FM Approvals®

Member of the FM Global Group

Approval Standard for Cooling Towers

Class Number 4930

October 2016

Foreword

Approvals are intended to verify that the products and services described will meet 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 Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for Approval shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing and/or applications shall ensure a consistently uniform and reliable product or service. Approval Standards strive to be performance-oriented and 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 Master 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 or service/application.

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

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Purpose

1.1.1 This standard states Approval requirements for cooling towers and cooling tower components. Cooling towers or cooling tower components that meet the requirements of this standard do not need automatic sprinkler protection.

1.1.2 Approval criteria may include, but are not limited to, fire, wind, ice, snow and seismic performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a follow-up program.

1.2 Scope

1.2.1 This standard sets the requirements for cooling towers constructed with combustible and non-combustible components. Typical combustible components may include, but are not limited to, structural carrying/support members, fill, drift eliminators, louvers, fan, fan deck, piping, enclosure walls or partition walls.

1.2.2 This standard applies to both factory assembled and field erected cooling towers. The cooling towers that meet the requirements for combustibility, as well as wind, ice, snow, and seismic loads, shall be eligible for Approval.

1.2.3 The fire performance of a cooling tower depends in part on the size, configuration and material formulation(s) of the individual components when assembled into a functional cooling tower. It is therefore necessary to evaluate these products as assembled units. These assembled units are included within the standard tests.

1.2.4 This standard is intended to verify that the systems as described will meet the stated conditions of performance, safety and quality useful to determine the suitability for end-use conditions of these products. The cooling tower manufacturer is responsible for the design of the thermal capacity of the cooling tower and to meet corrosion resistance requirements dictated by the end use of the tower.

1.2.5 The quantity and toxicity of the products of combustion are not analyzed as part of this standard. Additional precautions by the user may need to be taken if the product is utilized near an area susceptible to smoke damage.

1.3 Basis for Requirements

1.3.1 The requirements of this standard are based on experience, research and testing. The advice of manufacturers, users, trade associations and loss control specialists was also considered.

1.3.2 The requirements of this standard reflect tests and practices used to examine characteristics of cooling towers for the purpose of obtaining FM Approval. These requirements are intended primarily as guides, and strict conformity is not always mandatory. Cooling towers 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, cooling towers which do 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.

1.4 Basis for Approval

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

1.4.1 The Approval examination and tests on production samples to evaluate the combustibility, fire and wind hazard properties of the cooling tower and an engineering evaluation of the structural design to determine the ability of the assembly to adequately withstand certain live loads, including wind and seismic. A complete review of the product as well as construction specifications shall be conducted to ensure, as far as possible, a practical and reliable installation.

1.4.2 An examination of the manufacturing facilities and audit of quality control procedures is made to evaluate the manufacturer's ability to consistently produce the product which is examined and tested, and the marking procedures used to identify the product. These examinations may be repeated as part of FM Approvals' product follow-up program.

1.5 Basis for Continued Approval

Continued Approval is based upon:

- Production or availability of the product as currently FM Approved;
- The continued use of acceptable quality assurance procedures;
- Satisfactory field experience;
- Compliance with the terms stipulated in the Approval report;
- Satisfactory re-examination of production samples for continued conformity to requirements;
- Satisfactory Surveillance Audits conducted as part of FM Approvals' product follow-up program.

Also, as a condition of retaining Approval, manufacturers may not change a product or service without prior authorization by FM Approvals.

1.6 Effective Date

1.6.1 The effective date of an Approval standard mandates that all cooling tower products or components tested for Approval after the effective date shall satisfy the requirements of this standard. Products Approved under a previous edition shall comply with the new version by the effective date or else forfeit Approval.

1.6.2 The effective date of this standard is October 1, 2016 for compliance with all requirements.

1.7 System of Units

Units of measurement used in this standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Appendix A lists the selected units and conversions to SI units for measures appearing in this standard. Conversion of U.S. customary units is in accordance with the American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing Materials (ASTM) SI 10-2010, "American National Standard for Metric Practice."

1.8 Applicable Documents

The following standards, test procedures, test methods, and practices are referenced in this standard:

Procedure Class Number 4930: Full-Scale Fire Test Procedure for Cooling Towers

Procedure Class Number 4930: Intermediate Scale Fire Test Procedure for Fill and Drift Eliminator Components for Cooling Towers

Procedure Class Number 4930: Intermediate Scale Fire Test Procedure for Components Other Than Fill and Drift Eliminators for Cooling Towers

Procedure Class Number 4881: Test Method for Exterior Wall Systems Impacted by Windborne Debris

Procedure Class Number 4881: Structural Test Method for Exterior Walls Using Cyclic Air Pressure Differentials

Approval Standard 4881, Class 1 Exterior Wall Systems (November 2007)

FM Global Property Loss Prevention Data Sheet 1-2, *Earthquakes*, May 2008

FM Global Property Loss Prevention Data Sheet 1-6, *Cooling Towers*, January 2006

Seismic Approval of Cooling Towers (by Praveen K. Malhotra, FM Global Research, Senior Research Specialist, Jan 07)

ASTM E2058, "Standard Test Methods for Measurement of Synthetic Polymer Material Flammability Using a Fire Propagation Apparatus (FPA)"

1.9 Definitions

For purposes of this standard, the following terms apply:

Cold Water or Water Collection Basin – A collection pan located at the base of the cooling tower to receive the cold water after it has run down through the fill material and direct it from the tower.

Crossflow Cooling Tower – A cooling tower in which the cooling air flows horizontally across the falling water. These units may have one or two sets of fill. When two sets of fill are present, they are generally located opposite one another and are separated by an open plenum. To provide for cooling air flow, these units may have a top mounted horizontal fan (induced mechanical draft), a bottom mounted fan (forced mechanical draft), a large hyperbolic stack (natural draft), or a combination (fan and hyperbolic stack).

Counterflow Cooling Tower – A cooling tower in which the cooling air flows vertically upward against the falling water. Typically these units will have one set of fill. To provide for cooling air flow, these units may have a top mounted horizontal fan (induced mechanical draft), a side mounted vertical fan(s) (also, induced mechanical draft), a bottom mounted fan (forced mechanical draft), a large hyperbolic stack (natural draft), or a combination (fan and hyperbolic stack).

Distribution System – The method used to distribute the warm water throughout the cooling tower.

Drift Eliminators – Drift eliminators are located on the leeward or exit air side of the fill material and catch or stop small particles of water (drift) from exiting the tower.

Factory Assembled Cooling Towers – Cooling towers which are fabricated in a factory and are delivered to their destination as a complete unit. These are generally small in size allowing them to be located on

building roofs as well as at ground level.

Fan Blades – Mechanical device used for drawing or forcing cooling air through the cooling tower.

Fan Cylinders (Stack) – The area of the cooling tower which encircles the fan blades through which the cooling air travels.

Fan Deck – The uppermost horizontal surface of a cooling tower upon which the fan stack is located.

Field Erected Cooling Towers – Cooling towers in which individual components arrive separately at a site where they are assembled in place. These towers are generally much larger in size than the factory assembled towers.

Fill Material – The medium over which hot water flows within the cooling tower to provide a continuous water film (wetted surface) as cooling air flows past it to remove heat from the water, thus providing an efficient cooling capacity of the tower.

Flexible Cooling Tower – A cooling tower shall be considered flexible if its fundamental natural mode of vibration has a period greater than or equal to 0.033 second (i.e., fundamental natural frequency less than or equal to 30 Hz). The manufacturer shall demonstrate through rigorous testing or analysis that the cooling tower is either rigid or flexible. A spring-mounted (vibration isolated) cooling tower shall always be considered flexible.

Forced Draft Cooling Tower – A mechanical draft cooling tower where the fan and drive are located below and perpendicular to the fill and force cooling air through the fill, past the dripping water and out the exhaust stack of the tower. Forced draft cooling towers are usually counterflow type cooling towers.

Induced Draft Cooling Tower – A mechanical draft cooling tower where the fan is located at the top (air exhaust) of the tower and draws the cooling air through the fill, past the dripping water. Induced draft cooling towers may be either crossflow or counterflow type cooling towers.

Louvers – Blades located on the windward or entering air side of the fill material and direct the air into the fill and help contain the falling water within the tower.

Mechanical Draft Cooling Tower – A cooling tower in which fans are used to provide a continuous movement of cooling air. These types of towers fall into two basic categories: Induced Draft or Forced Draft

Natural Draft (Hyperbolic) Cooling Tower – A cooling tower with a very high vertical stack in which air movement is provided by the stack effect resulting from the difference in density between two interconnected columns of air at different temperatures. As warm air rises it draws in cool air from below.

Rigid Cooling Tower – A cooling tower shall be considered rigid if its fundamental natural mode of vibration has a period less than 0.033 second (i.e., fundamental natural frequency greater than 30 Hz). The manufacturer shall demonstrate through rigorous testing or analysis that the cooling tower is either rigid or flexible.

2 GENERAL INFORMATION

2.1 Product Information

2.1.1 Cooling towers may be fabricated with both combustible and noncombustible components. Combustible products that are found in the manufacture of a majority of the cooling tower components constructed today include the following:

- Casing Walls – Fiberglass Reinforced Plastic (FRP)
- Fan Stacks – FRP
- Fan Decks – FRP
- Distribution Decks – FRP
- Fans – Hollow Fiberglass Reinforced Polyester and Fiberglass Reinforced Epoxy
- Drift Eliminators – Polyvinyl Chloride (PVC)
- Counterflow Distribution – PVC or FRP mains with PVC laterals and full cone molded Acrylonitrile Butadiene Styrene (ABS) or polypropylene plastic nozzles.
- Cooling Tower Fill – Most cooling tower fill material in use today is made of formed PVC either in individual corrugated sheets or assembled into film packs. Splash bar fill is primarily extruded PVC. Wood fill is used where winter conditions require the fill to carry ice loads, however, wood components are not considered for Approval.
- Air Inlet Louvers – FRP
- Internal Partitions – FRP
- Cold Water Basin – FRP
- Wood is used in the construction of many types of cooling towers as structural members as well as fill material. However, wood is not considered for Approval due to the difficulty of providing adequate fire resistant chemicals that will withstand the harsh cooling tower environment without leaching out of the wood.

2.1.2 Cooling towers may be supplied factory assembled or field erected. The factory assembled towers are generally smaller towers such that they may be transported as an individual unit and put into service almost immediately upon arrival at its destination. Field erected towers are much larger towers which are too large to be transported as individual units. Individual components of these towers are typically manufactured at various locations and delivered to the site and assembled in place. Field erected towers may be as large as several hundred feet in diameter or length.

2.2 Approval Application Requirements

To apply for an Approval examination the manufacturer, or its authorized representative, shall submit a request to information@fmapprovals.com.

The manufacturer shall provide the following preliminary information with any request for Approval consideration:

- A complete list of all models, types, sizes, and options for the products or services being submitted for Approval consideration;
- General assembly drawings, complete set of manufacturing drawings, materials list, anticipated marking format, piping and electrical schematics, nameplate format, brochures, sales literature, spec. sheets, installation, operation and maintenance procedures;
- The number and location of manufacturing facilities.
- All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.

2.3 Requirements for Samples for Examination

2.3.1 Following authorization of an Approval examination by the manufacturer, FM Approvals shall review the submitted preliminary product information and determine the sample requirements for examination and testing.

2.3.2 Requirements for samples may vary depending on design features, results of prior or similar testing, and results of any foregoing tests.

2.3.3 At the sole discretion of FM Approvals, production of samples submitted for testing for Approval recognition may be witnessed by a representative of FM Approvals. The representative will place an identification mark on the component(s) to be evaluated. The components shall then be shipped to FM Approvals or the alternate test location. Any decision to use data generated using prototypes is at the discretion of FM Approvals.

3 GENERAL REQUIREMENTS

3.1 Markings

3.1.1 Marking on the product shall include the following information:

- name and address of the manufacturer or marking traceable to the manufacturer;
- date of manufacture or code traceable to date of manufacture or lot identification;
- model number, size, performance rating, wind pressure rating, seismic rating, capacity, etc., as appropriate. When hazard warnings are needed, the markings shall be universally recognizable.

3.1.2 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the product as FM Approved. The manufacturer shall not place this model or type identification on any other product unless covered by a separate agreement.

3.1.3 The Approval Mark (see Appendix B) shall be displayed visibly and permanently on the product and/or packaging as appropriate. The manufacturer shall not use this Mark on any other product unless such product is covered by a separate report.

3.1.3.1 Approved complete cooling towers shall bear a corrosion-resistant metal name plate denoting FM Approval. The nameplate shall bear the manufacturer's name, product identification, and the FM Approval Mark (see Appendix B). The nameplate shall also bear a cautionary statement that any changes to the tower will void the FM Approval. Examples of such changes are painting, coating or replacement of fill with different fill. The name plate shall be permanently attached to the exterior of the cooling tower. For factory assembled towers, the label shall be affixed at the factory. For field erected towers, the label may be affixed with the manufacturer's identification label when the installation is complete. A sample or facsimile of the nameplate shall be kept on file at FM Approvals.

3.1.3.2 Approved cooling tower components and/or packaging containers shall bear the manufacturers name and product identification. In addition, the product and/or container shall be marked with the FM Approval Mark.

3.1.4 All markings shall be legible and durable.

3.2 Manufacturer's Installation and Operation Instructions

The manufacturer shall provide the user with

- instructions for the installation, maintenance, and operation of the product;
- facilities for repair of the product and supply replacement parts; and
- services to ensure proper installation, inspection, or maintenance for products of such nature that it would not be reasonable to expect the average user to be able to provide such installation, inspection, or maintenance.

3.3 Drawings/Plans/Specifications Required

The manufacturer shall provide general assembly drawings that show location of all combustible components to include, but not limited to: walls, fill, piping, louvers, drift eliminators, fan and/or structural components.

3.4 Calibration

All examinations and tests performed in evaluation to this standard shall use calibrated measuring instruments traceable and certified to acceptable national standards.

3.5 Manufacturer's Responsibilities

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

3.6 Review of Documentation

During the initial investigation and, prior to physical testing, the manufacturer's specifications and details shall be reviewed to assess the ease and practicality of installation and use. Verification and confirmation of application specifications are assessed during the installation inspection in the field. The product shall be capable of being used within the limits of the Approval investigation.

3.7 Formulation Changes

Approval of formulation changes only to a previously Approved cooling tower component shall be based on a favorable comparison of the flammability characterization of the product with the modified formulation with the flammability characterization of the originally Approved component.

3.8 Configuration Changes – Fill

Approval of changes only to the configuration, or geometry, to a previously Approved fill shall be based on a favorable comparison of the maximum heat flux, as determined through intermediate-scale fire testing, of the modified product with the originally Approved fill.

3.9 Seismic Loads

Cooling towers erected, or installed, at locations within FM-designated Earthquake Zones 50 year, 100 year, 250 year or 500 year as shown in the FM Loss Prevention Data Sheet 1-2, shall be designed in accordance with the FM Loss Prevention Data Sheet 1-6 and the FM Design Procedure for Seismic Design

of Cooling Towers to withstand the seismic loading experienced in these areas. Towers located in >500 year zones are considered non-seismic and do not require analysis for seismic design. The design shall be certified by a Professional Engineer competent in this area of practice. Calculations shall be submitted to verify compliance with design requirements for the range of towers for which Approval is sought.

The FM Design Procedure for Seismic Design of Cooling Towers is as follows:

3.9.1 General

There are two broad categories of cooling towers: (1) mechanical draft, and (2) natural draft. This procedure deals only with the mechanical draft cooling towers. The natural draft cooling towers use very large concrete stacks. They shall be designed as non-building structures according to the prevailing design standards. The natural draft cooling towers are outside the scope of this method of seismic analysis.

The mechanical draft cooling towers shall be rated (Approved) for a base shear coefficient (acceleration). The manufacturer shall demonstrate (through tests or analysis) that the cooling tower shall remain intact and operational when subjected to the rated base shear coefficient. A seismically rated cooling tower can be erected in FM Global earthquake zones 50-through 500-year [1] as long as the rated base shear coefficient is greater than the design base shear coefficient calculated according to this standard. The anchorage of the cooling tower to the supporting structure shall be designed for the base shear, overturning moment about the two principal axes and torque about the vertical axis. The supporting structure shall be designed for the loads transmitted from the cooling tower. The seismic loads calculated according to this standard are intended for use in Load and Resistance Factor Design (LRFD) or Strength Design, also know as Ultimate Limit States Design, and shall, therefore, be used in LRFD load combinations with a load factor of 1.0 applied to the seismic loads.

FM Global does not require seismically rated cooling towers in >500-year earthquake zone. However, the applicable building codes may require seismic design of cooling towers in a >500-year zone. The FM Global earthquake zones do not correspond to the building code zones.

If the weight of the cooling tower exceeds 10% of the weight of the supporting structure, the dynamic interaction between the cooling tower and the supporting structure shall be considered in calculating the base shear coefficient; the simple procedure presented in this standard cannot be used for such cooling towers and a satisfactory alternative design method must be used.

3.9.2 Nomenclature

3.9.2.1 A_p – base shear coefficient (acceleration in g's).
3.9.2.2 S_{DS} – 0.2 second (short period) design spectral acceleration (g's)
3.9.2.3 a_p – dynamic amplification factor. Equal to 1 (for rigid) and 2.5 (for flexible) cooling towers.
3.9.2.4 R_p – height of the base of the cooling tower above ground, in feet.
3.9.2.5 z – height of the base of the cooling tower above ground, in feet. Equal to zero for a ground supported cooling tower.
3.9.2.6 h – total height of the supporting structure measured from the ground, in feet.
3.9.2.7 $\bar{h}$ – height of the center of gravity (C.G.) of the cooling tower from the base of the cooling tower, in ft
3.9.2.8 S_{MS} – free surface spectral acceleration
3.9.2.9 F_p – design base shear
3.9.2.10 W_p – weight (dead load) of the cooling tower, in lbs.
3.9.2.11 M_p – design overturning moment. Calculated using $M_p = F_p \cdot \bar{h}$

3.9.3 Base Shear Coefficient

The seismic base shear coefficient shall be calculated as follows:

$$A_{\mathrm{p}} = \frac{0.4 a_p S_{\mathrm{DS}}}{R_p}\left(1+2\frac{z}{h}\right) \quad (1)$$

3.9.4 Short-period spectral acceleration (S_{DS})

For sites within the USA, the short-period spectral acceleration S_{DS} shall be calculated according to the ASCE 7 standard [2], as follows.

The MCE (maximum considered earthquake) value of the 5% damping 'firm' rock spectral acceleration at 0.2 second (S_S) is read from the maps in ASCE 7. This is multiplied by the NEHRP (National Earthquake Hazard Reduction Program) soil amplification factor F_a [2] to obtain the free-surface spectral accelerations SMS:

$$S_{\mathrm{MS}} = S_{\mathrm{S}} \times F_{\mathrm{a}} \quad (2)$$

The design value is two-thirds of S_{MS}:

For locations outside the USA, S_{DS} shall be the 475-year return period value of 0.2 second period 5% damping spectral acceleration adjusted for local soil conditions. Alternatively, S_{DS} can be obtained from Table 1 for the FM Global earthquake zone in which the cooling tower is located.

Table 1. Suggested values of (0.2 second) short-period 5% damping spectral acceleration for various FM Zones [3]

FM Zone	S_{DS}
50-year	1.3 g
100-year	0.9 g
250-year/500-year	0.55 g

3.9.5 Design Loads for Supporting Structure

The design base shear is calculated as follows:

$$F_{\mathrm{p}} = A_{\mathrm{p}} \cdot W_p \quad (3)$$

The design overturning moment is calculated as follows:

$$M_{\mathrm{p}} = F_{\mathrm{p}} \cdot \bar{h} \quad (4)$$

Where applicable, the torque produced by mass eccentricity shall be considered in the design of the support structure.

3.9.6 Design Loads for Base Anchors

The design loads (shear, overturning moment and torque) applied to the base anchors shall be two times the design loads for the supporting structure.

3.9.7 LRFD Load Combinations

Examine both load combinations below to determine the more stringent design loads:

3.9.7.1 Operational ‘‘wet’’ condition dead load with full complement of process water:

(1.2 × Dead Load Wet) + [1.0 × Seismic Load (F_p)] + (0.2 × Roof Snow Load)

3.9.7.2 Non-operational “dry” condition dead load without process water:

(0.9 × Dead Load Dry) + [1.0 × Seismic Load (F_p)]

Note that the roof snow load shall be based on a mean recurrence interval of 50-years.

3.9.8 Inlet/Outlet Piping Flexibility

The inlet/outlet piping connections shall be designed to accommodate at least 6 inches (150 mm) of movement in all directions. As an alternative, the connection shall be designed to accommodate 1% drift. The inlet/outlet piping connections are the responsibility of the installing contractor, not the manufacturer.

3.10 Wind Loads

Cooling towers shall be designed in accordance with the FM Loss Prevention Data Sheet 1-6 to withstand the anticipated wind loads. The design shall be certified by a Professional Engineer competent in this area of practice. Calculations shall be submitted to verify compliance with design requirements for the range of towers for which Approval is sought.

4. PERFORMANCE REQUIREMENTS

4.1 Combustibility – Single Cell Towers

A complete single cell cooling tower shall demonstrate its ability to withstand damage from a fire exposure and not impose a fire hazard to adjacent structures or surroundings.

4.1.1 Test/Verification

Testing shall be conducted according to the Procedure Class Number 4930: Full-Scale Fire Test Procedure for Cooling Towers

4.1.2 Acceptance Criteria

4.1.2.1. Fire shall not produce a laterally self-propagating fire beyond the exposure area to the extremities of the unit in the test. The plan area of fill damaged by fire shall not exceed 25% of the total fill contained in the unit. Damage includes material consumed, charred, melted, or deformed by fire.

4.1.2.2. There shall be no structural damage to the tower or the fan support which will lead to structural failure of the cooling tower.

4.1.2.3. There shall be no burn through of the casing walls or joints.

4.1.2.4. There shall be no damage to the adjacent tower components which will result in tower failure.

4.1.2.5. There shall be no visible fire damage to the fan, motor and water distribution systems after the fire.

4.1.2.6. Additionally, for roof top mounted cooling towers, there shall be no flaming or glowing material falling and coming in contact with the test platform.

4.1.3 No paint or coating shall be applied to any part of the tower unless that paint or coating has been evaluated in a full scale fire test of the tower.

4.2 Combustibility – Multi Cell Towers

A complete multi-cell cooling tower shall demonstrate its ability to contain damage from a fire to the cell of origin and not spread to adjacent cells or impose a fire hazard to adjacent structures or surroundings.

4.2.1 Test/Verification

Testing shall be conducted according to the Procedure Class Number 4930: Full-Scale Fire Test Procedure for Cooling Towers

4.2.2 Acceptance Criteria

4.2.2.1. The plan area damaged by fire shall not extend beyond the cell of origin by spreading over, under, around or through walls or partitions to adjacent cells. Damage includes material consumed, charred, melted, or deformed by fire.

4.2.2.2. Damage in the cell of origin may be complete, but there may be no spread to adjacent cells or damage to the operability of same.

4.2.3 No paint or coating shall be applied to any part of the tower unless that paint or coating has been evaluated in a full scale fire test of the tower.

4.3 Combustibility – Roof Top Mounted Cooling Towers (Single Cell or Multi Cell)

Roof top mounted cooling towers may have fire hazards which are not found with ground level units. Should burning or glowing brands or embers from a burning tower come in contact with the roof surface,

the potential exists for the ignition of the roof cover or adjacent structure.

4.3.1 Test/Verification

Testing shall be conducted according to the Procedure Class Number 4930: Full-Scale Fire Test Procedure for Cooling Towers

4.3.2 Acceptance Criteria

In addition to the criteria listed above for single cell and multi cell cooling towers, as applicable, the roof mounted tower shall demonstrate the ability to prevent burning debris from falling onto the roof surface by retaining all brands within the cold water basin.

4.3.3 No paint or coating shall be applied to any part of the tower unless that paint or coating has been evaluated in a full scale fire test of the tower.

4.4 Flammability Characterization for Cooling Tower Fill

The cooling tower fill shall be tested to determine the material's Chemical Heat Release Rate (CHRR) and the Thermal Response Parameter (TRP).

4.4.1 Test/Verification

Testing is conducted in accordance with ASTM E2058, "Standard Test Methods for Measurement of Synthetic Polymer Material Flammability Using a Fire Propagation Apparatus (FPA)".

4.4.2 Acceptance Criteria

4.4.2.1 The tests are conducted to establish a base from which requests for formulation revisions are evaluated. FM Approvals places no limits on the values obtained. Additionally, these tests may be utilized to compare various materials for the most critical material to be tested in full-scale tests.

4.4.2.2 To qualify alternate sources of raw materials or formulations when no change in geometry occurs, the TRP of the proposed alternate component shall be greater than, or within 10% of, the TRP of the existing Approved component. In addition, the CHRR of the proposed alternate component shall be less than, or within 10% of, the CHRR of the existing Approved component.

4.5 Large Missile Impact on Walls and Fan Stacks

Damage from large missiles in a windstorm can reduce the efficiency of a tower or render the tower inoperable by opening holes in the wall panels or deforming the fan stack.

4.5.1 Test/Verification

Wall panels and segments of fan stacks shall be tested in accordance with Procedure Class Number 4881: Test Method for Exterior Wall Systems Impacted by Windborne Debris.

4.5.2 Acceptance Criteria

4.5.2.1 Penetration of the wall panel or damage at a wall panel seam allowing an amount of air leakage that reduces the operating capacity by 10% or more will be considered unacceptable.

4.5.2.2 A deflection of the fan stack significant enough to hinder rotation of the fan will be considered

unacceptable.

4.6 Static and Cyclic Air Pressure Differentials

4.6.1 Test/Verification

Wall panels shall be tested in accordance with Procedure Class Number 4881: Structural Test Method for Exterior Walls Using Static and Cyclic Air Pressure Differentials.

4.6.2 Acceptance Criteria

An opening at a wall panel seam allowing an amount of air leakage that reduces the operating capacity by 10% or more will be considered unacceptable.

4.7 Comparative Testing for Alternate Cooling Tower Fill and Drift Eliminators

The cooling tower fill and drift eliminators shall be tested to determine the heat flux and temperatures developed during a simulated cooling tower fire. Tests shall be conducted on the currently Approved fill or drift eliminator and the proposed alternate fill or drift eliminator so a direct comparison can be made.

4.7.1 Test Verification

Testing is conducted in accordance with Procedure Class Number 4930: Intermediate Scale Fire Test Procedure for Fill and Drift Eliminator Components for Cooling Towers

4.7.2 Acceptance Criteria

4.7.2.1 This test is not a requirement for Approval but will be conducted to establish a base from which requests for revisions are evaluated. FM Approvals places no limits on the values obtained. Additionally, this test may be utilized to compare various materials for the most critical material to be tested in full scale testing.

4.7.2.2 To qualify changes of geometry or alternate sources of raw materials or formulations when no change in geometry occurs and the Chemical Heat Release Rate (CHRR) of the proposed alternate component is greater than the Chemical Heat Release Rate (CHRR) of the Approved component, the heat flux and temperature developed from testing of the proposed alternate shall not exceed the heat flux developed from testing of the original Approved component by more than 10%.

4.8 Comparative Testing for Alternate Cooling Tower Components other than Fill and Drift Eliminators

The cooling tower components other than fill and drift eliminators shall be tested to determine the performance of the components during a simulated cooling tower fire. Tests shall be conducted on the currently Approved component and the proposed alternate component so a direct comparison can be made.

4.8.1 Test Verification

Testing is conducted in accordance with Procedure Class Number 4930: Intermediate Scale Fire Test Procedure for Components Other Than Fill and Drift Eliminators for Cooling Towers

4.8.2 Acceptance Criteria

4.8.2.1 This test is not a requirement for Approval but will be conducted to establish a base from which requests for revisions are evaluated. FM Approvals places no limits on the values obtained. Additionally, this test may be utilized to compare various materials for the most critical material to be tested in full scale testing.

4.8.2.2 The fire performance of the component being evaluated is compared to that of the originally Approved component. If performance compares favorably with the performance of the originally Approved component, the substitution is acceptable.

5 OPERATIONS REQUIREMENTS

A quality assurance program is required to assure that subsequent cooling towers produced by the manufacturer shall present the same quality and reliability as the specific cooling towers examined. Design quality, conformance to design, and performance are the areas of primary concern.

- Design quality is determined during the examination and tests, and is documented in the Approval Report.
- Continued conformance to this standard is verified by theSurveillance Audit.
- Quality of performance is determined by field performance and by periodic re-examination and testing.

5.1 Demonstrated Quality Control Program

5.1.1 The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- existence of corporate quality assurance guidelines;
- incoming quality assurance, including testing;
- in-process quality assurance, including testing;
- final inspection and tests;
- equipment calibration;
- drawing and change control;
- packaging and shipping;
- handling and disposition of non-conforming materials;
- manufacturer’s certification of proper field assembly or installation.

5.1.2 Documentation/Manual

There shall be an authoritative collection of procedures/policies. It shall provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system shall require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

5.1.3 Records

To assure adequate traceability of materials and products, the manufacturer shall maintain a record of all quality assurance tests performed, for a minimum period of ten years from the date of manufacture and installation.

5.1.4 Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the Approval Report, must be reported to, and authorized by, FM Approvals prior to

implementation for production.

- The manufacturer shall assign an appropriate person or group to be responsible for, and require that, proposed changes to FM Approved products be reported to FM Approvals before implementation. The manufacturer shall notify FM Approvals of changes in the product or of persons responsible for keeping FM Approvals advised by means of FM Approvals' Form 797, FM Approved Product/ Specification-Tested Revision Report or Address/Main Contact Change Report.
- Records of all revisions to all FM Approved products shall be maintained.

5.2 Surveillance Audit

5.2.1 An audit of the manufacturing facility is part of the Approval investigation to verify implementation of the quality assurance program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to insure a uniform product consistent with that which was tested and FM Approved.

5.2.2 These audits shall be conducted periodically but at least annually by FM Approvals or its representatives.

5.2.3 FM Approved products or services shall be produced or provided at or from the location(s) audited by FM Approvals and as specified in the Approval Report. Manufacture of products bearing the Approval Mark is not permitted at any other location without prior written authorization by FM Approvals.

5.3 Installation Inspections

Field inspections may be conducted to review an installation. The inspections are conducted to assess ease of application, and conformance to written specifications. When more than one application technique is used, one or all may be inspected at the discretion of FM Approvals.

5.4 Manufacturer's Responsibilities

The manufacturer shall notify FM Approvals of changes in product construction, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation.

APPENDIX A: Units of Measurement

LENGTH:	in -‘‘inches’’; (mm -‘‘millimeters’’) mm = in. × 25.4
	ft -‘‘feet’’;(m-‘‘meters’’) m=ft × 0.3048
AREA:	in^2 -“square inches”; (mm^2 -“square millimeters”) $mm^2 = in^2 \times 6.4516 \times 10^2$
	ft^2 –‘‘square feet’’;(m^2 -‘‘square meters’’) $m^2 = ft^2 \times 0.0929$
TEMPERATURE:	°F-‘‘degrees Fahrenheit’’;(°C-‘‘degrees Celsius’’) °C=(°F -32) × 0.556
LIQUID:	gal -‘‘gallons’’;(L -‘‘liter’’) L = gal × 3.785
	L-‘‘liter’’; (dm^3 -‘‘cubic decimeters’’) L= dm^3

APPENDIX B: FM Approvals Certification Marks

FM Approvals certifications marks are to be used only in conjunction with products or services that have been Approved by FM Approvals and in adherence with usage guidelines.

FM APPROVED mark:
Authorized by FM Approvals as a certification mark for any product that has been FM Approved. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.

Cast-On FM Approvals marks:
Where reproduction of the FM Approved mark described above is impossible because of production restrictions, use these modified versions of the FM Approved mark. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable.

FM Approved Mark with ‘‘C’’ only:
Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.

FM Approved mark with ‘‘C’’ and ‘‘US’’:
Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with US and Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.

FM Approvals Certification Marks

USAGE GUIDELINES

All FM Approvals certification marks are the sole property of FM Approvals LLC ("FM Approvals") and are registered or the subject of applications for registration in the United States and many other countries. They are for use only according to these guidelines.

FM Approvals certification marks may be used only on FM Approved products and related product packaging, in advertising material, catalogs and news releases. Use of FM Approvals certification marks on such material is not a substitute for use of the complete FM Approvals certification mark on FM Approved products and/or product packaging.

No FM Approvals certification mark or aspect thereof may be incorporated as part of a business name, Internet domain name, or brand name/trademark for products/ product lines. This includes both design aspects (the FM Approvals "diamond," etc.) and word aspects ("FM," "Approved," etc.). The use of any FM Approvals certification mark as a trademark is strictly prohibited.

The Approval Standard number or class number may not be incorporated as part of a business name, Internet domain name, or brand name/trademark for products/ product lines. For example, a company may not say "ABC Company's 4100 Fire Door is FM Approved"; the proper terminology is, "ABC Company's Fire Door is FM Approved per Approval Standard 4100."

FM Approvals certification marks, except for the FM Approvals Quality System Registration mark, may not be used on business stationery/cards/signage because this could mischaracterize the relationship with FM Approvals. Additionally, these items should not reference any FM Approvals certification mark.

Products or services may not be marketed under any mark or name similar to "FM Global," "FM Approvals" or any of the FM Approvals certification marks. Further, products or services may not be marketed to imply a relationship beyond the scope of any Approval made by FM Approvals.

When an FM Approvals certification mark is used in advertising material or on product packaging, all material must reflect the specific circumstances under which the product was FM Approved. The material must clearly differentiate between products that are FM Approved and those that are not, and may not, in any way, imply a more substantial relationship with FM Approvals.

A company may not reference the intent to submit a product for Approval or the expectation that a company will have a certain product FM Approved in the future. For example, a company may not state, "Approval by FM Approvals pending" or "Approval by FM Approvals applied for."

FM Approvals certification marks should not be preceded or followed by a qualifier that indicates a degree of certification or acceptability. For example, "exceeds," "first" or "only" may not be used to qualify any FM Approvals certification mark.

Only original artwork issued by FM Approvals should be used. The FM Approvals certification marks should not be altered in any way other than to resize the artwork proportionately. Unacceptable uses of the marks include, but are not limited to, adding/deleting wording or artwork, reducing the artwork to an illegible size, animation or distortion.

The text of the FM Approvals certification marks may not be translated into any language other than English.

FM Approvals certification marks must appear in a size and location that is readily identifiable, but less prominent than the name of the owner of the certification or the manufacturer/seller/distributor of the certified products.