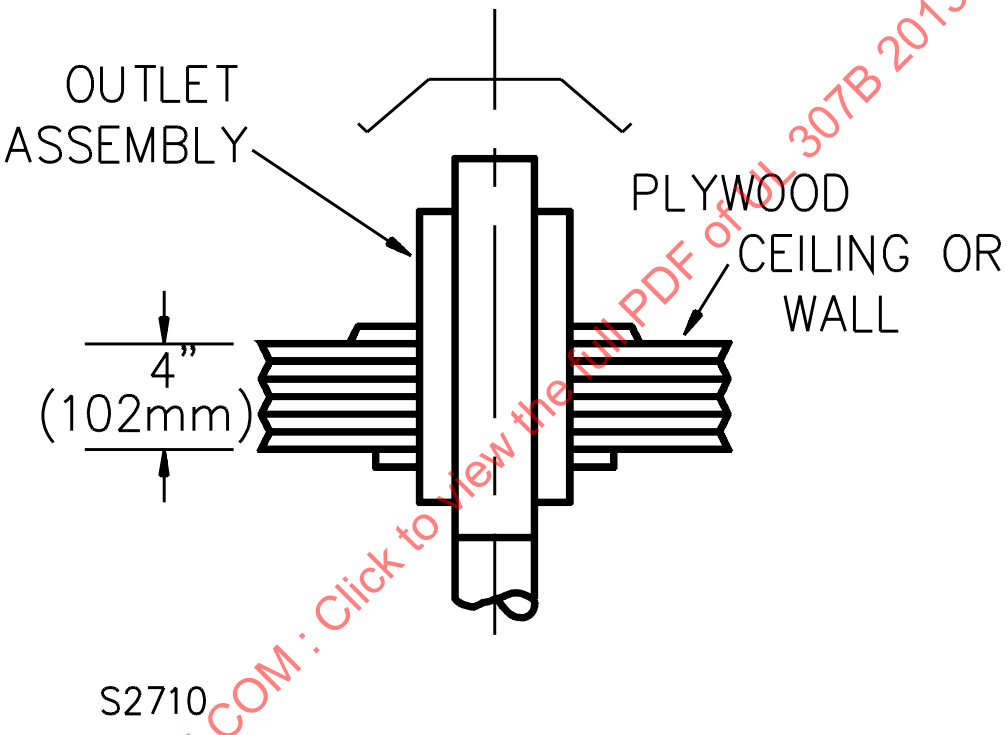
Exception: For a closet installation, the thermocouple is to be placed in the center of the lower ventilation opening into the closet when the manufacturer's instructions recommend that such opening be provided.

FLUE-GAS OUTLET ASSEMBLY

57 General

57.1 The outlet assembly furnished by the manufacturer with each appliance is to be installed in accordance with the instructions furnished with the appliance. The ceiling or wall opening is to conform to the outside surfaces of the outlet assembly with ceiling or wall material placed at zero clearance to those parts. Temperatures on the surface of the outlet assembly at points of contact with ceiling or wall material are to be determined. See Figure 57.1.

Figure 57.1
Flue-gas outlet assembly test installation



57.2 A draft hood furnished separately for mounting in the flue-gas outlet assembly is to be placed in the position specified in the manufacturer's instructions. An adjustable draft regulator, if provided, is to be adjusted in accordance with instructions furnished with the appliance.

INITIAL TEST CONDITIONS, TEST PRESSURES, AND BURNER ADJUSTMENTS

58 Initial Test Conditions

58.1 General

58.1.1 The appliance is to be set up for test in the appropriate enclosure and manner described in a preceding section. See Figures 50.1 – 53.1.

58.1.2 The appliance is to be fired at its rated Btu per hour input, plus or minus 2 percent, with the kind or kinds of gas and at the test pressures specified. A draft hood, if used, is to be in place.

58.1.3 Unless otherwise specified in the describing the tests, appliances are to be tested at the potentials indicated in Table 58.1.

Table 58.1
Test voltage

Rated voltage	Normal test voltage
110 – 120	120
200 – 208	208
220 – 240	240
254 – 277	277
Other	Rated

58.2 Warm air appliance

58.2.1 Unless otherwise specified in the describing of the tests, forced-air appliances are to be tested at the external static pressures indicated in Table 58.2.

Table 58.2
Relation of appliance input to external static pressure[a]

Input to appliance, btu per hour (W)	External static pressure,[b] inches (mm) water column			
	Temperature of outlet air determined by function of limit control			
	Above 165°F (73.9°C)		165°F (73.9°C) or less	
55,000 (16,000) and under	0.10	(2.5)	0.20	(5.1)
Over 55,000 to 80,000 (16,000 to 23,400)	0.12	(3.1)	0.24	(6.0)
Over 80,000 to 100,000 (23,400 to 29,300)	0.15	(3.8)	0.30	(7.6)

[a] Measured at static pressure connection located in supply plenum.

[b] An appliance may be tested at an external static pressure in excess of those specified as recommended by the manufacturer.

58.2.2 If an appliance is to be equipped with air filters, they are to be in place.

58.2.3 An appliance equipped with an air-circulating fan, the capacity of which is intended to be varied only by the installer, such as with a belt-drive or a motor-speed control, is to be tested with the fan speed adjusted so that approximately rated air delivery is obtained. This adjustment is to be maintained during all tests.

58.2.4 An appliance equipped with a device intended for manual change or adjustment by the user, such as a motor-speed control, or a circulating air damper, or the like, the positioning of which could affect the results in the following tests, is to be tested with the adjustable device in the position or positions likely to develop maximum temperatures or to disclose malfunction.

58.2.5 If the results of an appliance test involving the operation of a limit control are likely to be affected by the temperature of the inlet air, the test is to be conducted under conditions that maintain the inlet-air temperature between 60 and 80°F (15.6 and 26.7°C).

59 Test Pressures and Burner Adjustments

59.1 Unless otherwise specified, each test to determine conformance with these requirements is to consist of a series of three tests. One test is to be made at normal pressure, one at reduced pressure, and one at increased pressure, as shown in Table 59.1. A change in the rated gas input at a test pressure above or below the normal pressure is not to be corrected.

Table 59.1
Inlet test pressures

	Test pressure – inches water column (kPa)					
Test gas	Reduced		Normal		Increased	
Natural	3.5	(0.87)	7.0	(1.74)	10.5	(2.61)
n-Butane	8.0	(1.99)	11.0	(2.74)	13.0	(3.23)
Propane HD-5	8.0	(1.99)	11.0	(2.74)	13.0	(3.23)
Butane-air	3.5	(0.87)	7.0	(1.74)	10.5	(2.61)
Propane-air	3.0	(0.75)	6.0	(1.49)	9.0	(2.24)

59.2 The test pressure is to be applied at the inlet to the appliance pressure regulator. The pressure at the outlet of the regulator is to be as specified by the manufacturer, but not in excess of 7 inches (178 mm) water column for natural gas, and not in excess of 11 inches (279 mm) for LP-Gas. The adjustment of the pressure regulator shall not be changed during any of the tests unless otherwise specified.

59.3 The appliance is to be adjusted to its input rating at normal test pressure. When operated for 15 minutes, starting with all parts of the appliance initially at room temperature, the adjustment is to be within ±2 percent of the manufacturer's specified Btu input rating. Primary air is to be set for a good flame at this adjustment, and the primary air adjustment is not to be changed during a series of tests with any one test gas.

APPLIANCE TESTS

60 Combustion – Burner and Appliance

60.1 An appliance shall be capable of functioning as intended without producing excessive smoke or carbon monoxide when installed and adjusted in accordance with the manufacturer's instructions.

60.2 There shall be no carbon monoxide (CO) concentration in excess of 0.04 percent (0.02 percent on a water heater at reduced inlet pressure) present in an air-free sample of the flue gases when the appliance is tested in a room with a normal oxygen supply and is fired at the test pressures and inputs specified herein. During the test at maximum rated input and at normal test pressure, the stack losses from the appliance shall be not more than 25 percent.

60.3 The percent carbon monoxide concentration on an air-free basis is calculated according to the following formula:

$$CO_{(air-free)} = \frac{U}{CO_2} \times CO$$

Where:

CO = Carbon monoxide, percent in flue gases;

CO_2 = Carbon dioxide, percent in flue gases; and

U = Ultimate percent of CO_2 for fuel being burned.

Approximate values for U are:

13.8 percent for propane gas;

14.0 percent for butane gas; and

11.7 percent for natural gas.

60.4 Burner and primary air adjustments are to be made in accordance with 59.3.

60.5 After adjustment and with all parts of the appliance at room temperature, the pilot or pilots, if provided, are to be placed in operation and allowed to operate for a period of 5 minutes. The main burner or burners are then to be placed in operation and the appliance operated for 3 minutes at normal test pressure, at which time a sample of the flue gases shall be secured. Immediately upon securing the sample at normal test pressure, the reduced test pressure (see 59.1) is to be applied and, following a purge period of at least 2 minutes, another sample of the flue gases is to be secured.

60.6 The gas appliance pressure regulator shall then be adjusted to provide an increase in the input rate specified by the manufacturer of 12 percent for appliances for use with natural gas and 9 percent for appliances for use with liquefied petroleum gas. When the regulator outlet pressure cannot be readily adjusted to obtain this increase in input rate, the regulator may be removed or blocked in the open position, or the inlet test pressure may be increased as necessary. The appliance shall then be allowed to continue in operation for 15 minutes from the time it was initially placed in operation, at which time another sample of the flue gases shall be secured.

60.7 On an appliance provided with a power burner or induced draft, an additional combustion sample is to be secured with the appliance operating at normal test pressure and with the supply voltage reduced, as applicable, to either:

a) 85 percent of the appliance rating plate line voltage; or

b) The lowest predetermined direct current voltage which will cause main burner operation following an appliance off cycle.

The input rating may vary from normal as a result of the lower voltage.

60.8 The flue gas samples on direct-vent appliances are to be taken between the combustion chamber and the vent termination where uniform samples can be obtained. The flue gas samples on appliances equipped with a draft hood or draft diverter, are to be taken upstream of the draft hood or draft diverter relief opening where uniform and undiluted samples can be obtained. The flue gas samples are to be analyzed for carbon monoxide and carbon dioxide.

60.9 Appliances intended for use with natural gas are to be tested for combustion with natural gas at 4 inches (1.0 kPa) water column inlet pressure, except that the test need not be conducted when the manifold pressure at this inlet pressure is not less than the manifold pressure specified by the manufacturer for natural gas.

60.10 The tests in accordance with 60.9 shall be conducted with the burner adjusted for the manufacturer's specified normal input rating at 4.0 inches (1.0 kPa) water column inlet pressure after 15 minutes of operation, starting with all parts of the appliance at room temperature. Primary air shall be adjusted to give good flame. The appliance is then to be turned off and allowed to cool to room temperature. The pilot burner or burners, if provided, shall then be placed in operation and allowed to operate for a period of 5 minutes, at which time the main burner or burners is to be placed in operation. The appliance is to be operated for 3 minutes, at which time a sample of the flue gases is to be secured and analyzed.

61 Burner Operating Characteristics

61.1 Flash back

61.1.1 Burner flames shall not flash back when the burner is turned on and off in each manner specified in 61.3 and at each of the conditions specified in 61.2. If a primary safety control functions to shut off the gas supply when the gas input is reduced from rated high-fire input to a lesser input specified in 61.2, the appliance is considered to comply with this requirement.

Exception: Water heaters equipped with snap-action thermostats need not comply with the tests at one-fifth normal rate.

61.1.2 The burner is turned on and off at each of the following conditions:

a) At rated high-fire input and normal, reduced and increased test pressures specified in 59.1.

b) Upon 2-second delayed ignition of the main burner and 2- to 20-second delayed ignition of the pilot, at rated high-fire input and reduced and increased test pressures.

c) With the manual shutoff valve on the burner or in the gas supply line adjusted to obtain one-third (one-fifth for water heaters) rated high-fire input at normal test pressure.

d) On appliances for use with natural gas, at 4.0-inch water column (1.0 kPa) inlet pressure with natural gas.

Exception: This test need not be conducted when the manifold pressure at the 4.0-inch water (1.0 kPa) column adjustment is not lower than that specified by the manufacturer for natural gas.

e) On appliances equipped with forced-draft or induced-draft burners, at normal test pressure and with the supply voltage adjusted, as applicable, to either:

1) 85 and 110 percent of the appliance rating plate line voltage; or

2) The lowest predetermined direct current which will cause main burner operation following an appliance off cycle.

f) On appliances equipped with automatic step-rate or automatic modulating controls which provide for ignition and operation at a reduced input rating, at normal test pressure and at 87 percent of the lowest input rating, if this results in an input rating of less than one-third (one-fifth for water heaters) of the normal input rating.

g) On appliances equipped with automatic modulating controls which operate to reduce the input after ignition of the main burner gas, at normal test pressure and at 87 percent of the lowest input rating, if this results in an input of less than one-third (one-fifth for water heaters) of the normal high-fire input rating. These tests are conducted for operation and extinction only.

61.1.3 The appliance is to be adjusted for operation at each input and pressure specified in 61.1.2. Prior to these adjustments, with the appliance operated at rated high-fire input and normal test pressure, the outlet-air temperature of air-heating appliances, and the outlet water temperature of water-heating appliances, is to be within the range of normal operation. Observations are to be made of each ignition and extinction of the main burners, when the gas supply is turned on and off by means of:

a) Manually operating the manual gas shutoff valve;

b) By interrupting and closing the circuit to an electric shutoff valve; and

c) Causing a gas operating or regulating control of the complete shutoff type to open and close.

Each of the preceding tests are to be conducted with the main burners both hot and cold. The burner is to be cycled on and off five times at each test condition.

61.1.4 The arrangement of main burners, burner valves, pilots, and safety shutoff devices on the appliance are to be such that when only the pilots equipped with safety shutoff devices are in operation, the gas from any burner or combination of burners will be effectively ignited without delayed ignition, flashback, igniting at the orifice, flashing outside the combustion space or damage to the appliance. Flames shall carry across all ports of the burners. The burners shall ignite, operate, and extinguish without objectionable noise.

61.1.5 The appliance is to be operated at each of the conditions specified in 61.1.2, excluding (b), and in each manner specified in 61.1.3. An auxiliary pilot not equipped with a safety shutoff device is to be turned off. Observations are to be made of each ignition, operation, and extinction of the main burners. The burner is to be cycled on and off, and operated a sufficient number of times at each condition specified, so that conclusive results are obtained.

61.2 Back pressure

61.2.1 There shall be no back pressure at the burner mixer face, as evidenced by ignition of escaping air-gas mixture.

61.2.2 Compliance with 61.2.1 is to be determined when the appliance is tested at each of the conditions as specified in 61.1.2, and the tests are to be conducted with the burners both hot and cold. A flame is to be played on the mixer face of each burner in such a manner that any air-gas mixture escaping from the burner head will be ignited.

61.3 Flame extinguishment-water heaters

61.3.1 During operation of the water heater, flames shall not be extinguished from causes other than normal functioning of the appliance controls. See 61.3.2.

61.3.2 Water, at a temperature of 40 ±2°F (4.5±1°C), is to be supplied to the appliance through the inlet connection. After the system has been filled, the inlet water valve is to be closed. The appliance is to be operated at the increased inlet test pressure until condensation of the flue gases within the appliance ceases, or for a period of time sufficient to demonstrate that it would continue to operate in the intended manner.

62 Pilot Operating Characteristics

62.1 Ignition

62.1.1 Pilot burners shall effect ignition of gas at the main burner or burners immediately after gas reaches the main burner ports and shall not become extinguished and remain extinguished when the gas to the main burner or burners is turned on or off in a normal manner, except for intended turnoff of intermittent or interrupted pilots. Any failure to effect ignition immediately after gas reaches the main burner ports, or continued extinction of the pilot flame is considered to not comply with 62.1.1.

62.1.2 The appliance is to be fired at rated high-fire input and at all test pressures specified in 59.1. Appliances for use with natural gas, are also to be tested at 4.0 inches water column inlet pressure (1.0 kPa) with natural gas unless the manifold pressure at 4.0 inches water column pressure adjustment is not lower than that specified by the manufacturer for natural gas. Each pilot, main burner, and pilot igniter are to be adjusted according to the manufacturer's instructions for the appliance. The burner is to be turned on and off by each of the means specified in 61.1.3, for ten consecutive trials, with the gas flow maintained for 30 seconds and interrupted for 30 seconds for each cycle.

62.1.3 The pilot burner shall effect ignition of the gas at the main burners within 4 seconds from the time the gas supply is first admitted to the main burners. A pilot burner that becomes extinguished after having completed main burner ignition is considered to comply with this requirement, but additional tests are to be made at increasing pilot rates to determine that no condition exists where the pilot will remain lighted without igniting the main burner gas.

62.1.4 The appliance is to be adjusted for operation at rated high-fire input and normal test pressure. A safety shutoff device, the time of operation of which can be varied by means of an adjustment provided by the manufacturer of the device is to be adjusted for the maximum shutoff timing permitted. The following adjustments are to be made for the type of pilot employed. The appliance is to be placed in operation in the intended manner and the ignition of gas at the main burners is to be observed.

a) Single-Flame Pilot Burners (Pilot Burners Which Produce a Single Flame with Substantially Uniform Contour Under Turndown Conditions) – To conduct the tests, the pilot gas supply is to be reduced (by a manual valve in the pilot line) to a point where the flame is just sufficient to keep the valve of the safety shutoff device open, or just above the point of flame extinction, whichever represents the higher pilot gas rate.

b) Multi-Flame Pilot Burners (Pilot Burners Which Produce a Flame with Substantial Variation in Contour Under Turndown Conditions) – To conduct the test, all pilot flame ports, except the ports for heating the thermal element, are to be blocked. The pilot gas supply is to be reduced to a point where the flame is just sufficient to keep the valve of the safety shutoff device open,

or just above the point of flame extinction, whichever represents the higher pilot gas rate. The test is also to be conducted with the pilot burner at any input between the turned-down setting up to and including the specified normal pilot gas rate through the unblocked ports of the pilot.

c) Pilot Generators (Pilot Burners and Thermal Element Assemblies Which Supply Millivoltage for an Automatic Control System Which Includes a Safety Shutoff Device) – When the thermal element is the only source of power for operation of the automatic shutoff valve, the tests specified under (a) and (b) are to be conducted with the pilot burner flame adjusted to the minimum size (pull-in millivoltage) necessary to open the automatic shutoff valve. Any other system component such as a room thermostat is to be excluded from the tests. When a multi-flame pilot burner is provided, the test described in (b) at increased pilot input rates is also to be conducted.

d) Recycling Pilot Burners (Pilot Burners Which Operate Each and Every Time the Main Burner is Turned On or Off, Either Manually or by Automatic Controls) – The pilot gas supply is to be reduced to a point where it is just sufficient to light the gas at the ports used for heating the thermal element.

62.2 Flame travel

62.2.1 Flames shall travel freely to all pilot burner ports when the gas is ignited at any one port. This test is to be conducted on only those pilot burners in which separate ports are used for heating the thermal element of the safety shutoff device and for ignition of gas at the main burners.

62.2.2 The pilot burner is to be adjusted according to the manufacturer's instructions and the gas at the pilot burner is to be ignited. The flames are then extinguished by means other than interrupting the pilot gas supply, and gas from the ports used to heat the thermal element of the safety shutoff device is to be immediately reignited. The flames shall travel freely to all other ports on the pilot burner.

62.3 Protection from drafts

62.3.1 For appliances that do not inherently provide separation of the combustion system from the atmosphere of the manufactured home or recreational vehicle, pilot burners shall be protected from drafts. The pilot flame shall not be extinguished under the conditions described in 62.3.2.

62.3.2 To determine compliance with 62.3.1, the pilot burner is to be adjusted to its normal gas rate. With the gas supply to the main burners shut off, a draft having a velocity of 300 feet per minute and of sufficient volume to encompass the entire appliance is to be directed alternately at the front, sides, and rear of the appliance.

62.4 Carbon deposits

62.4.1 A pilot burner flame shall not deposit appreciable carbon during any of the performance tests, or when the pilot burner is tested in accordance with 62.4.2.

62.4.2 The appliance is to be adjusted for operation at rated high-fire input, and the pilot burner is to be adjusted in accordance with the manufacturer's instructions, at normal test pressure. The increased test pressure is then applied, and the pilot is to be lighted in a normal manner and allowed to burn for at least 1 hour. The pilot burner, and surfaces adjacent to the pilot, are to be observed for deposits of carbon.

62.5 Automatic relight pilot system

62.5.1 An automatic relight pilot system shall:

a) Ignite the pilot burner gas within 30 seconds; or

b) Lockout within the control manufacturer's maximum lockout time at voltages to the igniter of less than 85 percent of the appliance rating plate voltage.

1) After gas reaches the pilot burner ports while maintaining 85 percent of the appliance rating plate voltage to the appliance including the gas valve and 70 percent of the appliance rating plate voltage to the automatic relight pilot system. Pilot gas flow shall be initiated at normal test pressure and ignition observed. For an appliance for connection to a direct current electrical supply, this test is to be repeated at the lowest direct current voltage that will cause main burner operation following an appliance off cycle.

2) After gas reaches the pilot burner ports while maintaining 110 percent of the appliance rating plate voltage to the appliance.

3) With the pilot gas supply reduced to an amount just sufficient to keep the valve of the safety shutoff device open, or just above the point of flame extinction, whichever represents the higher pilot gas rate, pilot gas flow shall be initiated at appliance rating plate voltage and ignition observed.

62.5.2 The procedures described in 62.5.1 are to be repeated ten times, and in each instance ignition shall occur within 30 seconds after gas reaches the pilot burner.

63 Operation of Pilot Actuated Safety Shutoff Devices

63.1 Pilot flame establishing period

63.1.1 The combined time required for the safety shutoff device and automatic shutoff valve to turn on the main gas supply after the pilot burner has been lighted shall not exceed:

a) Two minutes for integral valve type automatic gas ignition systems;

b) Five minutes for electrical contactor type automatic gas ignition systems;

c) One and one-half minutes for an automatic gas ignition system requiring a continually applied manual force to assume the on position; and

d) One and one-half minutes for automatic gas ignition systems which operate every time the main burner or burners with which they are used are turned on and off.

63.1.2 The appliance is to be adjusted for operation at rated high-fire input and normal test pressure. The pilot burner only is to be manually lighted or automatically lighted, as appropriate, and the time required to turn on the gas supply is to be observed.

63.2 Shutoff time

63.2.1 The combined time for the safety shutoff device and the automatic shutoff valve to shut off the gas supply shall not exceed 120 seconds for burners provided with continuous ignition, intermittent ignition and interrupted ignition and 90 seconds for burners provided with direct ignition.

63.2.2 The appliance is to be operated at rated high-fire input and normal test pressure until steady-state conditions have been established. All gas to the appliance is then to be shut off by a quick acting manual valve in the gas supply line. The time required for the safety shutoff device to turn off the gas supply is to be observed.

63.2.3 A standing pilot equipped with an automatic relight pilot system which acts to reestablish the pilot flame in more than 0.8 seconds shall not cause excessive flame flashout or damage to the appliance. Appliances with control systems providing complete gas shutoff and a purge period of 5 minutes, or longer, are considered to comply with this provision. See 63.2.4 – 63.2.7.

63.2.4 The pilot igniter is to be rendered inoperative and the appliance is to be instrumented with a sampling tube or tubes to measure the gas-air ratio at various points in the unit. This sampling tube or tubes is to be connected to a gas-air analyzer coupled to a chart-type single-point recording potentiometer in order to produce a constant trace of the gas-air ratio at the sample point for a sufficient time to allow a complete evaluation of the system. The gas-air ratio trace is to be developed with the unit both hot and cold, and with all test gases for which the appliance is tested.

63.2.5 Unburned gas is to be allowed to flow into the unit for the maximum combined time required for the safety shutoff device and automatic valve to shut off the gas supply. Immediately following shutoff of the gas supply, an ignition cycle is to be initiated at normal rated voltage for alternating current appliances and at the lowest predetermined direct current voltage that will cause main burner operation following an appliance off cycle for direct current appliances. The time at which the pilot igniter would normally be energized is to be noted.

63.2.6 If the gas-air ratio at the time at which the pilot igniter would normally be energized does not exceed the lower explosive limit, the appliance is considered to comply with this provision. If this ratio is above the lower explosive limit, sufficient ignition tests are to be conducted between the time of energization of the ignition means and when the atmosphere of the appliance returns to below the lower explosive limit to determine that the automatic relight pilot system does not cause flame flashout or damage to the appliance.

63.2.7 Appliances with control systems not providing complete gas shutoff, but having a purge period of 5 minutes or longer, are to be tested as outlined in 63.2.4 – 63.2.6 except the purge time is to be 4-1/2 minutes. Pilot gas is to be allowed to flow during the purge period.

63.3 Nonautomatic shutoff

63.3.1 A pilot, not provided with automatic shutoff when the presence of the ignition source is not proved, shall not cause flame flashout or damage to the appliance. See 63.3.2.

63.3.2 The appliance is to be instrumented as described in 63.2.4. The pilot igniter is to be rendered inoperative and main burner gas flow is to be shut off. In a draft free environment, unburned pilot gas is to be allowed to flow into the appliance until equilibrium of the gas-air ratio is obtained. If the gas-air ratio during this time does not exceed the lower explosive limit, the appliance is to be considered as complying with 63.3.2. If this ratio is above the lower explosive limit, sufficient ignition tests are to be conducted at any time up to 1 hour of pilot gas flow to determine that the unsupervised pilot system does not cause excessive flame flashout or damage to the appliance.

64 Direct Ignition Tests

64.1 General

64.1.1 On an appliance where all air for combustion is supplied by mechanical means and the direct ignition system is reactivated after a purge period sufficient to provide a minimum of four air changes of the combustion chamber and flue passages, the lockout timing for direct ignition systems shall not exceed 15 seconds. For such systems, the trial for ignition between purges shall not exceed 15 seconds. On all other appliances, the lockout timing for direct ignition systems shall not exceed 60 seconds. For test purposes the control manufacturer's specified maximum lockout time for the ignition system is to be used.

64.1.2 A direct ignition system shall effect ignition of the gas at each main burner immediately after gas reaches each main burner port when the appliance is operated at its rated voltage.

64.1.3 While maintaining the supply voltage to the appliance at the rated value, the ignition system is to be placed in operation and ignition is to be observed. This procedure is to be repeated 25 times and after each trial, ignition is to occur immediately after gas reaches the main burner ports.

64.2 Ignition time

64.2.1 The ignition system shall effectively ignite the main burner gas within 4 seconds after gas reaches the main burner port or ports when tested as described in 64.2.2 and 64.2.3.

Exception: At voltages to the igniter of less than 85 percent of the appliance rating plate voltage, lockout within the control manufacturer's specified maximum lockout time is considered to comply with the above.

64.2.2 While maintaining the supply voltage to the appliance and all other electrical components including gas valves at 85 percent of the rated value, and while maintaining the supply voltage to the ignition circuit at 70 percent of the rated value, the appliance is to be placed in operation and ignition is to be observed. This procedure is to be repeated 25 times. The procedure is then to be repeated with the supply voltage to the appliance at 110 percent of rated value.

64.2.3 For an appliance for connection to a direct current electrical supply, the test described in 64.2.2 is to be conducted at the lowest predetermined direct current voltage which will cause main burner operation following an appliance off cycle.

64.3 Flame failure

64.3.1 The time required for the main burner gas supply to be shut off in the event of flame failure during an operational cycle shall not exceed 90 seconds. If the ignition means is reactivated, it shall be reenergized in not more than 0.8 second following flame failure and the ignition means shall reignite the main burner gas without flame flashout or damage to the appliance. On appliances where all air for combustion is supplied by mechanical means, the ignition means may be reactivated after a purge (recycle time) period sufficient to provide a minimum of four air changes of the combustion chamber and flue passages.

64.3.2 The appliance is to be operated at rated high-fire input and normal test pressure, and at rated supply voltage, until steady-state conditions have been established. The gas supply to the appliance is then to be interrupted by a quick-acting valve in the gas supply line, and then immediately restored. The time required for the safety shutoff system to turn off the gas supply is to be observed. For an appliance for connection to a direct current electrical supply, the above test is to be conducted at the lowest predetermined direct current voltage that will cause main burner operation following an appliance off cycle.

64.4 Venting

64.4.1 The construction of the appliance and the arrangement of the ignition system shall be such that, in the event of a delay in ignition of the main burner gas that might be caused by foreign debris or electrical shorting of the ignition means, the appliance will vent itself without flame flashout or damage.

64.4.2 The appliance is to be adjusted for rated high-fire input and normal test pressure. The appliance is to be placed in operation at room temperature and the ignition means is to be temporarily circumvented for varying intervals of time up to the point at which the ignition means is automatically de-energized or the main burner gas supply is automatically shut off. For recycling ignition systems, attempts to ignite are to be made for varying intervals of time up to lockout of the safety control. The resulting ignition at each time interval is to be observed for flame flashout or damage to the appliance.

65 Temperature Test

65.1 When a heating appliance is tested in accordance with these requirements, no part shall attain a temperature sufficient to damage required corrosion protection, to adversely affect operation of safety controls, to adversely affect the value of required thermal or electrical insulation, nor to cause creeping, distortion, sagging, or similar damage when such damage to the material or part may cause the appliance to present a risk of fire, explosion, electric shock, or injury to persons. The temperature rises at specific points shall be not greater than those specified in Table 65.1, unless otherwise indicated.

65.2 Motors shall not exceed the temperature rises indicated in Table 58.1 when tested as described herein.

Table 65.1
Maximum temperature rises

Materials and components	Column 1		Column 2	
	Degrees		Degrees	
	C	F	C	F
A.Motors[a,b]				
1. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches (178 mm) or less in diameter (not including universal motors):				
a. In open motors;				
Thermocouple or resistance method	75	135	115	208
b. In totally enclosed motors;				
Thermocouple or resistance method	80	144	115	208
2. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches (178 mm) and of direct-current and universal motors:				
a. In open motors;				
Thermocouple method	65	117	115	208
Resistance method	75	135	115	208
b. In totally enclosed motors;				
Thermocouple method	70	126	115	208
Resistance method	80	144	115	208
3. Class B insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches (178 mm) or less (not including universal motors):				
a. In open motors;				

Table 65.1 Continued on Next Page

Table 65.1 Continued

Materials and components	Column 1		Column 2	
	Degrees		Degrees	
	C	F	C	F
Thermocouple or resistance method	95	171	140	252
b. In totally enclosed motors;				
Thermocouple or resistance method	100	180	140	252
4. Class B insulation systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches (178 mm) and of direct-current and universal motors:				
a. In open motors;				
Thermocouple method	85	153	140	252
Resistance method	95	171	140	252
b. In totally enclosed motors;				
Thermocouple method	90	162	140	252
Resistance method	100	180	140	252
B. Components				
1. Capacitors:				
a. Electrolytic type[d]	40	72	(Not specified)	
b. Other types[d]	65	117	(Not specified)	
2. Field wiring	35	63	60	108
3. Relay, solenoid, and other coils with:[b]				
a. Class 105 insulated winding;				
Thermocouple method	65	117	115	208
b. Class 130 insulated winding;				
Thermocouple method	85	153	140	252
4. Sealing compounds	40°C (72°F) less than its melting point			
5. Transformer enclosures[b]				
a. Class 2 transformers	60	108	85	153
b. Power and ignition transformers	65	117	90	162
C. Insulated Conductors[e,f]				
1. Appliance wiring material				
75°C rating	50	90	65	117
80°C rating	55	99	70	126
90°C rating	65	117	80	144
105°C rating	80	144	95	171
200°C rating	175	315	200	360
250°C rating	225	405	250	450
2. Flexible cord – Types SO, ST, SJO, SJT including surfaces of the appliance which the cord may contact[e]	35	63	60	108
3. GTO cable	35	63	60	108
4. Wire, Code				
Types R, RU, RUW	35	63	60	108
Types RH, RFH, FFH, RHW, THW, THWN	50	90	75	135
Types T, TF, TFF, TW	35	63	60	108
Type TA	65	117	90	162
5. Other types of insulated wires	e	e	e	e
D. Electrical Insulation[f]				
1. Class C electrical insulation material	Not specified			
2. Class (180) electrical insulation material	As determined by test			

Table 65.1 Continued on Next Page

Table 65.1 Continued

Materials and components	Column 1		Column 2	
	Degrees		Degrees	
	C	F	C	F
3. Fiber used as electrical insulation or cord bushings	65	117	90	162
4. Phenolic composition used as electrical insulation or as parts where failure will result in a risk of fire or electric shock	125	225	150	270
5. Thermoplastic material	25°C (45°F) less than its temperature rating			
6. Varnished cloth insulation	60	108	85	153
E. Metals				
1. Aluminum alloys –				
a. 1100	183	330	239	430
b. 3003	239	430	294	530
c. 2014, 2017, 2024, 5052	294	530	350	630
2. Aluminum-coated steel[g]	656	1180	767	1380
3. Carbon steel sheet, cast iron	517	930	683	1230
4. Carbon steel – Coated with Type A19 ceramic	572	1030	628	1130
5. Galvanized steel[h]	267	480	350	630
6. Stainless steel –				
Types 302, 303, 304, 316, 321, 347	767	1380	878	1580
Type 309	961	1730	1072	1930
Type 310	1017	1830	1128	2030
Type 405	683	1230	795	1430
Types 403, 409, 410, 416	572	1030	683	1230
Type 430	711	1280	822	1480
Type 442	877	1580	933	1680
Type 446	961	1730	1072	1930
7. Zinc castings	89	160	145	260
F. General				
1. Air filter	50	90	97	175
2. Flue gases	i	i	i	i
3. Surfaces of the appliance at points of zero clearance to test structure	50	90	97	175
4. Surface of floor beneath and within 3 feet (0.91 m) of the appliance to be classified for installation on combustible floors	50	90	97	175
5. Surfaces of test enclosure (ceiling, walls, and the like)	50	90	97	175

[a] The motor diameter is to be measured in the plane of the laminations of the circle circumscribing the stator frame, excluding lugs, boxes, or the like, used solely for motor cooling, mounting, assembly, or connection.

[b] Coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices (such as a coil immersed in sealing compound) or unless the coil wrap includes thermal insulation or more than 2 layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like. For a thermocouple-measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor. At a point on the surface of the coil (not including universal motors) where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may exceed the indicated maximum by the following amounts, provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.

1. 5°C (9°F) for Column 1 limits for Class A insulation on coil windings of alternating-current motors having a diameter of 7 inches (178 mm) or less, open type.
2. 10°C (18°F) for Column 1 limits for Class B insulation on coil windings of alternating-current motors having a diameter of 7 inches (178 mm) or less, open type.
3. 15°C (27°F) for Column 1 limits for Class A insulation on coil windings of alternating-current motors having a diameter of more than 7 inches (178 mm), open type.

Table 65.1 Continued on Next Page

Table 65.1 Continued

Materials and components	Column 1		Column 2	
	Degrees		Degrees	
	C	F	C	F
4. 20°C (36°F) for Column 1 limits for Class B insulation on coil windings of alternating-current motors having a diameter of more than 7 inches (178 mm), open type.				
[c] For an electrolytic capacitor which is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may be not more than 65°C (117°F).				
[d] A capacitor which operates at a temperature higher than a 65°C (117°F) rise may be judged on the basis of its marked temperature rating.				
[e] For standard insulated conductors other than those specified, reference should be made to the National Electrical Code, ANSI/NFPA 70-1993; the maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question where Column 1 temperature rises are specified, and the maximum allowable temperature rise where Column 2 rises are specified is to be based on the heat resistant properties of the insulation.				
[f] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds which have been investigated and found to have special heat-resistant properties.				
[g] When the reflectivity of aluminum-coated steel is utilized to reduce the risk of fire, the maximum allowable temperature rise is 830°F (461°C).				
[h] The specified maximum temperature rises apply if the galvanizing is required as a protective coating, or the reflectivity of the surface is utilized to reduce the risk of fire.				
[i] The temperature of flue gases shall be consistent with the recognized temperature units for the flue-gas outlet assembly and the chimney or vent connector to be furnished with the appliance. The flue-gas temperature is to be measured during each test described in 73.1 – 73.4.				

66 Wind Test

66.1 General

66.1.1 The requirements in 66.1.2 – 66.4.2 are applicable to direct vent system appliances. Gas to the main burner and the pilot is to be at normal test pressure.

66.1.2 The pilot or pilots of an automatically lighted burner, and the main gas supply of a manual or automatically lighted burner equipped with an electric ignition system shall ignite when the vent-air intake terminal is exposed to wind of sufficient velocity to produce a static pressure at the appliance wall surface of 0.04 inch (1.0 mm) water column [nominal 10 mile per hour (16 km/h) wind velocity].

66.1.3 The appliance is to be installed in an appropriate test enclosure in accordance with Sections 51 – 56. A deflector wall is to be installed against the test enclosure and be of a size and configuration that wind from the wind apparatus will not effect that portion of the heating appliance normally intended for indoor installation.

66.1.4 A wind produced by a blower having sufficient capacity to develop a 0.04-inch (1.0-mm) water column static pressure [nominal 10 mile per hour (16 km/h) wind velocity] is to be directed against the outside surface of the test structure on which the vent-air intake terminal is attached. The blower is to be located so that the wind is directed perpendicular to the surface of the wall structure. Static pressure is to be measured by means of static pressure taps encompassing the area of the vent terminal. The static pressures at these points are to indicate uniform pressure distribution. Additional tests may be conducted with the same fan setting as determined above, with the wind directed from other directions.

66.1.5 With the appliance subjected to the above wind conditions, the pilot or pilots shall be capable of being ignited in accordance with instructions furnished with the appliance and within the pilot flame or ignition establishing period.

66.2 Main burners

66.2.1 The main burner or burners shall not become extinguished and shall ignite from the automatic ignition device or devices without excessive delay when the vent-air intake terminal is exposed to a wind of sufficient velocity to produce a static pressure at the wall surface of 0.66 inch (16.8 mm) water column [nominal 40 mile per hour (64 km/h) wind velocity].

66.2.2 The test is to be as specified in 66.1.4 and 66.1.5 except the blower is to be capable of producing a static pressure on the surface of the test wall of 0.66 inch (16.8 mm) water column. Each pilot, if provided, is to be ignited before the appliance is subjected to the wind. A manual or automatic operated appliance is to be operated at rated input. If the appliance is investigated for a firing rate range, it is to be adjusted to operate at any allowable input between the minimum and maximum firing rate. While operating under the aforementioned wind conditions, each pilot, when operating alone, and each pilot or igniter and main burner or burners when operating simultaneously shall not become extinguished during a 10-minute period. See 66.2.3 and 66.2.4.

66.2.3 The main burner valve is then to be shut off. After a period of at least 30 seconds the main burner valve is to be turned on and the main burner gas shall ignite from the pilot or pilots or ignition source without excessive delay. Automatically controlled appliances shall also comply with this test when the burner or burners are turned on and off by the automatic controls.

66.2.4 Additional tests may be conducted with the same fan setting and distance as determined above, with wind from other directions.

66.2.5 The performance of the appliance during tests as specified in 66.1.5 and 66.2.2 shall be such that ignition is obtained without flash of flame outside the heating appliance and without damage to any part of the appliance.

66.3 Carbon monoxide

66.3.1 An appliance shall not produce a concentration of carbon monoxide in excess of 0.04 percent in an air-free sample of the flue gases when its vent-air intake terminal is exposed to wind of sufficient velocity to produce a static pressure at the appliance wall surface of 0 to 0.66 inch (16.8 mm) water column [nominal 40 mile per hour (64 km/h) wind velocity].

Exception: This requirement does not apply to a direct vent water heater in which:

a) The combustion system is water backed;

b) The entire unit is enclosed in its own housing designed so that there are no air openings to the interior of the structure, and with all piping entering the combustion system gasketed; and

c) All access to the combustion system of the appliance is from the exterior of the structure.

66.3.2 The test is to be as specified in 66.1.4 and 66.1.5 except the blower is to be varied to produce static pressures on the surface of the test wall between 0 and 0.66 inch (16.8 mm) water column. During the application of this range of wind velocities, sufficient flue gas samples are to be secured and analyzed to determine that the carbon monoxide concentration does not exceed 0.04 percent in an air-free sample of the flue gases. Additional tests may be conducted with the same range of fan settings as determined above, with wind from other directions.

66.4 Operating characteristics

66.4.1 The operating characteristics of an appliance shall not be affected by the wind conditions specified in 66.3.1. Compliance with this requirement is determined when the variation in the carbon dioxide concentration in the flue gases is not in excess of the limits specified in 66.5.1.

Exception: This requirement does not apply to a direct vent water heater as described in the exception to 66.3.1.

66.4.2 The appliance is to be operated under still air conditions at normal test pressure until a constant flue gas temperature is attained. A flue gas sample is then to be secured and analyzed for carbon dioxide. The appliance is then to be adjusted to provide increased manifold pressure as specified in 59.2 and following a purge period of at least 2 minutes, another flue gas sample is to be secured under a still air condition and analyzed for carbon dioxide. The appliance is to be readjusted to operate at normal test pressure and operated until a constant flue gas temperature is obtained. The wind conditions specified in 66.3.1 is then to be imposed on the vent-air intake terminal or terminals and sufficient flue gas samples secured and analyzed under the various wind conditions to determine the carbon dioxide concentration.

66.5 Carbon dioxide

66.5.1 The carbon dioxide concentration with the furnace subject to any of the wind velocities specified in 66.3.1 shall not exceed by more than 0.3 percent the carbon dioxide concentration produced by the furnace when operated at increased manifold pressure under a still air condition and shall not be less than 50 percent of the carbon dioxide concentration produced by the furnace when operated at normal test pressure under a still air condition. Additional tests may be conducted with the same range of fan settings with wind from other directions.

66.6 Water heater tests

66.6.1 The requirements of 66.6.2 and 66.6.3 are applicable to water heaters. Gas to the main burner and the pilot are to be at normal test pressure.

66.6.2 Burner flames shall not flash back nor become permanently extinguished when subjected to a draft equivalent to a wind velocity of 3 miles per hour (1.34 m/s) striking the appliance from any side. See 66.6.3.

66.6.3 The appliance is to be operated for a period of 15 minutes. A 3 mile per hour (1.34 m/s) wind is then to be directed for a period of 1 minute alternately against the front, sides, and back of the water heater by means of a fan or blower to determine the stability of burner flames against such drafts. This test is to be applied with and without the main burner or burners in operation. See also 62.3.1 and 62.3.2.

67 Direct Vent System Leakage Test

67.1 In direct vent systems of appliances having a separate air intake section and a separate combustion chamber-vent section:

a) The leakage from the combustion chamber-vent section of the system shall not exceed 4.0 percent of the products of combustion; and

b) The leakage from the air intake section of the system shall not exceed 8.0 percent of the products of combustion.

67.2 The vent and air intake terminals are to be removed, and the entrance of the air intake section sealed at the point it enters the combustion chamber. The entire system, including the combustion air and flue gas connections between the appliance and the vent and air intake terminals, is to be installed and sealed in accordance with the manufacturer's instructions. Both the flue outlet and the air inlet is to then be sealed at the point of connection to the vent and air intake terminals. The sealing means is to include fittings for supplying air to both the air intake and combustion chamber-vent sections of the system and provisions for measuring the internal pressure in each section of the system.

67.3 The internal pressure in the system is to be measured by a water-filled manometer which may be read directly to 0.01 inch (0.25 mm) water column or equivalent means.

67.4 Clean air is to be permitted to flow through a metering device and into the section of the direct vent system being pressurized through the air supply fitting. The air supply fitting to the section of the system not being pressurized is to be open. The internal air pressure in the section of the system being pressurized is to be adjusted to:

a) 0.1 inch water column (25 Pa) above the normal operating system pressure for forced draft systems operating at positive combustion chamber pressures; and

b) 0.1 inch water column for all other systems.

The leakage rate is to be noted in cubic feet per hour for both the air intake and combustion chamber-vent sections of the direct vent system.

67.5 The leakage rate is to be determined by the following equations:

$$L_c = 0.04 \times V \times I$$

$$L_a = 0.08 \times V \times I$$

Where:

L_c = Allowable leakage rate from combustion chamber-vent section of direct vent system, cubic feet per hour.

L_a = Allowable leakage rate from air intake section of direct vent system, cubic feet per hour.

V = 15 cubic feet of flue products based on the formation of approximately 10 cubic feet of dry flue products plus 5 cubic feet of excess air, when 1000 Btu of fuel gas is burned.

I = Gas input rating, in thousands of Btu per hour.

67.6 In a direct vent system of an appliance having all or part of the vent portion of the combustion chamber-vent section enclosed within the air intake section:

a) The leakage from the combustion chamber-vent section of the system shall not exceed 4.0 percent of the products of combustion, as calculated in 67.5, and

b) The leakage from the total system shall not exceed 8.0 percent of the products of combustion plus the leakage, in percent, determined for the combustion chamber-vent section.

See 67.7 – 67.10.

67.7 A direct vent system in an appliance having all or part of the vent portion of the combustion chamber-vent section enclosed within the air intake section, the combustion chamber-vent section of the system shall be considered that portion of the combustion chamber-vent section not contained within the air intake section.

67.8 The vent/air intake terminal is to be removed, and the entrance of the air intake section sealed at the point it enters the combustion chamber. The entire system, including the combustion air and flue gas connections between the appliance and the vent/air intake terminal, is to be installed and sealed in accordance with the manufacturer's instructions. Any vent extension located within the air intake section need not be installed. The direct vent system is then to be sealed at the point of connection to the vent/air intake terminal. The sealing means is to include fittings for supplying air simultaneously to the air intake and combustion chamber-vent sections of the system and provisions for measuring the internal pressure.

67.9 Using the test apparatus and method of test outlined in 67.3 and 67.4, the total system is to be pressurized and the leakage rate noted in cubic feet per hour.

67.10 The combustion chamber-vent section of the system is then to be sealed, with the appropriate fittings noted above, at the first joint of the vent portion of the combustion chamber-vent section contained within the air intake section downstream of the combustion chamber. Using the test apparatus and method of test outlined in 67.3 and 67.4, the combustion chamber-vent section is to be pressurized and the leakage rate noted in cubic feet per hour.

68 Field Wiring Strain Relief Test

68.1 Each field wiring lead shall withstand a pull of 10 pounds-force (44.5 N) for 1 minute without loosening the connections at the terminal, causing damage to the lead from sharp edges or otherwise damaging the assembly.

69 Short-Circuit Test

69.1 Test no. 1

69.1.1 Inherent overheating-protective devices, bonding conductors or connections when required, and conductors of multiple motor circuits shall withstand short-circuiting when protected by a fuse of the size required by the appliance when samples are subjected to the conditions of this test.

a) Bonding conductors and bonding connections shall not open.

b) Motor-circuit conductors shall not become damaged.

c) There shall be no ignition of cheesecloth surrounding the enclosure of a protective device when three samples are tested.

69.1.2 The device is to be connected in a circuit having a capacity based on the full-load current and voltage rating of the appliance. See Table 69.1. The appliance full-load current is to be determined by adding the motor full-load current to that of each other motor, as determined in compliance with the National Electrical Code, ANSI/NFPA 70-1993, for the marked horsepower rating of the motor, and the current rating of each other load. Each simultaneous load condition is to be considered separately, and the maximum resulting current employed as the basis of selection of the capacity of the test circuit. The voltage source for the test circuit is to be an alternating-current supply and the circuit capacity is to be measured without the device in the circuit. See 69.2.1.

Table 69.1
Short-circuit test currents

Full-load amperes				
Single phase				Circuit capacity, amperes
115 volts	208 volts	230 – 240 volts	277 volts	
9.8 or less	5.4 or less	4.9 or less	–	200
9.9 – 16.0	5.5 – 8.8	5.0 – 8.0	6.65 or less	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
0 to 250 volts dc – 0 to 648 VA				200

69.2 Test no. 2

69.2.1 Except as specified in 69.2.4 – 69.2.6, an overcurrent protective or a thermal protective device on an appliance having more than one motor wired for connection to one supply line shall withstand short-circuiting without creating a risk of fire or electric shock when protected by a fuse rated at 400 percent of the full-load current of the largest motor of the group plus an amount equal to the sum of any additional loads supplied. There shall be no ignition of cheesecloth surrounding the enclosure of the protective device when samples are subjected to a short-circuit test.

69.2.2 A nonrenewable cartridge fuse is to be connected in series with the device. A new fuse and device, connection, or conductor are to be used for each test. The nearest standard size fuse, rated not higher than the current specified in 69.2.1, but not less than 15 amperes, is to be employed for the test. The maximum fuse size marked on the appliance shall not exceed this value.

69.2.3 With reference to 69.2.2, the protective device may be tested with a fuse having a lower rating than specified, provided the appliance will start and operate without opening the fuse and is marked to specify such a maximum limit of fuse protection.

69.2.4 If a thermally protected motor or a separately enclosed overcurrent protective device is located within an outer cabinet, and if the assembly is constructed so that it can be determined that flame and molten metal will be confined within the cabinet, and any combustible material except electrical insulation or an air filter is not located below the motor and will not sustain combustion upon removal of the ignition source, the Short-Circuit Test for risk of fire specified in 69.2.1 may be waived. However, if short circuiting between live parts of different circuits may result, the Short Circuit Test is not to be waived.

69.2.5 Short-circuit tests are not required for an assembly with more than one motor, if the rating of each motor does not exceed 1 horsepower (746 W output), and the assembly is intended to be used on a branch circuit protected at not more than 20 amperes at 125 volts or less or 15 amperes at 126 – 600 volts, provided the following conditions are met:

a) The marked maximum branch circuit protective device size does not exceed these; and

b) The full-load current rating of each motor does not exceed 6 amperes.

69.2.6 Short-circuit tests are not required for an assembly with more than one motor if the motor or motors have full-load current or horsepower rating or ratings in excess of those specified in 69.2.5, provided:

a) The marked maximum branch circuit protective device size of the assembly does not exceed the maximum size for protecting the motor of the smallest rating; and

b) It is determined that a fuse of marked size will not open under the most severe conditions of service which might be encountered.

69.3 Motor circuits

69.3.1 Conductors of motor circuits having two or more motors, one or more of which is thermal or overcurrent protected, and wired for connection to one supply line, shall withstand the conditions of a short-circuit test without creating a risk of fire or electric shock.

Exception: Conductors that conform to the following are considered acceptable without test.

a) The conductors have an ampacity of not less than one-third the ampacity of the required branch-circuit conductors (ampacities are determined from the ampacity tables in the National Electrical Code, ANSI/NFPA 70-1993, for the type of wire or cord employed, or for the wire or cord equivalent to appliance wiring material);

b) The conductors are 18 AWG (0.82 mm^2) or larger and not more than 4 feet (1.2 m) in length and the circuit will be protected by a fuse or HACR type circuit breaker that is rated 60 amperes or less as specified on the unit nameplate or provided as part of the unit and that is acceptable for branch circuit protection. This condition applies to any of the wiring materials specified in this standard, including those enclosed in raceways;

c) The conductor is a jumper lead between controls and is not longer than 3 inches (76 mm) unless the conductor is located in a control panel; or

d) The conductor is connected between two fixed impedances that reduce the risk of a high fault current within the conductor (examples of two such impedances are a motor running capacitor and a start winding of a permanent-split-capacitor motor).

69.3.1 revised February 2, 2009

70 Dielectric Voltage-Withstand Test

70.1 An appliance shall withstand for 1 minute without breakdown, the application of 60 hertz alternating potential between high-voltage live parts and dead metal parts, and between live parts of high- and low-voltage circuits. The test potential shall be:

a) One thousand volts plus twice rated voltage except as specified in (b).

b) One thousand volts for motors rated at not more than 1/2 horsepower (373 W-output) and not more than 250 volts.

70.2 If higher than rated voltage is developed in a motor circuit through the use of capacitors, the rated voltage of the appliance is to be employed in determining the dielectric voltage-withstand test potential; unless the developed steady-state capacitor voltage exceeds 500 volts, in which case the test potential for the parts affected is to be 1000 volts plus twice the developed voltage.

70.3 A low-voltage circuit shall be capable of withstanding, for 1 minute without breakdown, a 60 hertz alternating potential of 500 volts applied between low-voltage live parts of opposite polarity and between low-voltage live parts and dead metal parts.

70.4 The dielectric voltage-withstand test between low-voltage parts of opposite polarity may be waived on the complete assembly provided the components have been separately subjected to this test condition and the wiring is with material mentioned in Table 36.1.

70.5 A 500-volt-ampere or larger transformer, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with 70.1. The applied potential is to be increased gradually from zero until the required test value is reached and is to be held at that value for 1 minute. The requirement of a 500-volt-ampere or larger transformer can be waived if the high potential testing equipment used is such that it maintains the specified high potential voltage at the equipment for the duration of the test.

WARM AIR APPLIANCE TESTS

71 Limit-Control Cutout Test

71.1 The limit control shall act to shut off the fuel to the main burner or burners before outlet air of a warm-air heating appliance reaches a temperature in excess of 200°F (93°C). If the appliance casing forms the outlet air plenum the outlet air temperature of each warm air outlet shall not exceed 250°F (121°F).

71.2 The limit control is to be adjusted to the maximum setting allowed by its fixed stop and to the maximum indicated differential setting. A thermocouple is to be attached to a warm-air appliance limit-control sensing element at its midpoint with the thermocouple leads arranged so that the calibration of the control is not impaired. The appliance is to be fired until steady-state conditions are attained.

71.3 Each warm-air outlet of a central furnace is to be restricted symmetrically to raise the outlet-air temperature to a value not more than 10 degrees below the temperature that will cause the limit control to function. The static pressure in the supply duct is not to be more than the appropriate value indicated in Table 71.1.

Table 71.1
Relation of appliance input to external static pressure[a]

Input to appliance, btu per hour, Column I	External static pressure,[b] inches (mm) water column			
	Temperature of outlet air determined by function of limit control			
	Above 165°F, Column II		165°F or less, Column III	
55,000 (16,000) and under	0.10	(2.5)	0.20	(5.1)
Over 55,000 to 80,000 (16,000 to 23,400)	0.12	(3.1)	0.24	(6.0)
Over 80,000 to 100,000 (23,400 to 29,300)	0.15	(3.8)	0.30	(7.6)

[a] An appliance may be tested at an external static pressure in excess of those specified as recommended by the manufacturer.

71.4 A preliminary test is to be made to determine the degree of blocking the cold-air inlet, warm-air outlet, or both required to produce the air temperature that will cause the limit control to function. The blocking is then to be relieved sufficiently to permit continuous operation of the appliance; and the appliance is operated until a substantial equilibrium outlet-air temperature is obtained. If the appliance is equipped with a single cold-air inlet grille, not intended to be connected to a return-air duct system, the total area of the grille is to be blocked with layers of cloth attached progressively to a frame such as described in 74.6.

71.5 The degree of blocking is then to be gradually increased over a period of 10 minutes until the limit control acts to shut off the main burner. The outlet-air temperature (T_L), at the instant the limit control functions, is to be measured. The temperature (T_{L1}) of the limit-control sensing element is to be measured over the period beginning with the instant the limit control functions and ending when the sensing element temperature recedes from the maximum it attained. The outlet-air temperature thus obtained shall not exceed the values specified in 71.3. Also, after the limit control functions, its sensing element shall not attain a temperature that will adversely affect the limit-control calibration.

71.6 The circulating air flow of a wall furnace is to be gradually restricted (the fuel input may be increased also) until the limit control functions, and at this instant the temperature of the outlet air is to be measured. The limit-control sensing element temperature (T_{L1}) is to be determined also, as described in 71.4. The outlet-air temperature of a wall furnace, measured as described in 50.7.2 – 50.7.8, shall not exceed the value specified in 71.1. Also, after the limit control functions, its sensing element shall not attain a temperature that will adversely affect the limit-control calibration.

72 Continuity of Operation Test

72.1 A warm-air heating appliance equipped with a limit control, when fired at rated input, shall operate continuously without the limit control functioning to cause reduction in the input when the appliance is tested as described 72.2 – 72.6. The firing of the appliance shall not be interrupted by any control device included as part of the appliance.

72.2 An automatic temperature regulating control is to be bypassed to permit continued operation during this test. The appliance is to be placed in operation. A variable-speed air-circulating fan is to be adjusted so that approximately rated air delivery is obtained.

72.3 Each warm-air duct outlet of a forced-air appliance to be so equipped is to be restricted symmetrically to maintain an external static pressure in the supply plenum of the appropriate value indicated in Table 58.2. An adjustable register shutter is to be set in the position allowing maximum air flow.

72.4 If an appliance is intended for installation with an optional number of warm-air outlets, all except the minimum number of outlets to be always employed are to be closed. An adjustable outlet-air register shutter is to be set in the position allowing maximum air flow.

72.5 Operation of the appliance is to be continued until equilibrium outlet-air temperature is obtained. The outlet-air temperature (T_2) and the limit-control sensing element temperature (T_{L2}) are to be measured. Also, the electric-current input to the appliance and the static pressure at the appliance static pressure connection (see 5.7) are to be measured and recorded. The inlet-air temperature (T_1) is to be measured by a thermocouple located in the center of the air inlet opening and shielded from direct radiation from hot surfaces of the appliance.

72.6 The performance of a central furnace shall be such that:

$$T_2 \text{ minus } T_1 \text{ is not more than } T_L \text{ minus } 70°F\ (21.1°C).$$

The performance of a wall furnace shall be such that:

$$T_{L2} \text{ is not more than } T_{L1} \text{ plus } T_1 \text{ minus } 70°F\ (21.1°C)$$

Where:

T_1 = Inlet-air temperature.

T_2 = Outlet-air temperature.

T_L = Outlet-air temperature at which limit control functioned in Limit-Control Cutout Test, Section 71.

T_{L1} = Limit-control sensing-element temperature at which limit control functioned in Limit-Control Cutout Test, Section 71.

T_{L2} = Limit-control sensing-element temperature in this test.

70°F (21.1°C) = Assumed maximum inlet-air temperature demanding continuous firing of central furnace or wall furnace at high-fire input.

73 Continuous Operation Temperature Test

73.1 The limit control is to be bypassed to permit continued operation during this test. The appliance is to be fired at rated input.

73.2 The outlet-air temperature of a central furnace is to be:

a) 88°F (48.9°C) above inlet-air temperature for a central furnace equipped with a limit control that does not permit an outlet-air temperature in excess of 165°F (73.9°C).

b) 123°F (68.4°C) above inlet-air temperature for a central furnace equipped with a limit control that permits an outlet-air temperature in excess of 165°F but not more than 200°F (93.3°C).

73.3 The outlet-air temperature of a central furnace is to be established by gradually restricting the circulating air flow until the outlet-air temperature reaches the value specified in 73.2, ±5°F (2.8°C). The static pressure in the supply plenum of a forced-air appliance is to be not more than twice the appropriate value indicated in Table 58.2. Any restriction of a return-air inlet grille, not intended to be connected to a return-air duct system, is to be accomplished by layers of cheesecloth applied progressively. The cloth is to be attached to a frame such as described in 74.6.

73.4 Warm-air outlet registers forming a part of, or in close proximity to, an appliance casing are not to be restricted, except that an adjustable register shutter is to be set in the position producing maximum temperatures during this test. If an appliance is intended to be installed with an optional number of warm-air outlets, all except the minimum number of outlets to be always employed are to be closed. If a fan-type heater is equipped with a variable-speed fan, the fan speed is to be adjusted to the minimum recommended in the instructions furnished by the manufacturer with the appliance.

74 Blocked Register Temperature Test

74.1 To comply with 65.1, the cheesecloth shall not ignite or char during the tests. Furthermore, the temperature rises above room temperature shall not exceed the values specified in Column 2 of Table 65.1, during the period terminating 1 hour after the first shutoff effected by the limit control; or, if the limit control does not function, during the period terminating 1 hour after the coverage is applied. Thereafter, the temperature rises shall not exceed the values specified in Column 1 of Table 65.1, except that a motor may attain a temperature not in excess of 208°F (115°C) above room temperature during any part of these tests.

74.2 This test is to be conducted on central heating appliances provided with a warm-air or cold-air register or a combination warm- and return-air register or air opening forming a part of or in close proximity to the appliance casing and intended for alcove or closet installation, and on wall furnaces.

74.3 The bypass is to be removed from any limit control, and the limit control and any fan control are to be adjusted to the maximum allowable temperature setting and minimum differential. An adjustable register shutter is to be set at any allowable setting producing maximum temperatures. Any auxiliary warm-air outlet ducts are to be closed.

74.4 A central furnace and a wall furnace are to be fired at a fuel input not more than that required to maintain the limit-control sensing element at a temperature equivalent to 70°F (21.1°C) plus T_{L2} minus T_1, where T_1 and T_{L2} are the values obtained during the Continuity of Operation Test, Section 72.

74.5 When equilibrium temperatures have been attained, each main grille or register is to be covered progressively, using the frame described in 74.6, to the extent of 25, 50, 75, and 100 percent of its area, starting from any edge of the grille or register.

74.6 The frame is to consist of three layers of cheesecloth, of weight 16 – 17 square yards per pound (29.5 – 31.3 M^2/kg), count 28 by 24, stretched taut over a wood frame of a size and shape larger than the external dimensions of the grille or register. The frame is to be made of 1- by 2-inch trade size (3/4 by 1-1/2 inch) lumber. The cheesecloth is to be attached to one face of the frame. The frame is to be placed so that the cheesecloth is in direct contact with the outer surface of the grille or register. The frame is to remain in place for each trial until equilibrium temperatures are attained or failure becomes evident.

74.7 A manually regulated appliance is to be fired at any fuel-input rate between off or pilot-fire rate and high-fire input permitted by allowable adjustments of the metering device until equilibrium temperatures are attained. Each grille or register then is to be progressively covered as described in 74.5.

74.8 The tests described in 74.5 and 74.6 are to be repeated with one or more auxiliary grilles open.

75 Blocked Outlet Temperature Test

75.1 An appliance intended to be provided with warm-air outlet ducts is to be tested as described in 75.2 – 75.5.

a) If the appliance is of a type equipped with an automatic-reset limit control only the temperature rises above room temperature shall not exceed the values specified in Column 1 of Table 65.1.

b) If the appliance is of type equipped with an auxiliary manual-reset limit control, and the control functions during this test, the temperature rises above room temperature during the test shall not exceed the values specified in Column 2 of Table 65.1.

Exception No. 1: During the period terminating 1 hour after the first shutoff effected by the limit control, the temperature rises shall not exceed the values specified in Column 2 of Table 65.1.

Exception No. 2: A motor may attain a temperature not in excess of 208°F (115°C) above room temperature during any part of this test. See 65.1.

75.2 The bypass is to be removed from the limit control; and the limit control and the fan control are to be adjusted to the maximum temperature setting and minimum differential.

75.3 The appliance is to be fired and the flow of circulating air regulated to maintain an outlet-air temperature, sufficiently below that required to operate the limit control, to allow continuous operation of the appliance, maintaining a static pressure in a supply plenum not more than the appropriate value indicated in Table 58.2. After steady-state, air-temperature conditions are attained, the following test is to be conducted.

75.4 The warm-air outlets of the ducts are to be uniformly restricted to close 80 percent of the cross-sectional area of the duct and the appliance allowed to be cycled by the limit control if of the automatic-reset type, or otherwise to function as it will. If the appliance is of the downflow type equipped with an auxiliary manual-reset limit control, the test is to be continued until maximum temperatures are attained.

76 Blocked Inlet Temperature Test

76.1 An appliance provided with a return-air inlet intended to be connected to ducts is to be tested as described in 76.2 and 76.3. During this test, the temperature rises above room temperature shall not exceed the values specified in Column 2 of Table 65.1, during the period terminating 1 hour after the first shutoff effected by the limit control. Thereafter, the temperature rises shall not exceed the values specified in Column 1 of Table 65.1, except that a motor may attain a temperature not in excess of 208°F (115°C) above room temperature during any part of this test. See 65.1.

76.2 The appliance is to be operated under the conditions described in 75.2 and 75.3 to begin this test.

76.3 The appliance inlet-air opening or filter is to be gradually and uniformly restricted until the limit control functions. Then the appliance is to be allowed to operate until equilibrium temperatures have been attained.

77 Fan Failure Temperature Test

77.1 If the appliance is of a type equipped with an automatic-reset limit control only, the temperature rises above room temperature shall not exceed the values specified in Column 2 of Table 65.1, during the period terminating 1 hour after the first shutoff effected by the limit control. Thereafter, the temperature rises shall not exceed the values specified in Column 1 of Table 65.1, except that a motor may attain a temperature not in excess of 208°F (115°C) above room temperature during any part of this test. See 65.1.

77.2 If the appliance is of a type equipped with an auxiliary manual-reset limit control, and the control functions during this test, the temperature rises above room temperature during the test shall not exceed the values specified in Column 2 of Table 65.1.

77.3 A fan-type, warm-air appliance is to be operating under the conditions described in 74.2 and 74.3 to begin this test.

77.4 The circulating-air fan drive is to be disengaged unless the fan is directly attached to the driving-motor shaft, in which case the fan motor only is to be disconnected from the electrical circuit. The appliance is then allowed to be cycled by the limit control if of the automatic-reset type. If the appliance is of the downflow type equipped with an auxiliary manual-reset limit control, the test is to be continued until maximum temperatures are attained.

78 Stalled Fan Motor Temperature Test

78.1 This test is to be conducted on a fan-type appliance only if the impedance of the circulating-air fan motor provides the overcurrent protection for that motor. Only the fan-motor temperatures need be recorded. The maximum temperature rise above room temperature attained by the motor during the test shall be not more than 225°F (125°C).

78.2 The appliance is to be operated under the conditions described in 75.2 and 75.3.

78.3 The rotor of the fan motor is to be locked while the appliance is temporarily de-energized. The appliance is to be immediately re-energized and allowed to remain energized until the fan-motor temperature reaches a maximum. Any manually reset control that functions is not to be reset during this test.

79 Heating Element Endurance Test

79.1 A heating element of a central furnace shall have no openings or cracks after being subjected to 10,000 main burner operation cycles. See 79.3 – 79.8.

79.2 A power burner blower, combustion air blower and induced draft device, when used, is to be operated continuously during this test.

79.3 For the purpose of this test, a downflow furnace may be equipped with a blower shaft extending through the side of the furnace and connected to a suitable motor.

79.4 A furnace that uses a single motor to drive a combustion air blower and the circulating air blower is to be modified with separate combustion air and circulating air blower motors so that each may be independently controlled. The speed of each of the motors is to be controlled by loading the blower or by voltage variation to simulate actual operating conditions.

79.5 Heating element cycling rate is to be determined as follows:

a) Cycling rate determinations are to be made with a return air temperature of 75 ±5°F (24 ±3°C).

b) An outlet duct and return air duct, as specified in, General, Section 51, is to be installed on the furnace. A horizontal furnace is to be equipped with a return air duct oriented to avoid reverse air flow.

c) The furnace is to be equipped with the maximum length vent/air intake system.

d) The external static pressure is to be adjusted in accordance with Table 58.2 with the outlet air temperature adjusted to the maximum outlet air temperature permitted in 73.2. The balance between external static pressure and outlet air temperature is to be maintained by:

1) Adjusting the circulating air blower speed. Blower speed changes are to be restricted to motor speed taps or pulley adjustments; and

2) Adjusting the restriction on either the outlet duct or the inlet duct or both.

e) The maximum heating element temperature is to be determined.

f) For a furnace constructed to delay start of the circulating air blower, each cycle is to consist of a period with the burner operating and the circulating air blower off followed by a period with the burner off and the circulating air blower operating. The times for these two periods of each cycle are to be determined as follows:

1) Adjust the fan control to its maximum setting and with the heat exchanger at equilibrium temperature after a continuous pilot has been in operation for at least 15 minutes, ignite the main burner or burners. On a furnace not equipped with a continuous pilot, the heat exchanger is to be at room temperature when the main burner or burners are ignited. Determine the heating element temperature just prior to start of the circulating air blower.

2) The heating element temperature for the purpose of the cyclic test is the maximum temperature determined from (e) and (f)(1).

3) Install an on-off switch in the circulating air blower circuit and deactivate the fan control.

4) Operate the furnace with main burner gas on and the circulating blower off until the heating element temperature at any location reaches the value determined in (2). Immediately turn on the circulating air blower, shut off the main burner gas, and allow the blower to operate until the temperature at this location reaches 200°F (93.5°C). The circulating air blower is then to be shut off, the main burner gas turned on, and the furnace cycled in the manner outlined above until both a repeatable burner on/blower off time and burner off/blower on time are established. These times are to be recorded.

g) For a furnace constructed to start the circulating air blower simultaneously with main burner operation, each cycle consists of a period with the burner operating followed by a period with the burner off, both with the circulating air blower operating. The times of these two periods of each cycle are to be determined as follows:

1) The heating element temperature for the purpose of the cyclic test is the maximum temperature determined from (e).

2) Operate the furnace with the main burner on at full input and the circulating air restricted such that the maximum heating element temperature determined in (1) can be obtained in 4 to 5 minutes starting with this temperature location at 200°F (97°C). Immediately shut off the main burner until the temperature at this location again reaches 200°F (97°C) with continuous operation of the circulating air blower. The main burner is to be turned on and the furnace cycled in the manner outlined above until both a repeatable burner on time and burner off time are established. These times are to be recorded.

79.6 For the endurance test, a second furnace (not thermocoupled) shall be set up as described in 79.5 (a) – (e). The fan and limit controls shall then be bypassed. The automatic ignition system shall be operative. The furnace shall then be cycled 10,000 times, each cycle consisting of the two periods established in 79.5 (f)(4) or (g)(2), as applicable.

79.7 After completion of the 10,000 cycles, the furnace is to be operated with the blower on and the burner ignited and examined for normal flame pattern and stability. The furnace is to be readjusted and operated as described in 60.2, the furnace shall not produce carbon monoxide in excess of 0.04 percent in an air-free sample of flue gases when tested at normal input rating after 15 minutes of operation in a room having a normal oxygen supply.

79.8 The heat exchanger shall be removed and carefully examined. There shall be no openings or cracks through the heating element visible to the naked eye.

80 Horizontal Central Furnace Air Flow Test

80.1 During intended operation of a horizontal central furnace from a cold start, either the limit control or the fan control shall operate to prevent air temperatures in excess of those specified in 80.2 under conditions of reverse air flow through the appliance.

80.2 The maximum temperature indicated by any of the three thermocouples at the return-air opening of the appliance shall not exceed 90°F (50°C) above room temperature prior to or during the first or subsequent cycle of operation effected by the limit control or prior to the functioning of the fan control to circulate air in the intended direction.

80.3 A rectangular duct, the same size as the inlet-air opening of the appliance, is to be attached to the return-air inlet of the appliance and extended vertically by a 90-degree elbow to a distance of 6 feet (1.8 m) above the top of the return-air opening of the appliance. The appliance is to be arranged to operate against the appropriate external static pressure value indicated in Table 58.2. The limit control and fan switch, if adjustable, are to be adjusted to the maximum temperature setting and minimum differential.

80.4 Air temperature is to be measured by three individual bead-type 24 AWG (0.21 mm^2) thermocouples located in a plane of the return-air (inlet-air) connection of the appliance on a horizontal line one-third of the distance below the top of the return-air opening of the appliance. One thermocouple is to be located 1 inch (25.4 mm) from one side of the opening, one at the center, and the other 1 inch (25.4 mm) from the opposite side of the opening.

80.4 revised February 2, 2009

80.5 The appliance is to be adjusted for firing at rated input, and if a pilot is used, it is to be adjusted for minimum normal input. Starting with the appliance at room temperature, the pilot, if used, is to be lighted and allowed to burn for 15 minutes. The appliance is then to be fired and allowed to operate until the blower becomes operative or the limit control functions to shut off the main-burner flame.

81 Condensate Test

81.1 A furnace for installation downstream from a cooling unit which supplies air at temperatures below the dew point of the ambient air shall be constructed such that condensate from within the heating elements will not fall on any portion of the burners, pilots, or burner carry-over arms which will permit its entry to the inside of the burners, pilots, or burner carry-over arms.

81.2 Without the burners in operation, the blower is to be operated to circulate air through the furnace. Steam is to then be directed into the heating element or elements through each vent outlet for a sufficient length of time to determine the pattern of condensate flow within the heating element or elements. Care is to be used in selecting the velocity of steam flow and in directing it so as to avoid an unnatural flow of condensate within the heating elements.

82 Surface Temperature Test

82.1 When tested as described in 82.2 and 82.3, the temperature shall not exceed the values specified in 82.1, the resultant temperature recorded shall not exceed 140°F (60°C) above room temperature for fan type appliances, and not exceed 210°F (99°C) for gravity type appliances.

82.2 A wall furnace shall be installed as described in 54.1 and 54.2. The wall furnace is then to be operated under the conditions described in 82.3.

82.3 A grid pattern consisting of four vertical and four horizontal lines which divide the vertical front surface of the appliance into 25 equal squares is to be laid out on the appliance front. Sixteen bead type thermocouples are to be attached to the metal casing surface at the intersecting points of the four vertical and four horizontal lines. The appliance is to be operated at normal inlet test pressure and at normal voltage with any filters removed, until the temperatures of the vertical front surface have reached equilibrium. The eight thermocouples indicating the highest temperature are to be connected in parallel. The temperatures shall not exceed the values specified in 86.1.

83 Ignition of Flammable Fabric and Related Hazards Test

83.1 No ignition of the test fabric described in 83.2 shall occur during this test.

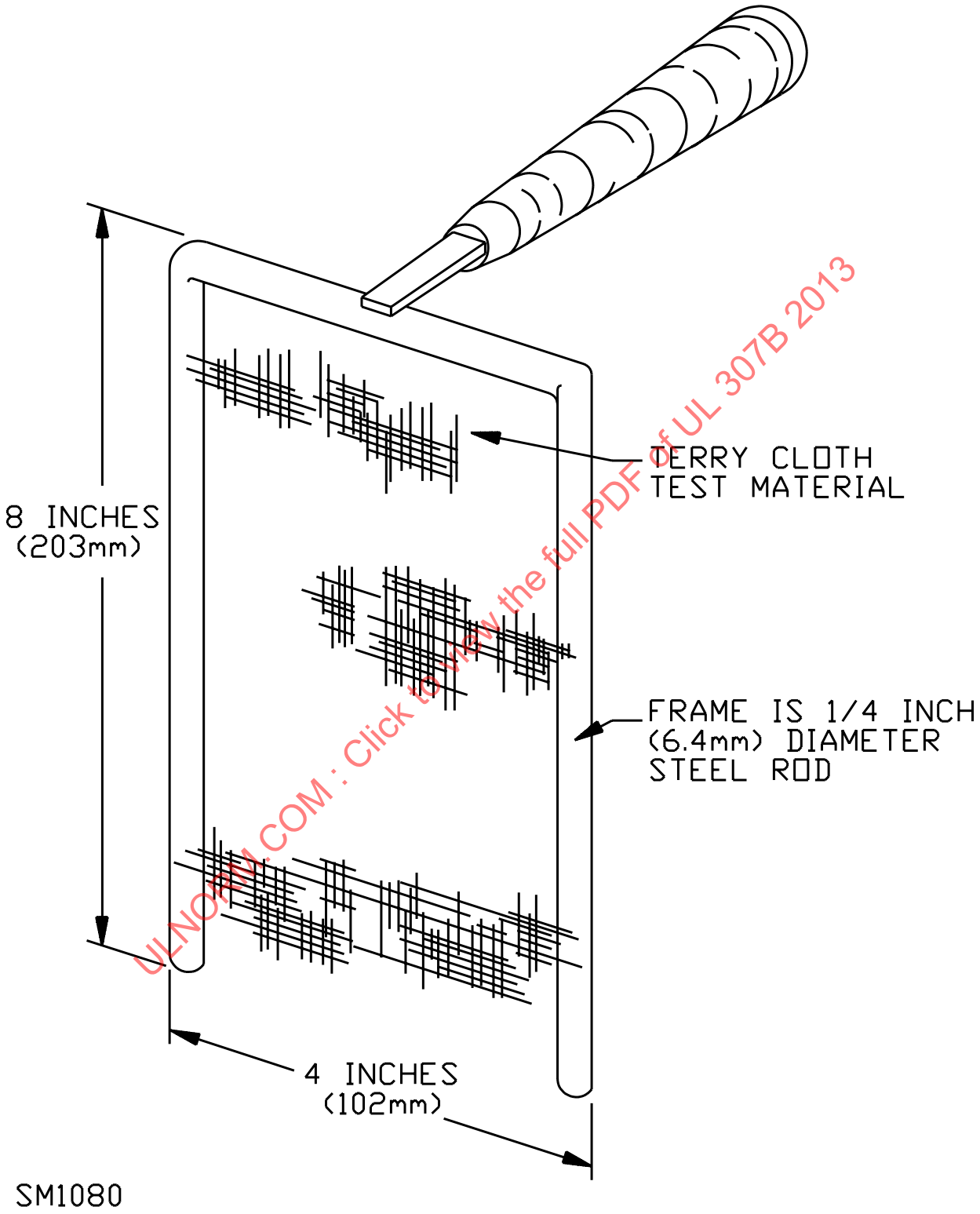
83.2 The test fabric mentioned in 83.1 is to consist of white, 100 percent cotton terry cloth material with a pile weave on both sides, nominal 8 ounces per square yard (0.27 kg/m^2).

83.3 Test samples are to be preconditioned at 30 percent relative humidity or less, at 75°F (23.9°C) for at least 24 hours before conducting this test.

83.4 Each test is to be conducted at normal test pressure on a test gas for which the maximum input for the unit has been specified.

83.5 The wall furnace unit is to be operated as described in 82.2. When temperatures reach an equilibrium, a sample of the test material, 16 by 4 inches (406 by 102 mm) is to be folded to cover a three sided U-shaped frame, 8 by 4 inches (203 by 102 mm). Refer to Figure 83.1. The folded edge is to be at the 4 inch (102 mm) wide open end of the frame. With the handle of the test frame maintained in a horizontal position at all times, the test frame is to be placed in contact with any surface or guard of the wall furnace unit for a period of 30 seconds. There shall be no flaming of the test material.

Figure 83.1
Test frame/fabric assembly



BOILER TESTS

84 Limit Control Cutout Test

84.1 When tested as described in 84.2 the temperature of the water in a water boiler shall not exceed 250°F (121°C). The pressure in a steam boiler shall not exceed 15 psig (103.5 kPa).

84.2 The outlet of a boiler is to be restricted to raise the temperature or pressure until the limit control functions. For this test, a thermostat or other operating control is to be bypassed.

85 Low Water Level Control Cutout Test

85.1 The operation of the liquid level limit control provided with a low pressure steam boiler shall operate to open the burner circuit and cause a safety shutdown before the water level falls below the lowest permissible level.

85.2 The steam boiler is to be operated at the maximum setting allowed by the operating control until equilibrium conditions are established. Water is to be slowly drained from the boiler until the liquid level limit control functions. The water level at which the control functioned is to be recorded and shall not be less than the boiler manufacturer's lowest permissible level.

86 Continuous Operation Temperature Test

86.1 During the test described in 86.2 – 86.4 the temperature rise above room temperature for any item shall not exceed the value indicated for such item in Column 1 of Table 65.1.

86.2 For boilers designed for hot-water use only, the feed-water inlet is to be throttled during the test until the water temperature at the outlet of the boiler has reached the value determined in accordance with 50.8.1, but not less than 200°F (93.3°C). The feed water is then to be supplied at such a rate as to maintain the temperature at the boiler outlet within ±5°F (2.8°C) of the specified value. A steam boiler is to be maintained at a pressure not less than 14 psig (96.6 kPa), and the feed water is to be supplied to maintain a relatively constant water level in the gauge glass. If the temperature of the boiler assembly components or the test enclosure would be affected during the test by the feed-water temperature, the temperature of feed water measured at the inlet to the boiler is to be maintained 20°F (11.1°C) below the outlet-water temperature for hot-water boilers and not less than 180°F (82.2°C) for steam boilers. Boilers for either hot water or steam operation are to be tested as steam boilers.

86.3 Firing of the appliance is to be continued until equilibrium temperatures are attained as evidenced by no changes in temperature rises for three consecutive readings taken at 15 minute intervals apart at observed maximum temperature points.

86.4 If the boiler is equipped with a burner operating on pilot or low fire during standby periods, the following additional test is to be conducted. The limit control is to be operative and adjusted to the specified setting and the minimum differential. See 50.8.1. The pilot or low-fire valve is to be adjusted to its maximum allowable setting. The boiler is to be fired at rated high-fire input and draft. The water inlet and the outlet of the boiler are to be gradually closed. CAUTION – A relief valve shall be used during this test. The burner is to be allowed to fire as it will until equilibrium or continuously receding temperatures are attained.

WATER HEATER TESTS

87 Water Temperature Control Test

87.1 When tested as described in 87.2 – 87.4, the maximum outlet water temperature of a storage-type water heater shall not exceed 194 or 200°F (90 or 93.3°C) as indicated in 32.6.2 at any time during the test.

87.2 An adjustable temperature-regulating control is to be adjusted to the maximum setting allowed by the fixed stop. A thermocouple or thermometer is to be installed 3 inches (76.2 mm) below the top of the storage vessel for measuring the temperature of the stored water. A pressure-relief device followed by a quick-acting valve is to be installed on the outlet connection of the storage vessel. A flow restriction, calibrated to permit a flow rate of 5 gallons per minute (18.9 L/minute), is to be connected to the outlet of the valve. A water-pressure regulator is to be located in the water supply line to the heater and adjusted so that at full flow the pressure at the inlet connection to the heater will be maintained at the valve required to deliver a steady flow rate of 5 gallons per minute (18.9 L/minute) during test draw periods.

87.3 The heater is to be filled with water at a temperature of 65 ±5°F (18.3 ±2.8°C). During the test, the inlet water temperature is to be maintained at 65 ±5°F (18.3 ±2.8°C). The heater is to be fired at rated high-fire input with the inlet water valve opened and the outlet water valve closed, until the temperature control functions to reduce the fuel supply to the burner to a minimum. Water is to be then drawn immediately at the rate of 5 gallons per minute (18.9 L/minute) until the control functions to turn on the fuel supply to the burner, and the maximum outlet water temperature is recorded. This operation is to be repeated until a constant or continually receding outlet water temperature is attained.

87.4 The heater, if equipped with a continuous pilot burner that operates when the thermostat reduces the fire, is to be allowed to continue operation following the test described in 87.2 and 87.3, but with the inlet-water valve shut off and the outlet-water valve open, until equilibrium or continually receding water temperatures are obtained. The temperature of the water at the top of the heater is to be more than 100°F (55.6°C) above room temperature.

88 Thermostat Control Test

88.1 Dials of thermostats provided with temperature markings shall be accurately calibrated in accordance with 88.2 and 88.3.

88.2 A thermocouple or thermometer is to be installed in the hot water outlet pipe of the water heater 1 inch (25.4 mm) from the outlet. The system is to be filled with water at 70 ±2°F (21 ±1°C). The thermostat is to be set at 140°F (60°C) setting, and the appliance operated at normal inlet test pressure until the gas supply is reduced to minimum or, in the case of a snap-acting thermostat, until the main gas supply is shut off. The water temperature at the outlet connection is to be observed, and if this temperature is not 140 ±5°F (60 ±2.8°C), adjustment is to be made and the above procedure repeated until a water temperature within the limits specified is obtained.

88.3 The temperature of the water is then to be decreased to 70 ±2°F (21 ±1°C), and the thermostat dial set at the lowest numbered position on the dial. The gas shall again be ignited and the outlet temperature at which the main gas supply is reduced to a minimum, or is shut off, observed. The outlet water temperature shall be within ±10°F (±5.5°C), of the temperature indicated by the dial setting. This procedure shall be repeated with the thermostat set to the maximum position at which it can be set by the user. At this setting, the outlet water temperature shall be within ±10°F of the temperature specified by the appliance manufacturer for that setting.

89 Limit-Control Cutout Test

89.1 When tested as described in 89.2, the water temperature measured in accordance with 50.9.1 shall not exceed 210°F (98.9°C) but shall be greater than that obtained in the Water Temperature Control Test, Section 87.

89.2 With the heater installed as in Sections 58 and 59, the temperature-regulating control is to be bypassed. The heater is to be fired at rated high-fire input with the inlet water valve opened and the outlet water valve closed, until the limit control functions.

90 Continuous Operation Temperature Test

90.1 During this test, the temperature rise above room temperature for any item shall not exceed the value indicated for such item in Column 1 of Table 65.1 and 65.1.

90.2 The temperature control is to be bypassed to permit continued operation during this test.

90.3 The heater is to be fired at rated input. The flow of water through the heater is to be regulated to maintain the outlet-water at a temperature of 10 ±5°F (5.6 ±2.8°C) below the outlet-water temperature that causes the temperature regulating control to function when adjusted to its maximum setting.

90.4 Firing of the heater is to be continued until equilibrium temperatures are attained as evidenced by no changes in temperature rises for three consecutive readings taken at 15 minute intervals at observed maximum temperature points.

90.5 A water heater equipped with a continuous burning pilot is to be operated for 48 hours with the primary safety control set in the pilot position such that the gas burner will not fire.

90.6 For a water heater provided with a continuous-burning pilot fire during the standby burning period water temperature shall not exceed 100°F (55.6°C) above room temperature.

91 Burner Durability Test

91.1 A water heater burner shall not sag, distort, melt, damage any protective coating sufficient to expose the base metal, exhibit appreciable corrosion or show leakage of gas during any of the tests specified by this standard or when the burner is operating with the flame burning within the mixer tube or burner head as described in 91.2.

91.2 The gas to the burner is to be adjusted to the increased test pressure as indicated in 59.1. The gas is then to be ignited in such a manner that it burns within the mixer tube or burner head and is to continue to burn there for 30 minutes. If the flame cannot be maintained within the mixer tube or burner head, the gas rate to the burner is to be reduced to a point where it can be so maintained.

92 Blocked Flue Test

92.1 The flue collar on an automatic storage water heater shall be constructed so that incomplete combustion will not result when the draft hood is removed and a flat object is placed over the flue outlet. The construction is not acceptable if the concentration of carbon monoxide exceeds 0.04 percent in an air-free sample of the flue gases when the appliance is tested in a room having approximately a normal oxygen supply.

92.2 This test is to be conducted on an automatic storage water heater equipped with a detachable draft hood and having an input rating of 5000 Btu per hour (1465 W) or less.

92.3 The appliance is to be tested at normal inlet test pressure with the draft hood removed. The appliance is to be filled with water at 70 ±2°F (21 ±1°C) and placed in operation. A flat plate sufficiently large to cover the flue outlet is then to be placed over the flue collar. Either immediately before the thermostat acts to reduce the gas flow or at the end of 15 minutes operation, whichever occurs first, a sample of the flue gases is to be secured from the flue passage at a point immediately preceding their discharge from the appliance and analyzed.

93 Draft Hoods

93.1 Blocked draft hood

93.1.1 Draft hoods provided on water heaters shall comply with the provisions in 93.1.2 – 93.7.1. With the outlet of the draft hood blocked, the carbon monoxide in an air-free sample of the flue gases shall not exceed 0.03 percent when the appliance is tested in an atmosphere having a normal oxygen supply and as described in 93.1.3.

93.1.2 For a water heater not of the direct vent type, the venting system as supplied or specified in the manufacturer's instructions is to be used and is to be terminated at the top of the enclosure. The vent cap, if provided, is to be removed for these tests.

93.1.3 The appliance is to be operated at normal inlet test pressure for 15 minutes. An appliance equipped with a throttling thermostat is to be operated until the input is reduced 5 percent or for 15 minutes, whichever occurs first. The outlet of the draft hood is then to be blocked and a sample of the flue gases secured and analyzed.

93.2 Downdraft – I

93.2.1 Total downdraft pressures ranging from 0 to 0.05 inch water column (13 Pa) imposed at the outlet of the draft hood shall not extinguish the main burner flames nor cause them to flash back, lift, float, burn outside the appliance, or produce carbon monoxide in an air-free sample of the flue gases in excess of 0.04 percent when the appliance is tested in an atmosphere having a normal oxygen supply and as described in 93.2.2 and 93.2.3.

93.2.2 The appliance is to be operated at normal inlet test pressure for at least 15 minutes. A straight section of flue pipe of suitable diameter and of a length at least equal to ten pipe diameters is to be attached directly to the outlet of the draft hood and connected to a blower. The total draft pressure is to be measured with a pitot tube and a differential gage which may be read directly to 0.005 inch water column (1.2 Pa). The pitot tube is to be inserted in the straight section of flue pipe at a point midway between its ends, so that

a) The head of the tube is coincident with the axis of the flue pipe; and

b) The impact opening of the pitot tube faces the flow stream.

93.2.3 The draft in the flue pipe is to be varied from the minimum total pressure to the maximum value specified in 93.2.1, and the effect on the main burner flames noted. Sufficient combustion samples are to be secured to verify satisfactory combustion over the entire range of downdraft pressures.

93.3 Downdraft – II

93.3.1 Downdrafts imposed as specified in 93.2.1 – 93.2.3 shall not extinguish the pilot nor cause it to flash back when it is operated separately from the main burner or burners. The ratio of the carbon dioxide concentration for normal operation, as determined under 60.2, to that under updraft, as determined above, shall not be more than $1+2(h_p +5h_v)$ where h_p is the pressure head and h_v is the velocity head.

93.3.2 A chimney action, consisting of static updraft and velocity updraft numerically totaling between 0.06 and 0.07 inch water column (15 and 17 Pa), applied to the outlet of the draft hood, shall not cause a fractional increase in the volume of the flue gases greater than twice the numerical sum of the pressure head and five times the velocity head, expressed as inches of water column. See 93.3.3 and 93.3.4.

93.3.3 The appliance is to be operated at normal inlet test pressure for at least 15 minutes. A flue pipe as described in 93.2.2 is to be attached directly to the outlet of the draft hood and connected to the blower.

93.3.4 An updraft is to be imposed at the outlet of the draft hood such that the numerical sum of the pressure head and velocity head is between 0.06 and 0.07 inch water column (15 and 17 Pa). Under this condition, a sample of the flue gases is to be taken ahead of the draft hood and analyzed for carbon dioxide. The ratio of the carbon dioxide concentration for normal operation, as determined under 60.2, to that under updraft, as determined above, is to be determined.

93.4 Static load

93.4.1 A draft hood shall be constructed and supported on the water heater to withstand the loading specified in 93.4.2 and 93.4.3 without becoming distorted and without alteration of its position with respect to the appliance.

93.4.2 A vertical or horizontal to vertical type draft hood is to be installed on the appliance in its normal operating position. When special means are provided for bolting or otherwise securing the draft hood to the flue outlet such means are to be employed. A vertical compression load equal to 5 pounds per inch (0.09 kg/mm) of nominal outlet diameter is then to be applied without impact to the draft hood outlet. This load shall not cause distortion of any part of the draft hood or alteration of its position relative to the appliance.

93.4.3 A horizontal draft hood is to be installed on the appliance in its normal operating position. When special means are provided for bolting or otherwise securing the draft hood to the flue outlet, such means are to be employed. A 10-foot (3.05-m) length of No. 24 U.S. standard gage (0.623 mm) sheet-steel vent pipe of suitable diameter is then to be attached in a horizontal position to the outlet connection of the draft hood, the other end of the length of pipe being supported at a point not more than 1 inch (25.4 mm) from its extremity. This load shall not result in distortion of any part of the draft hood or alteration of its position relative to the appliance.

93.5 Flue gases – I

93.5.1 On water heaters not of the direct vent type for installation in manufactured homes, flue gases shall not issue from the relief opening or openings of a draft hood when tested as described in 93.5.2.

93.5.2 For a draft hood to be for having a vertical outlet a sufficient length of vertical flue pipe is attached to provide a total height of 6 feet 6 inches (1.98 m) measured from the floor level. A draft hood having a horizontal outlet, an elbow, and a sufficient length of vertical flue pipe are to be attached to provide a total height of 6 feet 6 inches (1.98 m) measured from the floor level. Ninety-degree sheet-metal elbows with inlet and outlet connections of the same nominal size as the outlet collar of the draft hood, with no abrupt bends, and with a reasonably smooth inner contour are to be used. See 93.7.1.

93.6 Flue gases – II

93.6.1 On water heaters not of the direct vent type for installation in manufactured homes, flue gases shall not issue from the relief opening or openings of the draft hood when installed with the venting system supplied or specified in the manufacturer's installation instructions. See 93.6.2.

93.6.2 The tests specified in 93.5.2 and 93.6.1 are to be repeated:

a) On appliances which reduce the input rating by automatic means at the minimum input rating; and

b) On water heaters not of the direct vent type for installation in manufactured homes at 10 percent above the manufacturer's specified input rating. See 93.7.1.

93.7 Smoke leakage

93.7.1 The appliance is to be operated at normal inlet test pressure with sections of flue pipe or venting system as described in 93.5.2 attached to the outlet of the draft hood. Immediately after 15 minutes of operation, a fuming or smoking material, such as titanium tetrachloride, is to be introduced ahead of the draft hood so as to form a dense smoke. A beam of light is to be directed across the relief opening or openings. No smoke shall be observed escaping the relief opening or openings.

94 Vent System Leakage Test

94.1 On an automatic storage water heater having an input rating of 5000 Btu per hour (1465 W) or more, there shall be no leakage of flue gases around door cracks or any openings through which flue gas might pass through the jacket to the outside of the appliance when tested as described in 94.2.

94.2 This test is to be conducted in conjunction with the test specified in 93.5.1 – 93.7.1 with a stack as specified therein. A fuming or smoking material, such as titanium tetrachloride, is to be introduced into the combustion chamber in sufficient amount to indicate that, if combustion products are discharged through door cracks or other openings, their presence will be revealed by the smoke. No smoke should be observed escaping around door cracks or other openings in the appliance.

95 Nonmetallic Dip Tube Tests

95.1 Deformation and weight loss

95.1.1 A nonmetallic dip tube shall be subjected to the tests described in 95.1.2 – 95.1.4. The dip tube shall not have:

a) A linear deformation of more than 1/2 inch (12.7 mm);

b) A total lateral deformation of more than 1-1/2 inches (38.1 mm); and

c) A weight loss.

95.1.2 Twelve 51-inch (1.30-m) long dip tube samples are to be submitted for test. Each sample is to be cut to a length of 49 inches (1.24 m), and the weight of each tube is to be determined using a laboratory grade measuring device with a full scale reading that does not exceed three times the weight of the sample.

95.1.3 Linear deformation and change of weight are to be determined by suspending the samples as they would be in service for 48 hours in water maintained at 200°F (93°C). The samples are then to be removed from the water and cooled to room temperature. Any surface water is to be removed, and the length and weight are to be determined and compared to the original results.

95.1.4 Lateral deformation is to be determined by installing one end of each sample in a fixture (as it would be in a tank inlet fixture) and measuring the distance between the position of the centerline of the free end and the extended centerline of the fixture. Following immersion for 48 hours in water maintained at 200°F (93°C), the samples are to be removed from the water and cooled to room temperature, any surface water is to be removed, and the lateral deformation measured. The total lateral deformation of each sample is acceptable if it is within the limits of a circle having a radius of 1-1/2 inches (38.1 mm) measured from the extended centerline of the fixture.

95.2 Resistance to crushing

95.2.1 A nonmetallic dip tube shall not deform more than 1/4 inch (6.4 mm) when tested as described in 95.2.2 – 95.2.4. The results are acceptable if the average deformation of the samples does not exceed 1/4 inch (6.4 mm) and the rate of deformation is uniform. The lot submitted for test is unacceptable if immediate deformation of any test sample occurs upon application of the test load.

95.2.2 Ten 2-inch (51-mm) long dip tube samples are to be subjected to this test. The apparatus for the test is to be as illustrated in Figure 95.1. The dip tube is to be subjected for 24 hours to transverse loading under a weight of 870 grams while being maintained at a temperature of 225 plus 5 minus 0°F (107 plus 3 minus 0°C).

Figure 95.1
Heat deformation tester

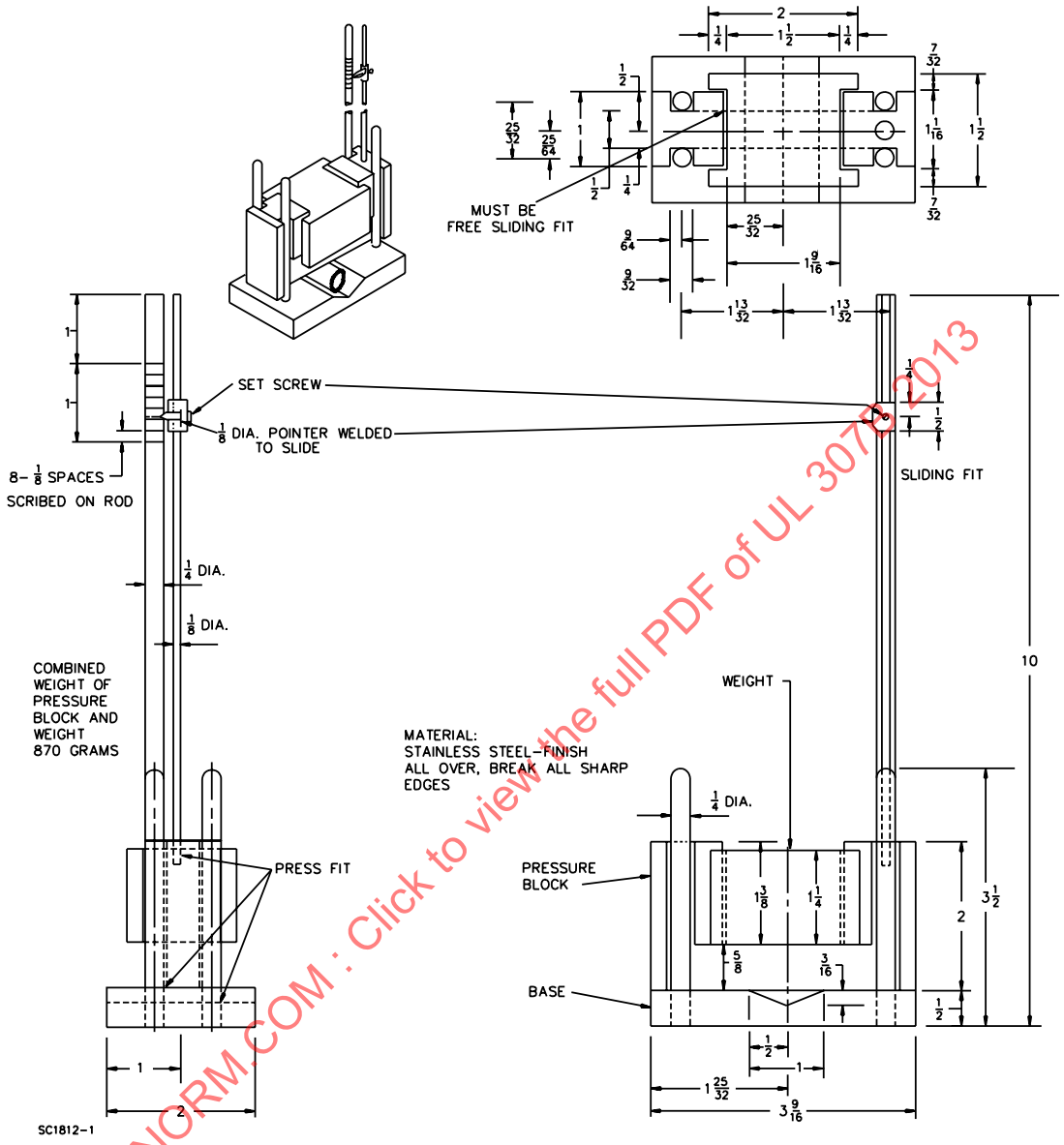


Table for SI equivalents for Figure 95.1

inch	(mm)	Inch	(mm)	inch	(mm)	Inch	(mm)
1/8	3.2	9/32	7.1	1	25.4	1-9/16	39.7
5/64	3.6	25/64	9.9	1-1/6	27	1-25/32	45.2
3/16	4.8	1/2	12.7	1-1/4	31.8	2	50.8
7/32	5.6	5/8	15.9	1-3/8	34.9	3-1/2	88.9
1/4	6.4	25/32	19.8	1-13/32	35.7	3-9/16	90.5
				1-1/2	38.1	10	254

95.2.3 The scale on the test apparatus illustrated in Figure 95.1 is to be at zero with a sample of the tube to be tested in place in the V trough beneath the pressure block. The sample is then to be removed and the test apparatus placed in a 1-liter glass beaker filled with ethylene glycol, glycerine, or a similar liquid to a depth sufficient to cover the pressure block when at the zero scale setting. The glass beaker is then to be placed over a hot plate and heated until the temperature of the liquid and test apparatus, as determined by a thermometer placed in the beaker with its bulb on the base of the test apparatus, has reached 225 plus 5 minus 0°F (107 plus 3 minus 0°C). The temperature is then to be held constant for the duration of the test.

95.2.4 The pressure block is then to be raised and the sample of the dip tube to be tested placed in the V trough below the block. The block is then to be lowered without impact onto the dip tube sample and the time recorded. At the end of 24 hours the distance or travel of the indicator on the scale is to be recorded, the test sample removed, and the test repeated on the remaining test samples.

95.3 Collapse

95.3.1 A nonmetallic dip tube shall be immersed in water at a temperature of 225 plus 5 minus 0°F (107 plus 3 minus 0°C) under the conditions of test described in 93.4.1 – 93.5.2. The dip tube shall not collapse, as evidenced by a reduction in internal diameter of more than 1/8 inch (3.2 mm).

95.3.2 The internal diameter of a 49-inch (1.24-m) long dip tube sample is to be determined before the conditioning described in 95.3.4 – 95.3.6.

95.3.3 The sample is to be installed in the hot-water outlet of a representative water heater. A quick-acting valve is to be installed at the outlet connection of the storage vessel. The minimum cross-sectional area through this valve is to be equal to or greater than that of a Schedule 40, 1/4 inch pipe having an internal diameter of 0.364 inch (9.25 mm) as specified in Welded and Seamless Wrought Steel Pipe, ANSI/ASME B36.10M-1985. A flow-restricting device adjusted or constructed so as to maintain a flow rate of 5 gallons (18.9 L) per minute during the test is to be connected to the inlet of the heater.

95.3.4 A mercury thermometer graduated to 1°F (0.5°C), or a thermocouple for connection to a potentiometer, is to be installed in the storage vessel within the top 6 inches (152.4 mm) of the tank. A water-pressure regulator is to be located between the inlet connection to the storage vessel and the water supply line and adjusted so that, at a steady flow rate of 5 gallons (18.9 L) per minute, the pressure at the inlet connection will be 40 psig (276 kPa).

95.3.5 The storage vessel is to be filled and the test water heater placed in operation, with the thermostat, if any, bypassed. When the temperature indicated by the thermometer or thermocouple in the top of the storage vessel is 225 plus 5 minus 0°F (107 plus 3 minus 0°C), the quick acting valve is to be opened and water allowed to flow until the outlet-water temperature is the same as the inlet-water temperature.

95.3.6 The dip tube is then to be removed from the test heater and examined for compliance with the requirement in 95.3.1.