9336

NATIONAL BUREAU OF STANDARDS REPORT

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Meetings of

ISO/TC 92, WG 3,4, and 5
The Hague, 23-27 June 1966

by

A. F. Robertson

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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FIRE RESEARCH MEETINGS IN EUROPE

by

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ABSTRACT

Visits were made to Denmark and the Netherlands where meetings were attended of the Working Group on Fire of the Conseil International du Batiment and Working Groups 3, 4, and 5 of ISO/TC 92 on Fire Test Methods. The report summarizes the discussions held and observations made during visits to three laboratories.

An important new development in European fire research is the increasing technical concern for problems of accidental fires. Germany has constructed a beam furnace of 2-1/2 x 11 meters size at Braunsweig, while the Danes and Swedes,each, are planning floor-beam furnaces of 4 x 11 meters size. There are plans under way to build a furnace to study steel constructions in an opening of 8 meters high by 4 wide. This furnace is planned for construction at Metz in Alsace. Not only are new and larger test facilities in planning as well as currently available but the technical level of the work is of high calibre. Plans are well in progress to solve problems of unwanted fires by technical understanding rather than empiricism

The United States is still asleep so far as Government effort and leadership on building fire studies.

SEVENTH MEETING CIB COMMISSION W14

Copenhagen, Denmark 16-19 May 1966

The meetings of the Working Group on Fire were held at the Studenterforeningen, H.C. Andersens Blvd. 6.

We met as a group with delegates from ten different countries as shown in Appendix A. Dr. van Hoogstraten of TNO, Netherlands, was nominated and chosen as chairman.

We then divided ourselves into three groups which proceeded to discuss: I. Endurance, II. Spread and Measurement of Smoke, III. Fires in Compartments.

I elected to join Group III for the first day. Mr. Heselden was elected Secretary of this group. He led most of the discussion reporting on the progress to date on the international cooperative enclosure fire study.

Analysis of the data now available shows that there are no significant biases between laboratories for the radiation and temperature measurements. However, one laboratory, Australia, did show significant bias with respect to burning rate data, both with its own data as well as in comparison with other laboratories. These variations were attributed to changes in box material used.

Heselden reported that previous work had shown that the fuel consumption rate kg/min in enclosures could be closely correlated with $A\sqrt{h}$ in meters 5/2. The slope of the line was found to be 6 and thus in analyzing the data, they have elected, for convenience, to plot burning rate against $6A\sqrt{h}$ or, for normalization purposes, these same coordinates divided by B the box floor area.

Mr. Heselden discussed the findings reported in [1] in some detail. It was suggested the findings implied:

1. The enclosure fires with 1/3 stick spacing seem to correlate well at 1/4 or less window opening, but show significantly lower burn rates for larger windows. Perhaps this is associated with the transition zone we reported in our paper [2].

2. Similarly, the window radiation level for the cribs with 1/3 spacing was significantly below that for cribs of greater spacing.

3. The burning rate seems to increase with stick spacing for the larger window opening although the radiation level through the window did not vary greatly for spacings of 1 to 3.

4. Thus, the fire severity, which may be assumed proportional to radiation intensity times fire duration, is greatest for cribs of 1 spacing.

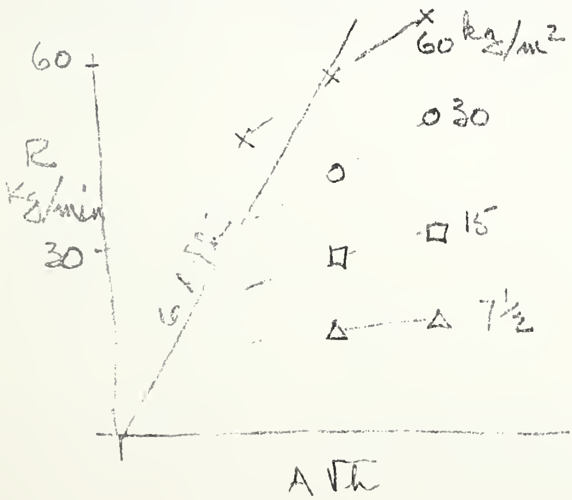
Mr. Heselden continued discussion by proposing a new cooperative program [3] intended to explore factors influencing the growth and spread of fires in enclosures. Both JFRO and TNO have done some preliminary work on this study. Further exploratory work is scheduled but the plan of the experiment calls for 8 laboratories to carry out a balanced statistical experiment measuring the effects of 8 factors each at 2 levels and each experiment repeated once. Later work would consist of further exploration of factors found to be important.

I spoke in favor of this project and agreed to the extent permitted by our facilities to participate. I pointed out various detailed comments furnished by Mr. Gross on the proposed program. Others agreeing to participate included:

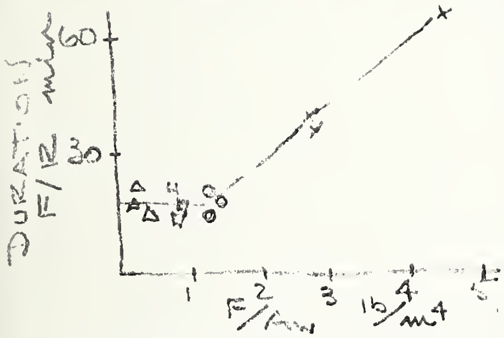
1. Joint Fire Research Organization, England
2. TNO, Netherlands
3. National Research Council, Canada
4. State Testing Institute, Sweden
5. Dr. Rumberg, Dortmund, Germany
6. CSTB, France
7.

Mr. Heselden showed some pictures of preliminary experiments performed on this program.

He closed the meeting with a brief review of the findings in their large-scale burnout tests partially supported by steel interests. This compartment was of 2,1,1 shape, 2 units wide 1 deep and 1 high, and the scale was about 4 meters. The window size was arranged for 1/4 and and 1/2 the large wall area. The results for burning rate R vs. A√h correspond roughly to that for the model work. However, in all cases, the cribs seemed to limit burning rate.



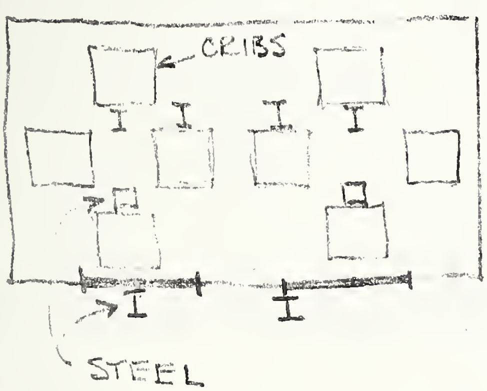
If these data are plotted per unit fire load F in kg/m², then they plot as shown here:



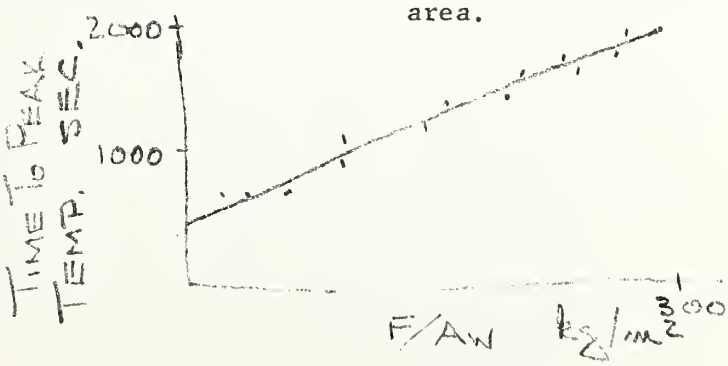
A further correlation was found to be useful as shown here. This suggests that the fire duration is roughly constant up to some critical ratio of fire load to window area beyond which the fire duration increases with F/A_W ratio. It might be well to compare our enclosure fire data on this basis.

Temperature measurements in these tests showed that the most severe fire exposure resulted from the 1/4 window opening rather than 1/2, [4].

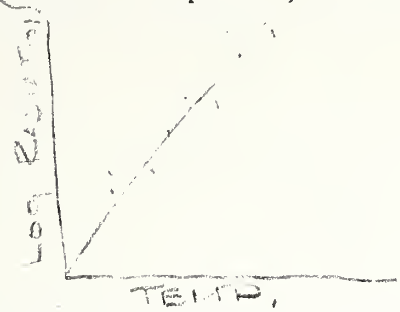
During these studies, various steel shapes both protected and unprotected were exposed to the compartment fire conditions as shown in the sketch. For columns protected with blown slag insulation, the temperature of the columns were rather uniform along their length. In general, there was a fairly good correlation between column temperature and gas temperature in enclosure. Data were analyzed on the assumption that all thermal resistance was in insulation and all heat capacity in the steel columns.



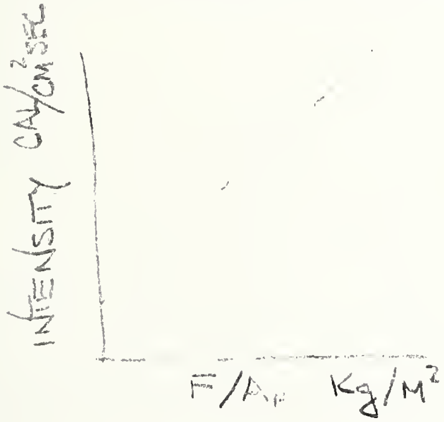
The time to peak fire temperature was reported as linearly related to ratio of fire load to window area.



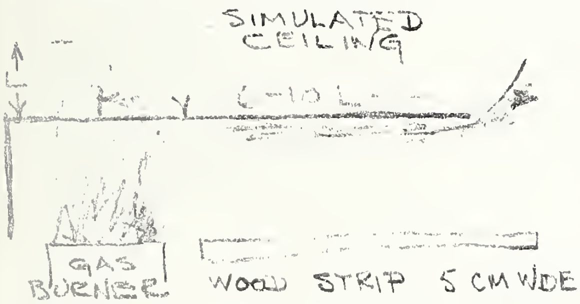
As would be expected, the logarithm of the radiation at the window opening was found to be linearly related to gas temperature.



A plot of radiation intensity at the window was reported as linearly related to fire load per unit floor area. On the basis of these findings, it was suggested that the temperature of steel could be derived from maximum compartment temperature which could be inferred from the rate of fuel consumption. I must admit that although the reasoning appears appropriate, it is not clear that the data correlations described should be as straightforward.



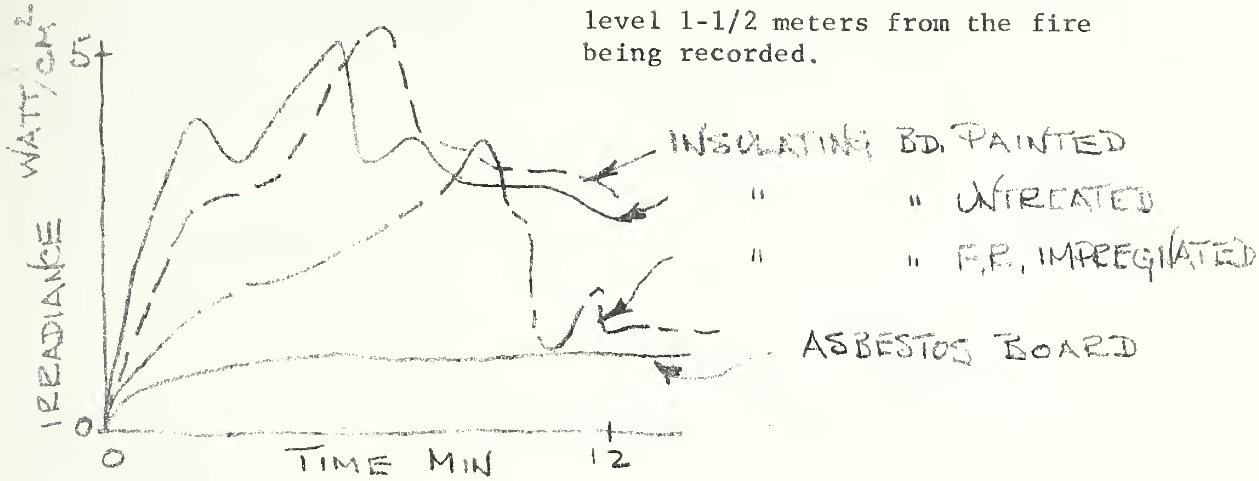
A brief review was also made of the recent British study of fire spread below ceilings.



Apparently, Professor Atallah has been active in following these tests. The flame length along the underside of the ceiling was reported to be 6 to 10 times that which would occur above the ceiling position, if it were removed.

The flame spread along the wood strip was reported as sould be expected at left.

Experiments had been performed with various types of ceiling material. The radiation at floor level 1-1/2 meters from the fire being recorded.



On Tuesday we were taken for a visit to the A-S Rockwool Cadanhus, GI Kangenej 60, Copenhagen V. This company manufactures a wide range of fibrous insulation materials. The fiber is produced by melting basalt and limestone with the use of coal in a furnace on a continuous basis; the molten glass falls in a stream onto water-cooled metal drums and is blown with compressed air or steam to form the fiber. I believe the process used is licensed to them by Johns Manville Company. The fiber has a softening temperature of about 1200 C. We were shown through their plant and research laboratories. One interesting method they were using for production control was air permeability as a means for estimating thermal conductivity. They agreed to forward information to us on this technique. They admitted that, while it could be used with high accuracy ±2% on their standard products, it would have to be recalibrated when applied to a competitor's product. They were performing furnace tests using their "Brandbatt" a low phenyl binder (0.5%) which was recommended for high temperature insulation. A batt perhaps 12" x 12" was placed as an enclosing door of an electric muffle furnace operated at 900 C. Observation was then made of the depth of burning beneath the surface after prolonged exposure. They reported that the binder content of their regular product was about 2%.

In the afternoon, we were taken for a visit to the Vedex Dansk Skovindustri A.S., the Danish Forest Industry Ltd., at Noestred, Denmark. Their manager, Chr. Christoffersen, showed us through their present plant where they are producing their new product, Fire-Resistant Compact Wood (FRCW). This is a beech plywood the plys of which are individually impregnated with a newly-discovered secret impregnant formulated from

28 different chemicals. The chemical add on amounts to about 17 percent. Its density is about 120 kg/m^3 and they have tested it under 200 hours exposure in both boiling water and steam without evidence of loss of fire retardance or delamination. They attribute its good properties to both the impregnant and the special glue. They have produced a 35 mm solid door and frame which has performed well in a fire endurance test for 60 min. Reports were furnished on various tests of this product. We were told there was never any flaming when the material was tested and almost no smoke. I asked for a sample of both the untreated and treated product. These were to be mailed. I informed them that I could not make an official report of the test results we might plan.

On Wednesday, I was asked to review, briefly, with the Task Group III, our recent work on smoke measurement methods. Accordingly, I spent most of the morning with this group. They were quite interested in our proposal for reporting smoke measurements in terms of specific optical density and, in the report of their meetings submitted later, they emphasized its usefulness.

During this meeting it became evident that Dr. Rumberg still considers the irritation effects of decomposition products of prime concern. Although animals could be useful for assessing toxic hazard, they were not likely to be useful for study of irritation caused by decomposition products. It seemed that such measurements could be most usefully made with groups of people exposed to such gases. It appeared likely that large numbers of people would be required for such experiments to avoid errors resulting from desensitization resulting from repeated exposures.

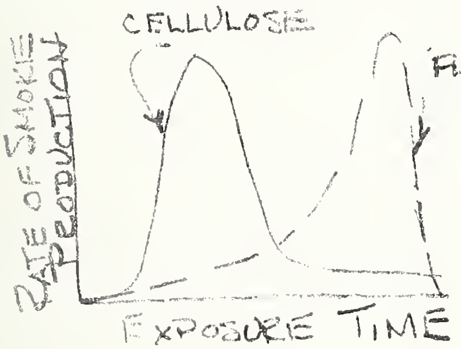
Dr. Rumberg reported that they had experienced difficulty in using chromatographic equipment because of the water present in all combustion products. He also was critical of the use of colorimetic detector devices. He said that they have shown seriously low indications in CO measurement when $HC\ell$ was present. He indicated that there was evidence of synergistic effects between CO and $HC\ell$. In answer to a question I posed, he indicated that HF had been measured during burning of teflon.

Dr. Rumberg suggested that Germany would probably go along with a qualitative classification scheme proposed by the Swiss. They subjectively rate four properties of plastics as follows:

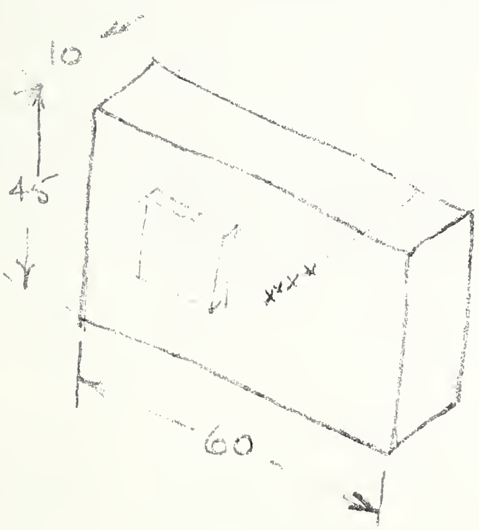
(a) Flame propagation
(b) Smoke production
(c) Dripping behavior
(d) Toxicity

Four classifications 1 to 4 would be used to describe material behavior with regard to each characteristic for the purpose of selecting plastics acceptable for building use. Further details of method of reaching conclusions were not described. Dr. Rumberg is at present actively preparing two standards for use in Germany, one on decomposition products and the other on smoke.

Mr. Lawson reported continued work with chromatographic studies of decomposition products in their enclosure fire experiments in which fire load and ventilation are being varied. Both UK and TNO in Netherlands are trying to use photometers in connection with their box-type spread of flame tests. Dr. Lie furnished me with a copy of his preliminary report on this work. He has performed experiments in which he places his spread of flame test equipment in an enclosure and finds that the rate of change of density in the enclosure is proportional to the density of the smoke column rising above his box. He reported data in agreement with our finding that plastics produce most smoke when flaming, while the converse is true for cellulosics. Although he has been considering box volume as we have, he has not yet correlated data with specimen size and, although he apparently is in agreement with the specific optical density concept, he had not yet arrived at this idea on his own.



On Wednesday afternoon, I sat in on discussions of Group I. Here, the main discussion was on the question of design of heat flux measurement block for use by laboratories planning to construct walls for comparison of furnace exposure conditions. After lengthy discussion, it was decided to go along with proposal for a block large enough to be used with our standard pad so that both heat flux and temperature failure criteria could be assessed and compared. Three specimens would be mounted in each panel and it was hoped that 2 or 3 tests could be run. It was decided that, as a first try, only Holland, I.K., Germany and France would participate. Germany (DAM) was to prepare the specimens.



On Thursday, all the groups met together and tried to summarize findings. A report from each was presented by the secretary. These reports are enclosed as Appendices B, C, and D. Lawson then proceeded to amplify on the usefulness of knowledge gained through model studies. He pointed out that their work had made clear the fact that wall linings and,especially the ceiling thermal properties, had a great effect on fire development. The time at which flames reach the ceiling is a critical one in fire development because the then rapidly spread over the ceiling surface. This increases heat transfer back to unignited material on the floor. Thus, high ceilings tend to delay lateral spread and growth of fire while low ceilings increase it. The flame height to diameter ratio of a fire in the open has been shown to be given by:

$$H/D = K(m^2/\rho g D^5)^{1/3}$$

where m is the burning rate ρ is the density and g is the gravitational constant. From this, he argued that for a given burning rate, as compartment height increases, the size of the fire at the floor must increase. However, the time taken for the fire to reach the ceiling and thus start encouraging lateral growth increases more significantly than the necessarily larger fire diameter at floor level.

In this way, the greater the height of a compartment, the more gradual may be the horizontal growth of a fire and thus,at any given time, the quantity of goods damaged in a high compartment may be significantly less than one with low ceiling. However, the early detection of fires with thermal detectors may be more prompt in low ceilinged rooms. This difference may be serious, but could perhaps be overcome by use of smoke or other types ot detectors.

Because of these considerations, they are currently exploring heat transfer between flames, ceilings, and floors as H varies.

Lawson said England had recently experienced two cases where roof venting had failed to control fire spread because of the flammability of the stored material. They now are planning to explore the use of water curtains as a means of wetting down a perimeter around the fire thus delaying spread until the vents can become fully effective.

Lawson closed by emphasizing that they were convinced that the newly proposed studies for growth of fires were important for showing ways in which life and property loss could be reduced.

Both the French and Danes, as well as English, plan to clean up some uncompleted work on the enclosure fire study. It was hoped that this would make possible analysis of all the data and draft of a report by the next meeting.

It was proposed that the next meeting be held in Canada and the United States in connection with the CIB Congress in September 1968.

On Friday, those of the group wishing to were invited to visit the fire laboratories of the "State Testing Station" of Denmark. The facilities have been rather completely described [5]. The fire laboratories are relatively new having been built in 1957. The space available is too small, but the equipment seems very good. A floor furnace of 6 x 2.5 meter specimen size, a wall furnace of 3.5 x 2.5 meter specimen size. Numerous small furnaces, spread of flame, and combustibility apparatus.

In spite of the relatively new condition of this laboratory, they find it inadequate for their needs and are hoping for relocation of their whole laboratory. At that time they plan to build a furnace for beams and floors with fire exposed area of 4 x 11 meters.

We were shown their mockup of a ship cabin and corridor for their stateroom fire tests. The cabin itself is mounted on load cells so that it may be weighed during burnout tests. Previous discussion of laboratory facilities was included in [6].

Working Groups of
ISO/TC-92

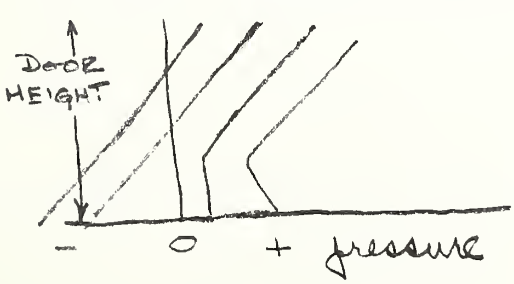
Meetings of three working groups of ISO/TC 92 were attended as a result of an invitation from the Secretariat resulting from concern aroused during the IMCO meetings that American thinking be presented during meetings. I was present, therefore, in observer status, but was encouraged to participate freely in discussion.

The first group No. 3 on "Test Methods for Door Assemblies" met on Monday and Tuesday, 23 and 24 May. Those, in addition to myself, participating included Ashton and Malhotra (UK), Malmstedt(Denmark), Col. Cabret and Bellisson (France),Minne (Belgium),Westhoff (Germany), van Hoogstraten (Netherlands), Shorter (Canada) Sung and van Toutenhoofd (Secretariat ISO).

Mr. Malhotra was selected as future chairman since Mr. Ashton plans to retire in the near future.

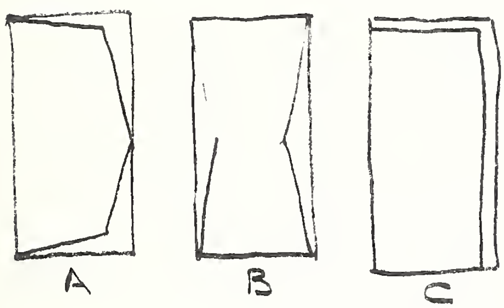
The meeting started off with a general discussion of problems with doors during fires. The working group has been charged to develop a test method for doors which will eventually become a part of the fire endurance test method. It was emphasized that the door frame may be equally important with the door in containment of fire and smoke. England and Canada have similar problems since the door and frame are not supplied by the same manufacturers. In both countries, however, the code requires performance of both door and frame. I described our recent experiments on upgraded doors [7], but emphasized that, although an ASTM test procedure [8] was available several aspects relative to qualification of doors were not clearly defined therein and that in our country most doors used for control of fire spread were tested by Underwriters Laboratories. In France, it was stated that chief concern was for limitation of spread of smoke and gas through or around the door.

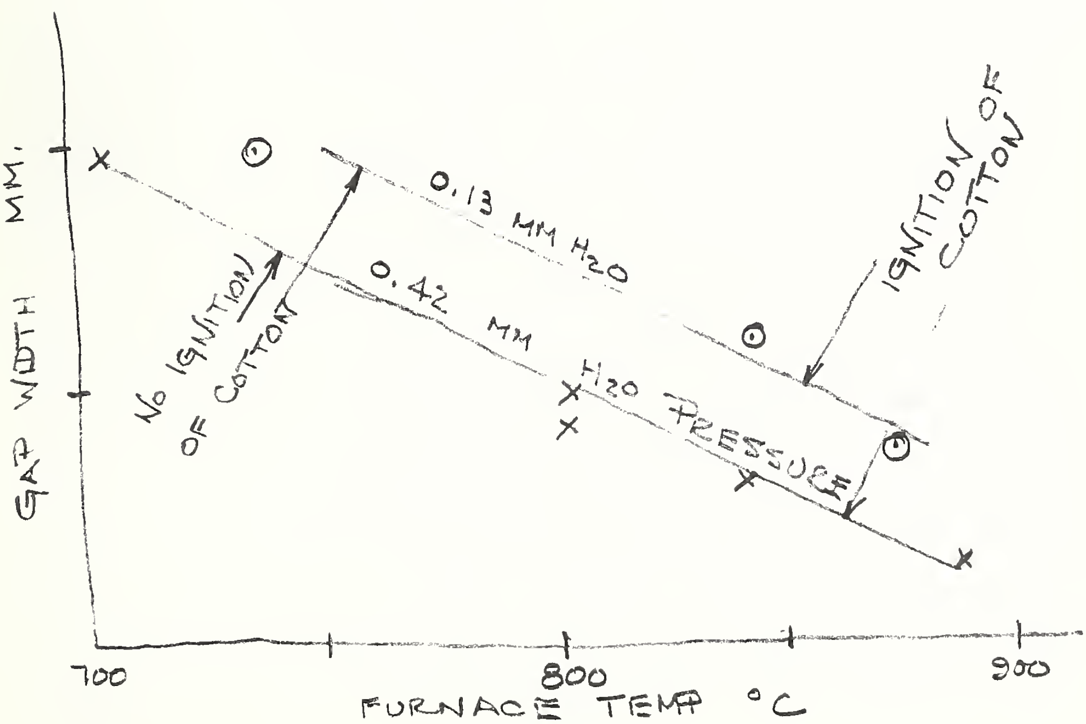
There was considerable discussion of problems relating to control of position of the neutral pressure zone in the furnace. Apparently, Britain and Canada have not been able to position this zone easily. In Denmark, they have perhaps pioneered in control of the location of this zone, but apparently have had difficulty in moving this below the 1/3 height. Malmstedt reported that when he tried to raise the furnace pressure, he got results as shown to the left. He, Malhotra and Shorter indicated they planned further experiments taking more care with the measurement of static pressures in the furnace.



I indicated that our panel furnace was designed for the neutral zone to be below the specimen, but this could be varied by changing draft conditions.

The group had previously initiated studies between laboratories on use of a canopy above the specimen and fitted with radiation and convection measuring units. Three simulated doors were to be used as shown sketch. The "doors" were to be of asbestos wood 3/8 in. thick and of the shapes shown. The shapes were intended to simulate the types of cracks likely to develop with hinged, sliding and folding doors. British and Danish delegates compared their initial measurements with type "A" doors. There seemed to some evidence of agreement of heat flow measurements between laboratories and it was agreed to continue work with some modification of techniques.





The figure summarizes the British studies on ignition of cotton gauze over various crack sizes.

It was agreed that France, Netherlands, Germany Denmark, Belgium and U.K. would participate as planned in the canopy tests for heat transfer measurement through cracks. Belgium would make measurements with small-scale specimens. Other problems such as grills, hardware, paint, etc., were left for future consideration. The meeting was adjourned with a plan to meet again on 7 and 8 March in Copenhagen, with perhaps a prior meeting in October or November of this year, if sufficient progress had been made by that time.

Papers secured at this meeting included:

ISO/TC 92 WG.3 (Secretariat-89) 194
Test Requirements for Door Assemblies
Report of Paris Meeting 27 and 28 April 1965

ISO/TC 92 WG.3 (UK-1) 1
"Program of Tests to Study the Effect of Door Gaps"

ISO/TC 92 WG.3 (UK-2) 2
"Program of Tests to Study the Effect on the Value of Doors as Fire Barriers of Gaps at the Edges"
Report No. 1

ISO/TC 92 WG.3 (UK-3) 3
Same as above but Report No. 2

ISO/TC 92 WG.3 (DK-1) 4
Letter from Malmstedt re: Door Test Instrumentation

Working Group 4

The meeting of Working Group No. 4 was held on Wednesday. This group is concerned with the Reaction to Fire Test Methods (flammability). However, it was indicated that they had been charged with the additional problems of collecting information on Smoke and Toxic decomposition products. Those present included Odeen (Sweden), Minne (Belgium), Malmstedt (Denmark), Amy (France), Dorn (Germany), van Hoogstraten and Lie (Netherlands), Malhotra (UK), Shorter (Canada) Sung (ISO Secretariat) and myself.

I agreed to send preprints of our coming paper on smoke as well as try to send the others to be presented next month at the ASTM symposium.

The group had previously participated in round robin flammability tests of 25 materials, in six or eight countries. Since many of the flammability test methods were of different character, it is not surprising that some large differences in material ranking resulted. Mr. Amy had made a statistical study of the results and most of the morning was spent in discussing his findings (France-1) 1. In doing this he observed that each test method classification was based on a number of different experimental observations such as flame arrival time at different stations, stack temperature rise or time at which temperature rise exceeded a certain level. As a result, it occurred to him that perhaps the lack of correlation was based on poor selection of overall index rather than lack of merit of the test itself. He decided to try to check this and selected a number, 2 to 5, of these observations for each test method and then selected pairs of different tests (laboratories) and then proceeded to calculate the correlation coefficient between the two laboratories' results for each of the observations selected. Usually, the coefficient varied significantly and he then selected the two observations showing the highest coefficient. In this way he was able to select one of the observations made by each test method likely to yield the best correlation between all laboratories. The ranking of the various materials on this basis were then listed and it was found that the general overall ranking of materials was quite similar to that originally made. However, by the new ranking method, several of the initial worst offenders were significantly improved. There did not seem to be clear evidence that the ranking of plastics was significantly different, as had been the previous observations.

There was considerable discussion on what these findings meant. In the course of this, the British reported that, as a result of round robin tests in their own country with their box method, they have found that a new manner of calculation of classification permits better correlation. They, therefore, will have to provide Mr. Amy with the new observations for the materials, so he can again review the correlation.

The meeting was closed with an agreement that each laboratory would make a critical review of its own test method with the objective of deciding whether some other weighing of the various observations might not result in a more appropriate overall classification. The participating countries agreed to do this and we were invited to furnish a technical review of the flammability test methods used in our country.

On Wednesday afternoon, Mr. Lie,of Netherlands, and I were asked to review,very briefly, our recent work on smoke. I reviewed our work with the box test method, while Mr. Lie described his photometric measurements in the smoke column above their box flammability test chamber. He has made a correlation of this as a measure of rate of smoke production with the slope of the smoke accumulation curve when the test box is enclosed in a larger container. In general, his thinking is similar to ours, but the concept of a specific optical density as a specimen property had not been developed.

The group agreed to try to meet again in November or December probably at the same time as GS 4 in Copenhagen.

The following papers were distributed during the meeting:

ISO/TC 92 WG.4 (Secretariat-91) 212 July '65
"Report of Meeting Held in Paris 26 and 28 May '65"
Working Group 4.

ISO/TC 92 WG.4 (France-1) 1
"Part III Statistical Analysis of the Results of
Spread of Flame Test" (WG.4)

ISO/TC 92 WG.4 (Sweden-1) 2 Octber '64
"Tendency of Surface Finishes to Contribute to Rapid
Flame Spread and Heavy Smoke Development" (WG.4)

Working Group 5

The meetings of Working Group 5 were held on Thursday and Friday. This is a newly constituted group formed to study restraint, deformation and loading of fire test specimens during endurance tests. The following delegates participated: Malhotra (UK), Ehm and Pastel representing Professor Hardina who was ill (Germany), Professor Pettersson and Odeen (Sweden), van Santè and van Hoogstraten (Netherlands) Shorter (Canada) and myself as observer.

Prof. Pettersson was elected Chairman. He started the meeting off by asking each delegate to review the requirements in his country with regard to specimen loading restraint and structural failure criteria during fire tests.

Germany DIN 4102

Mr. Ehm reviewed this standard.

1. Floors: Floors are always tested in a freely (support and rollers) supported condition, no restraint in plane of the structure. At Braunsweig, their furnace takes specimens of 4-1/2 meters span while the standard requires a minimum size of 2 x 4 meters. The standard requires that the load applied be sufficient to stress the structural components to the maximum intended in design. Load failure is based on a rate of deflection criterion,

$$\Delta f/\Delta t \geqq \ell^2/9000h$$

where:

$\Delta f/\Delta t$ is rate of deflection at midspan in cm/min.

ℓ is the free span in cm.
h is the structural depth of the specimen cm

2. Walls: Walls are required to be of at least 2 x 2 meter size. No restraint is provided against lateral or vertical expansion of the specimen. Loaded walls are unconfined at sides and loaded from either top or bottom. Both top and bottom are restrained against rotation. Observations are made of bowing deflection of walls during test. Wall must remain structurally stable throughout test. No reload required.

ASTM E-119

Mr. Shorter and I described this test method. We pointed out that several aspects of the method were not completely defined. Thus, the way in which load failure is assessed, degree of restraint applied to specimen, etc., were not clearly defined and could be interpreted differently between laboratories.

BS - 476

Mr. Malhotra described the British Standard.

1. Beams and floors: These members were freely supported unless it could be shown that this situation would never occur in practice. The standard requires that such members be tested under conditions of restraint simulating those intended in the construction. Floors are usually tested with the two edges free and unrestrained or supported. Loading by deadweights for floors, but hydraulic 4-point loading for beams. The standard requires that specimens stand exposure without collapse, but ability to carry test load 48 hours after test is required. To assess this, the load is left on floors for this period while beams are again reloaded after 48 hours.

2. Walls: Load-bearing walls are tested with the two side edges unconfined. Top and bottom of walls are secured against rotation. Non-bearing walls are tested fully restrained. Degree of restraint is not specified. Load failure not detailed, but structural stability requirement as for floors. Reload after 48 hours required for walls.

3. Columns: Columns are tested with both ends fixed against rotation. Both wall and column furnaces can apply a load of 500 tons. Columns,like other load-bearing structures, must be tested to determine ability to carry load 48 hours after test.

NEN 1076D

The test method used in the Netherlands was described by Mr. van Santé. He stated that a general requirement was that structures should be tested under conditions simulating intended practice in use.

1. Floors and Beams: These members are usually tested without lateral or longitudinal restraint,usually without moment restraint at ends. In some cases, floors intended for two-way support are tested with support for all four edges. When proper loading is applied which recognizes the type of support, it is usually found that performance is somewhat poorer than a similar structure loaded and tested in simple bending. Deadweight loading is used and test method requires that specimen not collapse. In the TNO laboratory, they have used the same rate of deflection criteria used by the Germans. The furnace for beams at TNO is capable of testing specimens with a fire-exposed length of 8 meters. Longer specimens have been tested with ends extending over ends of furnace.

2. Walls: Walls are tested with lateral edges free and only low capacity loading equipment is available. Non-bearing walls are free to expand on three edges.

INSTA 28/2

This new Scandinavian test method is still in draft form. Professor Pettersson described its basic requirements. The standard calls for specimens of the following maximum sizes:

Floors	2 x 4 meters
Walls	2-1/2 meters high x 2 meters wide
Columns	2-1/2 meters high
Beams	4 meters span

The test load is to be equal to the design load unless other loading is shown to be more correct for actual practice. Load is to be applied one day prior to test and remain on for one day after specimen has cooled to room temperature. At this time, the structure shall be loaded to failure. Although it was stated that walls are to be tested in a manner similar to that used in Germany and Netherlands, the test specification calls for restraint of specimens in a manner to simulate that actually existing in a structural assembly. It was stated that the standard could be interpreted to require axial restraint of expansion of columns. One interesting feature of this proposed standard is the fact that it suggests ways in which classifications of structures can be based on computation and tests of similar structures.

The meetings of this group were interrupted by a visit on Thursday afternoon to the fire laboratories of TNO at Delft and the Bow Centrum in Rotterdam. On Friday, they resumed review of their task. They agreed to circulate standards of other countries including Australia, Japan, France, etc. They enumerated various topics for consideration under the three main tasks or aspects of their duties: loading, restraint, and deformation, and asked that delegates be prepared to discuss problems in greater detail during the next meeting, probably at Copenhagen in March 1967.

I agreed to furnish copies of papers developed for ASTM symposium. Papers distributed during this meeting included:

ISO/TC 92 WG.5 (Sweden-1)2
"Fire Resistance Test. Determination of Fire Resistance of Parts of Building Construction" INTSTA 28/2

ISO/TC 92 WG.5 (Sweden-2)3
"Comments on above, showing ways in which it differs from ISO Std.

ISO/TC 92 WG.5 (USA-1)4
"Fire Tests of Building Materials and Constructions" ASTM E-119-58.

ISO/TC 92 WG.5 (Germany-1)5
"Brandverhalten von Bonstoffen und Bauteilen" (DIN 4102 Blatt 2) Definitions, Requirements and Tests in German.

ISO/TC 92 WG.5 (Germany-2)6
"Brandverhalten von Baustoffen und Bauteilen" (DIN 4102 Blatt 4) Classifications in German.

ISO/TC 92 WG.% (Holland-1)7
"Fire Tests on Concrete and Brick Floors" Report No. 19/1728/1965 TNO.

Visit to TNO Fire Laboratories

We visited these laboratories on Thursday afternoon. The only large furnace of special interest is used for tests of beams. They have recently completed tests of prestressed concrete beams of about 40 ft length;only 26 feet were fire exposed, the end portions extended over the furnace ends and were loaded to simulate continuity over supports. The beams had been specially designed with additional negative moment steel to permit carrying the bending movements at supports even when fire-exposed concrete had been badly damaged. This beam had shown unusually good performance, 8 hours.

We were shown a small cylindrical furnace used to test plastic piping used in such a way that it penetrated building floors. Failure was measured by collapse of piping or temperature rise on outside of pipe above simulated floor. PVC and one or two other plastics had been tested, but most failed in less than 15 minutes. This is not surprising since standard time temperature curve is used in the furnace.

We were shown a new experimental fires building in which an enclosure fire model of 4 x 5 x 2-1/2 meters height could be weighed while the load was burned. Provisions were being made to use a corridor of about 10 meters length with this compartment to study fire spread down the passageway. We were shown several other tests including fabric flammability and spread of flame (box test). Time was not available for detailed discussion of findings and nothing else specially new in the form of test equipment was seen. We were driven by the new TNO laboratories on the border of Delft. These were large and impressive. We were told there were about 10,000 employees in TNO which covers most governmental technical work.

I trust, in summary, that this record of my visits and meetings will serve a useful purpose for those willing to struggle through the pages.

References

[1] CIB/CTF 66/12 UK "Some preliminary Results of the CIB International Program Studying Fully-Developed Fires" by Hesselden and Smith, JFRS Internal Note No. 252.

[2] CIB/CTF 65/39 USA "Experimental Fires in Enclosures" by D. Gross and A. F. Robertson, 10th Symposium International on Combustion.

[3] CIB/CTF 66/11 UK "Proposals for a Second International Cooperative Research Program on Fire Behavior in Buildings" by P. H. Thomas and A.J. M. Hesselden, JFRO, Internal Note No. 251.

[4] Report of Visit to British Fire Research Station,5 and 6 July 1965, by A. F. Robertson, NBS Tech. Report No. 8926.

[5] "Statsproveanstaltens nye Brandlaboratorium",K. Malmstedt,Saertryk Ingenioren No. 12 June '61.

[6] "CIB Meeting and European Fire Research 1964" by D. Gross and A. F. Robertson, NBS Tech. Report No. 8377.

[7] "Doors as Barriers to Fire and Smoke" by H. Shoub and D. Gross, NBS Building Science Series No. 3.

[8] "Fire Tests of Door Assemblies" ASTM Procedure E-152.

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APPENDIX A

List of names and hotel addresses of the participants
in the 7th meeting of C.I.B. Commission W14
Copenhagen, 16th - 19th May, 1966

Canada

Mr. G.W. Shorter	Hotel Europa H.C. Andersens Boulevard 5o - 12 68 68

France

M. Bellisson Colonel Cabret	Hotel Richmond Vester Farimagsgade 33 - 12 97 o1
Commandant Haure M. le Puloc'h M. Traverse	Park Hotel Jarmersplads 3 - Mi 3ooo

Germany

Dipl.-Ing. W. Becker Dipl.-Ing. Hans Dorn Dr. H. Seekamp	Park Hotel Jarmersplads 3 - Mi 3ooo
Dr. E. Rumberg Dr. Wolfgang Westhoff	Missionshotellet Løngangsstræde 27 - Ce 657o
Dr.-Ing. Paul Bornemann	

Japan

Dr. K. Nakata	Hotel Europa H.C. Andersens Boulevard 5o - 12 68 68

Netherlands

Dr. G.W. van Hoogstraten Ir. Lie T.T. Ir. F. van Sante	Hotel Alexandra H.C. Andersens Boulevard 8 - 14 22 oo

Norway

Mr. P. Lossius	Hotel Hebron Helgolandsgade 4 - 31 69 o6

Poland

Mr. L. Baranowski	Missionshotellet Løngangsstræde 27 - Ce 657o

United Kingdom

Mr. L.A. Ashton Mr. D.I. Lawson	Hotel Europa H.C. Andersens Boulevard 5o - 12 68 68
Mr. J.F. Fry Mr. A.J.M. Heselden	Park Hotel Jarmersplads 3 - Mi 3ooo

Sweden

Kai Odeen V. Sjolin	State Testing Laboratory, Stockholm, Sweden Royal Institute of Technology

U.S.A.

Mr. A.F. Robertson — Hotel Europa, H.C. Andersens Boulevard 5o - 12 68 68

Denmark

Dr. P. Becher, The Danish National Institute of Building Research
Mr. G. Danielsen, The laboratory of the Copenhagen fire-fighting service
Mr. Gerhard Hansen, The Danish State Testing Laboratory
Mr. H. Lundsgaard, Danish Fire Protection Association
Mr. K. Malmstedt, The Danish State Testing Laboratory
Dr. J. Mygind, chief of the Frederiksberg fire-fighting service
Mr. Jens V. Petersen, chief of the Næstved fire-fighting service and chairman of the association of fire-chiefs

Secretariat

Mr. Jens Holst
Mrs. Annemarie Gjetting

Interpreters

Mr. R.K. Lockner
Mr. Gérard Ilg

The following will participate in the dinner in Tivoli on Monday, 16th May

Mr. J.H. Ammitzbøll, chief of the Copenhagen fire-fighting service
Mr. H.W. Schmidt, vice-chief of the Copenhagen fire-fighting service
Mr. Jørgen Johansen, chief of the Gentofte fire-fighting service
Mr. Marius Kjeldsen, architect, Ministry of Housing
Mr. R. Serring, chief of the Danish Fire Protection Association
all with ladies

APPENDIX B

Seventh Meeting of C.I.B. Commission W.14

Report of Group 1

The following delegates participated in the discussions:

M. Bellisson		Mr. van Sante	
Col. Cabret		Mr. Lossius	(part time)
M. Traverse		Mr. Baranowski	
Mr. Becker		Mr. Robertson	(" ")
Dr Seekamp		Mr. Shorter	(" ")
Dr. Westhoff		Dr. Becher	(" ")
Dr. Bornemann	(part time)	Mr. Ashton	

Mr. Ashton who was Chairman of the Group at the sixth meeting of W.14 was asked to resume the post on this occasion. He suggested, however, that in view of ~~the~~ his impending retirement it would be preferable for the sake of continuity to chose a new Chairman, and Mr. van Sante was proposed and accepted.

At the previous meeting some participants had undertaken to make a review of existing information on the fire resistance of structural elements for the purpose of supplementing the co-operative project on the correlation of furnaces. Reports of these reviews had not been prepared in time to be circulated before the meeting, and therefore each author gave a brief account of his study and of his conclusions. Each account was followed by questions and discussion.

Mr. Bornemann (1) compared published results of tests on reinforced concrete floors in Germany, Holland and the United Kingdom. He used only data for simply supported floors spanning in one direction, rejecting results of tests in which spalling of the concrete cover occurred. He was not able to give a complete analysis of results in terms of heat transfer because of lack of knowledge of all factors, but he suggested that a limited programme of carefully controlled tests could give the information needed.

Dr. Westhoff had been asked to find out whether the results of tests on brick walls, both with and without plaster, could be used to correlate furnaces. Unfortunately, there is no recent test information on solid brick walls. Published data are not complete records and relate to tests made more than 20 years ago. Unless information on some physical properties of the test specimens could be supplied no useful comparison was possible.

Mr. Becker (2) examined published reports of investigations on reinforced concrete columns made in the U.K., the U.S.A. and Germany, but for comparative purposes he found only the U.K. and German results were relevant. His study took account of structural behaviour as well as of heat transfer, but two important facts were established. (1) With a given thickness of concrete cover the rise in temperature of the main reinforcement was always slower in the German than in the British tests. (2) The maximum elongation of the columns tested in Germany was three times as large as for similar columns tested in the U.K.

Mr. Ashton reported on the stage reached in the co-operative work on furnace correlation agreed at the last meeting. To design the experiments in the best possible way he had circulated a questionnaire to the participating countries which asked for answers to matters relating to the making and preparation of the test structure, the test procedure and the measurements to be made during the tests. Only three countries replied - Holland, Australia and Germany (West Berlin). The Group discussed the information supplied by these delegates and by the U.K., and also if the original proposal was likely to achieve its intended objective. After considerable discussion the members agreed in principle to the original proposal and decided on the essential details of construction for the test elements. A suggestion that the investigation should be extended to

include combustible elements was not accepted because of doubts about the ability of participants to complete such tests before the next meeting. Moreover, it was not practicable for all laboratories to take part since manufacture and distribution of the test elements on a large scale would be a formidable task. It was decided, therefore, to confine the investigation in the first instance to a limited number of laboratories, including those with gas- and oil-fired furnaces. The participating countries are Germany (3 laboratories), Holland, France and U.K., and Germany agreed to make and distribute the elements. The results of this work should be reported to the next meeting of Commission W.14 when the need for an extension to other laboratories could be examined. Details of the limited programme would be agreed in the course of the next few months by the participating laboratories who undertook to keep other countries informed.

The suggestion was made that it would be of value if the results of tests made in different laboratories on constructions containing Rockwool or Navilite could be examined to see if information on furnace correlation was obtainable.

Refs: (1) Fire Endurance of Reinforced Concrete Slabs. Dr.-Ing. P.Bornemann

(2) Comparative Investigations of the Behaviour of Reinforced Concrete Columns in Fire Tested at Various Institutes. Dipl.-Ing. W.Becker

APPENDIX C

Seventh Meeting of C.I.B. Commission W.14

Report of Group 2

The following attended the discussions in group 2:

Mr. G.W Shorter
Mr. Gerhard Hansen
Mr. H.Lundsgaard
Commandant Haure
M. le Puloc'h
Dr. E.Rumberg
Dr. K.Nakata
Ir. Lie T.T.
Mr. D.I.Lawson (chairman)
Dr. A F Robertson
Mr. J.Holst (secretary)

Mr. G.W Shorter stated that Canada is interested in smoke hazards in tall buildings, and is measuring pressure distribution with a view to keeping smoke from escape routes.

Laboratory work - investigating smoke and toxic hazard of different materials using a flow system with atmospheres 0 - 21% oxygen. The toxic measurement will be made by gaschromatograph.

No laboratory work in progress, but M. le Puloc'h described some interesting fires involving bundles of PVC insulated cables in a vertical shaft 40 x 60 cm. The HCl vapours produced had caused great damage to a computer system. M. le Puloc'h said that tests had been made by the late Colonel Fackler for Electricité de France and a report has been prepared.

Other tests had been carried out in Rue Lefèvre and the CO produced by the fire had been measured. A report is available.

M. le Puloc'h thought that the Swiss system was a good one in which the plastic were graded for flammability, smoke, toxicity of combustion products and ability to form drops of molten material.

Everybody agreed but the difficulty was that their knowledge of smoke and toxic hazards was too limited to permit of a grading system being used at present.

Dr. Rumberg described a furnace in which a ring oven moves over a tube containing the test piece of cross-section of 2 mm x 5 mm. In some experiments the specimen is replaced by steel for temperature standardization. Dr. Rumberg said that the vapours must be led directly to animal chambers for the assessment of toxicity. The smoke is led into a tube where it is diluted with a current of air for photometric measurements. Dr. Rumberg thinks that gaschromatography is not suitable for measuring toxic gases as some break down in the presence of water. Mass spectrometry is better.

Two standards are in preparation:

1) Thermodegradation,
2) Smoke density.

Dr. Rumberg stated that some toxic products are synergistic, so that their combined effect is greater than their separate effect, e.g. CO and HCl.

Dr. Nakata stated that Dr. Handa is working on the visibility in smoke. He believes that the radius of smoke particles is important, and he will be making measurements of this.

Mr. Saito is making measurements of the smoke production of building materials heated to various temperatures. The smoke is collected in a box and the transmission is measured with a photocell.

The Tokyo Metropolitan Fire Board have carried out tests in an underground car park.

The ventilating system made the visibility in fire worse, because the outlets were situated at floor level. It was furthermore found more difficult to move in smoke than expected.

Mr. Kumano has developed a portable detector for fires in smoke. It costs about 110 $ and is being tried by the Fire Brigade.

Dr. Lie reported that they were adapting their flammability test to measure smoke. They had tried different wave-lengths of light in the absorption measurements, but they now use white light. They had also tried venting the smoke products into a compartment 2 x 1 x 1 m. The reduction in density should be calculable and it was for most materials, but polyurethane was an exception. They will continue testing other materials.

Mr. D.I.Lawson stated that U.K. is adapting its flammability apparatus for the measurement of smoke. The specimen is subjected to radiation and some of the smoke from the flue is diluted in a current of air and its light absorption is measured. As far as toxic measurements are concerned a series of fires are being carried out in model compartments lined with PVC.

The fuel load and the ventilation of the compartment will be varied. The atmospheres are being analyzed on a chromatograph. Measurements have already been made of the production of CO in cellulosic fires. Concentrations as high as 10% have been produced when the opening in the wall is 3% of the total wall area.

Mr. Lawson said that the plastics industry were striving to produce low flammability plastics by adding chlorine, bromine, phosphorus and antimony either in molecular combination or as an additive. They were so far content if the toxic product from the plastic itself was low, but it is probably more important to see that the toxic products from the plastics are low when involved in a fire, not necessarily of their own making.

Dr. Robertson said that it is important that the surface of materials should not produce smoke. This allows many manufacturers to improve surface treatments. Samples were exposed to radiation 2,5 watts/cm^2 in a compartment, and the smoke density measured in a vertical direction to overcome the effects of stratification. Dr. Robertson thought it important to measure the specific optical density, i.e. the optical density per meter. This is a dimensionless quantity involving the ratio of light intensities and the volume of the compartment divided by the pathlength and the area of the specimen. Dr. Robertson said that some materials, e.g. polystyrene emit more smoke when flaming whereas others, e.g. fibre insulation board emit more when smoldering.

Conclusions

1. Toxic products and irritants would probably be as important, and perhaps even more important than smoke in preventing escape.
2. The only way of getting an assessment of irritants would be to use human volunteers.
3. Fire Brigades should be asked to withdraw samples of plastics from fires in which these had been involved and submit them for examination together with a report on the breathing difficulties.
4. In any model fires the CO content should be measured in the future.
5. It was thought that the American system of measuring specific optical density was useful. The quantity $\frac{V}{A \cdot L}$ would lead direct to building regulations, in which V is the volume of the compartment, A the area of plastic allowable and L a pathlength of vision related to the distance of viewing the word EXIT at the illumination level on staircases, etc.

APPENDIX D

Seventh Meeting of C.I.B. Commission W.14

Report of Group 3

The following delegates participated in the discussions:

M. Bellisson	(part of the time)	Dr. Robertson	
Mr. Danielson		Dr. van Hoogstraten	
Dipl.-Ing. Dorn		Mr. Ödeen	
Mr. Fry	(" " " ")	Mr. Sjölin	(part of the time)
Mr. Heselden	(Secretary)	Dr. Rumberg	(" " " ")
Mr. Malmstedt	(part of the time)	Mr. Lossius	
Dr. Mygind			

Cooperative research programme (fully-developed fires)

An analysis of the Series 1 results had now been carried out and had shown that there were no significant differences between the results of the various laboratories except in those cases where different box lining materials had been used.

Further experiments of Series 1 and 2 had been carried out and a report had been issued which surveyed the available data and showed that some scaling laws could be found. Data were lacking in some areas and Mr. Heselden suggested that it was desirable that the following experiments should be carried out:

(1) 121 shape, $1\frac{1}{2}$ m scale. The original design should be modified to include fewer fire load densities, since this factor appeared to be relatively unimportant for this shape, and another level of window opening.

(2) 441 shape, $1\frac{1}{2}$ m scale. These experiments were part of the original programme and would be carried out by the J.F.R.O. this summer.

(3) 211 shape. Data are as yet incomplete, but the C.S.T.B. is at present carrying out 1 m scale experiments and when these are finished it will be easier to see how well the data can be correlated. In any case the C.S.T.B. would carry out two extra tests.
The J.F.R.O. would carry out some experiments to find the reason for the fall in burning rate with increasing window opening.

Second cooperative research programme

Mr. Heselden introduced proposals for a new cooperative research programme studying the early stages of growth of fire in a compartment. Some work had already been carried out by T.N.O. In the first part of the programme 8 laboratories would carry out a balanced statistical design measuring the effects of 8 factors each at 2 levels. In the second part the effects of factors shown to be important would be studied in more detail. Special attention would be given to the effect of various lining materials, both flammable and non-flammable, on the rate of growth. Other factors studied would include shape of compartment, fireload density, position and size of ignition source. The fuel would consist of both continuous and discontinuous beds. Some trials had been made and it had been found necessary to modify a few of the experimental details of the proposals made in CIB paper 66/11, but the main proposals were unaltered.

Dr. van Hoogstraten said that there was much uncertainty as to what the results of the various "reaction to fire" tests meant in terms of real fire behaviour. It was for this reason that his laboratory had already made studies of the growth of fire to flashover. He thought that experimental work in this field was highly desirable and said that he would try to obtain experimental support at the meeting of the ISO working

group next week.

Dr. Robertson said that he was very interested in this problem and would be glad to participate in a cooperative programme of the kind suggested, although his position was not very certain at present. He suggested that it was necessary to check that 1 m scale compartments were sufficiently large before embarking on the programme.

Various suggestions for possible measurements were discussed.

Mr. Malmstedt said that he would probably be able to take part in the programme but he could not undertake both this and the $1\frac{1}{2}$ m scale tests of the first programme which he had been planning to do.

Mr. Shorter, Dr. Rumberg and Dipl.-Ing. Dorn considered that their laboratories might be able to participate. It was agreed that Dr. Isaacs should be asked if he could take part.

Mr. Malmstedt suggested that temperature and velocity measurements in a duct leading the combustion gases away should be made to measure the rate of heat production of the fire. The group considered these measurements might be helpful but that it might be necessary to keep the experimental arrangements very simple in the early stages of the programme. A pilot experiment would be helpful in deciding what measurements should be made.

Dr. Rumberg said that Group 2 had proposed that measurements of smoke density, CO and possibly CO_2 concentration should be made in the tests of the second cooperative research programme. It was agreed that such measurements ought to be made and that the methods to be used and the point of measurement should be decided during preliminary experiments.

Fires in compartments (General)

Mr. Heselden described a series of experimental fires made at the J.F.R.O. in a compartment about 8 x 4 x 3 m containing steel members.

Various correlations had been obtained between fire duration, fire temperature, steel temperature, and fireload density and window opening.

Below a critical value of fireload per unit window area of about 150 kg/m^2 the fire was controlled by the fuel bed and the fire duration was constant. At higher values the fire was controlled by the window opening and the duration increased with increasing fuel quantity or decreasing window size.

Mr. Ödeen described experimental fires he had carried out in a compartment 9 m long with various amounts of fuel and with various controlled rates of air supply. He was going to relate the temperature-time relations obtained to those in other fires, and would be making a study of the flow of heat into the walls of the compartment.

In a discussion on flashover Mr. Sjölin said he had found that altering the dispositions of the fuel could produce or eliminate flashover.

Mr. Heselden described the studies being made at the J.F R.O. on the early stages of growth of fire in a compartment. The downward radiation from flames travelling under a ceiling was thought to be of great importance in determining the rate of spread of fire at ground level and on the rate of growth to flashover.

DEPARTMENT OF COMMERCE ★ NATIONAL BUREAU OF STANDARDS ★