This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: C411 – 19

Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation[1]

This standard is issued under the fixed designation C411; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers the determination of the performance of commercial sizes of both block and pipe forms of thermal insulating materials when exposed to simulated hot-surface application conditions. The term "hot-surface performance" has reference to a simulated use-temperature test in which the heated testing surface is in a horizontal position.

1.2 This test method refers primarily to high-temperature insulations that are applicable to hot-side temperatures in excess of 150°F (66°C). It is used for materials such as preformed insulations, insulating cements, blankets, and the like, by proper laboratory preparation of the samples.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

C167 Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations

C168 Terminology Relating to Thermal Insulation

C356 Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat

3. Terminology

3.1 *Definitions*—Terminology C168 shall apply to the terms used in this test method.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *sag, n*—the extent of thickness loss of pipe insulation, at the top longitudinal center, due to material fatigue or decomposition due to elevated temperature.

4. Significance and Use

4.1 Performance in service is the final measure of value for a thermal insulation, but simulative service tests give useful indications. One type involves application for a specified time to a surface heated at a temperature approximately that of intended service, and noting during the test and afterward, changes in the material and its properties. Measurement of these changes are used for predicting what occurs in service as a result of exposure to temperatures corresponding to those of the tests.

5. Apparatus

5.1 *Heating Plate*—The heating plate shall consist of a corrosion-resistant and heat-resistant plate with a preferred exposed test area of 36 by 18 in. (914 by 457 mm), but having a minimum test area of 18 by 18 in. (457 by 457 mm). The heated area shall have an insulated, heated guard area having a minimum width of 3 in. (76 mm) around the entire periphery of the test area. The plate shall be supported in a horizontal plane at a sufficient number of points to prevent sagging. It shall be heated on the under side by gas or electricity. The surface temperature of the plate shall be measured by not less than five thermocouples. Four of the thermocouples shall be located along the diagonals that extend from the corners of the exposed area of the plate and at a distance of 6 in. (152 mm) in from each corner. A fifth thermocouple shall be located near the

[1] This test method is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.31 on Chemical and Physical Properties.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

center of the test plate area. The temperature at no point of measurement shall vary more than ±5 % or ±25°F (±14°C), whichever is less, from the desired temperature. A heating chamber beneath the heating plate shall be formed to retain the heat generated by the heating means. A 6-in. thickness of insulation shall form the bottom and the sides, and the heating plate shall form the top of the chamber. Two suitable types of heating plates are shown in Fig. 1 and Fig. 2.

5.2 *Heating Pipe*—The heating pipe shall consist of a corrosion-resistant and heat-resistant pipe having a length of not less than 3 ft (0.9 m) and preferably 6 ft 6 in. (1.98 m). It shall be supported horizontally. The nominal diameter of the pipe shall preferably be 3 in. (76 mm). The pipe shall be heated electrically with a spiral heating coil placed along the inside of the pipe. Supplementary end heaters, and a guard section at least 3 in. long of the same insulation as that being placed on the test section, shall also be provided to guard against excessive losses from the ends of the test specimen. (Where possible, the use of standard thermal conductivity pipe test apparatus to serve as the heating pipe is recommended.) The surface temperature of the pipe shall be measured by means of thermocouples, not less than one for each 1 ft (0.3 m) of length of the test specimen, and located spirally around the pipe at 90° intervals. The test portion of the pipe shall be that area under a full length of a pipe insulation undergoing test. The temperature at any point of measurement on the test portion shall not vary more than ±5 % or ±25°F (±14°C), whichever is less, from the desired temperature.

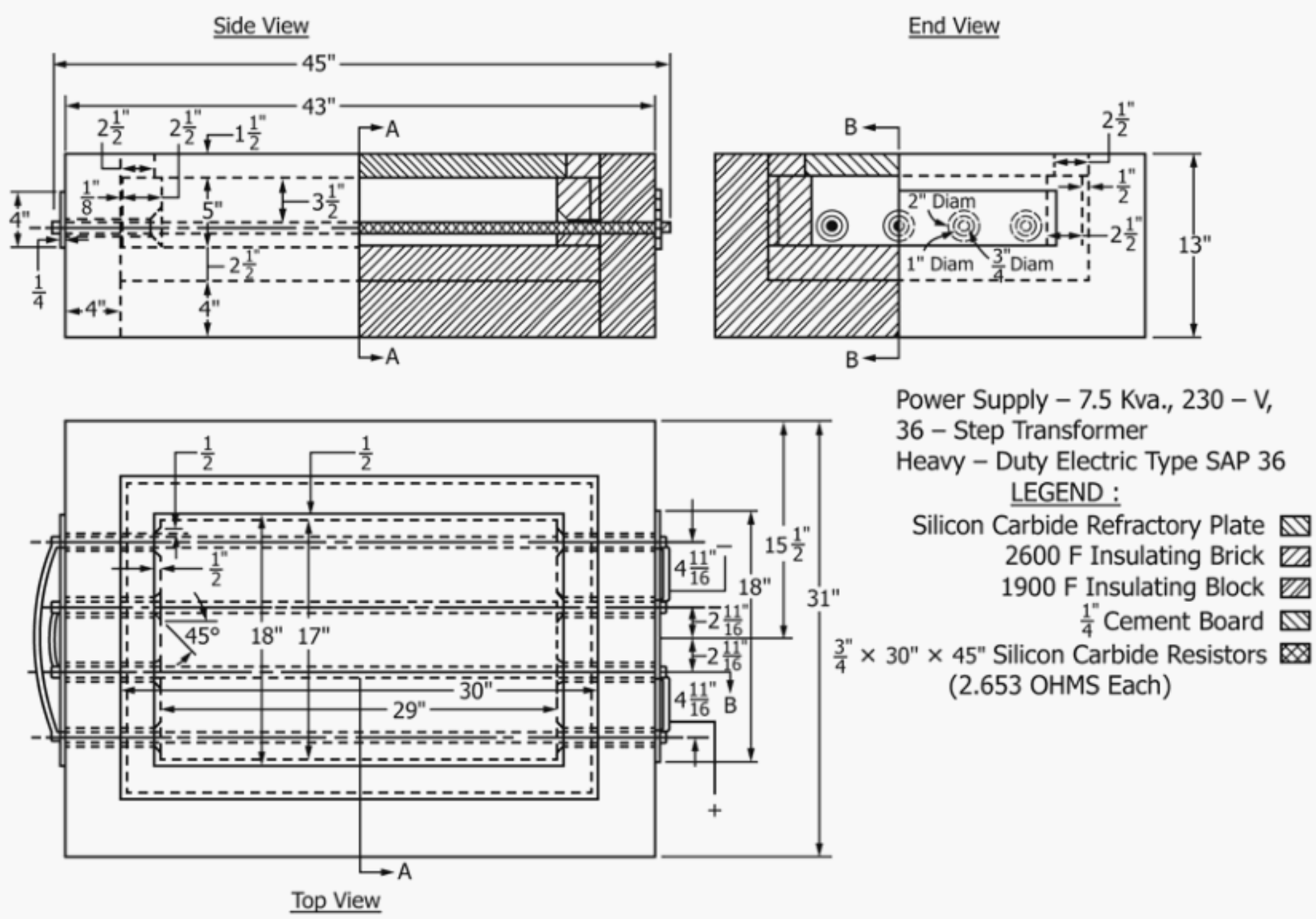
5.3 *Temperature Measurement*—Thermocouples shall be used to measure the surface temperature of the heating plate and the heating pipe. They shall be applied either by peening the individual wires into small holes drilled into the surface and separated by not more than ⅛ in. (3 mm) or by joining the wires with a welded bead and cementing them in grooves with the bead tangent to the surface but not projecting above it. The thermocouples shall be made from wires having a size not greater than No. 22 Awg (0.644 mm), and preferably not larger than No. 26 Awg (0.405 mm). The combination of the thermocouple and measuring instrument used shall ensure an accuracy of temperature measurement of ±1 %.

NOTE 1—This requires different thermocouples and measuring instruments for high-temperature tests than for moderate-temperature tests.

5.4 *Straightedge and Rule*—A straightedge having a length of at least 36 in. (0.9 m) and a small rule divided in 1/64 or 1/10 of 1 in. shall be used to determine warpage.

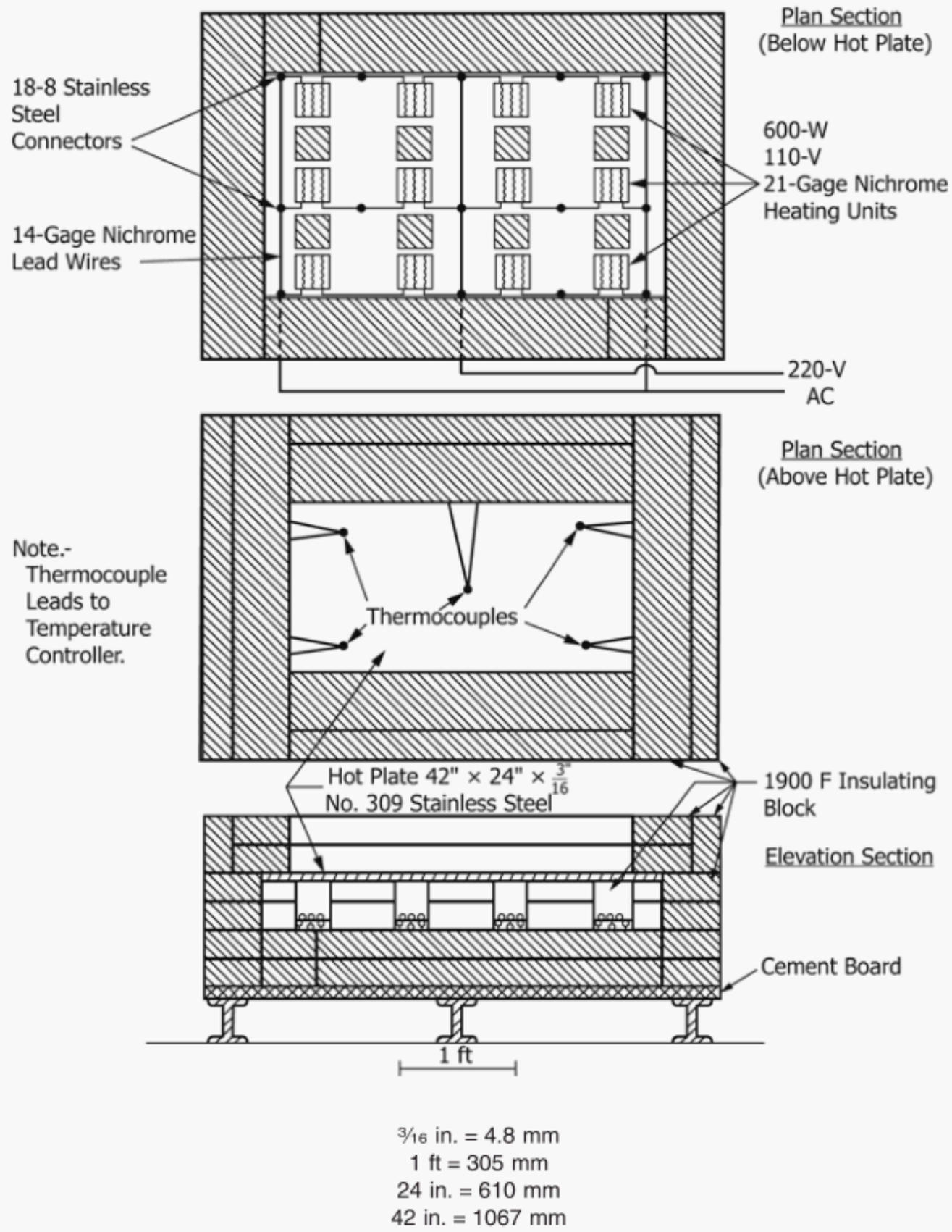
6. Sampling and Preparation of Test Specimens

6.1 All samples that are required to complete the tests shall be selected at one time and in such a manner so as to be fully representative of the average of the material. Test specimens for any one test condition shall be selected from the original



in.	⅛	¼	½	¾	1	1½	2	2½	2 11/16	3½	4	4 11/16	5	13	15½	17	18	29	30	31	43	45
mm	3	6	13	19	25	38	51	64	68	89	102	119	127	330	394	432	457	737	762	787	1092	1143

FIG. 1 Type A Heating Plate for Hot-Surface Performance Test



NOTE 1—Thermocouple leads to temperature controller.

FIG. 2 Type B Heating Plate for Hot-Surface Performance Test

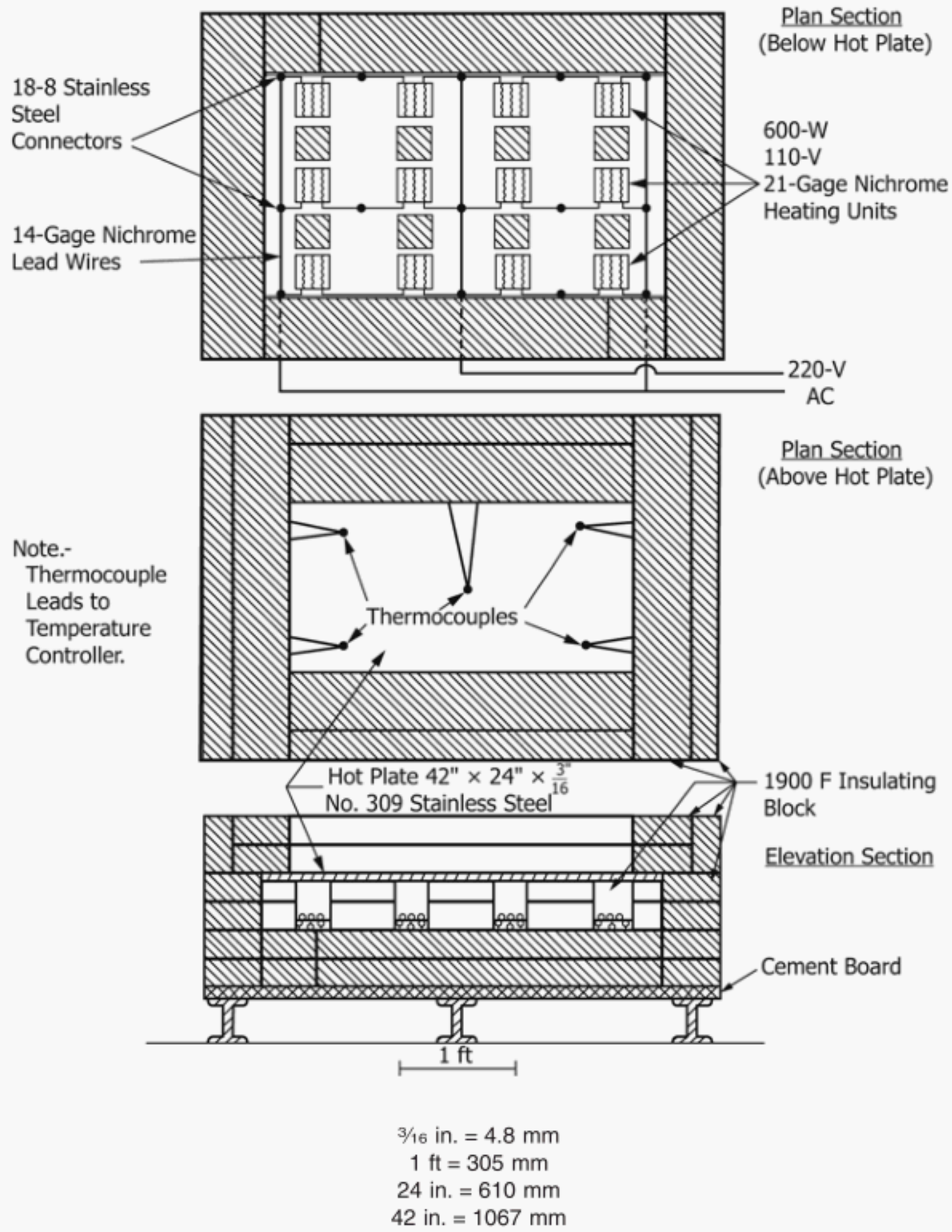
sample lot so as to be as representative as possible. The test specimens shall be commercial pieces. For pipe insulation, the full-size, commercial pipe sections shall be selected. Any diameter pipe insulation for which equipment is available is potentially tested. However, only pipe insulation of 3-in. (76-mm) nominal inside diameter need to be tested.

7. Procedure

7.1 Use the heating plate for testing the flat or block form of insulation. Use the heating pipe for pipe insulation. The thickness of the layers in multilayer insulation and the total thickness of insulation applied to the hot surface for a test shall be that recommended by the manufacturer for the temperature of the hot surface in question, or as agreed between the manufacturer and the purchaser. When multi-layer applications are to be tested, stagger each joint between adjacent test pieces in the same layer with respect to the joint in the next layer. Equally dispose about that joint the test piece in the next layer that covers a joint of the preceding layer.

7.2 *Assembly of Specimen on Heating Plate*—Specimens for testing on a heating plate shall be 6 by 18 in. (152 by 457 mm) with the thickness as described in 7.1. Check each block for flatness and measure and record any initial warpage. Cover the test area of the heating plate with the test blocks. If any blocks have initial warpage, place the concave face toward the hot side. Apply additional layers to the first layers when necessary to give the total required thickness.

7.3 *Assembly of Specimen on Heating Pipe*—Apply a full length of pipe insulation to the test pipe. If the test pipe is longer than the specimen, the latter can advantageously be centered on the pipe and the ends covered with sawed lengths of the insulation being tested so as to help guard the full length specimen from end losses. The thickness of the test specimen shall be as required in 7.1. Apply additional layers of insulation as necessary to give the required total thickness. Apply the various layers of insulation and secure tightly around the pipe by the usual recommended practice.



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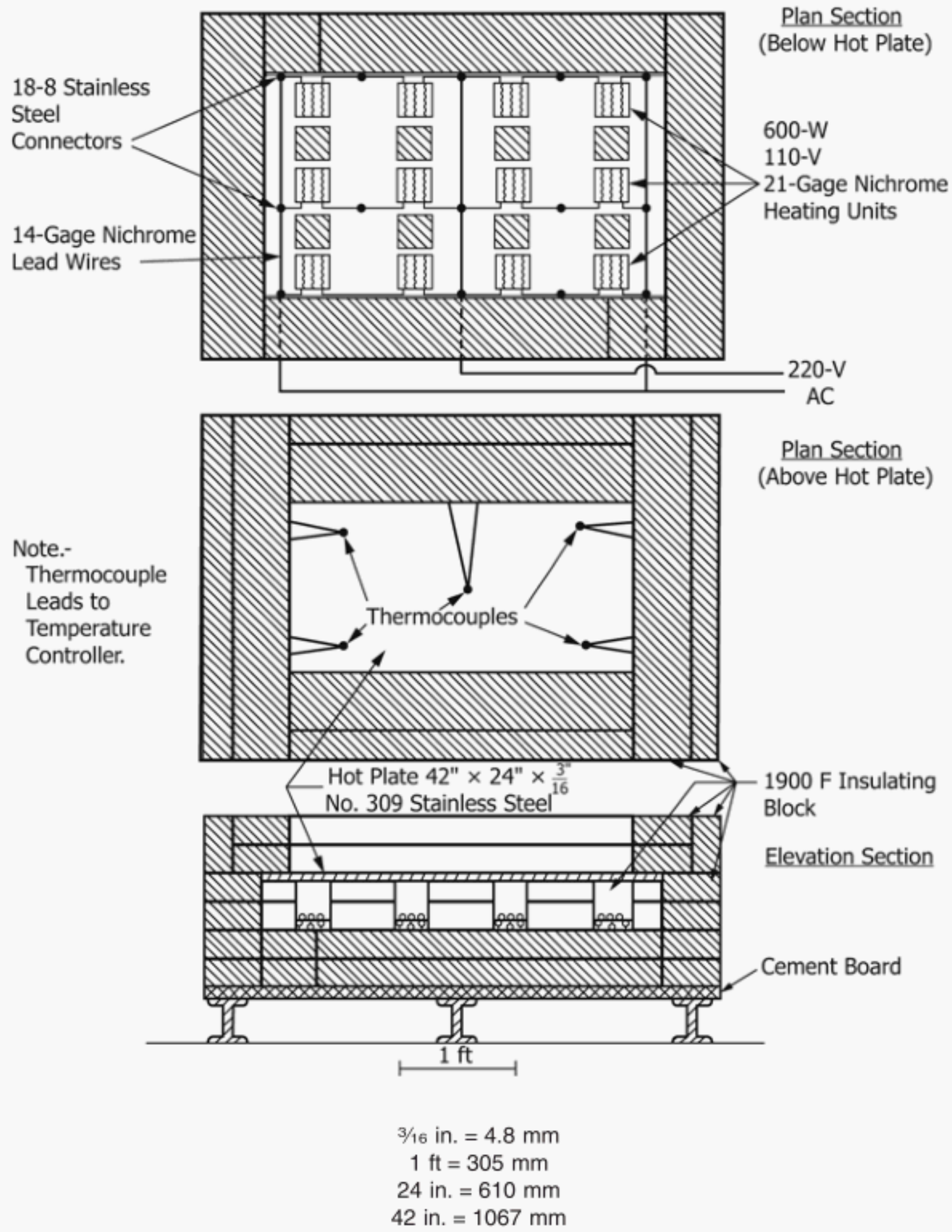

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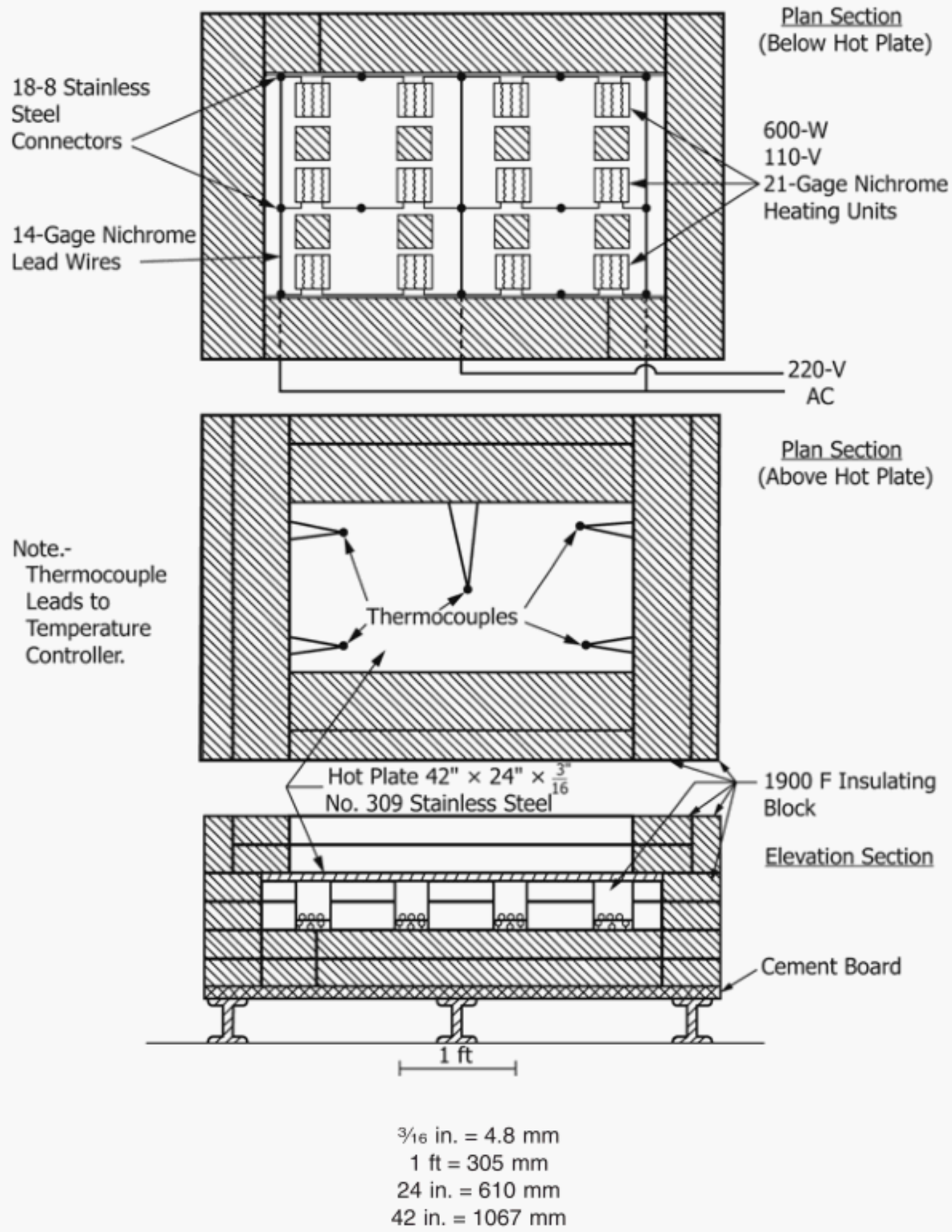

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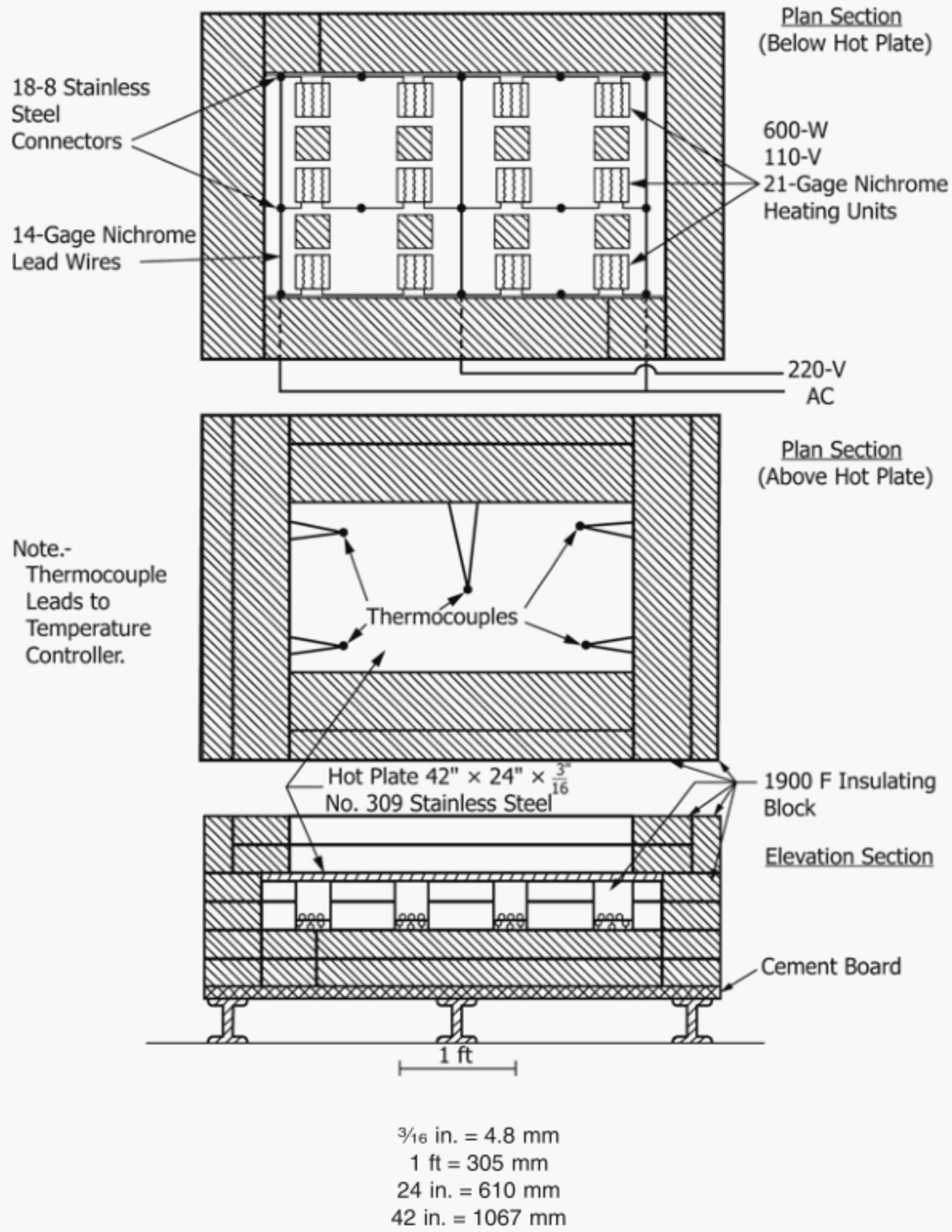

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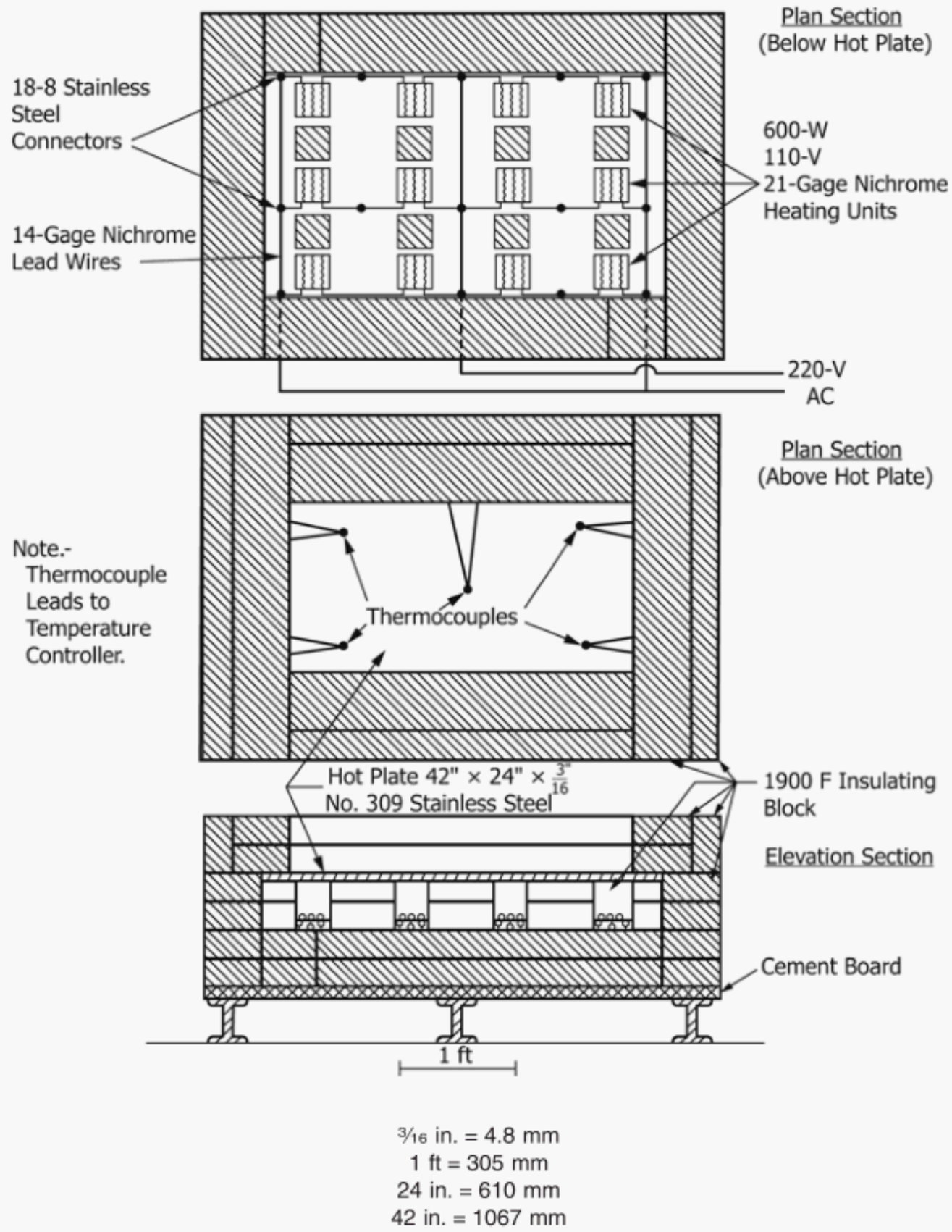

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