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FIRE PROTECTION HISTORY-PART 248: 1918 (STRUCTURAL FIRE RESISTANCE TESTING)

By Richard Schulte

The twenty-second Annual Meeting of the National Fire Protection Association was held in Chicago in May 1918. Among the various subjects discussed at this meeting was a draft standard for determining the fire resistance of the structural elements of buildings. The following is a transcript of the report on Fire Tests:

"***Mr. Woolson:*** *The next report is the Specification for Standard Fire Tests, and the Classification of Materials and Construction as Determined by those Tests. The committee is conceited enough to feel that this is one of the most important specifications ever presented to this Association. That is a pretty strong statement, but it is not based upon the fact that it happens to be presented through this committee. It is based upon the fact that the representatives of ten other large technical societies have been co-operating with this committee in the drafting of these specifications over a period of two years. As a result, we prepared a tentative report which was presented to you last year and is now coming before you in a revised condition for adoption. A report which has had the consideration of so many technical societies, I submit, Mr. Chairman, may justly be considered most important.*

Fire Tests.

[This report has been submitted to ballot of the committee which consists of eighteen members, of whom seventeen have voted affirmatively and one has refrained from voting.]

The Committee, realizing the immense importance of having standards established as nearly as possible in harmony with the ideas of all investigators in this line of work, decided to attempt the assembly of a joint conference of as many technical bodies interested in the subject as possible. The cooperation of the Committee on Fireproofing in the American Society for Testing Materials was first secured, and these two Committees invited assistance from other organizations. This effort was eminently successful, and two such conferences have been held. The results are herewith presented as a part of this Committee's Report for consideration by the Association. Similar reports will also be made to the other constituent members of the Conference by the representatives who were present.

*From Report of 1917, and as amended by further conferences reported in 1918.

The organizations represented at the Conference were:–

Committee on Fire-resistive Construction, N. F. P. A.
Committee on Fireproofing, A. S. T. M.
National Bureau of Standards.
National Board of Fire Underwriters.
Underwriters' Laboratories.
Assoc. Factory Mutual Fire Insurance Cos.
American Institute of Architects.
American Society M. E.
American Society C. E.
Canadian Society C. E.
American Concrete Institute.

The membership of the two original committees, together with the representatives of the organizations named, formed a group of qualified technical experts which include the majority of this class in the country. These Conferences accomplished three important objects:

1. An agreement with the principle adopted by this Committee and endorsed by the Association that fire-resisting materials and construction should be classified into three or more grades based upon the degree of protection which they would afford when measured by a fire test conducted in accordance with a standard time-temperature curve. For various reasons, it was decided that the terms, "Full," "Partial" and "Temporary Protection," previously recommended, were unsatisfactory. In place of this plan to classify standards of fire-resistance by groups, the Conference decided to adopt the terms "Four-Hour Protection," "Two-Hour Protection," "One-Hour Protection," etc. This classification harmonizes easily with the fire test work already done under the standard specifications of the American Society for Testing Materials, by the Underwriters' Laboratories, and other investigators. It is also evident that it will be a simple matter to interpolate other classes as they may become necessary.

2. The adoption of a tentative standard time-temperature curve to control the conduct of the fire tests of materials and construction, and establishment of conditions controlling application of water after fire test.

3. Preparation of detailed specifications for the conduct of fire tests upon floors, roofs and partitions as follows:–

Specifications for Standard Fire Tests of Materials and Construction.

[Note.– These specifications were presented in tentative form in 1917, and are now presented for final adoption.]

[**Fig.1. Standard Time Temperature Control Curve for Fire Tests Omitted**]

Control of Fire Tests.

1. The conduct of fire tests of materials and construction shall be controlled by the standard time-temperature control curve shown in Fig. 1. The points on the curve which determine its character are,

1000° F. at 5 minutes,
1300° F. at 10 minutes,
1550° F. at 30 minutes,
1700° F. at 1 hour,
1850° F. at 2 hours,
2000° F. at 4 hours,
2300° F. at 8 hours.

2. The temperature fixed by the curve shall be deemed to be the average true temperature of the furnace gases as obtained from the readings of several thermocouples (not less than three) symmetrically disposed and distributed in such a manner as to show the temperatures of the gases near all parts of the sample.

3. The temperatures shall be read at intervals not exceeding five minutes during the first hour, and thereafter the intervals may be increased to not more than fifteen minutes.

Classification as Determined by Test.

4. Fire-resistive materials and construction shall be classified in accordance with the degree of protection they afford when measured by a fire test conducted in conformity with the standard time-temperature control curve as,

4 hour protection,
2 hour protection,
1 hour protection,
1/2 hour protection,
1/4 hour protection.

Other classes may be interpolated or added as needed.

Test Structures.

5. The test structure may be located at any place where all the necessary facilities for properly conducting the test are provided.

Entire freedom is left to each investigator in the design of his test structure and the nature and use of fuel, so long as the test requirements are met.

Test Sample.

6. The material or construction shall be truly representative of the regular practice.

Loading.

7. For any material or construction intended to carry load other than its own weight at least the full rated safe working load shall be applied during the entire fire test.

Duration of Test.

8. The fire test on the sample with its applied load, if any, shall be either (a) continued till failure occurs, or (b) stopped at the period for which classification is desired, allowed to cool and loaded to failure.

Application of Water.

9. A second and separate test shall be made to determine the effect of a hose stream on a sample under fire test, the water being applied not later than one hour after the beginning of the test.

10. The size of nozzle, water pressure and time of water application shall be as indicated in the following table.

Parts of Structure	Type of Protection	Size of Hose Nozzle in.	Water Pressure at Nozzle lb.	Time of Application min.
Floors and Roofs	4 hour	1[-]1/8	50	10
	2 ″	″	50	5
	1 ″	″	50	2.5
Walls, Columns and Partitions	4 hour	″	50	5
	2 ″	″	30	3
	1 ″	″	30	2.5

The hose stream shall be first directed at the middle of the sample and then at all parts of the exposed faces, changes in direction being made slowly.

Floor and Roof Tests.

11. For floor and roof tests the sample shall be of such a size that the minimum span of the supporting beams of the floor arch shall be twelve feet, and the supporting beams and girders shall have a clearance of at least eight inches from the walls of the test structure.

12. The floor may be tested as soon after construction as desired, but within forty days. Artificial drying will be allowed if desired.

13. If the construction is to be plastered in practice, the sample shall be plastered in the same manner.

14. The floor shall be loaded so as to develop in each member of the construction stresses up to the maximum working stress allowed in the material of the member.

15. The test shall not be regarded as successful unless the following conditions are met:–

(a) No fire shall have passed through the floor or roof during the test.

(b) The floor or roof shall have safely sustained the full rated safe working load during the test.

(c) After a fire test that has not been carried to failure, or after a combined fire and water test, the floor or roof shall sustain safely the dead load plus at least two and a half times the designed live load applied not less than twenty-four hours nor more than seventy-two hours after the completion of the fire test.

(d) If the fire test has been continued to failure, the failure shall not have occurred within a period of 25 per cent in excess of the period for which classification is desired.

Non-Bearing Partition Test.

16. For partition tests the area of the sample shall be not less than 100 square feet and no dimension less than 9 feet.

17. Temperatures on the outer surface of the sample shall be read by thermometers, not less than five, symmetrically disposed and placed against the surface of the sample with their bulbs properly protected against radiation of heat.

18. The distance of the nozzle from the sample during the application of water shall be not more than twenty feet when the hose stream is applied approximately normal to the surface of the sample which distance shall be reduced by one foot for each ten degrees of angle from the normal when the hose stream is applied at an angle to the surface of the sample.

19. The test shall not be regarded as successful unless the following conditions are met:–

(a) No fire shall have passed through the partition during the fire test.

(b) Transmission of heat through the sample shall not have been such as to raise the temperature on the outer surface of the sample in excess of 300° Fahrenheit.

© Partition must have safely sustained the pressure of the hose stream, in case water was applied.

(d) Partition must not have warped or bulged or disintegrated under the action of the fire or water to such an extent as to be unsafe.

***Mr. Woolson:** The report has been revised, not by changing the requirements, but by amplifying them somewhat and rearranging the method of presentation. We have now made it a very simple matter for an inspector or any person interested in the quality of a partition or column or any other part of a building to know what its quality is. When you say it is a partition which will give two-hours' protection, it means it will resist a fire two hours according to the standard control curve given. That curve, which was presented last year purely as an arbitrary curve, has had a year's service by the Underwriters' Laboratories and by the Bureau of Standards at its laboratories in Pittsburgh. The unanimous judgment of those who have used it is that it should not be changed, at least at the present time. There is nothing to justify the supposition that the curve is not approximately right for the work the Laboratories are doing. Those of you who were at the Laboratories yesterday and saw the column test probably realized that test was run upon this standard curve. The number of classes of protection has been increased from four hours down to one-quarter of an hour by adding on the one-half hour and the one-quarter hour; that is very slight protection, but in these days of war emergency building construction the committee felt it might be necessary to recognize protection as low as one-quarter hour. If we do not need those classes, it is easy enough to leave them out.*

I wish to change Article 9, "Application of Water," and make it read as follows:

"A second and separate test shall be made to determine the effect of a hose stream on a sample under fire test, the water being applied at three-fourths of the period of time for which protection is sought."

That is, if a man asks for two hours' protection, the water will be applied at three-fourths of the two hours' time, but not longer than one hour after the beginning of the test. The committee has decided this little addition would be an advantage.

Mr. Robinson: *There is a little misunderstanding there; he would not, in any case, test longer than an hour.*

Mr. Woolson: *I stated it wrongly; if a two-hour classification were sought, he would not test longer than one hour, anyway. If a half-hour classification were desired, fire would be applied for three-quarters of the half-hour.*

The Chair: *Is that quite clear?*

Mr. Woolson: *Perhaps that wording will have to be changed a little to make it clearer, but the idea is that if a man is making the fire and water test the water will be applied at a period which is three-fourths of the period of time for which he is seeking protection, but never more than one hour.*

The Chair: *Is there any discussion of this report of Specifications for Standard Fire Tests?*

Mr. Woolson: *The Chairman would like to present the report to the Association for adoption, with the understanding that it will be presented as soon as possible to each of the constituent organizations which aided in its preparation for similar endorsement and adoption, as part of their own standards, if they have standards,– such as the American Society for Testing Materials.*

The Secretary: *I second the motion.*

The Chair: *Could not this take the same course as Mr. Forster's report, be referred back to this committee for this change, and then to the Executive Committee, with power?*

Mr. Woolson: *That is the only change, and the committee made it. I see no necessity for referring it to the Executive Committee at all.*

Mr. John A. Ferguson (Building Code Committee, Pittsburgh): *For the purposes of the Pittsburgh Building Code I should like to ask how a column would be considered as having passed its test. We would like to get some light on this, because within the next two weeks we have got to produce our report for the City of Pittsburgh.*

The Chair: *The subject of columns I believe is only touched on in a general way.*

Mr. Woolson: *That was left open purposely because of the incompleteness of the Laboratories tests upon columns. Until the Laboratories tests are completed, we do not feel that we are justified in putting forward specifications for columns.*

Mr. Ferguson: *The report in Pittsburgh was planned after this fashion, that at the end of the first test for classification, we put a load test on the column, because we expect to find out by that test whether or not the column will be safe to support the occupancy of the building. I notice in the specification for floor tests, that there is a chance for making the loading test in two ways, one to find out what you have left at the end of the classification period, and another by which you classify according to a certain proportion of the period of test before failure. Is it likely that your column report will follow the same plan? We have got to produce something immediately, and we desire, of course, to have it fit as closely as possible to what your forthcoming report will have in it.*

Mr. Woolson: *In answer I would say that the Committee did not feel justified in passing upon that. Perhaps Mr. Robinson can tell you something about that.*

Mr. Robinson: *I do not know that I quite sensed the question, but the idea is to test a column to its ultimate failure in fire or to an otherwise absurd point. What strength is left in such a column may be determined by the application of a load after the period of fire test. We are now doing that. Some columns will resist fire under this standard curve for eight hours, and to ascertain the load value and strength after that period, we are sometimes obliged to increase the load to three times the safe rated load,–perhaps a little beyond that. This will enable us to judge of the value of a column, but such a procedure has not been reduced to a rule yet. We probably would assume that a column was far beyond any reasonable requirement if it stood the fire test and its safe rated load for the period of the fire test.*

Mr. Ferguson: *I notice that the floor load requirement is 2*[-]*½ times the live load applied after the first test. Has that requirement been co-ordinated with the American Society of Civil Engineers' report, so that the matter will be standard? I am looking for light in these cases so that our Pittsburgh specification will be right up to the last minute. I understand that there was a previous report where the load was 1*[-]*3/4. Whether it applies in this case, I don't know.*

The Chair: *I know of no other specification for fire tests than that of the American Society for Testing Materials. This same report is to be submitted to the American Society for Testing Materials at its annual meeting in June, for its consideration and probable adoption.*

Mr. Ferguson: *Does this requirement of 2*[-]*½ times the live load differ from any report or standard of the American Society?*

Mr. Woolson: *There are no other standards that I know of, except the A. S. T. M. and this will be introduced as a substitute for the existing standard of that Society.*

Mr. Ferguson: *Just one more question and I will be through; the data, as I understand it, that is taken all along through the fire test gives the temperature of the columns at each stated period of, say, five minutes, and if a person desires a four-hour classification for a steel column with a certain protection and the temperature of that steel is not raised to a dangerous point (let us say two-thirds or three-fourths of the point at which it appears to fail in the fire test), would that column be considered, in a general way, to have its full strength and the building be considered safe for future occupancy?*

Mr. Woolson: *We have not covered that point.*

Mr. Ferguson: *I only want to get some light.*

Mr. S. H. Ingberg (Bureau of Standards, U. S.): *In Section 8 you specify two methods of procedure: in (a) the fire test is continued till failure occurs and in (b) it is stopped at the period for which classification is desired, allowed to cool and loaded to failure. In Section 15 (c) –it is not clear to me what constitutes approval in the two alternatives (a) and (b). They are not separated so as to make it clear what the floor, under each alternative, is supposed to withstand.*

The Chair: *Isn't it shown in paragraph (d) of Section 15? (c) covers this first and (d) covers the first case; in other words, if a test is continued until failure occurs, then the failure shall not have occurred until the period of test shall have exceeded the specified time by at least 25% of that time. According to ©, of Section 15, if the test is stopped at the end of the period for which the approval is desired, and then the specimen is tested to failure, it shall carry a load of two and a half times its safe rated load, in order to be acceptable.*

Mr. Ingberg: *Is or is not the floor whose test stops, say, at a period of 25% in excess of the period for which classification is desired, subject to a final excess load?*

The Chair: *It is not, because it may have failed entirely and not be capable of any load at that time, and if it has done so, it is felt that it is entitled to some value. In other words,– if I am not presuming on the Committee–*

Mr. Woolson: *All right; we are glad to have you.*

The Chair: *In other words, if a specimen is tested and fails at four hours, it is entitled to a rating of four-fifths of that time; that is, it would be rated at least as a two hour protection, or even better.*

Mr. Ingberg: *I would like to raise the point of the desirability of having the two alternatives. A specification as we usually think about it, is supposed to amplify methods of procedure, and here is a case where it does not do it; it leaves open two ways of procedure, and when this specification is used in practice it will be up to someone to decide which way the floor is to be tested. It seems to me it would be a good thing to have one uniform method. It does not appear that the differences in the two alternatives are very great, it is just a matter of 25% difference in time that a floor shall stand up. That means 15 minutes for a one-hour test and one hour for a four-hour test. I believe that two men qualified to judge would differ in opinion as to how much to expect there by that amount, so I would suggest that only one method be specified; which it should be had better be left to the Committee.*

The Chair: *Do you wish to offer an amendment?*

Mr. Ingberg: *I do not know that I want to offer an amendment, but I would suggest this, that the fire test be continued until failure, or at least until the period for which classification is desired, and as much beyond that as it is desirable to carry it to get what information you can on the fire-resisting qualities of the floor; then after the fire and water test, apply the excess load in all cases. You can carry that load to failure if you want to, only with the limitation you indicate that the floor shall at least be able to maintain 2*[-]*½ times the live load. In that way you can get information on the fire resistance and load capacity of the floor.*

Mr. Robinson: *I do not believe that in the floor tests we are going to be able to reach the ultimate fire-resisting point in the majority of cases. If we were obliged to test a floor to destruction by fire, it would be putting an unnecessary burden on the person who makes the test, particularly as in structures of that character the necessary strength qualifications, in many cases at any rate, will carry well beyond fire-resisting requirements. This may not be universally true, particularly if it becomes popular to skin down floors, but in most of the existing constructions, I think it may be true. If we set the period as the Committee has already done at, say, 25%, it seems to me we are safe from that standpoint. I do not quite know the effect of the load after the fire and water test. I would move that the subject be referred to the Committee for consideration, to be referred by them to the Executive Committee with power to act. Let it take the course embodied in the first motion suggested by the Chair.*

The Chair: *The motion before us is simply to adopt the report with the change that was suggested by the Chairman in Section 9. Does Mr. Robinson offer the other suggestion as an amendment?*

Mr. Robinson: *If agreeable to the Chairman, I offer that as an amendment.*

The Chair: *The amendment is that the report be referred back to the Committee for consideration of the suggestion here offered and then referred to the Executive Committee, with power.*

The amendment was adopted.

The Chair: *That carries with it the original motion.*

Mr. Ferguson: *Does that include the column report?*

The Chair: *No, the Committee is not prepared at present to go into details of the column test. As I understand it, the Committee contemplates writing a specification possibly during the course of the next year for the testing of columns.*

Mr. Woolson: *It must follow the Laboratories' test.*"

As was noted by the chairman of the Committee, Ira Woolson, the proposed fire testing standard was perhaps the most important standard considered by the National Fire Protection Association since its very first meeting in 1896.

Of particular interest is the standard time-temperature curve defined in the proposal. It is the same time-temperature curve presently being utilized in fire testing in the United States today.

Also of note is the fact that the proposed standard makes no attempt to define the actual construction features of the furnace to be utilized in making fire tests.

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Source: "*Proceedings of the Twenty-Second Annual* [NFPA] *Meeting*", Chicago, Illinois, 1918.