



Member of the FM Global Group

Approval Standard for Fire Protective Coatings for LP Gas Steel Storage Vessels and Process Structures

Class Number 4971

September 1981

Foreword

The FM Approvals certification mark is intended to verify that the products and services described will meet FM Approvals' stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of Approval Standards is to present the criteria for FM Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for certification by FM Approvals shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing shall ensure a consistently uniform and reliable product. Approval Standards strive to be performance-oriented. They are intended to facilitate technological development.

For examining equipment, materials and services, Approval Standards:

- a) must be useful to the ends of property conservation by preventing, limiting or not causing damage under the conditions stated by the Approval listing; and
- b) must be readily identifiable.

Continuance of Approval and listing depends on compliance with the Approval Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic follow-up audits of the manufacturing facility.

FM Approvals LLC reserves the right in its sole judgment to change or revise its standards, criteria, methods, or procedures.

TABLE OF CONTENTS

I. INTRODUCTION	1
II. SCOPE	1
III. PRODUCT TESTING	2
IV. TEST SAMPLE PREPARATION	2
V. FIRE TEST PROCEDURE	3
VI. HOSE STREAM TEST	4
VII. HEAT OF COMBUSTION TEST	4
VIII. CONDITIONS OF ACCEPTANCE	5
IX. MANUFACTURER'S RESPONSIBILITIES	5
X. QUALITY CONTROL PROCEDURES AUDITS AND RE-EXAMINATIONS	5
XI MARKING	6
APPENDIX A: FM Approvals High Temperature Furnace	10
I. DESCRIPTION	10
II TEMPERATURE LIMITS	10
III TEMPERATURE MEASUREMENT	10

I. INTRODUCTION

- 1.1 This Standard serves as the basis for FM Approval of fire protective coatings for the following two categories: liquefied petroleum gas (LPG) steel storage vessels, and flammable liquid/gas process structures when subject to fire conditions and the associated rapid cooling effect of water. The Standard is applicable to aboveground installations of vessels and structures.
- 1.2 Protective coatings for these vessels and structures are designed as a thermal barrier, to prevent steel temperatures from exceeding the limits noted in Paragraph 8.1.1.

CAUTION

Local authorities having jurisdiction should be consulted prior to covering a pressure vessel nameplate. Remounting of the plate to raise it above the level of coating proposed may be required.

- 1.3 FM Approval is based upon satisfactory performance of the protective coating and manufacturing quality controls in the following major areas:
 - 1.3.1 Examination and tests of the product are conducted to evaluate: 1) suitability for its intended end-use; 2) its installation and performance; and 3) as far as practicable, its durability and reliability.
 - 1.3.2 Periodic in-plant audit inspections of the manufacturing and quality controls are conducted to assure continued productions of coatings equivalent to those tested and Approved.
- 1.4 For continued Approval, the coating material must be manufactured under adequate quality control and manufacturing procedures, be applied according to strict application methods, and result in satisfactory field experience.
- 1.5 The requirements of this Standard identify FM Approval tests and practices. Protective coatings which do not conform to these requirements may be Approved if they meet the intent of this Standard. Conversely, those that do conform may not be Approved if other conditions prevail.

II. SCOPE

- 2.1 Coatings formulated to meet the needs of this Standard shall be able to provide reliable service under anticipated weather conditions. Consideration shall be given to minimizing corrosion of the steel surface in contact with the coating.
- 2.2 Complete instructions for application of the coating and any weather resistant covering required shall be provided by the manufacturer.
- 2.3 The material may be designed for trowel, spray or other means of application.

2.4 Required testing in both subject categories of coatings will include:

- 2.4.1 A fire test of two hour duration followed by a hose stream test,
- 2.4.2 A fire test of one hour duration followed by a hose stream test, immediately followed by another one hour fire test on the same sample, and
- 2.4.3 A heat of combustion test, intended to provide a benchmark against future product evaluations.

III. PRODUCT TESTING

3.1 General

- 3.1.1 Protective coatings and their weather resistant membrane if required, for either category of use shall be subjected to the following series of tests.
- 3.1.2 Fire tests shall be conducted on the FM Approvals High Temperature Furnace. See Appendix A for a description of this furnace.
- 3.1.3 Heat of combustion tests shall be conducted in equipment specified by ASTM Standard D 240 Test Method.

3.2 Fire Tests

- 3.2.1 One sample in each category shall be exposed to an uninterrupted two hour period of fire exposure; after which the sample shall be removed and immediately subjected to a hose stream application.
- 3.2.2 The second sample in such category shall be exposed to an uninterrupted one hour period of fire exposure; after which the sample shall then be removed and immediately subjected to a hose stream application. Without undue delay, the sample shall then be returned to the furnace for one additional hour of uninterrupted fire exposure. A hose stream test is not required after this second hour of fire exposure.

3.3 Hose Stream Tests

- 3.3.1 A hose stream application shall be applied for one minute duration moving the water stream slowly over the exposed surface of the fire tested sample.

3.4 Heat of Combustion Tests

- 3.4.1 One sample in each category shall be subjected to a heat of combustion test. Required weather resistant coatings shall also be subjected to the same test procedure.

IV. TEST SAMPLE PREPARATION

4.1 General

- 4.1.1 Test samples shall be prepared by the manufacturer and shall be witnessed by an FM Approvals representative.

- 4.1.2 Two identically prepared samples are required for each category.
- 4.1.3 If required for weatherability, the base coating shall be covered with the weather resistant covering for all fire tests.

4.2 LPG Tank Coatings

- 4.2.1 The coating is to be applied over one surface of each of two 24 × 42. in. (610 × 1067 mm) carbon steel plates, of 5/8 in. (16 mm) thickness, in the thickness and manner recommended by the manufacturer, using equipment specified by the manufacturer.
- 4.2.2 The steel plate temperatures shall be monitored and recorded, at least once every five minutes, at five (5) symmetrically placed locations in which the thermocouples are imbedded 5/16 in. (8 mm) deep into the steel plates. See Illustration 2 for thermocouple locations.
- 4.2.3 The thermocouple wires shall be 0.0449 in. (1.14 mm [18 ga]) diameter Chromel/Alumel.
- 4.2.4 The coating shall be applied to the test plates while the plates are in a vertical position, in accordance with the Paragraph 3.2.1. It shall be representative of field application and thickness.

4.3 Process Structures

- 4.3.1 The coating is to be applied to the exposed surfaces of the lightest weight steel shape for which Approval is sought, and in the thickness and manner recommended by the manufacturer, using equipment specified by the manufacturer.
- 4.3.2 The steel temperatures shall be monitored and recorded, at least once every five minutes at five (5) symmetrically placed locations in which the thermocouples are imbedded to mid-depth of the steel shape thickness. See Illustration 3 for thermocouple locations.
- 4.3.3 The thermocouple wires shall be 0.0449 in. (1.14 mm [18 ga]) diameter Chromel/Alumel.
- 4.3.4 The coating shall be applied to the shapes while they are in the vertical position, in accordance with Paragraph 4.3.1. It shall be representative of field application and thickness.

V. FIRE TEST PROCEDURE

5.1 General

- 5.1.1 A noncombustible cover shall be placed on the furnace and the furnace preheated until brick temperatures reach 1050°F (566°C).

5.2 LPG Tank Coatings

- 5.2.1 At completion of the preheat period, the exposure fire shall be extinguished, the furnace cover removed and the first sample to be tested shall be placed, coated side down, over the furnace chamber openings when brick temperatures reach 1000°F (538°C).
- 5.2.2 The exposure fire shall be re-ignited as soon as possible. The air temperature within the furnace shall be raised to 1800°F (982°C) within twenty minutes (see Illustration 1). The furnace temperature shall then be held constant for the remainder of the two (2) hours exposure period, unless the conditions of acceptance noted in Section VIII are exceeded in a shorter period. At completion of the fire test, the sample shall be removed from the furnace and subjected to the impact, thermal shock and eroding effects of a hose stream test. (See Section VI.)

5.3 Process Structure Coatings

- 5.3.1 At completion of the preheat period, the exposure fire shall be extinguished, the furnace cover removed, and the first sample to be tested shall be placed within the furnace chamber when brick temperatures reach 1000°F (538°C), and the cover replaced.
- 5.3.2 The exposure fire shall be re-ignited as soon as possible, exposing the test sample to an 1800°F (982°C) temperature within twenty minutes and held at that temperature for the remainder of the two (2) hours of exposure, unless the conditions of acceptance noted in Section VIII are exceeded in a shorter period. At completion of the fire test, the sample shall be removed from the furnace and subjected to the impact, thermal shock and eroding effects of a hose stream test. (See Section VI.)
- 5.3.3 The second sample shall be fire tested in an identical manner, except that after one (1) hour of fire exposure, the sample shall be removed from the furnace and subjected to the hose stream test. Without undue delay, following the hose stream test, the sample shall be replaced in the furnace, the cover replaced, the exposure fire re-ignited and the sample exposed to one (1) additional hour of fire exposure. A second hose stream test is not required at the completion of this second hour of fire test.

VI. HOSE STREAM TEST

- 6.1 This test procedure is applicable to both end-use categories of coatings.
- 6.2 The samples to be subjected to the hose stream test shall be removed, when noted, from the furnace, exercising care in handling to avoid damage to the coatings.
- 6.3 The samples shall be suspended vertically, 20 ft (6.1 m) from the hose nozzle.
- 6.4 A water stream shall be delivered through a 7/8 in. (22 mm) diameter hose equipped with an adjustable spray nozzle. The nozzle shall be adjusted to provide the most solid stream possible.
- 6.5 The water stream pressure shall be 45 psi (310 kPa) as measured at the perimeter of the stream by means of a pitot tube, approximately 6 in. (150 mm) from the nozzle. The stream is to be moved slowly and continuously over as much of the fire exposed surface(s) as possible for a duration of one (1) minute.

VII. HEAT OF COMBUSTION TEST

- 7.1 Separate heat of combustion tests shall be conducted on all coatings and their weather resistant coverings.
- 7.2 The tests shall be conducted in equipment required and in the manner outlined in the American Society for Testing and Materials Standard Test Method D 240, Heat of Combustion of Liquid Hydrocarbon Fuels.

VIII. CONDITIONS OF ACCEPTANCE

- 8.1 A coating, with its weather resistant covering if required, shall be considered as meeting the requirements for acceptable performance when it remains attached to the steel plate or structural shape substrates during the fire and hose stream tests, within the following limitations:
- 8.1.1 The coating shall not permit steel temperatures to exceed 800°F (427°C) as measured by any individual thermocouple.
 - 8.1.2 Expansion or contraction during the preceding tests shall not result in spalling or fissures extending the full depth of the coating, exposing bare steel.

IX. MANUFACTURER'S RESPONSIBILITIES

CAUTION

Local authorities having jurisdiction should be consulted prior to covering a pressure vessel nameplate. Remounting of the plate to raise it above the level of coating proposed may be required.

- 9.1 The manufacturer shall supply all necessary instructions and other assistance as may be needed to assure proper installation.
- 9.2 The manufacturer shall confirm that the coating will not induce corrosion to the steel surface of the tank for a period of at least ten years, which would otherwise limit its life expectancy.

X. QUALITY CONTROL PROCEDURES AUDITS AND RE-EXAMINATIONS

- 10.1 An audit of quality control procedures of the manufacturing facilities shall be conducted before Approval is granted. Its purpose is to determine that equipment, procedures and manufacturing and quality controls are such as to assure continued production of material equivalent to that originally tested and Approved.
- 10.2 Periodic quality control procedures audit inspections and/or re-examinations shall be conducted following Approval.

XI MARKING

- 11.1 Coatings Approved by this Standard shall be identified by an imprinting on the containers as FM Approved, consisting of the manufacturer's name and address, the FM Approvals logo, the word "Approved", the product name, and the following statement of intended end-use: "For protection of liquefied petroleum gas tanks (and/or process structures), when installed in accordance with the manufacturer's installation procedures. See FM Approvals Report J.I. No. xxxxx.xx."

Attached: Illustrations 1, 2 and 3
Appendix A and Illustration A1

Furnace Temperature

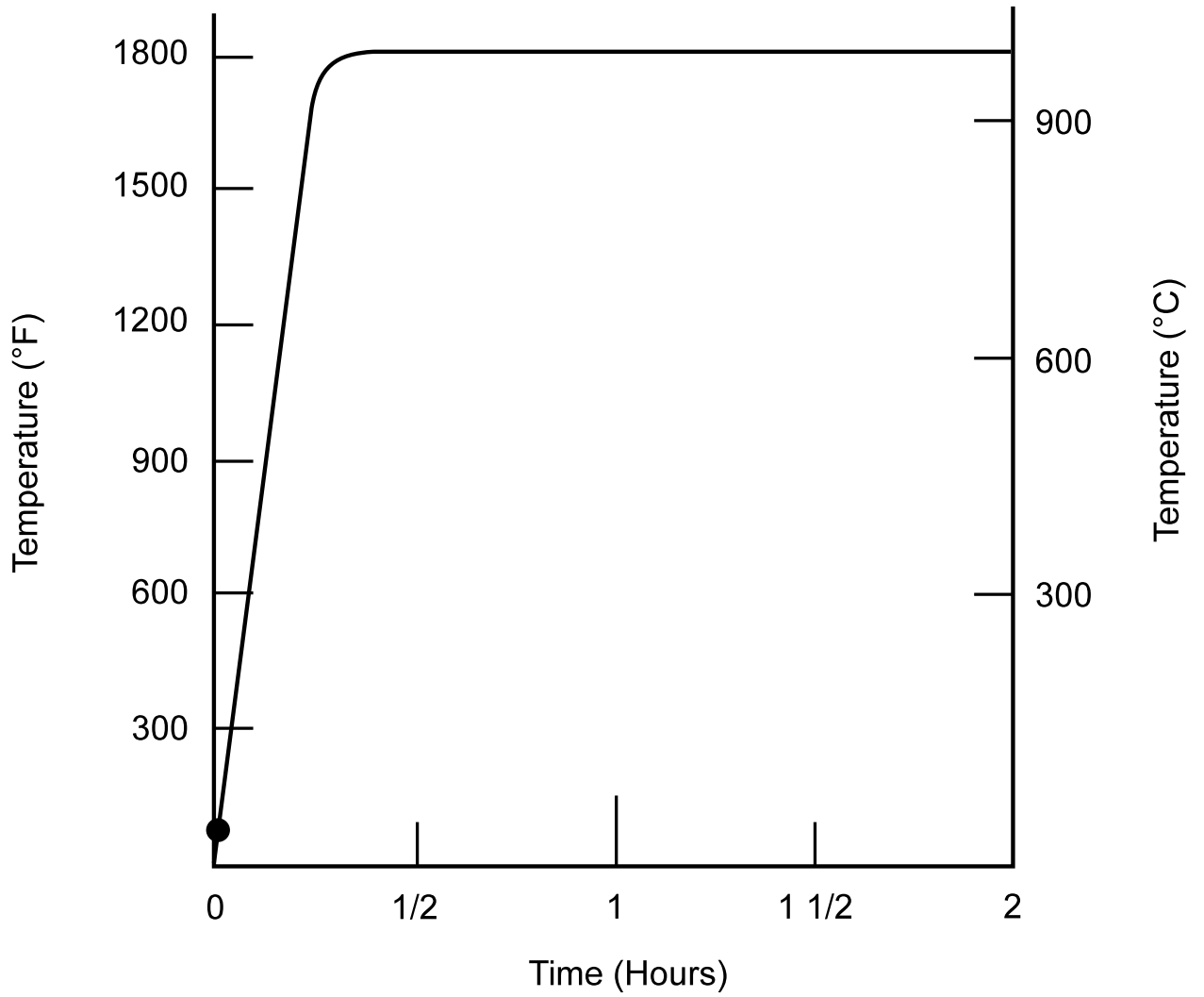


Illustration 1

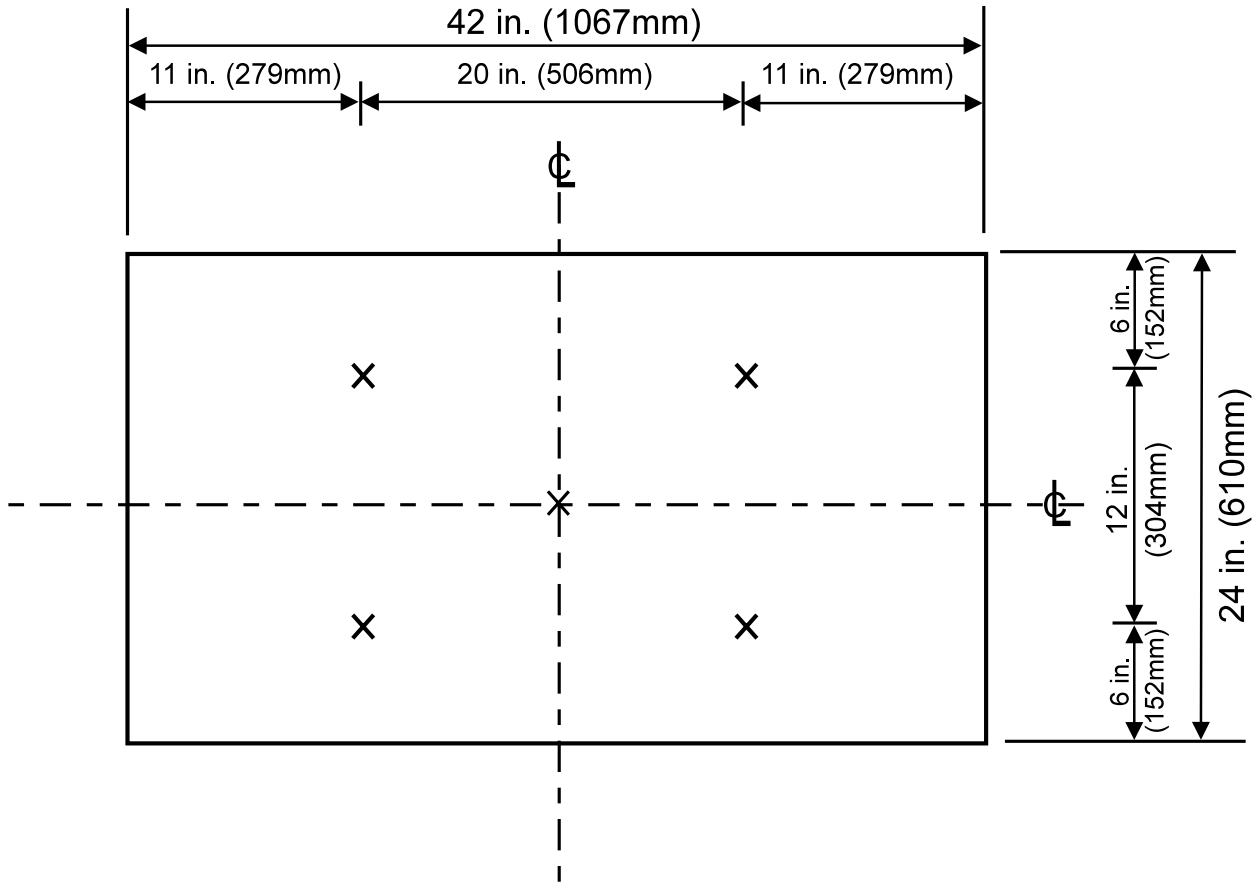
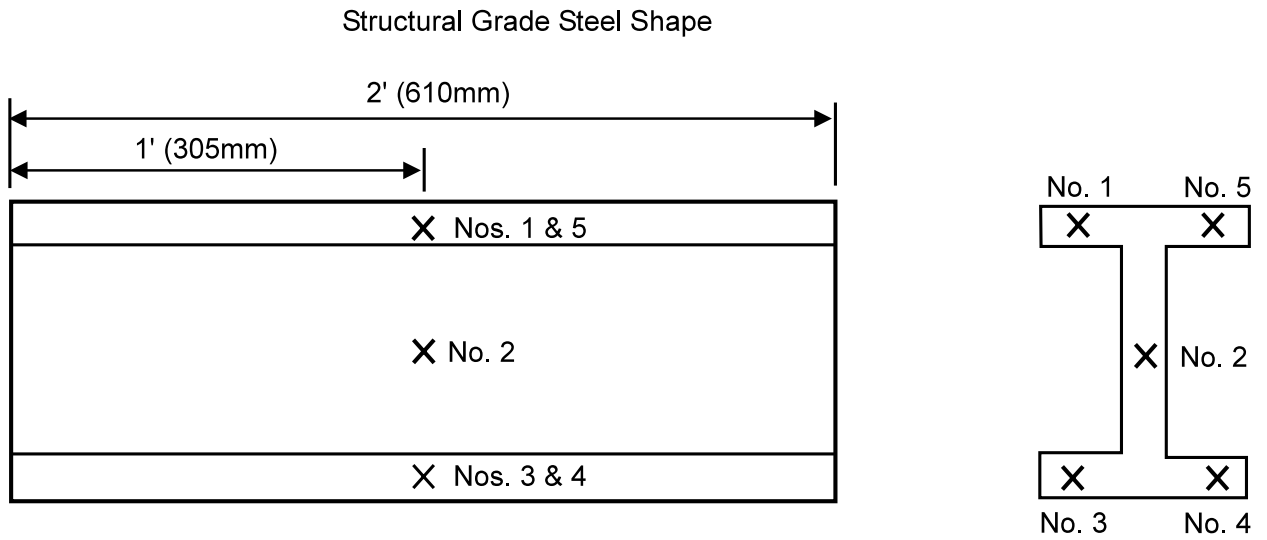


Illustration 2

X = Sample Thermocouple Locations



X = Sample Thermocouple Location (at mid-thickness)

Illustration 3

APPENDIX A

FM Approvals High Temperature Furnace

I. DESCRIPTION

- 1.1 The furnace is a horizontal rectangular unit consisting of common clay brick exterior walls lined with 2400°F (1315°C) insulating firebrick.
- 1.2 The furnace interior is 18 in. (457 mm) wide by 38½ in. (978 mm) long by 18 in. (457 mm) deep.
- 1.3 The excess air type burner uses natural gas for combustion fuel.

II TEMPERATURE LIMITS

- 2.1 The furnace is capable of maintaining relatively constant temperatures from ambient up to 2000°F (1093°C) for protracted periods.

III TEMPERATURE MEASUREMENT

- 3.1 Furnace temperature shall be deemed to be the average values as measured by four (4) thermocouples, symmetrically placed and suspended one (1) inch (25 mm) below the test sample surface. See Illustration A1 for thermocouple locations.
- 3.2 Brick temperatures are monitored by a thermocouple imbedded ¼ in. (6 mm) below the inner wall surface of the insulating brick located at the center point of the long dimension of the furnace chamber.
- 3.3 The thermocouple wires shall be 0.0449 in. (1.14 mm [18 ga]) diameter Chromel/Alumel.

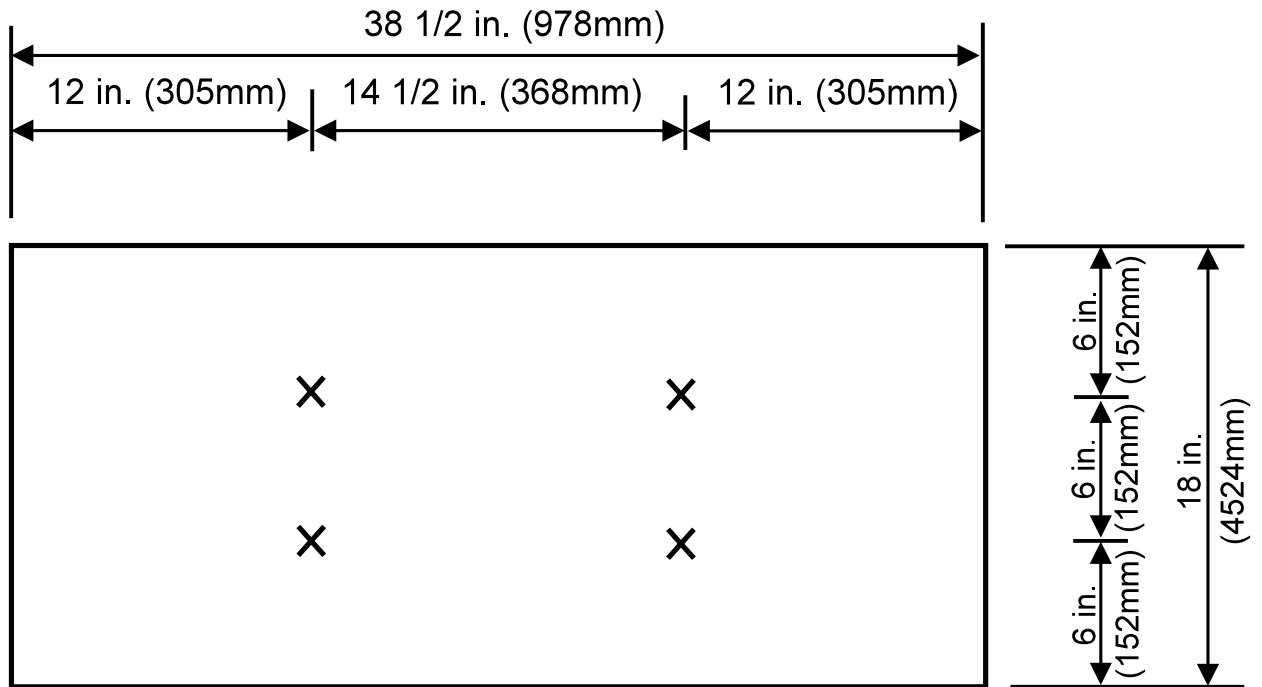


Illustration A1
Furnace Thermocouple Locations