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THEATRE SAFETY CURTAINS

I. INTRODUCTION

The function of the fire resistive curtain in theatres is to close the proscenium opening against the passage of fire and smoke into the auditorium in dangerous and alarming amounts. Many cities and a few states have laws or regulations requiring safety measures and police supervision for theatres and opera houses because of the loss of life from fires. It is usually required that the curtain be made of asbestos cloth, or other incombustible material. Other essential details, however, are given by relatively few of these regulations. Even in the same city a wide range in materials, mountings, and construction of curtains were found in surveys of such installations in three cities. From these findings the question arose as to what kinds of curtains would give the desired degree of protection to theatre audiences. The answer could be given, at least in part, from the results of tests. Accordingly, fire tests were made on sections of proscenium curtains as large as the test furnace would accommodate.[1] The fire tests included two of steel curtains and four of asbestos cloth curtains. One of the steel curtains was made of plates riveted to plate-and-angle girders spanning horizontally between the vertical members of the channel-iron marginal frame. The other was made of welded steel pan-shaped sections 9 feet long by 3 feet high bolted together. Both were covered on the stage side with 0.4 inch thick asbestos millboards. Each afforded protection exceeding 30 minutes.

Two of the asbestos cloth curtains were of the flexible type mounted on cable guides as has been quite usual practice in such installations. One of these was made of two plies of plain (unreinforced) asbestos cloth each weighing 2.6 pounds per square yard covering a framework consisting of pipe battens at the top and bottom with wire cables spaced 8 feet apart spanning vertically between them. The other was like it except that it had only one ply of 4.6 pound metallic (wire-reinforced) asbestos cloth. The other two asbestos cloth curtains had comparatively rigid frames sliding vertically between rigid guides mounted on the furnace test frame. Each had one ply of wire-reinforced asbestos cloth on each side of the framework.

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[1] Mitchell, Nolan D., "Tests of Theatre Proscenium Curtains", Bureau of Standards Journal of Research, v. 11, no. 4, October, 1933. "The Safety of Theatre Proscenium Curtains", Safety Engineering, v. 49, no. 2, p. 63, February, 1925.

The reinforcement for the cloths consisted of brass, nickel, or monel-metal wires spun into the asbestos yarns in their manufacture. Of these curtains only the one with a framework to keep the two plies of asbestos cloth apart over the entire area was adjudged to give full 15 minutes protection.

Supplemental tests with small specimens gave the strengths of all the different asbestos cloths used in the curtains at temperatures up to 1000°C (1832°F). Other tests were made to determine stretch, permeability to air, and the content of asbestos, cotton, and metal.

Previous to the exposure of the flexible types of asbestos cloth curtains to fire, tests were made to determine their frictional resistance against sliding while they were subjected to air pressure. Other tests determined the sliding friction of shoes of various materials moving over rigid steel guides of various degrees of roughness, with and without lubricants.

During the fire tests, dense smoke was given off from three of the asbestos cloth curtains by the filler and decorative coats of paint, and consequently tests were made to find a paint that would be satisfactory. Of the several tried, a binder composed of solutions of casein and sodium silicate was best.

II. RECOMMENDED REQUIREMENTS FOR THEATRE PROSCENIUM CURTAINS

The following requirements for theatre proscenium curtains are based on the results of the fire tests of curtains and the surveys, and are deemed suitable for use in building codes with only minor modification or additions. The lower limit of seating capacity of places of public assembly to which the requirements should be applied depends upon the type of building construction, the interior arrangement, and the exit facilities. The discussion which follows amplifies the intent of the code requirements and should be helpful in their administration.

1. RECOMMENDED REQUIREMENTS[2]

(a) PROTECTION REQUIREMENTS

Every theatre or place of assembly, on the stage of which there are materials or equipment such as might induce panic or endanger life in the event of fire, shall have a proscenium curtain, and its appurtenances, of incombustible materials. The curtain shall be mounted on rigid guides so as to close the opening and intercept flame, hot gases, and smoke, from a severe fire on the stage, and prevent glow from showing on the auditorium side for a period of 15 minutes.

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[2]Changes in headings and arrangement and also insertion of the titles of administrative officers may be necessary in adapting the requirements to a particular code.

The curtain, with its mounting, shall be designed and constructed to withstand, when in the closed position, lateral pressure of 10 pounds per square foot of area with a factor of safety of not less than 2 on the ultimate strength of the construction, and to close while subjected to lateral pressure of 5 pounds per square foot of area. Hoisting machines and cables shall have factors of safety of not less than 8.

(b) OPERATION OF CURTAIN

The curtain shall be operated normally by manual control, and for emergency closure the manual control shall be supplemented by automatic heat-actuated controlling devices. Positive closure of the curtain from the full open position, in either normal or emergency operation, shall be effected in not more than one minute, but the last 5 feet of travel shall require not less than 5 seconds.

(c) OPERATION OF VENTILATORS

The emergency operation of the curtain, whether manual or automatic, shall cause a ventilator at the top of the stage room to open.

(d) APPROVAL[3]

Complete details of any proposed proscenium curtain and curtain installation, including mechanism and structural supports, shall be submitted, together with satisfactory proof that such installation meets the requirements as to strength, fire resistance and smoke-tightness when subjected to a fire test with exposing temperatures averaging not less than 1440 degrees Fahrenheit and rising to not less than 1700 degrees Fahrenheit at 15 minutes. Approval shall be obtained before erection is started. After completion, operating tests of the curtain shall be made and approval of its functioning obtained before a public performance is staged.

2. DISCUSSION OF REQUIREMENTS

(a) CONDITIONS AFFECTING DESIGN AND PERFORMANCE

Every place of public assembly having a stage with fittings and appurtenances such as would seriously endanger the lives of those in the assembly room in the event of a stage fire should have an effective proscenium wall and curtain to lessen the danger. Although as a rule most places of assembly can be emptied within 5 minutes the curtain should afford protection for not less than 15 minutes in order to give a margin for conditions such as failure of the audience to give orderly response. In order that all may know that the curtain is operative it should be raised and lowered every time an audience is present, hence a requirement that the fire-resistive proscenium curtain shall be used

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[3]The approval required is that of the official having administrative jurisdiction of this section of the code.

regularly seems justifiable. This, we believe, should be a police regulation and is, therefore, not included in the above recommended requirements.

The wall and curtain should not only resist fire but should be capable of resisting pressures to which they are likely to be subjected whether from winds, drafts, or fire. Sometimes pressures exceeding those specified might be experienced, but during an emergency requiring the curtain to function as a protective device, this would rarely happen.

(b) IMPORTANCE OF RELIABLE OPERATION

Manual controls and heat-actuated devices for lowering the curtain in emergency should be provided. The heat-actuated devices must be considered secondary since their functioning ordinarily would require fires of considerable size or intensity, and should be expected to serve only when the response of assigned personnel is delayed or prevented.

Reports of theatre fires and fire tests lead to the conclusion that if closure of the proscenium curtain can be effected within one minute after the outbreak of a stage fire, and adequate vents opened above the stage to discharge smoke and gases, conditions intolerable to those assembled in the auditorium are not likely to develop. Prompt response of the curtain to the controls should be required but the movement of the curtain need not be fast and it is particularly desirable that the last few feet of curtain travel be slow enough to give ample time for persons to get out of its way.

(c) BASES FOR APPROVAL

The requirements given in paragraph 1(a)(1) are fundamental, but judgment as to the sufficiency of a given type of curtain to meet them must be based on a review of the details and design, since tests of the completed curtain to determine these points are not practicable. Judgment as to the fire resistance of full-size curtains and their component parts may be based on the results of tests such as those referred to in this paper or on reports of other fire tests.[5] For curtains differing widely as to construction from those which have been tested, fire tests may be necessary.

The procedure outlined in the Standard Specifications for Fire Tests of Building Construction and Materials of the American Standards Association as applicable to non-load-bearing partitions with the following changes and exceptions is recommended for fire tests of proscenium curtains: The test shall continue for a

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[5] Loc. cit. 1: John R. Freeman, Proc. A.S.M.E., v. 27, 1906; Bureau of Buildings, Borough of Manhattan, New York; Bulletins 7 and 9, Annual report, 1926.

period of not less than 15 minutes unless failure shall have occurred previously. The temperatures of the exposing fire shall be attained at one-fourth the time designated on the standard furnace curve, reaching the temperature of 1700 degrees F (927°C) at 15 minutes. The temperatures on the unexposed surface may be measured by thermocouples with wires not over 0.02 inch in diameter having junctions and adjacent wire so mounted as to indicate surface temperature as accurately as possible. The temperature of the testing room adjacent to the unexposed surface shall not be lower than 50 degrees F (10°C) at the beginning of the test and shall be free of convection currents except such as are induced by the fire test. The average temperature on the unexposed side of the curtain shall not exceed 700 degrees F (371°C) at 15 minutes. The unexposed face of the curtain shall not glow within the test period nor shall there be any passage of flame through the curtain. Smoke should not be given off in undue amount.

Evidence of compliance with the requirements of paragraphs 1(b) and 1(c) should be derived from tests of completed curtains. These can be accomplished at the same time as the tests required by paragraph 1(d). Experience appears to fully justify the requirement that satisfactory operating tests of the curtain and automatic ventilator shall have been made as a requisite for permission to open a place of assembly for a stage performance.

(d) ASBESTOS CLOTH FOR PROSCENIUM CURTAIN

Asbestos cloths for the coverings of fire resistive curtains should have reinforcement of nickel, nickel alloy, or brass wire, spun into the yarn, should weigh not less than 3 pounds per square yard, and have not less than 180 pounds strength per inch width of warp and 85 pounds strength per inch width of filling, unless they shall have been proven adequate for such service by performance tests. Cotton content of the asbestos cloth should not exceed 5 percent of the weight of the asbestos fiber. Filling is required for asbestos cloths to reduce their permeability to smoke and gases. Paints composed of 4 parts casein, 10 parts water glass with mineral pigments and water in suitable proportions have been found satisfactory for the purpose. Other paints for this use should be proven satisfactory by tests.

(e) LIMITATIONS OF CURTAINS

Many of the curtain installations encountered in practice were found inadequate to give protection without being supplemented by other safety measures. The most common deficiencies were insufficient strength to withstand wind pressures to which they were liable to be subjected, high frictional resistance when subjected to pressure, and inadequate sealing of the proscenium opening against the passage of smoke or fire. The additional safety measures usually most effective are well-planned exits and adequate vents.

Ventilators should be provided over both the stage and the auditorium. Those over the stage should be interconnected with the curtain controls so as to open whenever the curtain is lowered automatically, or through the emergency release. Independent operation should also be possible. The suggestion has been made that the emergency or automatic lowering of the curtain open a ventilator of about one-fifth the total required vent area. This one open ventilator would direct the heated air upward to cause the further automatic opening of additional ventilators if needed.

The tests in the model theatre in Vienna, Austria, in 1905, indicated that open ventilators were essential to the prevention of suffocation. Without them and with the steel curtain down, smoke in great volume was forced around the curtain into the auditorium from the fire on the stage, but with the ventilators open above the stage the fire progressed rapidly without smoke and gas entering the auditorium even when the curtain was up. In the latter case, however, the radiant heat was unbearable. Several fires in theatres have indicated that open ventilators above the stage are effective in discharging smoke and gases from stage fires, whereas lack of ventilators leads to unbearable conditions.[6]

Although not pertinent to the operation of the curtain itself, there are other measures which have been found desirable. The openings in the proscenium wall to permit passage around the closed curtain should be limited to two above and two below the stage floor and should be fitted with fire doors. There should be means and personnel at hand for combating fires. In addition to hand fire extinguishers and standpipe and hose, automatic sprinklers over the stage are desirable and are, in fact, required by many city ordinances. When there is a large assembly, trained personnel should be present for ushering or directing the egress of crowds.

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[6] Among such fires the following are notable because of great loss of life: Brooklyn Theatre Fire, Brooklyn, N. Y., 1876; Ring Theatre Fire, Vienna, Austria, 1881; Exeter Theater Fire, England, 1887; Iriquois Theatre Fire, Chicago, Ill., 1903.