Approval Standard for Class 1 Conveyor Belting

Class Number 4998

August 1995

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.

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I INTRODUCTION

1.1 Purpose

This standard states FM Approval requirements for Class 1 conveyor belting. The establishment of such a classification is used in determining acceptable fire protection requirements applicable to specific installations.

1.2 Scope

1.2.1 This standard sets performance requirements for establishing a classification for horizontal, inclined, and vertical conveyor belts made from plastics, fibers, and natural and synthetic rubbers used to transport materials in commercial or industrial applications.

1.2.2 This standard examines the ability of conveyor belting to limit fire spread by measuring its resistance of self-sustaining fire propagation. This standard also examines surface buildup of static electricity, friction, and the adverse effects on fire performance caused by ultraviolet (UV) and/or water exposure and mechanical wear.

1.2.3 This standard is not intended to determine the suitability for all end-use conditions of this product. Conditions such as strength, elongation, durability, impact resistance, operating temperature range, corrosion resistance, etc., are not evaluated as part of this Approval examination.

1.2.4 This standard provides a means for determining the sprinkler protection requirements needed strictly due to the flammability characteristics of the conveyor belting. The effect of conveying combustible materials, enclosure housings constructed of combustible material or the presence of ordinary combustibles near or under the conveyor belt have not been considered. The sprinkler protection requirements when these conditions exist are not included or determined by this standard.

1.3 Basis For FM Approval

FM Approval is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

1.3.1 Examination and tests on production samples to evaluate:

- the ability to resist self-sustaining fire propagation;
- the ability to retain its fire performance properties after accelerated weathering (UV and/or water) exposure and mechanical wear;
- the ability to develop sufficient conductance to prevent the buildup of static electricity;
- the temperature on a drum's surface created from friction between a spinning drum and a ''locked'' belt; and
- the suitability and reliability of the product, as far as practical.

1.3.2 Examination of the manufacturing facilities and audit of quality control to evaluate the manufacturer's ability to produce the product as examined and tested, and the marking procedures used to identify the product. These examinations are repeated as part of FM Approvals' product follow-up program.

1.4 Basis For Continued Approval

Continued Approval is based upon:

- production or availability of the product as currently Approved;
- the continued use of acceptable quality control procedures;
- satisfactory field experience;
- compliance with the terms stipulated in the Approval agreement; and
- re-examination of production samples for continued conformity to requirements.

1.5 Basis For Requirements

1.5.1 The requirements of this standard are based on experience, research, testing and/or the standards of FM Approvals, and other national and international organizations. The advice of manufacturers, users, trade associations and loss control specialists was also considered.

1.5.2 Meeting these requirements qualifies a product as Approved Class 1 conveyor belting. Requirements prohibit component substitution or modification without prior authorization by FM Approvals.

1.5.3 The requirements of this standard reflect tests and practices used to examine characteristics of conveyor belting for the purpose of obtaining FM Approval. These requirements are intended primarily as guides, and strict conformity is not always mandatory. Conveyor belting having characteristics not anticipated by this standard may be Approved if performance equal or superior to that required by this standard is demonstrated, or if the intent of the standard is met. Alternatively, conveyor belting which does meet all the requirements identified in this standard may not be Approved if other conditions which adversely affect performance exist or if the intent of this standard is not met.

1.6 Effective Date

The effective date of an Approval Standard mandates that all products tested for Approval after the effective date shall satisfy the requirements of that standard. Products Approved under a previous edition shall comply with the new version by the effective date or else forfeit approval. The effective date shall apply to the entire Approval standard, or, where so indicated, only to specific paragraphs of the standard.

The effective date of this standard is for full compliance with all requirements is the date of issue.

1.7 System Of Units

Units of measurements are U.S. customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. Appendix A lists the selected units for quantities dealt with in testing these products; conversions to SI units are included. Conversion of U.S. customary units is in accordance with ASTM E380.

II GENERAL INFORMATION

2.1 Product Information

Conveyor belts, typically manufactured in laminated layers from plastics, fibers, and natural and synthetic rubbers, are used to transport a wide variety of materials. Past experience has shown that they are capable of providing a sufficient combustible loading, in and of themselves, which allows for fire to spread from one area to another, even in cases where the conveyed product and enclosing structure, if provided, are noncombustible.

2.2 Requirements

2.2.1 In order to qualify as a Class 1 Conveyor Belt, each conveyor belt shall satisfy all of the following performance criteria.

2.2.2 The Approval examination includes 1) observation of test sample manufacture, 2) flammability characterization of the conveyor belt 3) electrical conductance test, 4) testing to determine the effects of mechanical wear on flammability characterization, 3) testing to determine the effects of UV and/or water exposure on flammability characterization, 6) drum friction test, and 7) other tests as noted. A complete review of installation specifications and, at the discretion of FM Approvals, inspection of one or more field installations shall be conducted to assure, as far as possible, the practicality and reliability of product installation.

2.2.3 When different materials or polymers are used in the construction of the top and bottom surfaces, the above tests may be required for both surfaces to verify that both surfaces meet the requirements of this standards.

2.3 Recognition

Conveyor belting meeting the requirements specified in this standard shall receive a listing in the Approval Guide as Class 1 Conveyor Belting. Limitations for use will be designated within parentheses following the Class designation. Any such limitations are based on the ability of the material to maintain its non-fire propagating characteristics after extended exposure to simulated natural and mechanical elements. See Section 3.2 for designations and limitations on their use.

III APPLICABLE DOCUMENTS AND GLOSSARY

3.1 Applicable Documents

The following standards or reports are referenced in this document:

ASTM G53-93, ‘‘Standard Practice for Operating Light-and-Water Exposure Apparatus (Fluorescent UV — Condensation Type) for Exposure of Nonmetallic Materials’’

ASTM E380-93, ‘‘Practice for Use of the International System of Units (SI)’’

BSI BS 871:1981(1988), ‘‘Specification for Abrasive Papers and Cloths’’

BSI BS 3289:1990, ‘‘Textile Carcasse Conveyor Belting for Use in Underground Mines (Including Fire Performance)’’

FM Global Property Loss Prevention Data Sheet 7-11, ‘‘Belt Conveyors’’, August 1987

FM Global Technical Advisory Bulletin ‘‘Conveyor Belt Flammability’’, July 1993

ISO 284 (1975), ‘‘Specification and Method of Test for Electrical Conductivity of Conveyor Belts’’

3.2 Glossary

Class 1 Conveyor Belting — Conveyor belting material that meets FM Approvals test requirements as non-fire propagating material and all other conditions of this standard. These materials show no adverse effects on their fire propagation properties after extended UV, water exposure and mechanical wear tests. The materials may be used in totally enclosed, partially open, or open system applications.

Class 1 (U) Conveyor Belting — Conveyor belting material that meets FM Approvals test requirements as a non-fire propagating material and shows no adverse effects on its fire propagation properties after extended water exposure and mechanical wear, and exhibits suitable anti-static electricity properties. The materials may be used in totally enclosed system applications or where conditions are wet but there is no exposure to sunlight, such as underground mine tunnels.

Class 1 (TE) Conveyor Belting — Conveyor belting material that meets FM Approvals test requirements as a non-fire propagating material and exhibits suitable anti-static electricity properties. These materials show no adverse effects on their fire propagation properties from mechanical wear. However, they show adverse effects on their fire propagation properties from extended UV and /or water exposure. Use of these materials is restricted to totally enclosed systems where extended water and UV exposure is minimal or nonexistent.

Conveyor Belt — A material handling product used to transport a wide variety of materials, usually of the raw bulk type. Belts vary in width and length. They are generally made from natural and synthetic rubbers and plastic.

Chemical Heat Release Rate (CHRR) — The actual heat release rate during the fire propagation process. It is determined from the generation rates of carbon monoxide and carbon dioxide.

Fire Propagation Index (FPI) — A measure of the fire propagation tendency of a material. It is the ratio of the heat flux provided by the flame off the surface of the material and the material’s Thermal Response Parameter (TRP).

Heat Flux — The rate of heat flow measured across a given surface.

Non-Fire Propagating — The ability of a material to resist flame propagation and to limit the spread of fire within the ignition zone.

Open System — A conveyor system with no housing or hood to protect the conveyor belting or conveyed material from weather conditions such as rain, dew and sunlight.

Partially Open System — A conveyor system having an enclosure with continuous openings along the sides or floor. A conveyor with a weather hood or no floor would be an example of a partially open system.

Thermal Response Parameter (TRP) — A property of a material describing its reaction to heat in terms of ignition temperature, thermal conductivity, density and specific heat; i.e. a measure of the ability for thermal wave penetration into a material.

Totally Enclosed System — A conveyor system having an enclosure that has no continuous openings along the sides or floor and serves to minimize or eliminate exposure of the conveyor belting or conveyed material to potentially harmful weather conditions such as rain, dew and sunlight. Occasional openings such as doors or inspection hatches are permitted. Elevated or grade level structures or tubes, subgrade tunnels, mines, and other underground applications are examples of totally enclosed systems.

IV GENERAL REQUIREMENTS

4.1 Markings

4.1.1 Approved conveyor belting shall bear the following information:

- FM Approval Mark (See Appendix B)
- Manufacturer's name
- Class designation

4.1.2 The markings shall be a repeating pattern placed along the edge of the bottom surface at 10 feet (3.0 m) linear intervals. They shall consist of a wear-resistant stencil, brand or other type suitable to FM Approvals, and be of a contrasting color for ease in identification.

4.1.3 Markings shall be applied only to products that meet FM Approval requirements and only within and on the premises of the specific facility where the finished product was manufactured, and that are inspected under the FM Approvals Facilities and Procedures Audit Program.

4.2 Instructions

Printed installation instructions shall be provided by the manufacturer detailing the necessary installation procedures to be followed by installers.

4.3 Drawings/Formulations/Specifications Required

4.3.1 Detailed drawings shall be submitted for each type of conveyor belt for which Approval is desired. At a minimum, the drawings shall show the product name/number, allowable widths, thicknesses and identification of each layer of material.

4.3.2 Proprietary product formulations, raw materials and suppliers, and a manufacturing process schematic diagram for each product shall be submitted to FM Approvals for review and kept on file at FM Approvals on a confidential basis.

4.4 Manufacturer's Responsibilities

4.4.1 All Approved conveyor belting shall be manufactured with the identical raw materials, additives, and processes as originally tested.

4.4.2 The manufacturer shall notify FM Approvals of any change in product construction, components, raw materials, or component formulation prior to application of Approval marking, distribution, or sale.

4.4.3 The manufacturer shall determine the suitability of the conveyor belting for specific end-use conditions such as strength, elongation, durability, impact resistance, operating temperature range, corrosion resistance, and other product characteristics not evaluated as part of the Approval examination.

4.5 Observation of Test Sample Production

A representative of FM Approvals shall inspect the manufacturing facility for, witness the production of, and place his/her mark on each conveyor belting to be evaluated.

V PERFORMANCE REQUIREMENTS

5.1 Flammability Characterization

5.1.1 Requirement

The flammability characterization of conveyor belting materials is used to determine whether they can be classified as Class 1. Based on these characteristics, a material Fire Propagation Index (FPI) can be determined. Conveyor belts samples with a resulting FPI ≤ 7, shall be termed non-fire propagating and are candidates for FM Approval recognition. Conveyor belt samples with a resulting FPI >7, shall be termed propagating and are not candidates for FM Approval recognition.

5.1.2 Test/Verification

Flammability Characterization using an FM Approvals 50kW Scale Flammability Apparatus as described in Appendices C, D and E.

5.2 Anti-Static Electricity Test

5.2.1 Requirement

The maximum electrical resistance of conveyor belting shall be tested in order to ensure that the material is sufficiently conductive to drain off electrical charges that may form on its surface while in use. The measured electrical resistance shall not exceed 3×10^8 ohms on either surface of the conveyor belting being tested.

5.2.2 Test/Verification

BSI BS 3289:1990, ‘‘Textile Carcasse Conveyor Belting for Use in Underground Mines (Including Fire Performance)’’, Section 15 or I.S.O. 284 (1975), ‘‘Specification and Method of Test for Electrical Conductivity of Conveyor Belts.’’ The conveyor belting sample shall be placed on a sheet of insulating material. An annular brass electrode connected to ground or the low voltage terminal of a measuring instrument shall be placed on the sample. A cylindrical brass electrode connected to the high voltage terminal shall be placed on the sample and within the annular electrode. Voltage is applied for 1 minute and the resistance is measured.

5.3 Accelerated Aging Test

5.3.1 Requirement

The Accelerated Aging Test shall be conducted to determine the effect caused by UV and/or water exposure and mechanical wear on the fire performance characteristics of conveyor belting. The aged samples shall be tested to determine the FPI.

If the FPI obtained after the FM Approvals Accelerated Aging Test procedures is not greater than the allowable limits per Table 1 and less than or equal to 7, then Approval recognition can be extended, provided that the performance requirements as detailed in Paragraph 5.1 and 5.2 are also met.

Table 1

Allowable Percent Increase

Initial FPI	*After Accelerated Aging*
FPI≤2.0	20
2.0<FPI≤4.0	10
4.0<FPI≤6.6	5
FPI>6.6	0

5.3.2 Test/Verification

FM Approvals Accelerated Aging Test Method as described in Appendix F.

5.4 Drum Friction Test

5.4.1 Requirement

Drum friction tests shall be conducted to determine the temperature of the drum surface and to monitor the belt for flaming or glowing. There shall be no flame or glow of the conveyor belting during or after the test. Additionally, the maximum temperature of the drum surface shall be reported.

5.4.2 Test/Verification

BS 3289:1990, ‘‘Textile Carcasse Conveyor Belting for use in Underground Mines (Including Fire Performance),’’ Section 16.1. This test simulates the condition of a ‘‘locked’’ conveyor belting over a rotating drum. Samples of conveyor belting are held in tension around half of a steel drum surface. The steel drum is rotated at constant speed until the conveyor belting breaks. Observations include recording the presence or absence of flame or glow, the maximum temperature of the drum surface; and the amount of time elapsed until the sample breaks.

VI OPERATIONS REQUIREMENTS

6.1 Demonstrated Quality Control Program

6.1.1 A Quality Control Program is required to assure that each subsequent length of conveyor belting produced by the manufacturer shall present the same quality and reliability as the specific samples examined. Design quality, conformance to design, and performance are the areas of primary concern.

Design quality is determined during the examination and tests.

Conformance to design is verified by control of quality in the following areas:

- existence of corporate quality control guidelines
- incoming assurance, including test
- in-process assurance, including test
- final inspection and test
- field installation procedures
- equipment calibration
- drawing and change control
- packaging and shipping
- handling nonconforming materials.

Quality of performance is determined by field performance and by re-examination and test.

6.1.2 The manufacturer shall establish a system of product configuration control to prevent unauthorized changes, including, as appropriate:

- engineering drawings
- engineering change requests
- engineering orders
- change notices

These shall be executed in conformance with a written policy and detailed procedures. Records of all revisions to all Approved products shall be kept.

6.1.3 The manufacturer shall assign an appropriate person or group to be responsible for obtaining FM Approvals authorization of all changes anticipated to Approved products. FM Approvals Form 797, ‘‘Approved Product Revision Report or Address/Contact Change Notice’’, is provided to notify FM Approvals of pending changes. Any such changes shall be submitted prior to fabrication and/or distribution, and shall be agreed to in writing by FM Approvals.

6.2 Facilities and Procedures Audit (F&PA)

6.2.1 An inspection of the product manufacturing facility shall be part of the Approval investigation. Its purpose shall be to determine that the raw materials, formulation, equipment, products, and the manufacturer's controls are properly maintained to produce a product of the same quality, construction and formulation as initially tested.

6.2.2 Unannounced follow-up inspections shall be conducted to assure continued quality control and product uniformity.

APPENDIX A

UNITS OF MEASUREMENT

LENGTH:	in. – ‘‘inches’’; (mm – ‘‘millimeters‘‘) mm = in. × 25.4
HEAT FLUX:	Btu/ft^2/min – ‘‘British thermal units per square foot per minute’’; (kW/m^2 = ‘‘kilowatts per square meter’’) kW/m^2 = Btu/ft^2/min × 0.1891
TEMPERATURE:	°F – ‘‘degrees Fahrenheit’’; (°C – ‘‘degrees Celsius‘‘) °C = (°F – 32) × 5/9 °C = degrees Celsius (°K = degrees kelvin) °K = °C + 273.15
VOLUME PER UNIT TIME:	cfm – ‘‘cubic feet per minute’’; (m^3/s – ‘‘cubic meters per second) m^3/s = cfm × 0.000472

APPENDIX B

APPROVAL MARKS

REPRODUCTION ART: FM Approval Marks

For use on nameplates, in literature, advertisements, packaging and other graphics.

1) The FM Approvals diamond mark is acceptable to FM Approvals as an Approval mark when used with the word ‘‘Approved.’’

2) The FM Approval logomark has no minimum size requirement, but should always be large enough to be readily identifiable.

3) Color should be black on a light background or a reverse may be used on a dark background.

For Cast-On Marks

4) Where reproduction of the mark described above is impossible because of production restrictions, a modified version of the diamond is suggested. Minimum size specifications are the same as for printed marks. Use of the word ‘‘Approved’’ with this mark is optional.

NOTE: These Approval marks are to be used only in conjunction with products or services that have been FM Approved. The FM Approval marks should never be used in any manner (including advertising, sales or promotional purposes) that could suggest or imply FM Approval or endorsement of a specific manufacturer or distributor. Nor should it be implied that Approval extends to a product or service not covered by written agreement with FM Approvals. The Approval marks signify that products or services have met certain requirements as reported by FM Approvals.

Additional reproduction art is available through

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P.O. Box 9102,
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APPENDIX C

DETERMINATION OF THE FIRE PROPAGATION INDEX (FPI)

C-1 Introduction

The test method utilized in this standard is based on a quantitative numerical value called the Fire Propagation Index (FPI). It is assigned to a material based on ignition and heat release properties as measured in a test apparatus. Using advanced calorimetry testing technology, this test method has been developed which has an excellent correlation to existing full-scale test methods, such as the U.S. Bureau of Mines (USBM) Large-Scale Fire Galley, used to determine the flame propagation characteristics of conveyor belting.

In order to determine the FPI for a material, it is necessary to conduct two tests using the FM Approvals 50 kW Flammability Apparatus (See Appendix D, Figure D-1). The first test is the Piloted Ignition Test. The second test is the Fire Propagation Test (See Appendices D and E, respectively, for details of these test methods).

C-2 Piloted Ignition Test

C-2.1 For details of the Piloted Ignition Test method, see Appendix D.

C-2.2 In the Piloted Ignition Test, conveyor belt samples are exposed to a different external radiant heat flux. The heat flux values and the time to ignition, t_{ig}, are recorded for each sample. The relationship between each external radiant heat flux and the inverse of the square root of time to ignition is then plotted in graphical form (Figure C-1).

A regression analysis is performed on the linear portion of the inverse slope of the curve to obtain the Thermal Response Parameter (TRP) of the conveyor belting. This can be expressed as:

$$TRP = \Delta t_{ig} (k p c)^{1/2}, \text{ where:}$$

Δt_{ig} is the ignition temperature rise above the sample surface temperature of K,
k is the thermal conductivity, Btu × ft/(h × ft^2 × °F)(kW/m-k) of the sample,
p is the density, lbs/ft^3 (kg/m^3) of the sample,
and c is the specific heat, cal/g- °C(kJ/kg-k) of the sample.

C-3 Fire Propagation Test

C-3.1 For details of the Fire Propagation Test method, see Appendix E.

C-3.2 In the Fire Propagation Test, all fire products, along with the ambient air, are captured in the sampling duct. In the duct is a measurement section where concentrations of CO (carbon monoxide) and CO_2 (carbon dioxide), total volumetric flow, gas temperatures and ambient temperatures, are measured as a function of time.

Based on the measurements of the generation rates of CO and CO_2, the Chemical Heat Release Rate (CHRR) of the material, Q_{chem}, as a function of time can be computed using a formula:

$$\dot{G}_i = \dot{v} c_i p_i$$

where:

$\dot{G}_i$ is the generation rate of i (either CO or CO_2) in lb/s(g/s)
$\dot{v}$ is the volumetric flow rate of ft^3/s (m^3/s)
c_i is the measured concentration of i (either CO or CO_2), and
p_i is the density of i (either CO or CO_2) in lb/ft_3 (g/m_3)

The chemical heat release rate, $\dot{Q}_{ch}$ in kW as a function of time is calculated from the generation rates of CO_2 and CO as follows:

$$\dot{Q}_{ch} = 12.5\ \dot{G}_{CO_2} + 9.5\ \dot{G}_{CO},$$

where:

constants 12.5 and 9.5 are average values for conveyor belt material $\dot{G}_{CO_2}$ and $\dot{G}_{CO}$ are the generation rates of CO_2 and CO, respectively, in g/s.

C-4 Fire Propagation Index

C-4.1 The FPI is calculated as a function of time based on the results obtained from the Piloted Ignition Test and the Fire Propagation Test according to the formula:

$$FPI = \frac{[(X_{rad} / X_{ch})\ \dot{Q}'_{chem}]^{1/3} \times 10^3,}{TRP} \times 10^3$$

where:

X_{ch} is the combustion efficiency
X_{rad} is the radiant component of X_{ch}
X_{rad} / X_{ch} is assumed to be 0.40 for turbulent fires,
and $\dot{Q}'_{chem}$ is the CHRR per unit width for the sample in kW/m

C-4.2 Based on the above, the FPI of a material can be determined. A higher value of the FPI is associated with a higher fire propagation rate.

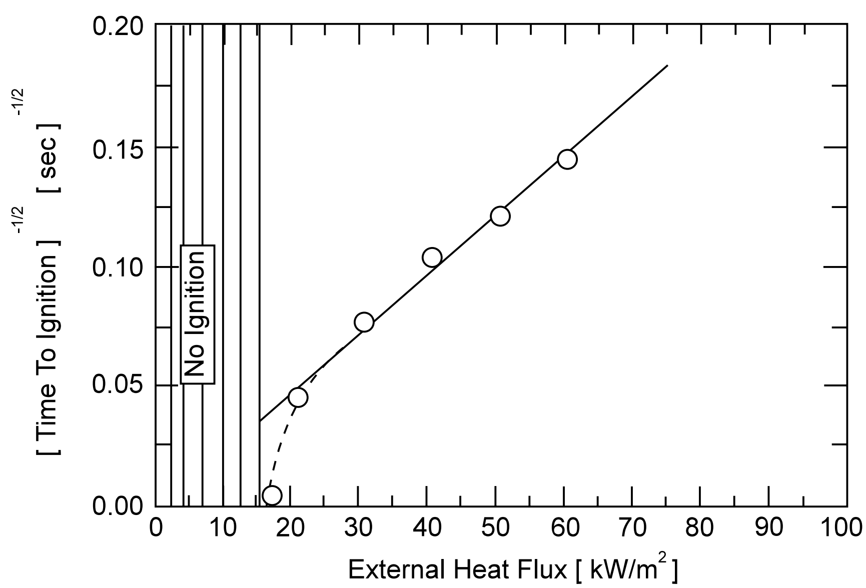

Fig. C-1. Relationship Between Time to Ignition and External Heat Flux

APPENDIX D

PILOTED IGNITION TEST METHOD

D-1 Introduction

The Piloted Ignition Test method is used to determine the TRP of conveyor belting materials for the evaluation of fire propagation behavior.

D-2 Test Apparatus

D-2.1 The Piloted Ignition Test is conducted using the FM Approvals 50 kW Flammability Apparatus as shown in Figures D-1 and D-2. Figure D-1 shows an overall sketch of the apparatus whereas Figure D-2 shows the lower part of the apparatus used for the Piloted Ignition Test.

D-2.2 For this testing, a conveyor belt sample, 3 in. × 3 in. (76 mm × 76 mm), is placed on the sample holder/platform of the test apparatus. Prior to placement in the apparatus, the sample is coated with carbon black. The sample is surrounded by four high density tungsten-quartz radiant heaters. The radiant heaters are used to expose the sample to various external heat fluxes. The combustible vapors that are generated, as a result of the external heat flux, are ignited with a pilot flame.

The pilot flame, adjusted to provide a blue-white flame, consists of a horizontal premixed ethylene-air flame, established at the ceramic tip of a 0.25 in. (6 mm) diameter metallic tube, attached to ethylene and air cylinders. The pilot flame is about 0.4 in. (10 mm) long and is located within 0.4 (10 mm) of the conveyor belting surface.

D-3 Test Procedure

D-3.1 Conveyor belt samples, supplied by the manufacturer, shall be prepared and cleaned. Each sample shall be 3 in. × 3 in. (76 mm × 76 mm), and thoroughly cleaned using a warm, soapy solution to remove all surface deposits, film or residue that may impact ignition. Any oil, grease or other residue remaining on the surface shall be removed by use of methyl, ethyl or isopropyl alcohol. The surface shall be towel-dried and allowed to stand at room temperature until completely dry.

D-3.2 The cleaned surface of the conveyor belting shall be lightly coated with carbon black.

D-3.3 The sample is then placed on the holder/platform which is positioned such that the height of the centerline of the sample is located at the point of maximum heat flux intensity.

D-3.4 The pilot flame, adjusted by the flow of ethylene and air, shall be 0.4 in. (10 mm) long and placed within 0.4 in. (10 mm) of the surface of the conveyor belting material.

D-3.5 The water-cooled radiant heater shield shall be raised and power to the radiant heater turned on. The voltage shall be increased to produce the initial test setting of 158 Btu/ft^2/min (30 kW/m^2). After one minute, the shield shall be lowered and a stopwatch shall be started. The elapsed time on the stopwatch shall be defined as time to ignition, t_{ig}.

D-3.5.1 A split stopwatch shall be used to record flash (entire sample ignites briefly, but fails to support combustion) time(s) as well as sustained ignition time. The sustained ignition time shall be designated as the ‘‘time to ignition’’.

D-3.5.2 An individual test shall be terminated if the sample fails to ignite after 15 minutes. In this case, the test results shall be recorded as ‘‘No Ignition’’.

D-3.6 The above procedure shall be repeated for each of the radiant heater test sequences shown in Table D-1. The measured data for time to ignition, t_{ig}, and the corresponding external heat flux, shall be recorded for each sample.

If the piloted ignition data is graphically plotted and exhibits clear curvilinear behavior between the heat fluxes of 158 to 211 Btu/ft^2/min (30 to 40 kW/m^2) as shown in Table D-1, Test Sequence 1 data point shall be discarded and Test Sequence 5 added. The heat flux of Test Sequence 5 shall be either 238 to 291 Btu/ft^2/min (45 to 55 kW/m^2).

Table D-1

Radiant Heater Test Sequence for Ignition Testing Heat Flux

Test Sequence	*Btu/ft^2/min*	*(kW/m^2)*
1	158	(30)
2	211	(40)
3	264	(50)
4	317	(60)

D-4 Test Results

D-4.1 The values for each incremental external heat flux and the corresponding inverse of the square root of the time to ignition, $t_{ig}^{-1/2}$, shall be plotted on the x-axis and y-axis, respectively.

D-4.2 The TRP shall be determined from the inverse of the slope of the best fitted line formed from the above, using the least-mean square procedure. A regression analysis of the data shall be performed and shall result in a least-mean square correlation coefficient of at least 0.996. This will assure a maximum 5% error in determining the TRP.

D-4.2.1 When ignition occurs at all heat fluxes, but the correlation coefficient is determined to be less than 0.996, the data shall be plotted as shown in Appendix C, Figure C-1.

D-4.2.2 If the plot clearly indicates that the 158 Btu/ft^2/min (30kW/m^2) data point is outside the linear range, it shall be discarded and a substitute ignition test conducted at a heat flux of either 238 or 291 Btu/ft^2/min (45 or 55 kW/m^2).

D-4.2.3 If the resulting correlation coefficient of these four points is less than 0.996, four additional piloted ignition tests at the heat fluxes normally selected between 211 and 317 Btu/ft^2/min (40 and 60 kW/m^2) shall be conducted.

D-4.2.4 If the ignition plot does not suggest curvilinear behavior at the 158 Btu/ft^2/min (30 kW/m^2) heat flux, four additional ignition tests shall be performed at different heat flux settings.

D-4.3 If ignition of the test sample does not occur at 158 Btu/ft^2/min (30 kW/m^2) after a full 15 minutes, and the correlation coefficient for the remaining three points is greater than or equal to 0.996, the TRP shall be determined from these three points. If the correlation coefficient is less than 0.996, five additional ignition tests shall be conducted at elevated heat fluxes.

D-4.4 If the test samples fail to ignite at both 158 and 211 Btu/ft^2/min (30 and 40 kW/m^2), six additional ignition tests shall be conducted with the heat fluxes selected so that the eight total data points are distributed with three each at 317 and 291 Btu/ft^2/min (60 and 55 kW/m^2) and the remaining two points at 264 Btu/ft^2/min (50 kW/m^2).

While this may not significantly improve the correlation coefficient, the confidence level of the best fit line drawn through the eight data points will be higher.

D-4.5 After all the tests for plotted ignition have been completed, the tests described in Appendix E, Fire Propagation Test Method, shall be performed.

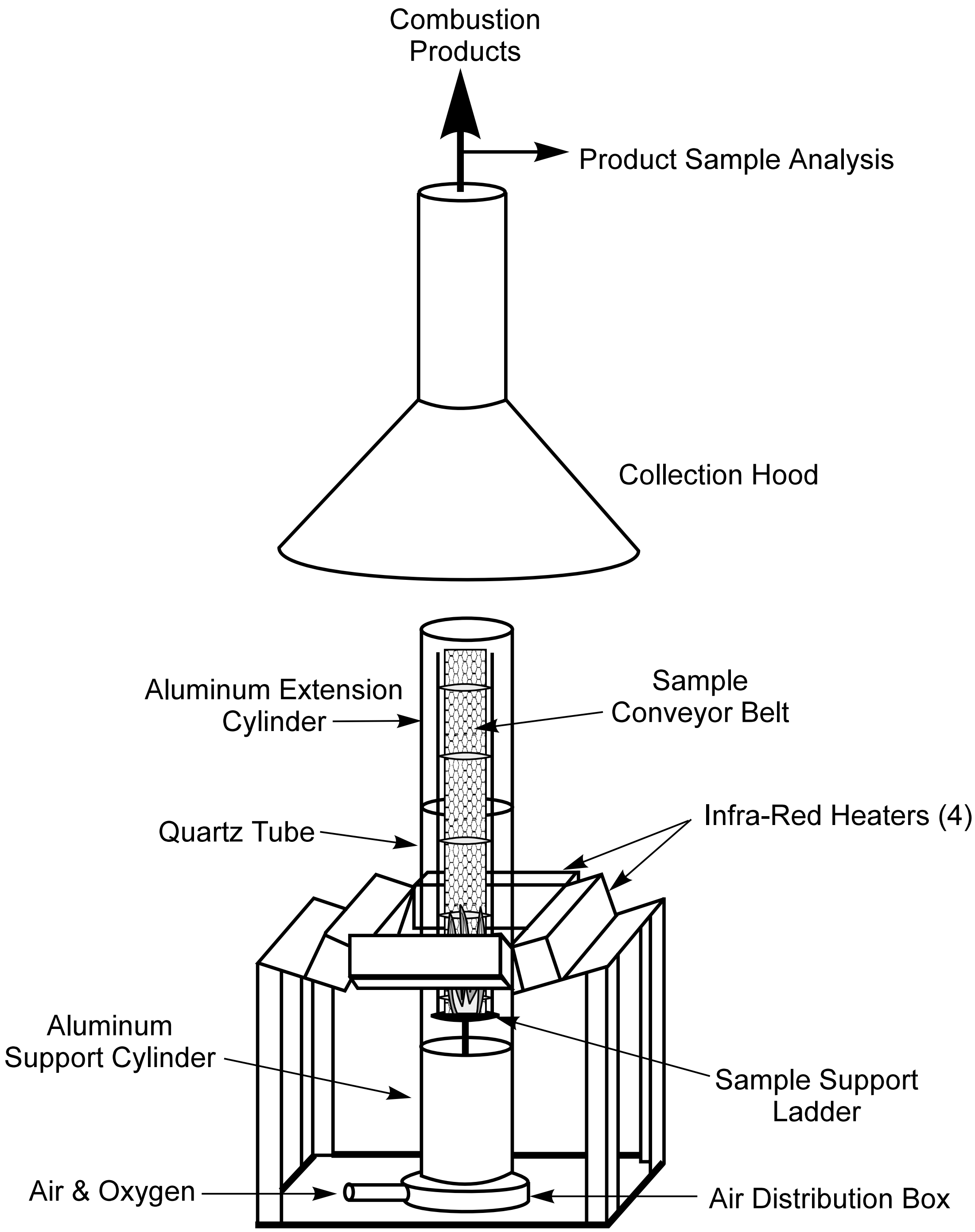

Fig. D-1. 50 kW-Scale Flammability Apparatus

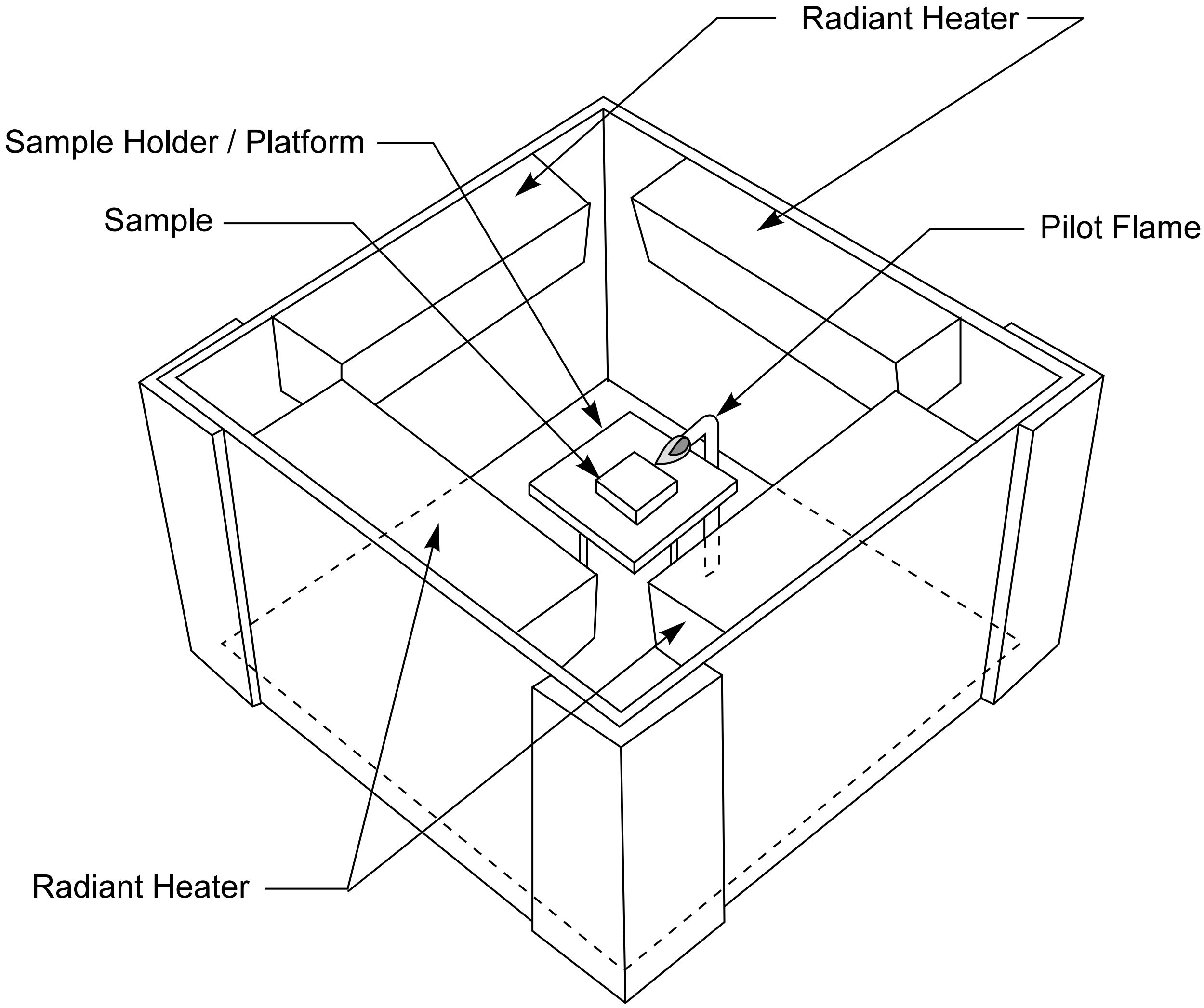

Fig. D-2. Piloted Ignition Test Method Setup

APPENDIX E

FIRE PROPAGATION TEST METHOD

E-1 Introduction

The Fire Propagation Test method is used to obtain the generation rates of CO (carbon monoxide) and CO_2 (carbon dioxide). These values are needed to determine the Chemical Heat Release Rate (CHRR) for evaluating the fire propagation behavior and to determine the Fire Propagation Index.

E-2 Test Apparatus

E-2.1 The Fire Propagation Test is conducted using the FM Approvals 50kW Flammability Apparatus as shown in Appendix D, Figure D-1, which shows the lower part of the Apparatus where the conveyor belting sample is placed for fire propagation testing.

E-2.2 For this testing, a conveyor belt sample 3 in. wide by 12 in. long (76 mm × 305 mm) is required. Heavy duty aluminum foil is used to cover the back and ceramic paper is used to cover the edges of the sample, leaving only the front face exposed. The sample is surrounded by a quartz or Pyrex tube, 12 in. (305 mm) in diameter and approximately 24 in. (610 mm) in length. Placed on top of the quartz or Pyrex tube is a 12 in. (305 mm) diameter aluminum extension tube approximately 24 in. (610 mm) in length which directs all gases and particulates into the collection funnel. Holes ⅜ in. (9.5 mm) in diameter are drilled through the tube, vertically, for observation purposes.

The sample is placed in the FM Approvals sample holder until it rests upon the base, is centered and then fastened near the bottom by three set screws in the base of the holder, and held firmly near its upper end by No. 24 gauge nichrome wire attached to the two upright supports. The conveyor belt height is adjusted so that 3 in. (76 mm) above the top edge of the base of the sample holder corresponds to the peak level of the directed external heat flux.

E-2.3 The conveyor belt sample is surrounded by four radiant heaters and the bottom 3 in. (76 mm) of the belt is exposed to 264 Btu/ft^2/min (50 kW/m^2) of external heat flux. A pilot flame, located 3.5 in. (89 mm) above the bottom end of the sample is used to ignite the combustible vapors.

The pilot flame, adjusted to produce a blue-white flame, consists of a horizontal, premixed ethylene-air flame, established at the ceramic tip of a 0.25 in. (6 mm) diameter metallic tube attached to ethylene and air cylinders. The pilot flame is about 0.4 in. (10 mm) long and is located within 0.4 in. (10 mm) of the conveyor belting surface.

E-2.4 To simulate large-scale flame radiation conditions, air with an oxygen concentration of 40% is introduced at the air distribution chamber inlet and travels upward through the quartz (Pyrex) tube at a flow rate of 7 cfm (0.2 m^3/min) (see Appendix D, Figure D-1). The oxygen concentration of the air is monitored by an oxygen analyzer and an airflow meter.

E-2.5 The fire products generated during the test are captured in the sampling duct of the Apparatus. Measurements are made for the concentrations of CO, CO_2, and volumetric flow rate, $\dot{v}$

E-3 Test Procedure

E-3.1 Conveyor belt samples shall be prepared and cleaned. Each sample shall be 3 in. wide by 12 in. long (76 mm × 305 mm) and thoroughly cleaned using warm, soapy solution to remove all surface deposits, film or residue that may impact ignition. Any oil, grease or other residue remaining on the surface shall be removed by use of methyl, ethyl or isopropyl alcohol. The sample shall be towel-dried and allowed to stand at room temperature until completely dry.

E-3.2 Heavy duty aluminum foil is used to cover the back of the sample and ceramic paper to cover the edges leaving only the front face exposed. The test sample is then placed, centered and secured, in the test sample holder, both of which are then inserted into the central base of the air distribution chamber.

E-3.3 The exhaust stack blast gate is then opened and the data acquisition system turned on. The pressure transducer in the exhaust shall be adjusted to zero referenced value. The exhaust blower shall be turned on. All gas analyzers are calibrated.

E-3.4 The pilot flame shall be lit and the ethylene-air mixture adjusted to produce a flame cone length of 0.4 in. (10 mm). The horizontal flame shall then be directed to within 0.4 in. (10 mm) of the samples outer surface. The quartz (Pyrex) tube shall be placed over the sample. The aluminum extension tube is placed on top of the quartz (Pyrex) tube. The airflow into the bottom of the tube shall be set at 7 cfm (0.2 m^3/min.). The oxygen concentrations in the air entering the tube shall be increased to 40% ± 1% by adding a metered concentration of 100% oxygen while maintaining the proper airflow through the Apparatus at 7 cfm (0.2 m^3/min.).

E-3.5 The computer acquisition system shall be initiated and compile three minutes of background data (ambient conditions). The pilot flame shall be lit and the test sample cooling shield raised. The cooling water supply for both the shield and the infrared heaters shall be turned on. The infrared radiant heater's power controller shall be turned on and adjusted to a setting of 264 Btu/ft^2/min (50kW/m^2), which is to be stabilized within 30 seconds. An additional 30 seconds shall be allowed, but not exceeded, before the start of the test is initiated. This protocol prevents re-radiated heat from affecting the conveyor belt above the protecting cooling shield.

E-3.6 A stopwatch shall be used to record event times. The cooling shield shall be dropped at 30 seconds. Observation and notes shall be recorded.

E-3.6.1 As the test sample is exposed to the energy produced by the infrared radiant heaters, vapors are generated. When they reach a combustible level, they will be ignited by the pilot flame. Following ignition of the test sample, the pilot flame is turned off.

E-3.6.2 During the course of the test, exhaust gases are drawn from the exhaust stack and analyzed. The concentration of CO and CO_2 are recorded. The volumetric flow rate, $\dot{v}$, shall be measured using the exhaust stack mounted pilot tube.

E-3.7 The test sample shall be allowed to burn until it self-extinguishes. Data shall continue to be collected for an additional three minutes at which time the test shall be terminated and the radiant heaters and supplementary oxygen supply turned off. The exhaust blower should be left on to aid cooling of the Apparatus.

E-4 Test Results

E-4.1 Following completion of the test, the data generated over the length of the test is analyzed by computing the FPI. $\dot{Q}'_{ch}$ is calculated from the CO_2 and CO generation rates, which are taken at a scan rate of one scan per second. Then using Eq. C-4.1, the FPI is determined for 15 sec. rolling average of $\dot{Q}'_{ch}$ as a function of time. The peak FPI is reported.

This averaging is used to prevent nonrepresentative, transient fire spikes from adversely influencing the peak FPI values that are reported. A sample plot is shown in Figure E-1.

E-4.2 In order to receive FM Approval, three individual Fire Propagation Tests shall be conducted on each conveyor belting material. The three FPI peak values determined shall also be subjected to a statistical evaluation to determine their means and standard deviation values. These calculated values shall then be substituted into the equation below. The FPI value thus obtained shall be the average peak value of the sample population.

$$FPI = 1.1S_x + \bar{x},$$

where

1.1 = 90% confidence level factor for the sample size of three
S_x = Standard deviation
$\bar{x}$ = Mean (average) value

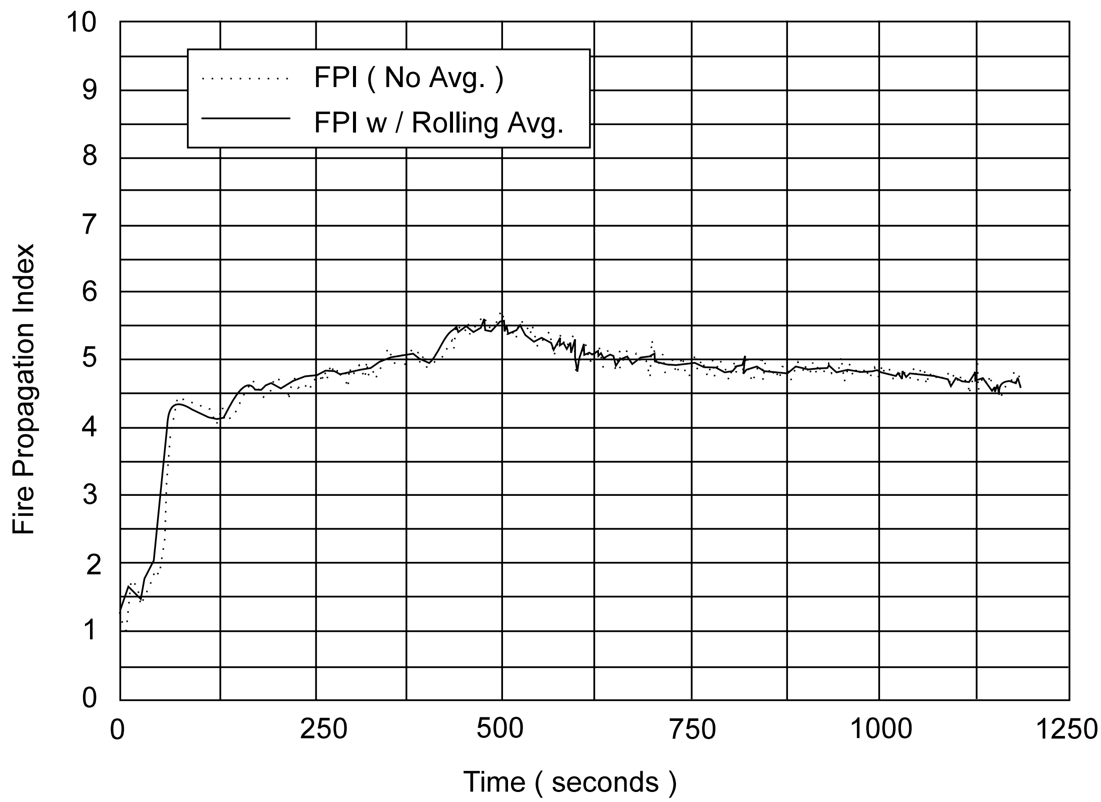

Fig. E-1. Fire Propagation Index for Conveyor Belt as a Function of Time

APPENDIX F

FM APPROVALS
ACCELERATED AGING TEST METHOD

F-1 Introduction

The FM Approvals Accelerated Aging Test is intended to simulate the deterioration caused by the ultraviolet energy of sunlight and/or water as rain or dew and mechanical wear. It is not intended to simulate the deterioration caused by localized weather phenomena such as atmospheric pollution, biological attach, or saltwater exposure.

This test procedure includes the FM Approvals Accelerated Wear Test procedures, optional FM Approvals Accelerated Weathering Test procedures, and Flammability Characterization.

F-2 Sequence of Testing

F-2.1 All conveyor belting shall first be aged by mechanical wear. Mechanical wear shall be simulated by the FM Approvals Accelerated Wear Test procedures.

F-2.2 Upon completion of the mechanical wear test procedures, optional weathering exposure will be completed. Weathering shall be simulated by the FM Approvals Accelerated Weathering Test procedures. The type of weathering exposure to conveyor belting is subjected to, will be at the discretion of the manufacturer. The type of exposure needed for the desired Approval recognition is summarized in Table F-1.

Table F-1

Approval Aging Exposure for Recognition

Desired Recognition	
Class 1:	Mechanical Wear and UV and Water
Class 1 (U):	Mechanical Wear and Water
Class 1 (TE):	Mechanical Wear

F-2.3 After the conveyor belting has been aged per Table F-1, the FPI will be determined utilizing the FM Approvals 50 kW Scale Flammability Apparatus.

F-3 FM Approvals Accelerated Mechanical Wear Test

F-3.1 A sample conveyor belt measuring 4 in. by 54 in. (102 mm x 1371 mm) shall be prepared by removing the cover of the surface to be tested for flammability characterization. The cover shall be removed down to the carcass such that all the knuckles of the fabric are exposed.

F-3.2 The cover shall be removed by buffing on a band facer until all the knuckles of the carcass fabric are exposed. The belting shall be applied intermittently to avoid frictional heating. Care shall be taken to avoid spreading a layer of cover material over the knuckles of the fabric.

F-3.3 The abrasive band shall be grade P60 in accordance with BS 871.

F-4 FM Approvals Accelerated Weathering Test

The FM Approvals Accelerated Weathering Test shall be conducted in accordance with ASTM G 53 ‘‘Standard Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials.’’ The exposure cycles shall be as follows:

F-4.1 (A) For UV and water exposure tests the samples shall be placed in the test apparatus and conditioned for 6 weeks (1008 hours). The cycle time shall be 8 hours UV at 140°F ± 5°F (50°C ± 3°C). The UV source shall be UV-B lamps with a peak emission of 313 nm.

F-4.2 (B) For water exposure tests, the samples shall be placed in the test apparatus and conditioned for 2 weeks (336 hours), during which time the sample will be continuously exposed to condensation at 122°F ± 5°F (50°C ± 3°C).

F-5 Flammability Characterization

The FPI of the aged samples shall be determined by using the FM Approvals 50kW Scale Flammability Apparatus as described in Appendices C, D and E.