10.0 file

NATIONAL BUREAU OF STANDARDS REPORT

8377

C.I.B. MEETING AND EUROPEAN FIRE RESEARCH 1964

by

D. Gross
and
A. F. Robertson

NBS

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards is a principal focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. Its responsibilities include development and maintenance of the national standards of measurement, and the provisions of means for making measurements consistent with those standards; determination of physical constants and properties of materials; development of methods for testing materials, mechanisms, and structures, and making such tests as may be necessary, particularly for government agencies; cooperation in the establishment of standard practices for incorporation in codes and specifications; advisory service to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; assistance to industry, business, and consumers in the development and acceptance of commercial standards and simplified trade practice recommendations; administration of programs in cooperation with United States business groups and standards organizations for the development of international standards of practice; and maintenance of a clearinghouse for the collection and dissemination of scientific, technical, and engineering information. The scope of the Bureau's activities is suggested in the following listing of its four Institutes and their organizational units.

Institute for Basic Standards. Electricity. Metrology. Heat. Radiation Physics. Mechanics. Applied Mathematics. Atomic Physics. Physical Chemistry. Laboratory Astrophysics.* Radio Standards Laboratory: Radio Standards Physics; Radio Standards Engineering.** Office of Standard Reference Data.

Institute for Materials Research. Analytical Chemistry. Polymers. Metallurgy. Inorganic Materials. Reactor Radiations. Cryogenics.** Office of Standard Reference Materials.

Central Radio Propagation Laboratory.** Ionosphere Research and Propagation. Troposphere and Space Telecommunications. Radio Systems. Upper Atmosphere and Space Physics.

Institute for Applied Technology. Textiles and Apparel Technology Center. Building Research. Industrial Equipment. Information Technology. Performance Test Development. Instrumentation. Transport Systems. Office of Technical Services. Office of Weights and Measures. Office of Engineering Standards. Office of Industrial Services.

---

* NBS Group, Joint Institute for Laboratory Astrophysics at the University of Colorado.
** Located at Boulder, Colorado.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT
1002-12-10120

JUN 1 1964

NBS REPORT
8377

C.I.B. MEETING AND EUROPEAN FIRE RESEARCH 1964

by

D. Gross

and

A. F. Robertson

NBS

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

C.I.B. MEETING AND EUROPEAN FIRE RESEARCH 1964

by

D. Gross

A. F. Robertson

ABSTRACT

A summary is presented of the proceedings at the sixth meeting of the Working Party on Fire of the Conseil International du Batiment (CIB/CTF) held in Berlin. Following this meeting, visits were made to laboratories engaged in fire research and allied fields in England, Scotland, Denmark, France and the Netherlands. A survey of their current activities and a brief list of published references is included.

TABLE OF CONTENTS

CIB MEETING AND EUROPEAN FIRE RESEARCH 1964

D. Gross
A. F. Robertson

Part I - C. I. B. Meeting

The meeting was opened with a welcome from Dr. Seekamp of BAM. Colonel Fackler, as Chairman, also expressed pleasure that the numerous delegates could be present. The list of delegates in attendance is included as Appendix A. The complete list of circulated papers is given in Appendix B. In accordance with the original plan, we split up into groups for discussion of three topics:

1. Fire endurance
2. Spread of smoke and toxic gases
3. Enclosure fire models

The following resumé provides an indication of the activities of each group.

Group 1

Neither Mr. Gross nor I were able to attend discussions of this group, the recommendations of which are presented in Appendix C. It appears, however, from this report and the discussion which developed that there was a rather general feeling that it would be impossible to do justice to the many reports which had been submitted. Instead, it was considered desirable initially to consider technical differences in the conduct of fire endurance tests. In such tests the fire exposure shall be controlled and the temperatures measured as specified by the ISO Standard.

All countries which were represented by delegations (including NBS for the USA) agreed to participate in these tests. Other countries will be invited. First work is to submit suggestions on manner of conduct to Ashton, who agreed to combine the suggestions and to formulate the ground rules for a test program. In addition, Dr. Lie indicated that T.N.O. would consider setting up a small test apparatus which would be suitable for a specimen 50 x 50 cm and would involve approximately 10 KW electric power.

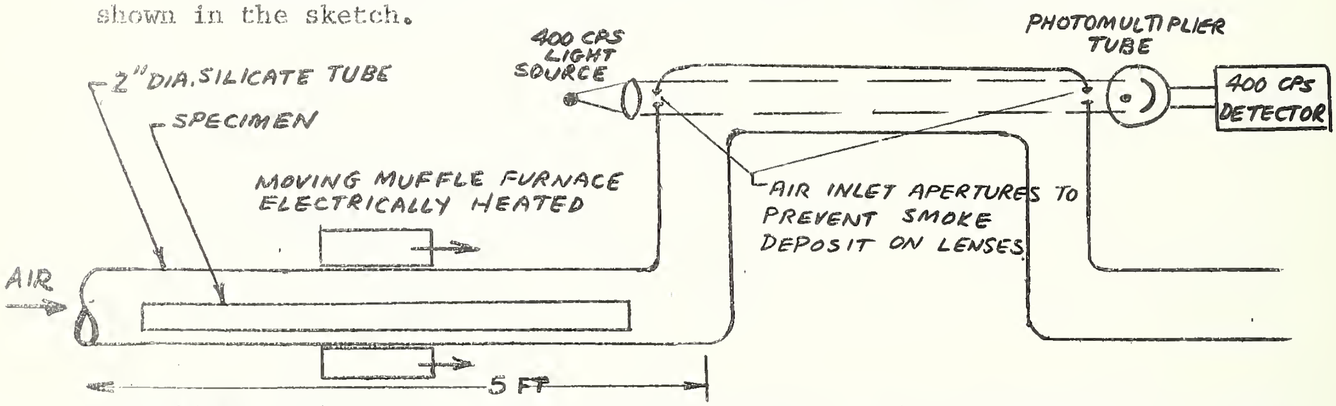
A desk study was proposed for comparisons of test results in various countries. The objective here being to use existing data to show the way in which similar specimens would perform in different furnaces. Suggestions were made to send complete test data for analysis to the following delegates:

On reinforced concrete slabs - Mr. Bornemann
On reinforced concrete columns - Mr. Becker
On brick walls, with and without plaster - Mr. Westhoff
On combustible B bulkheads - Mr. Malmstedt

Group 2

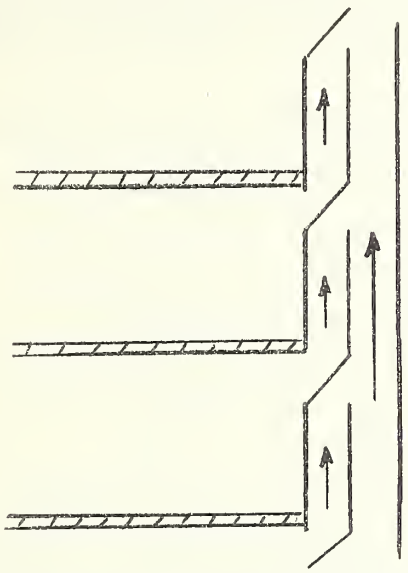
The report of Group 2 on the Spread of Smoke and Toxic Gases is included as Appendix D. During the discussion in Group 2, it was indicated that Dr. F. Saito of the Building Research Station, Japan, had been discouraged in his efforts to use smoke meters and had been using the filter method with much more success. He was using small enclosures of 2,2,1 geometry (l,w,h) and ventilation of 1 and 1/4 openings, 20 and 40 kg/m^2, fire loads, and one cm sticks placed with 2 cm spacing. His filter was placed 5 cm below the radiometer at the top of box opening. Smoke was aspirated for a 30 sec period every 2 minutes during the test. They were reporting results in terms of optical density of the filtered deposit. Smoke was found to increase with fire load and decrease of window opening.

Dr. Rumberg reported on work he had been doing. Their apparatus is shown in the sketch.



Variables which can be changed during the test include temperature of oven, velocity of oven along tube, and airflow rate. The photometer makes use of a photomultiplier tube and filter to correct for spectral sensitivity of the dark-adapted eye. It makes use of a 400 cps modulated light source and in this way changes in room illumination and flames do not affect results. This equipment has just been set up and it is still too early to report results.

Mr. Traverse described two fire tests to study smoke behavior in large buildings the first is described in CIB/CTF-62/23(F) and in the January NFPA Quarterly, as well as CIB papers. The second is in CIB/CTF-62/63(F). Both were in buildings of 20 to 22 stories height. In the first, it became quite evident that the open stairways could not be used as a means of escape during a fire and that special ventilation facilities were needed to avoid flooding the building with smoke.



The second test was run in a building equipped to provide ventilation for the hallway in case of fire. A fresh air outlet was placed at floor level and a smoke duct opening near ceiling. Two satisfactory smoke ducts were shown, one using no dampers but requiring a double stack while the other required automatic dampers which would remain closed until a fire occurred and would then be opened at the locations required. It was suggested that size of ducts be 40 cm^2 per room based on a combustible load of 20 kg/m^2. It was reported that this arrangement permitted firemen to stay in the hall near the stairway throughout the test.

Mr. Shorter reported recent work in North America, UL work on smoke and toxic gases, SWRI work on toxic hazards. He reported that they were planning to pyrolize plastics and put products through chromatographic analysis. He referred to a recent paper [1] relating to this subject.

Shorter then introduced McGuire's paper in which he suggested maintenance of the neutral axis above the top of the door as a means of avoiding smoke penetration. We agreed to try to run some tests making use of this idea.

Dr. Rumberg indicated that VFDB was planning a special meeting during their October gathering in Karlsruhe on analysis of decomposition products. He stressed the importance of irritants, and requested individuals who may be able to contribute to the discussion to contact him. It was further requested that any information on toxicity effects using animals be forwarded to Mr. Lawson.

Mr. Lawson reported on their preparation for tests in an escape stairway with adjoining rooms. They believe that by pressurizing stairways with 0.05 in. water pressure they can maintain them clear or, if slightly higher pressures are used (0.1 in. H_2O), a smoke-filled room or stairway could be cleared of smoke. They are, at present, fitting a building for such clearance means. They also are conducting a survey, both before and after fires, in existing buildings to determine whether smoke stop doors are properly used.

Group 3

The summary report of Group 3 on Fires in Single Compartments, including the cooperative research program on models, is included as Appendix E.

On the cooperative research program, Dr. Thomas presented tabular summaries of the available data and indicated several tentative conclusions, e.g. regarding the effects of floor area, ventilation, fire load and crib construction. It was indicated by Dr. Magnus that the opening of a door into the laboratory during a test affected the rate of burning measurement, and it was agreed that statistical "probable best values" need to be reported. With regard to the uncompleted portions of the program on the 1 meter scale, Colonel Fackler offered to perform the tests originally assigned to France, but indicated that it would take about one year, and Dr. Robertson offered to take over the shape 121 tests originally assigned to Italy.

At the conclusion of the group discussions, the suggestion was made by Mr. Fry, and well received by all delegations, that the proceedings and technical reports presented at the meeting could be included in a comprehensive report to the Secretary-General of CIB and published under its sponsorship.

CIB Meeting Theme

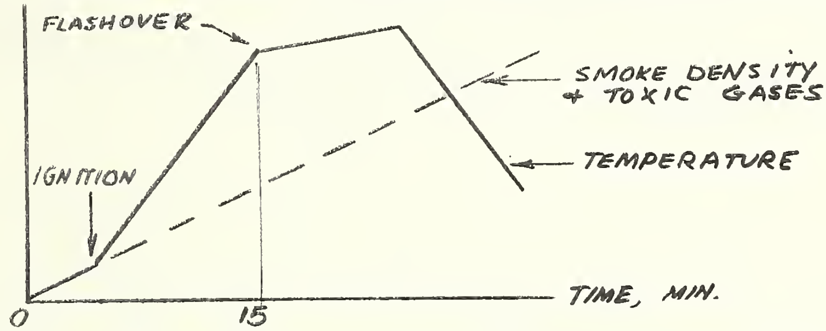
The Desirable Limitations on the Size of Buildings and Compartments

The following papers were submitted as appropriate to the principal "theme" of the meeting:

CIB/CTF 64/20 (C)	)	
CIB/CTF 64/21 (N)	)	Size of Compartment
CIB/CTF 64/6 (UK)	)	
CIB/CTF 64/7 (F)	)	Size of Buildings
CIB/CTF 64/25 (USA)	)	

In the paper by Thomas and Ashton, exploratory estimates were made of the effect of increase in building size on fire costs and fire-fighting effort. It was concluded that, althought no sharply defined criterion exists, there is the tendency for increased areas to produce a disproportionate increase in both fire costs and in fire-fighting effort required.

Although no specific paper was included by Japan, Mr. Yokoi also contributed to the discussion on the size of buildings. Firstly, the special conditions in Japan, involving large crowds in public buildings, make life hazard of primary concern and it is considered necessary to limit the size of buildings. Although no firm conclusion has been reached on the importance of smoke or toxic gases to life hazard, a maximum time limit of 15 minutes is tentatively assumed (see sketch). It is possible to calculate the size of compartment and the size and number of exits, if information on the rates of smoke development and toxic gas, and of temperature, are known. This information is not generally available.



Secondly, there is a unique problem in Japan associated with multistory buildings having small floor area and without complete compartmentation. Because of the possibility of earthquake-weakening of a building with a burned out floor, it is necessary to provide two separate exits: one for the escape of occupants and a second for the entry of fire-fighting forces.

Colonel Fackler presented the current policies in France with regard to limitations on building size and the technical bases for fire hazard restrictions. He also stated that life hazard, rather than property damage, was the most important risk. It is considered necessary to concentrate on protection measures to minimize the hazards of fire initiation and fire spread and to provide proper compartmentation for localizing a fire. Without full justification for the chosen values, the established requirements included:

> Maximum floor area 2500 m^2; maximum length 75 m; two stairways with a separation between exits from a compartment onto stairways from 10 to 30 meters; stairs with double doors; two independent electric lines to elevators; two hours minimum fire endurance time, including both the flaming period and the period of increasing temperature; for a fire load of 150 kg/m^2, the endurance time is increased to four hours.

Due to an accident, Mr. Kirkland could not be present and a summary of his paper was presented by Dr. Robertson. Mr. Shorter made the comment that mixed occupancies are becoming more common in North America and that it will become more logical and important to think in terms of compartments rather than in terms of buildings such as has been used in the past and which formed the basis for Mr. Kirkland's presentation. Dr. Thomas indicated that no clear distinction between life and property hazard was made and that the "1500 ft^2 factor" gives relative values, but does not permit conclusions to be drawn on the absolute size limitations.

Following the presentation of prepared papers on the theme, there was a lively discussion among the delegates. Among the subjects discussed were fire spread between floors through exterior windows, the important factors affecting fire-load and endurance time calculations, and economical evaluation of fire-safe requirements of multi-story buildings.

It was stated that experience with traditional buildings showed rare occurrences of fire spread through windows; however, in modern buildings with large window areas and curtain wall construction, this is of considerable concern. The importance of providing a greater set-back (i.e., projection of the floor slab) in such cases was emphasized.

Dr. Becker informed us of information presented by Mr. Halbert and Mr. Bub at the VFDB meeting in Luneberg and which will form the basis of a DIN standard to be prepared in the near future on fire-load calculations. The duration of a fire was related to the fire-load (expressed in terms of an equivalent weight of wood) and multiplying factors for area, type of construction (i.e., number of stories, size of windows, etc.) and type of combustible load. For these calculations, it was assumed that the fire-load would be completely burned regardless of its location or the existence of fire-fighting facilities (except for a standing 24-hour fire brigade in a factory). The primary concern is that building collapse shall not occur, without regard to rebuilding the structure after a fire. Copies of a report should be available for distribution in approximately three months.

With regard to future activities, it was suggested that the main areas for the working group should be the presentation of papers, general discussions and discussions on a particular theme, and cooperative research programs. In order for each laboratory to keep abreast of the work of the others during the two-year period between meetings, it was agreed that a one-page summary of current work be sent to Mr. Fry each six months, and that he in turn would collect and distribute the complete collection to the participating laboratories.

Invitations to act as hosts for the next meeting were received from Mr. Yokoi (Tokyo) and from Mr. Shorter (Ottawa). Dr. Robertson extended a welcome for delegates to include a visit to Washington, should Mr. Shorter's invitation be accepted. No decision was reached, and it was agreed that Mr. Fry would explore possible locations by letter.

Visit to BAM Laboratories

The organization chart for the Bundesanstalt für Materialprüfung BAM is shown in Appendix F.

We made a brief visit to a portion of Dr. Zehr's division where a demonstration of burning behavior of liquid fuels was presented. In another laboratory we were shown calorimetric equipment for combustibility tests. Also shown was a micro balance with sensitivity of one micro gram. This was set up and used by Dr. Heinrich as part of a Sartorious differential thermal analysis equipment. Appropriate references to the analysis method [2] and its application to polyvinyl alcohol [3] were noted.

The fire laboratories were located in one side of a four-sided building with a court in the center. One side was used for specimen preparation, one for acoustic work, one for heat transfer on large wall panels about 2 x 2 meters. They had a Volkswagon Microbus set up for field acoustic tests. The fire laboratory housed test equipment for 3 M column tests, 3 x 3 M wall tests and 3 x 3 M floor tests. The floor furnace was designed so that one wall could be moved, thus accepting specimens of different widths. Fuel oil was used in the burners and it appeared that radiant heat transfer from the flames would be an important factor during the early portion of the tests. For testing the integrity of chimneys, an artificial smoke generator is used. The package contained this information:

Designation:	Rauch-röhrchen (rote Kennzeichnung) Besteld Nr. 4980	Company:	Auergesellschaft Aktiengesellschaft Berlin 65

Equipment was also shown for tests of chimney blocks and roofing. In this latter test a package of excelsior was placed on an inclined roof surface (e.g. corrugated polyester) and ignited. The burning behavior of the roofing was observed. One other most interesting test provided a means for preliminary tests of insulation material proposed for columns. A steel plate was covered with insulation, and the assembly was exposed to the standard time-temperature exposure in a gas-fired furnace, using an electrical guard heater to prevent heat loss from the plate to ambient air. This technique was described in Reference 4. We should have equipment of this type.

Part II - European Laboratories

A. Joint Fire Research Organization - England

The organization chart for the Fire Research Station is shown in Appendix C. We started our discussions here with a visit to the Chemistry Section.

Chemistry and Chemical Engineering Section - Dr. D. J. Rasbash

Dr. Rasbash briefly summarized the work they are now doing as follows:

1. Plastics in fires and decomposition products. This work is under the direction of Mr. Stark. They are hoping to determine the quantitative kinetic laws (activation energy, frequency factor) of toxic product formation as a function of temperature and ventilation conditions. This will include the maximum CO which can be formed from cellulosic materials and then the most toxic products from typical plastics. With known ventilation flow rates and air supply, the dilution throught a building will be estimated. Reference [5].

They have considered it desirable that preliminary work be done on analysis of decomposition products of cellulosic materials and for this purpose, are burning spherical balls of excelsior centrally supported in a 3-ft cube box. Only a very small ventilation opening is normally used along the upper portion of one side but openings up to 12 inches have been used. The fuel is ignited by an electrical resistance element (a few watts for a half minute) at the center of the sphere. Fuel is in the form of 6-, 12-, and 30-in. spheres (confined in metal cages) with weights ranging from 50 to 400 grams. Combustion is complete in 10 minutes for a 2 in. opening and about 40 minutes for a 1/8 in. opening. Gas sampling at a rate of 1 liter per min. with a mechanical diaphragm pump is performed using a 6 ft metal tube of 1/4 in. dia. located at the center of the back of the box. No traps are used, the gases being pumped through a series of sampling bottles perhaps 18 to 24 in number. These can be closed off at times of interest and gas analysis is performed by chromatographic apparatus within 24 hours. Instrumentation includes a double-tube chromatograph, Thermocell Power Unit, d.c. amplifier (±100 microvolts) and integrating amplifier. The carrier gases are helium and argon (to determine H_2). At present, the analysis procedure includes CO, CO_2, N_2, H_2, CH_4 and presumably O_2. Analysis for CO_2 was performed separately to avoid interference effects. The maximum CO measured was about 1.3 percent with a 100 gram specimen and 2.8 percent with a 400 gram specimen. About 0.1 percent CH_4 was also measured. The conditions most likely to produce the maximum concentration of carbon monoxide were (1) a large quantity of fuel, (2) a certain degree of ventilation, depending on the quantity of fuel, and (3) a high temperature.

This work is just well started and probably won't be completed for some time. Asked about analytical methods for plastic decomposition products, they indicated confidence in ability to use chromatographic equipment but admitted this had not been set up yet. When available (in about a year), infrared apparatus will also be used for identification.

2. Burning rates under low O_2 (14-21%) conditions. This work is also under Mr. Stark with Mr. Langford assisting. The interest in it arises from previous inerting studies with both gas and foam. They have set up a small tunnel perhaps 10 in. square and 6 ft long supplied with a (variable) mixture of compressed air and nitrogen at atmospheric pressure. This mixture is discharged through holes in an annular ring, and then passes through a straightener section slowly along the length of the box. This flow is so slow that the flame from a burning crib remains vertical and laminar. The burning rate of small cribs made of 1/8 in. dowels and somewhat similar to those used by Fons is observed. These cribs are 12 in. long, 1 in. wide and 3/8 in. high. Time-lapse photographic recording is used. I believe this work is just starting and just a few preliminary tests have been performed. For a single stick, the rate of burning reduces to zero at an O_2 concentration of 16.7 percent. Oxygen-rich atmospheres will also be investigated.

3. Formation of soot in diffusion flames. Dr. McLintock is heading up this work. He is currently trying to get started on a basic study of soot formation. His equipment consists of a cylindrical glass tube about 5 in. diameter by 10-in. high within which he can burn gases using various sizes of concentric metal burner tubes for gas (now using ethylene) and air. He collects soot by deposition on glass fiber filter paper placed above the burner and through which the products are mechanically drawn. The paper will stop 0.2 micron particles and the deposit is weighed to 0.1 mg. Calculation is made of the percent ethylene converted to soot. He is planning to use inert gases to examine the change in soot formation and may also sample gases for CO and CO_2. He indicated that he had only been able to locate one other good reference to work in this field, that of Milberg [6] on acetylene flames. He also mentioned other work under high pressures, Reference [7]. These latter workers had reported soot both on a weight basis and also on the basis of CO_2 formation after ignition.

4. Vapor and dust explosions. This work is being done by Palmer and Rogowski and was not discussed in detail, but appears to represent the major current effort of the chemical group. This includes a study of possible use of flame arrestors for venting explosions which may occur in small compartments which may enclose electrical apparatus such as motors, switch gear, etc., and which cannot be designed to exclude all explosive mixtures. They also are in the process of setting up a large-scale experiment with dusts burning in ducts, in a new dust separator building.

5. Unstable substances. We spent just a brief time in a visit with Mr. Bowes discussing his recent work in this field. They have made real progress in their work on the hazard of spontaneous heating and explosion of benzoyl peroxide. However, they find that, though the reaction constants they compute on the basis of isothermal ignition experiments correlate well with time to explosion, they have not been effective for predictions of critical size. I did not follow their explanation for this, but the paper now in process should elaborate on it. They are now planning experiments with much larger samples. He informed us of Russian work on thermal explosion theory by Merzhanov and Dubovitskii [8, 9].

6. Jet engine for inerting or production of H.E. foam. The jet used has been shown capable of use in three different ways: (a) As an inert gas producer of hot gas ($\sim$200°F) with 12% O_2 at 50,000 cfm, (b) as a "cool" gas producer ($<$200°F) of 17% O_2 at 40,000 cfm, (c) as a producer of high expansion foam of 17% O_2 gas at the rate of 12,000 cfm. The use of 7% O_2 gas for production of foam yields a product too hot to work in and it results in rapid foam breakdown. They have found that the Amonium lauryl sulphate is best foaming agent for stability, it shows a 50% drainage time of 10 min whereas the other foam materials do not show more than 4-5 min under similar conditions. This foam material does, however, have poor behavior under low temperature conditions. The Safety Development Corp (USA) produces foam generators. This company was formed by a group from the Bureau of Mines known as the "Greensborough Boys".

They are investigating the possibility of using liquid CO_2 or N_2 for deep seated smoldering fires involving packed cotton bales and other materials stored in ship holds, warehouse basements, etc. Such fires require reduction of O_2 content below 2-3% for periods of a day or more for proper control, Reference [10]. It was estimated that the cost of liquid CO_2 on a 5 or 10 ton truck may be about $1,000 but could be effective for 4 or 5 hours supplying 1,000 cfm. However, CO_2 is toxic and therefore questionable for use in urban area basements. Mention was made of a Gibbons gas generator which produced 2,000 cfm of gas of less than 2% O_2 which had been cooled to about 90°F. This apparently required bulky steam-producing equipment and probably water as a cooling agent, but is very good for complete extinction of deep-seated fires.

Reference was made to Coleman's paper on flammability at high pressure, Reference [11]. Apparently this is the only work of this type they have performed. For pressurized operating rooms, Rasbash felt that flame-retardant clothing and sheets would be helpful. For survival conditions, a warm water deluge system would be recommended.

A collection of recent reports on work with the jet engine were given to us, Reference [12].

Ignition and Growth of Fire Section - Dr. P. H. Thomas

The visit with Dr. Thomas was somewhat briefer than that with Dr. Rasbash. Their work on roof venting has been summarized in a very comprehensive report, Reference [13]. In general, they find that with large openings, the method of Yokoi, employing a neutral axis, etc., cannot be used, and the entrainment of air must be considered in velocity calculations. Furthermore, since the area for ventilation may be only about 3 percent and the required area for complete fire-removal about 15 to 20 percent, the use of plastic (PVC) dropout panels may be more advantageous.

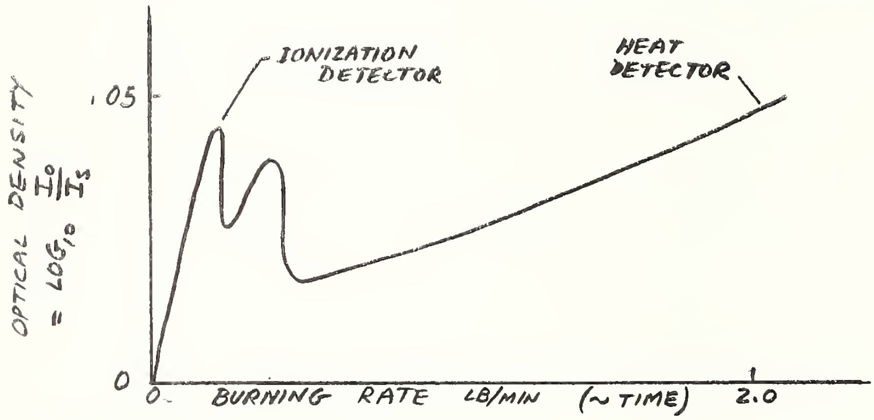
At present, they are doing work to study horizontal spread of flames beneath ceilings (Mr. Hinkley). They have set up an inverted trough 15 ft long and 18 to 24 in. wide. This is fed by diffusion flames from a gas burner. An attempt is being made to measure the heat distribution within the tunnel. Temperature profiles are determined in the flowing gas and heat flux rates through the walls. The oxygen concentration does not appear to change along the tunnel length. Results to date seem to show that the length of flames in the tunnel is about 5 times that expected from a vertical convection column for the same gas supply per unit width. They have performed some experiments by fastening fiberboard sheets of various lengths to the ceiling surface and find that this tends to increase the flame length in the tunnel by about one-half the length of fiberboard which was used. Half the cost of this study is provided by a commercial interest.

They have done some recent work on merging of diffusion flames from four one-foot square porous plates; this has not been reported yet. It appeared that they were in the midst of preparing reports on several studies. Thomas indicated that one of the latest, Reference [14], attempted to summarize and correlate information currently available on wooden crib fires. He also has done some recent analysis of the work of Fons and Curry on fire spread in pine needles. The still air fire spread data was correlated in terms of the ratio of the volume of voids to the solid surface area. He is now planning to examine the effect of wind and experiments are planned to see whether charring rates tie up with theory.

In their studies of fires in enclosures (Mr. Heselden), they are examining the partitioning of energy and are making use of a split heat-flux meter, which has one-half polished for convective heat measurement and one-half blackened for radiation.

Thomas indicated that he was planning to prepare a computer code for analysis of the enclosure model CIB test results. He would wait for all the data before proceeding with the analysis.

Mr. Pickard has been making a study of photoelectric smoke detectors. Preliminary work with open wooden crib fires has seemed to indicate that smoke production is proportional to rate of weight loss due to combustion (See Sketch). He has made a literature search on smoke measurement. Two references we have not seen are reported as References [15] and [16].



Building Materials and Structures Section - Mr. L. A. Ashton

We were impressed with the program with which Messrs. Ashton and Malhotra were confronted. In summary, this included studies of:

(a) Spalling of concrete. Mr. Dougill at Imperial College is doing work on this aspect of concrete performance. To date all work has been theoretical on the assumption that thermal stress is of controlling importance and water is considered only as an elastic medium. Experiments to follow.

(b) Flammability test. The box test has not yet been adopted as a British Standard. Apparently they have found it desirable to develop two additional test methods. First, an ignition test in which a small sample of the material is exposed to an ignition flame to determine whether its combustion is self-supporting, and secondly, an enclosed vertical panel test or flammability test to serve as the name implies. In this test the specimen is about 4 in. wide and about 18 in. long. This is placed nearly vertically in a 6 x 6 x 24 in. box with ventilation openings near the base and provision for gas flame ignition near the bottom of the specimen. It was indicated that these tests were considered as useful for screening purposes, and that assemblies of poly (vinyl chloride) with fiberglass and hardboard and with urethane and hardboard, performed poorly. This study was stimulated by a BOAC aircraft fire.

(c) Properties of concrete at high temperature. This project, while on the books, is not active. It is proposed as a continuation of Malhotra's earlier work.

(d) Fire resisting glazing. It appears that this project, too, is not very active. It has been proposed to include studies of both type of glass and window size and resistance to fire penetration.

(e) Composite action and fire resistance of elements of construction. This project contemplates studies of interactions between concrete and steel and between floors and walls, beams and floors, floor-column assemblies. Building designers and engineers now considering mutual restraint for strength calculations. This reduces the factor of safety. It appeared that here, too, this work is in planning rather than in active stage.

(f) Continuity and fire resistance of beams and floors. A series of beam specimens have been prepared to investigate influence of continuity without axial restraint. These include reinforced concrete, prestressed concrete and steel beams. Those intended for movement restraint are 37 feet in length. The others are of 25 ft length. These specimens have been drying for about one year.

(g) Correlation of fire resistance tests of floor (C.I.B.). This study which involves the application of co-planar restraining forces to floors, apparently is currently inactive. They have asked the Building Research Station for information on forces likely to be experienced.

(h) Fire resistance of slender reinforced concrete to columns. The columns being studied are for the most part of rectangular rather than square section and of greater than usual l/r ratio. The work is being done in response to increasing use of such columns in modern architectural design. It was stated that such columns fail more frequently (Reference [17]) by buckling rather than crushing, probably because of the large l/r ratio and the steel-concrete area ratio. Variables considered in the study include:

(1) Size and shape. H sections of 4 x 6, 4 x 8, 5 x 10, 6 x 6, 6 x 12, 8 x 8, and 6 x 24 inch size and T sections of 6 x 24 inch size.

(2) Aggregates include sand and gravel, limestone, and expanded clay.

(3) Steel grades include hot rolled mild steel, and high tensile steel.

(4) Stress levels of 100, 75, and 50 percent of design levels.

(5) Type of encasement.

(6) Concrete cover of steel of 1 and 2 inches.

(7) Columns will be tested both with and without reinforcement of cover.

(i) Fire resistance of unprotected laminated timber columns and beams. This work which is currently about 50 percent complete involves variations in wood species, glue, size and shape as well as quality or grade of timber. Preliminary results show no influence of species, grade of wood, anddifferences in thermosetting glues (urea, resorcinol and phenolic) on performance. Casein type glued columns have shown poor performance. It was observed that the endurance of the specimens has varied from 30 to 45 min largely dependent on charring performance. They are currently testing impregnated (monoammonium phosphate) columns, and plan to study laminated beams in the future.

(j) Behavior of steel structures in fire and correlation with standard tests. This study is sponsored by the British Iron and Steel Institute. Two large buildings have been constructed for this study. One of these simulates "flats" or apartments now being built in high rise buildings in England. Two apartments are involved one above the other. The lower is being furnished for several experimental burnout tests. The steel work involved is protected by gypsum board cover and its performance will be judged on the basis of temperature measurements. Part of the objective of the steel interest is to explore the severity of fires in modern apartments. The people at FRS are more interested in tests to be made with the second structure which comprises a two-story structure designed for successive burnout of the lower unit. The two compartments are of similar size to the building but no partitions are at present in place. The windows are large and provide a means for exploring window size variables on structure behavior during fire.

(k) Development of small furnace to supplement large fire endurance tests. This is planned for 3 x 3 ft specimens vertically mounted.

(l) Development work in connection with ISO activities. Three tests are of present concern and the British thinking with respect to them may be outlined as follows:

(1) Combustibility tests of two types are under review, the bomb calorimeter, and the vertical tube furnace. It was pointed out that the small specimen size (one gram) limits the sensitivity of the bomb calorimeter test to about the same level as can be achieved by the vertical tube furnace. This latter, as currently specified, has deficiencies, but work is under way to correct these. In accordance with discussions at latest ISO meeting, comparison tests are planned using both methods.

(2) Fire endurance. This test is now the basis of a draft ISO standard. Revisions are needed and will be developed as part of the CIB program. Fire door standard also under consideration.

(3) Reaction to fire. Here many tests have been proposed and the outcome is very uncertain, see discussion under (b) above.

(m) Revision of BS 476. It is proposed to revise this test method and in doing so, separate and more completely define the different tests of walls, floors, columns, beams, etc. This project is inactive at present.

(n) Measurement of smoke and toxic gases on escape routes. This project seeks to provide experimental indication of the extent to which fire doors act as smoke-stops. A good "smoke-stop" door according to BS 476 (e.g., the Snitkordoor) would not be considered good where the temperature rise is less gradual. A smoke generator has been developed and this is being used in the 4-story burnout structure which has been modified for the study, see Reference [11]. Another aspect of the study involves exploration of ways of clearing smoke from building exitways through the use of permanent openings in walls or louvers, and of positive pressures in certain areas (see discussion under report of C.I.B. Group 2 above). There was little, if any, evidence that their smoke measurement techniques were better than our own although the program was more comprehensive.

Obviously a program as large as this cannot be effectively carried on by the limited staff available. Mr. Lawson later indicated that he planned to split up the work of the group and, with additional staff, form two groups from it.

Extinguishing Materials and Equipment Section - Mr. P. Nash

Mr. Nash, as previously, is concerned with tests and investigations on fire detection equipment, sprinklers, and alarm systems. Recent work has included development of a new British Standard for heat sensitive detector, correlation of behavior of line and point detectors, studies of detector sensitivity as a function of ceiling height and geometry, vibration and impact tests on detectors, and reliability of electrical alarm systems. The work on building geometry influence on detector sensitivity will be published shortly. It was mentioned that the heat release at floor level required to operate the detector is proportional to the 5/2 power of detector height.

Operational Research and Intelligence Section - Mr. J. F. Fry

Some time was spent with Mr. Fry in discussions relative to fire loss records and clothing fire accident problem. Their previous sampling procedure in analyzing fire loss records made use of one in five incidents. They have modified this now by working with one in two for industrial and commercial fires, maintain the one in five analysis for fires in the home, and only use one in twenty of the heath fire records.

Their special study of clothing fire accidents was done over a period of just a few years. It was reported in Reference [18]. Samples of fabrics were collected when available together with the reports which were furnished by hospitals specializing in burn accidents. The results of this study showed that young children and elderly people were by far the greater bulk of casualties. The seriousness of the burn could not be correlated with character of the fabric.

Mr. Simms indicated that with the use of cotton or even metal threads, sufficient mechanical support for a normally melting thermoplastic fabric may be obtained to result in a self sustaining highly flammable material. It was also stated that the washing of a fire-retardant fabric with soap and water containing lime will mask its fire retardancey.

At the present time, the Consumer Protection Act provides the only means of protection of the public if fabrics or other household commodities are shown to be unduly flammable. I was told that fire retardant-treated flannel was commercially available on the market. Five yards of this were purchased at a department store. This is reported as complying with British Standard BS 3120. The salesclerk reported sales as good and the price appeared in line with untreated material. The Proban treatment used was reported as that developed at the Southern Regional Laboratory under the name THPC.

At his request, a visit was made to Dr. Lawrence Abel who is Chairman of the Committee on Research of the British Medical Association. He asked for any information we could furnish on fabric flammability and fire accidents, any developments on fabric production, etc. I agreed to send what we could and put him in touch with the Fire Research Station.

B. The Laboratory of the Fire Brigade - Copenhagen

The head of the laboratory, Mr. G. Danielsen received Mr. Gross kindly and described their work in some detail. Although the staff is small (4), this group keeps abreast of the technical literature on fire through a full-time librarian, Mr. A. Froloff, and has the assistance of the fire brigade for large test projects. A report of their operation [19], indicates that they were established in 1932. Mr. Danielsen has been with the laboratory since 1934. A report summarizing the activities of the Copenhagen Fire Department [20], including those of the Laboratory, was also secured.

Mr. Froloff told me of the delays sometimes of a year or so of procuring reports from sources within the States, and particularly OTS. Although they receive NFPA publications and Fire Research Abstracts & Reviews regularly, he felt that a central source from which reports on fire problems could be purchased would be very desirable. It is possible that the Technical Information Center, currently being organized in the NBS Institute for Applied Technology, as the central Government clearing house for publications and reports, will be useful in this respect. Inasmuch as they serve as consultants to the Fire Brigade and to other institutions and the general public in Denmark, the possession of more complete technical files is considered essential. Information contained in the NBS volume, "Precision Measurement & Calibration Handbook 77," for example, is in great demand, but unavailable (very costly).

Of the specific test projects they have worked on, one involves a demonstration of the potential hazard of gasoline leaking from a tanker truck during transit through a town or city. This work was sponsored by the Danish Fire Prevention Committee and the Petroleum Industry. A fire with flames extending 125 meters in height and 65 meters in width resulted when 4000 liters out of the 10,000 liters capacity leaked out and was set afire. Although the outer welded shell deformed from the heat, it did not burst; but thermal expansion did cause one of the four compartment walls to collapse. Pressures of three atmospheres absolute resulted, but without explosion. It was learned that the zinc pressure relief caps would melt and reseal the openings, that aluminum hatch covers would melt and that glass level gages would break, compounding the danger. This work was done in late 1960 but the report has as yet not been released publicly. When released and published, it should prove extremely valuable information in the USA.

The problem of self-ignition in peat piles has been studied. In general, little or no oxygen has been found in the pile except near the surface, and ingnition in the form of glowing has been observed on or near the surface only.

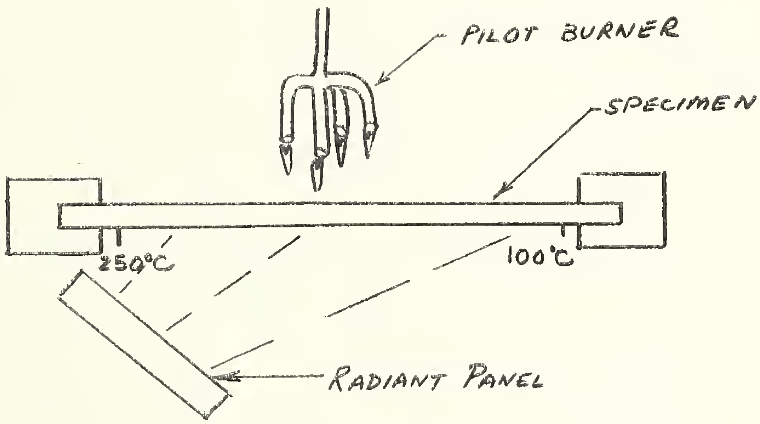
Studies have also been made to reconstruct the chronological details of actual building fires, and also to arrange for future testing in condemned buildings.

Mr. Danielsen has done considerable work in the field of plastics and may plan to write a book on this subject. He will also attend and prepare a comment for the VFDB meeting in Karlsruhe, October 1964.

C. Danish Government Testing Institute - Copenhagen

Mr. Malmstedt, who represented Denmark at the C.I.B. meetings in Berlin, is head of the Building Test Section which is a part of the Institute headed by Mr. Gerhard Hansen (who visited NBS in 1962). The Laboratory cooperates with Sweden and Norway. It was built about four years ago, but may be moved soon to a suburban location. I arrived just at the completion of a fire test on a door (62 minutes for a door with an impregnated laminated assembly and impregnated wood frame), and also saw their other test activities in the short time available. They have a furnace for horizontal specimens (2-1/2 x 6 m) and a vertical furnace for walls (2-1/2 x 3 m), doors or columns. The former can be loaded hydraulically and both are down-draft gas-fired with only two-thirds of the stoichiometric air premixed with the gas and the remaining one-third (secondary air) supplied further back to provide more uniform flaming. The time-temperature curve is programmed automatically and all TCs are bare und unshielded. The furnace pressure is continuously adjusted to approximate room conditions, i.e., positive over the upper two-thirds and negative over the lower one-third. The testing program proceeds at the rate of about one test per day. A control room on the floor above contains the control, measuring and recording instruments. Mr. Jens Chr. Snitker, Manager, S.O.S. B-Class Divisions, 22 Dronning Margrethesvej, Roskilde, Denmark, manufactures and sells a prefabricated strip which contains an intumescent mixture and which can be placed within a groove along the edges of panel doors to provide a seal for fire and smoke. It is claimed to be very good. Mr. Malmstedt is engaged in a study of the fire endurance of protected steel columns (Marinite & Navalite). He is particularly concerned over the fact that a structural column or wall can receive a 6-hour fire rating in the standard fire resistance test but could fail in perhaps 1-1/2 hrs during an actual building fire. This is an important problem and results from forces and moments induced by differential expansions, deformations and complex restraint conditions in assemblies of building elements exposed to fire. In an experimental approach to the problem, he is making tests in which steel columns of two or three sizes and with three thicknesses of insulation will be studied and with fire exposure over one, two, three and four surfaces. He has ordered instruments for measuring deflections and will obtain complete deflection curves. The results of these tests and calculations may be available about next summer.

The test for flammability consists of a gas-fired radiant panel for exposure of a test specimen and the application of a multiple pilot flame (see diagram). The pilot is only applied after the specimen reaches a predetermined temperature distribution and for a specified duration (15 sec). The test is repeated with a more severe exposure and the difference in the areas involved indicates the extent of specimen contribution. To be acceptable, a material cannot be involved to a greater extent than a standard chipboard of known density and properties. The test is modified (by deleting the preheating) for materials like thermoplastics which drip away from the test area.



PLAN VIEW

The corridor tests (described by Christensen at the C.I.B. meeting) will be resumed in a month or two. Measurements include:

Weight of igniting compartment (2-man cabin): 3 load cells
Temperatares: Bare thermocouples
Pressures : Tubes and inclined water manometers
Gas Sampling: In bottles for Orsat analysis
Heat Flow : Transducers at selected locations within corridor ceiling.

On 12 April, Mr. Gross visited with Mr. Snitker who came down from Roskilde with an interpreter. Since about 1956, he has patented fire-ratardant impregnated cork insulation for doors and bulkheads and intumescent paints and strips for doors and frames all over the world. These are known as "S-O-S B-Class Snitkordoors" and comprise door and frame including hardware. A one-half-hour door sells for as little as $10.

The doors are available throughout Europe but are made only in Germany. The present foaming strip has been available for about 9 months; previously, it was available as a foaming paste in a polyvinyl tube. The strips are manufactured in three sizes: 1, 3, and 8 mm x 10 mm and sell for about 10¢, 15¢ and 50¢ per meter length. Besides having received approvals for use aboard ships (30 and 60 min ratings) in most European countries, they are also used in hospitals, public buildings, etc. and are good-looking and soundproof. They are tested periodically and randomly by the Danish State Testing Institute (Mr. Malmstedt). It is claimed that strips can be installed in grooves in the door (also frame if door is steel) with thermoplastic cement and can be expected to expand under fire conditions to provide a smoke and flame seal even when the groove is oversize, eccentric, etc. It is desirable that the doorstop be set out 20-25 mm in order to provide charring volume under fire conditions. After fire, the door can be easily opened to provide entrance for rescuers and escape of occupants. Standard hardware is used, but with cert ain precautions.

Several years ago, Underwriters' laboratories, Inc. wrote to Mr. Snitker who asked them to observe the fire performance of his doors. However, Mr. Snitker felt that he could not bear the cost (~$1500) of paying for transportation for two persons from the United States. He would very much like to find a commercial outlet for his doors in the United States. I suggested that we might be interested in performing a test on a door containing his strips but could not promise him any information. He agreed to have the German company send some material and instructions for its use. He claims that the intumescence begins at about 200°C, that the material is water-resistant (for use aboard ships) and will stop penetration of all but a slight quantity of smoke even if produced artificially (by burning wood) in the furnace.

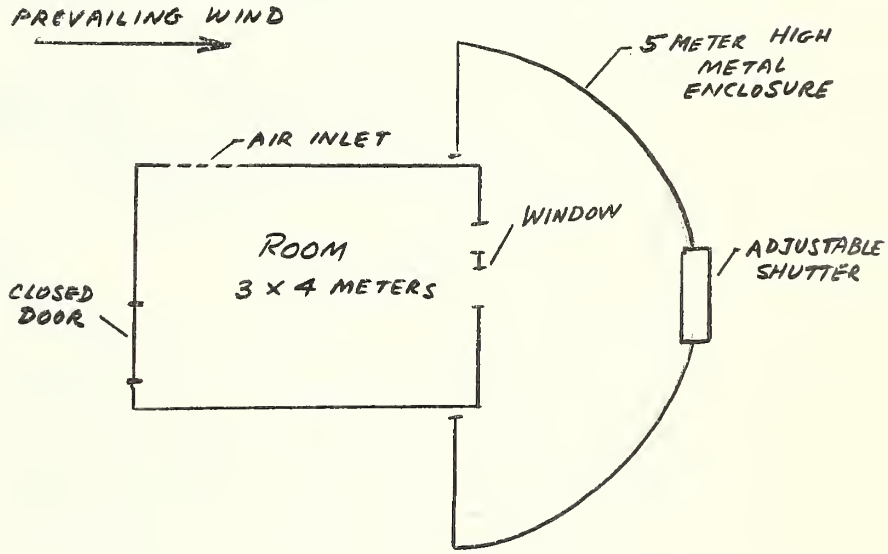
D. Centre Scientifique et Technique du Batiment, Paris and Champs-sur-Marne

Colonel Fackler is in charge of two sections, Reactions to Fire, and Nuclear Physics. In the first section, he has only two engineers, Mr. Favard, who works in the fields of ignition, non-combustibility, oxygen bomb calorimetry, etc., and Mr. Bellisson, who is in charge of fire resistance and model tests. There are about four technicians. In addition, because Col. Fackler acts as consultant to the Paris Fire Department, he has the services of two men from the Department at all times. One of these, Mr. Tourette, performed a DER model test during my visit.

Fire Propagation - Flashover Tests

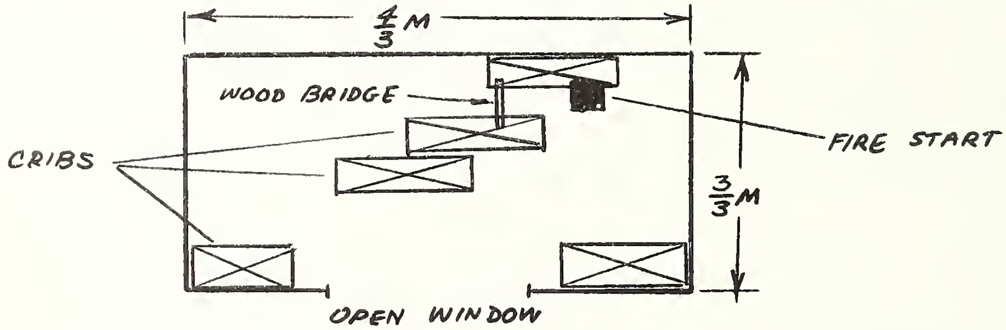
Except for fire endurance tests, this test program appears to be receiving maximum effort. There are two test series, one employing a full-size room and the other a one-third scale model room. The test procedures have now been standardized, but the program is still in progress and the results are not yet available in report form.

1. LEPIR (Laboratorie Experimental Pour Incendie Réal) is the code name for full-size room (4 by 3 meters, 2.5 meters high) tests. These are two single-room brick structures unprotected from the weather which would normally be subject to the effects of wind disturbance. The adjoining sketch indicates the location of a 5 meter high sheet metal enclosure which is provided with adjustable shutters arranged to minimize wind effects. The walls of the room are of vermiculite concrete to which the internal linings to be tested are attached. Room ventilation consists of not more than a dozen holes (1"dia.) located near the floor level close to the ignition location - plus two window panes which are initially half-open. The window is 1 meter in width and 2 meters high, or one-sixth of the floor area, and consists of six glass panes backed by asbestos plates. Considerable thought was given to standardizing the removal of window panes because of the importance of ventilation on the growth of fire in the room. Unless a standard procedure is employed for their removal, excessive variability in the burning pattern results. According to the British method of test, a pane is removed as soon as it cracks. The cracking of a pane due to heat could be a function of temperature T, of rate of temperature rise dT/dt, or or the temperature gradient dT/dx. The temperature of the pane at the time of cracking was measured and found to range between 80 and 200°C. The current CSTB practice is to remove a pane when its temperature reaches 100°C, according to a thermocouple mounted on its surface. The door is kept closed throughout the test. Mock wooden furniture is used and this is conditioned to 10 to 12 percent moisture content in the test structure prior to a test. Wood floors of 2 cm thickness are used. Test results to date indicate a flashover time of 20 or 21 min when the walls are noncombustible and about 4-1/2 min when the walls are lined with plywood.



2. DER (Dispositive Experimental Reduction) is the code name for the one-third scale model room. Here, the window is proportionately larger because, if it were reduced linearly, the ventilation factor A√h would not scale in the same way as the floor area. At first, 50 exploratory tests were performed, but 60 to 70 additional tests were required to iron out difficulties. The breaking of window glass was also a problem here and various window constraints were tried. Now an open window is used exclusively.

A model chair used earlier has been replaced by several wooden cribs to improve reproducibility. There is an attempt to get flames on the wall and ceiling and the first flame involvement is considered zero time.



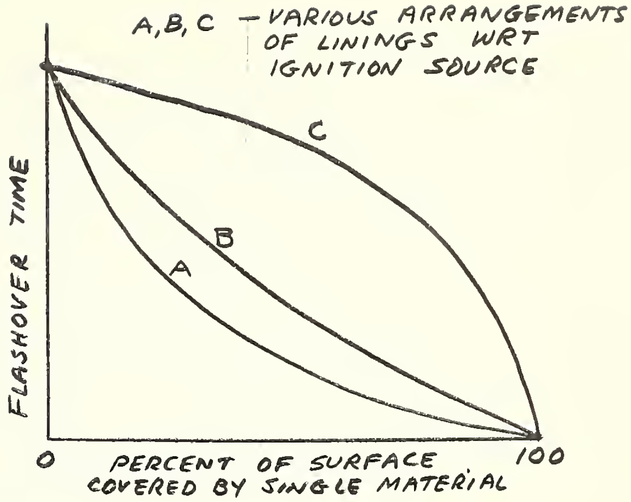
The cribs consist of wood sticks conditioned to 10 - 12 percent moisture content. A kerosene or alcohol-soaked fabric (small quantity) is used to initiate flaming. After the linings are installed, the top of the box is bolted on. The box is made of asbestos board (~15 mm thick) which has withstood more than 70 tests. Practically all the smoke leaks out from the top closure. The linings are fastened to asbestos furring strips. A gas sample is sucked through a smoke trap (cotton), then through the pump, a second filter and a drier to a carbon monoxide infrared analyzer.

When flashover occurs, the door opening is covered over to knock down the fire and then water is applied with a hand pump. At this time, only a small protion (perhaps 10%) of the wooden crib load has burned and charring is not deep. Thus, it appears that surface area rather than fire load is the governing factor.

Materials tested to date include:

Wood fiberboard - unfinished and with various paints; fir; plywood; hardboard and wood-fiberboard acoustic tile.

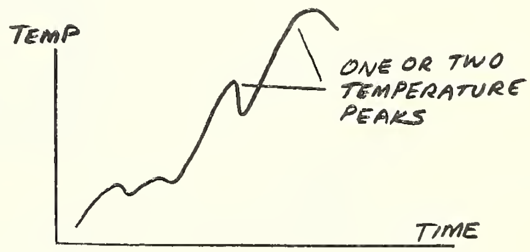
For each material, there are a minimum of three tests on the ceiling only, three tests on the walls only, and three tests on the ceiling and walls, making a total of nine to twelve tests for each material. The floor is noncombustible.



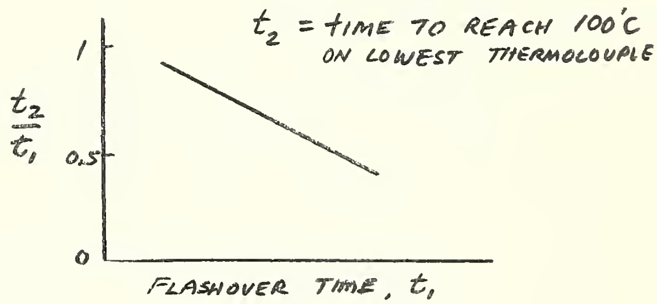
Since the orientation of the combustible linings with respect to the ignition source is so important, the use of a single universal relationship between the surface area covered and the time to flashover is not possible (see sketch).

There is agreement between the one-third and the one scale when certain materials are used on the ceiling only. However, fiberboard is an exception being less dangerous on ceiling than on walls. Other materials are more dangerous on the ceiling. Flaming is generally observed below (~4") rather than directly on ceiling surface.

Flashover Criterion

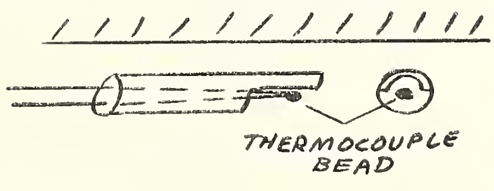


There are a number of possible criteria for judging the time at which "flashover" occurs, e.g.,the attainment of a certain temperature; complete flame involvement; strong flames through window; uniform temperature in room, according to the thermocouples; or the time of involvement of the last piece of furniture (crib). However, it has been found that actual times for all criteria are not much different. A typical temperature-time record, and a preliminary relationship between the time to reach 100°C and flashover time, are shown in the adjoining sketches.



Fire Endurance

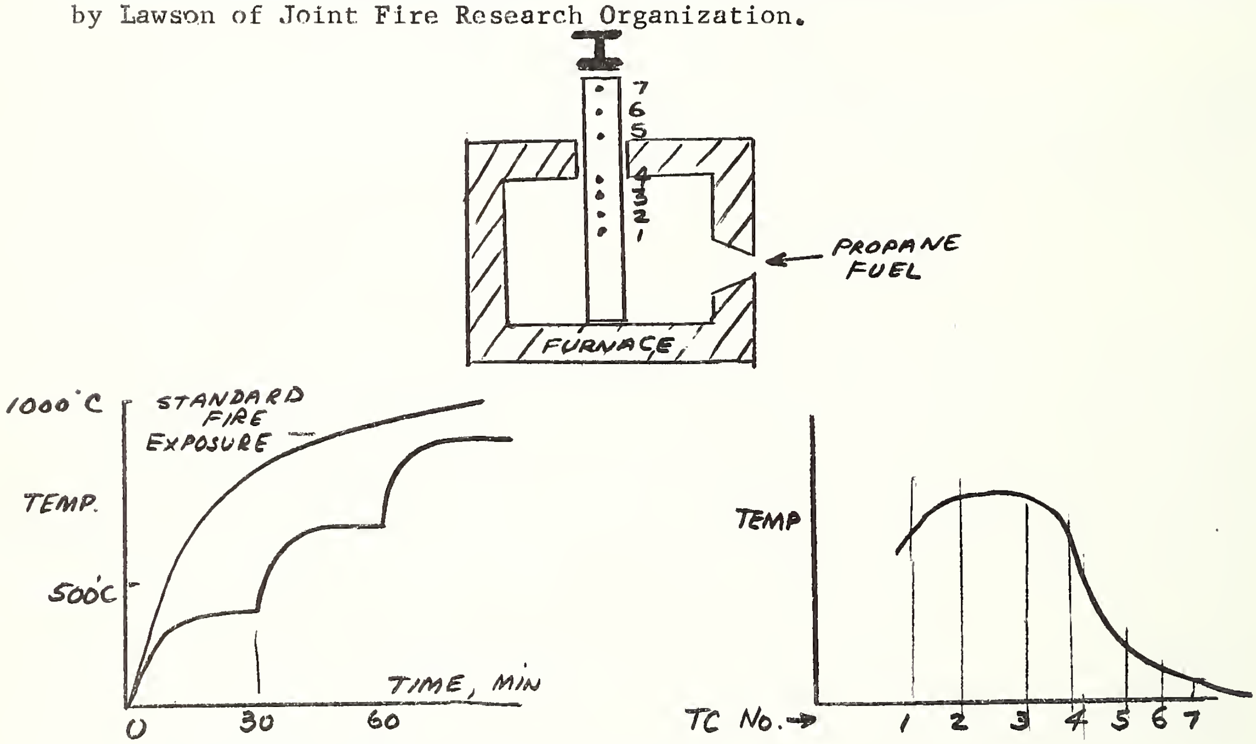
Oil-fired, down-draft furnace, with two combustion chambers (one on each side) and no direct flames within furnace. Thermocouples have half-round protection tube between bead and specimen in order to minimize radiative transfer from specimen to thermocouple.



The loading mechanism contains four hydraulic jacks with ball-joint action in order to maintain the load normal to the test structure. For beam tests, blank panels are set on each side of the centrally placed beam. An addition to the building of about 60 meters is planned to accommodate a new furnace for walls and columns.

Test of Bare Steel Column

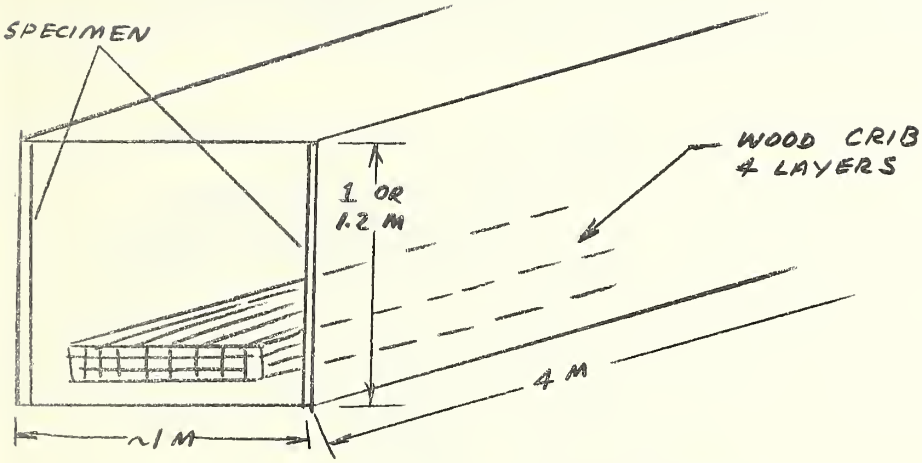
This was a test performed to examine the extent of heat conduction in bare steel columns. The temperature was brought up in steps in order to permit the attainment of steady-state and soaking in of heat. It is also planned to run a test with the ends of a long column immersed in water to satisfy steel interests. These tests are based on a suggestion by Lawson of Joint Fire Research Organization.



E. Institute for Fire Prevention, TNO

Certain specific problems were discussed with Dr. Lie.

Model Tunnel - This was constructed because of anomalies in the results of some materials in BS 476; for example H. H. Robertson protected steel jumps from Class I (i.e., <20cm) to Class IV (i.e., >30cm in 1/2 min) when a sudden flame advances to ~31 cm (avg. of 6 specimens) followed by flame extinction.



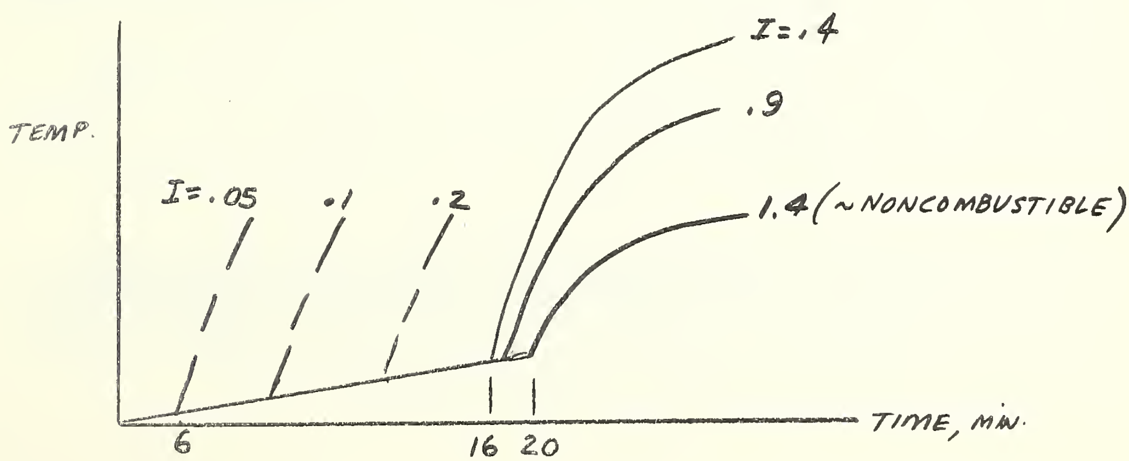
The tunnel is open at both ends and uses a wood crib as an ignition source. The time for flames to travel along the walls (which are lined with the specimen) and out the other end is measured.

Venting: A study was made several years ago and illustrated the extent to which the vent area and vertical partitions could be useful [21].

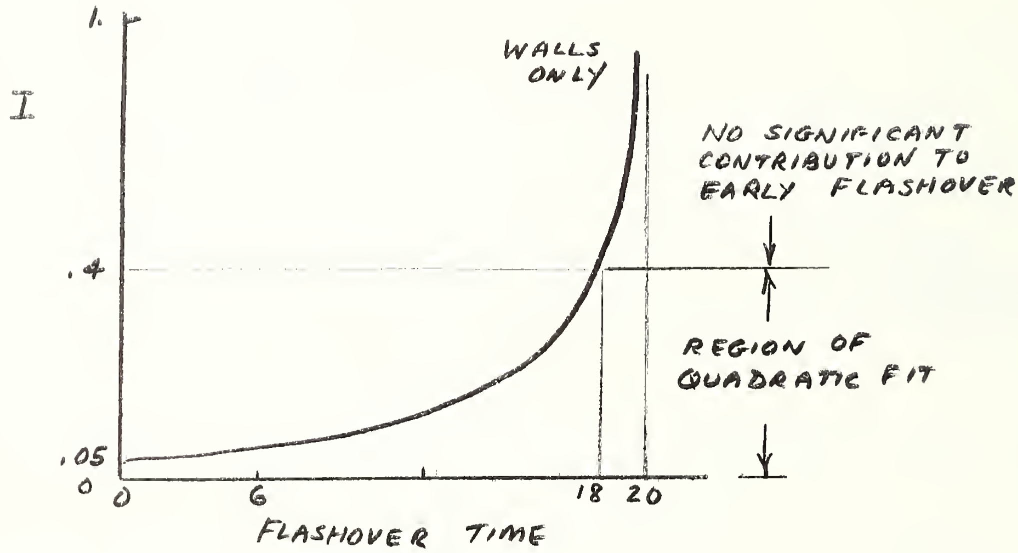
Box Test

At TNO, BS 476 is used primarily for materials to be used in very large buildings where no heat accumulation occurs (since the effect of heat accumulation does not enter in BS 476). NEN 1076 is almost identical to BS 476.

The Box test [22] is now included in NEN 1076. A multi-burner gas ignited with a 10 watt electrical igniter (to maintain the pilot flame) is used. The temperature-time curve for the enclosure tests is shown in the sketch



Previous results using electrical energy showed that energy was proportioned to flashover time. The current correlation between flashover time and flashforming intensity (F.O.T. = $\alpha \sqrt{I}$) is shown in sketch.



Fabric Test Results[23]

In this test, flames extend out and above the vertically mounted fabric (15 by 160 cm). An average flame spread rate (in cm/sec) is determined from the times at which flames propagate 25 cm lengths along the specimen. The times are electrically recorded upon the burning of thin tin strips connected in individual circuits at each location.

Testing of "Proban" fiber (~ 2 years old, manufactured by Proban Ltd., Manchester). This is a THPC type treatment which penetrates deep into the fiber, followed by NH_3 gas treatment. Plastic is formed inside the fiber with particles too large to be washed out. Fabric does not flame but turns to charcoal with no flame or afterglow. No deterioration after 200 washings.

A TNO textile group is currently studying a flame-retardant fabric in which the retardancy is chemically bound in the fiber.

Furnaces

In addition to wall and beam furnaces indoors, there is an outdoor furnace for testing the effect of a cold water hose spray on concrete specimens after heating to about 400°C. The top of the furnace is open. The specimen is examined visually for cracks and spalling and a core is taken for analysis by the Building Research Group.

They have just completed construction of a building in which to conduct large model enclosure tests. The rate of weight loss will be recorded, and fire extinguishment tests will be performed at the same time.

Building Research Group, TNO

A short visit was made with Mr. B. H. Vos. He stated that thermal conductivity measurements can never be made without some influence of moisture, but that the effect can be minimized if the imposed temperature difference is kept small. The principle of the thermal conductivity measurement he uses [24] involves a thin heater with a thermocouple on or near it and a second TC at a considerable distance to represent ambient conditions. After a sufficient time interval (in the order of minutes), the solution for thermal conductivity is of the form:

$$\lambda = q \frac{\partial \ln t}{\partial \theta} \qquad t = \text{time},\ \theta = \text{temp.},\quad q = \text{heat}$$

Thus the slope of a temperature vs ln time curve is a measure of conductivity. θ is about 1°C. (for quick interpretation, the recorder is fixed with a log-time scale; full-scale = 0.3 mv).

The "hot" probe consists of a glass tube ~3/16"D containing the heating element and a series of nine equally spaced Cr-Al (or Cu-Kn) TC's. The cold probe contains a similar series of 9 TC's in a polyethylene tube (≈1/8"dia). Using 9 TC's permits determination of λ as a function of position if this varies with moisture content distribution. The hot probe receives a thin coat of cement so as to make good thermal contact in the hole drilled in the sample. This probe has been checked in the laboratory on materials of known conductivity, moisture content, etc., and is now being used extensively in the field. Utilizing Jespersen's relationship between λ and moisture content, the device has also been used to estimate moisture content as a function of depth in a specimen [25]. The use of such a probe in the drying of concrete may introduce serious error if appreciable heat of setting occurs.

F. Department of Scientific and Industrial Research - National Engineering Laboratory - Glasgow

A. F. Robertson made a visit to these laboratories at East Kilbride near Glasgow, Scotland.

This laboratory which has been built up in the last fifteen years was reorganized two years ago. Three main technical groups are currently involved under a Director and Deputy Director, these are:

X. Machinery Group

1. Machine tools and Metrology Division
2. Mechanism Noise Control and Vibration Division
3. Fluid Power Division

Y. Fluids Group

1. Basic Heat Transfer and Properties of Fluids Division
2. Fluid Mechanics Division
3. Applied Heat Transfer Division

Z. Materials Group

1. Plasticity Division
2. Fatigue Wear and Stress Analysis Division
3. Creep and Non-metallic Materials Division

Dr. Grunberg, Superintendent of the Fluids Group was the initial contact. He arranged for visits with two of his divisions and Divisions 2 and 3 of the Materials Group. The visit,although very interesting, was unsuccessful in that information on short-time high temperature strength and thermal conductivity of building materials was not being obtained.

The main emphasis is long-term creep performance of materials and heat transfer problems relating to heat exchangers.

Various aspects of the work I discussed involved the following:

Y2 - Fluid Mechanics

I was shown their excellent hydraulic machinery laboratories [26],and was specially impressed with their facilities for calibration of high capacity fluid flow meters [27],[28]. The equipment involves the use of three water collection and weighing tanks of one-, three- and thirty-ton capacity. The overall accuracy of calibration at the 95 percent confidence level is ±0.1 percent.

They have also devised improved methods of making pitot-tube surveys of the cross-section of ducts carrying gases for the purpose of measuring air flow.

They are doing pioneer work on supercavitating pumps and turbines as well as developing mixed flow fans which can operate under high efficiency conditions.

Y1 - Basic Heat Transfer and Properties of Fluids Division

My visit here was very brief. They have recently cooperated in the publication of new steam tables and are currently active in the preparation of tables of critical properties of fluids. Some work is contracted out to universities.

Work is under way on development of new and improved viscometers as well as more accurate measurement of viscosity of fluids.

A radioactive tracer technique was being used for measurements of the condensation coefficient of gases leaving the surface of a liquid by evaporation. This is of considerable importance in condenser design.

Z1 - Plasticity Division

A large laboratory equipped with at least 250 creep testing machines was visited. Some of these were suitable for loads as high as 15 tons, and for use over a range of temperatures. Some machines were filled for stress relaxation measurements by use of electronic servo load control mechanism.

Z2 - Fatigue Wear and Stress Analysis Division

Behavior of materials under ambient conditions is emphasized. Very large vibration test equipment seems to be the specialty. They were familiar with the work of John Bennett in our Metallurgical Division.

The visit to NEL was not rewarding from the point of view of information specifically desired, however, it was well worth the time spent for the contacts made and the specialized information obtained.

References

[1] Fish, Franklyn and Pollard. "Analysis of Toxic Gaseous Combustion Products" J. App. Chem. Nov 13, 1963.

[2] D. W. van Krevelen, C. van Heerden, and F. J. Huntjens. Fuel, 30 253, 1951.

[3] Dr. B. Kaesche-Krischer and Dr. H. J. Heinrich. Chemie-Ingenieur-Technik Zeitschrift, 32, 598-605, 740-747, 1960.

[4] Bongard. "Exterior Building Columns Behavior Under Fire Conditions" VFDB, 12, No. 4, 117-125, Nov 1963.

[5] A. Kelly. "Atmospheres from Fires in Rooms with Little Ventilation, Part I" FR Note 494/1962, JFRO

[6] M. E. Milberg. J. Phys Chem 63, 578, 1959.

[7] McFarlane and Holderness. NGTE Report No. R253 and Memorandum No. M364 of the National Gas Turbine Establishment Pyestock Hants.

[8] A. G. Merzhanov and F. I. Dubovitskii. "The Quasi-Stationary Thermal Regime in Explosion Reactions" Acad. Sci. USSR Proc (Phys. Chem. Sect) 120, 1068, 1958.

[9] A. G. Merzhanov and F. I. Dubovitskii. "The Quasi-Stationary Theory of the Thermal Explosion of a Self-Accelerating Reaction" Russian J. of Phys Chem 34, 1062, 1960

[10] Rushbrook. "Fire Aboard" Technical Press, London, 1961.

[11] E. H. Coleman. "Effect of Compressed and Oxygen Enriched Air on the Flammability of Fabrics" British Welding Journal, 406, Sept 1959.

[12] a. D. J. Rasbash. The Engineer, May 31, 1963
b. D. J. Rasbash. et al. "Control of Fires in Large Spaces with Inert Gas and Foam Produced by a Turbo-Jet Engine" Part 1 (FR Note 507), Part 2 (FR Note), Part 3 (FR Note 512), Part 4 (FR Note), Part 5 (FR Note 511), Part 6 (FR Note 527) Part 7 (FR Note 519). JFRO.
c. D. J. Rasbash. "Potentialities of Jet Engine Inert Gas and Foam Generators for Control of Fires in Large Spaces" Internal Note No. 177, JFRO.
d. FR Note No. 539 "Symposium on the Use of Inert Gas and High Expansion Foam for the Control of Fires in Large Spaces," JFRO.

[13] Thomas, Hinkley, Theobold and Simms. "Investigations into the Flow of Hot Gases in Roof Venting" Fire Research Technical Paper No. 7, HMSO, 1963.

[14] Thomas et al. "Fire Spread in Wooden Cribs" Fire Research Note No. 537.

[15] W. W. Foster. "The Attenuation of Light from Wood Smoke" Brit. J. Appl. Physics, Vol. 10, Sept 1959.

[16] A. Prussmann. "Smoke as a Symptom of Fire," Paper No. 1257. Institut für Elektrische Nachrichtentechnik, an der Rhein-Westfalen Technische Hochschule, Aachen, Germany.

[17] Bongard. "Aussenstutzen aus Stahl in Feuer" VFDB, 12, No. 4, 117-125, Nov 1963.

[18] Fry and Hinton, "Casualties Due to the Direct Ignition of Clothing," FR Note No. 407, 1959.

[19] "The Laboratory of the Fire Brigade of Copenhagen"

[20] "Copenhagen Fire Department - Summary of the Organization and Scope of Operation of the Fire Department," May 1964

[21] T. T. Lie, and C. W. van Hoogstraten. "Brandvertraging door schotten en ventilatie," BOUW, 38, 1170-2, Sept 1961.

[22] T. T. Lie. "Bouwmaterialen bij verhitting - Beoordeling van gedrag in besloten ruimten," BOUW, Aug 1958

[23] T. T. Lie. "Verticale Vlamsnelheid aan Weefsels," De Tex, Nov 1961.

[24] B. H. Vos. "Bestimmung der Warmeleitzahl, des Warmedurchlass-widerstandes und der Feuchtigkeit in Konstruktionen," Gesundheits-Ingenieur, 10, 300, 1963.

[25] B. H. Vos. "Non-Steady-State Method for the Determination of Moisture Content in Structures," Int. Symp. on Moisture" Wash.,D. C. (to be published).

[26] S. P. Hutton. "Techniques for Hydraulic Machinery Research," Institution of Engineers and Shipbuilders in Scotland. Trans. 351-411, 1957.

[27] E. A. Spencer and A. T. J. Hayward. "The Accurate Calibration of the Flow Meters with Water," Trans. Soc. Instrument Technology, 9, No. 1, 1-12, 1957.

[28] Anon "Flow Meter Calibration Facilities at NEL," NEL Leaflet No. 419, May 1962.

Appendix A

List of Delegates at Meeting

Sizuo Yokoi	-	Building Research Institute of Japan 4 Chome Hyakunin-Cho Shinjuku-ku Tokyo
Rene Haure	-	Bureau Technique et de l'Equipment du Service National de la Protection Civile 60B Gallerian St. Cyr Paris II
Roland Traverse	-	(same as above)
Jean Husson	-	Regiment de Sapeurs Pompiers Service Technique 1 Place Jules Renard Paris XVII
G. W. Shorter	-	National Research Council Ottawa, Canada
F. J. van Sante	-	Stichting Ratiobouw Technisch Fysicche Afdeling Wenna 700 Rotterdam, Holland
Dr. C. W. van Hoogstraten	-	Centrum voor Brandveilligheidsinstituut TNO Lange Kleiweg 5, P. O. Box 49, Delft Ryswyk (Z.H.) Holland
Dr. T. T. Lie	-	(same as above)
Dr. P. H. Thomas		Joint Fire Research Organization Boreham Wood, Herts England
D. I. Lawson	-	(same as above)
L. A. Ashton	-	(same as above)
J. F. Fry (Secretary CIB/CTF)	-	(same as above)
P. Bornemann	-	Institut fur Bausleffkinde und Stahlbetonbau Techn. Hochschule Braunschweig Braunschweig, West Germany

Appendix A (concl'd)

Dr. Jeschke	- c/Senator fur Bau u Wohnungswesch Bauaufsicht 1 Berlin - Wilmersdorf
Dr. H. Seekamp	- Bundesanstalt für Materialprüfung 1 Berlin 45 (unter den Eichen 87)
Mr. Becker	- (same as above)
Mr. Westhoff	- Staatliches Materialprüfungsamt Nordheim - Westfalen Dortmund-Aplerbeck 1, Germany Marsbruch Str 186
Dr. Rumberg	- (same as above)
Dr. G. Magnus	- Forschungsstelle für Brandschuletechnik Technische Hochschule Karlsruhe Karlsruhe 1, Germany Hertzstr.
D. Gross	- National Bureau of Standards Washington, D. C. 20234
A. F. Robertson	- (same as above)
W. G. Kirkland	- American Iron & Steel Institute, New York City (unable to attend because of accident suffered en route to meeting).
K. Malmstedt	- Danish Government Testing Institute Amager Boulevard 108 Copenhagen S. Denmark
Mr. G. Christensen	- (same as above)
J. P. Fackler	- President CIB/CTF Centre Scientifique et Technique du Batiment 4 Avenue du Recteur Poincaré Paris XVI

Appendix B

COMPLETE LIST OF PAPERS CIRCULATED TO DELEGATES SINCE OCTOBER 1961 MEETING

CIB/CTF 61/53(C)	-	Small-Scale Fire Extinguishment Test on Mechanical Foam. Part I. D.B.R. Internal Report No. 224
CIB/CTF 61/54(UK)	-	Fire-Resistance of Floors and Ceilings. Fire Note No. 1
CIB/CTF 61/55(UK)	-	Destruction of Forty Gallon Drum by an Experimental Gaseous Explosion. F.R. Note No. 467
CIB/CTF 61/56(UK)	-	Some Fires in a Single Compartment with Independent Variation of Fuel Surface Area and Thickness. F.R. Note No. 469
CIB/CTF 61/57(UK)	-	The Burning of well ventilated Compartment Fires. Part III. The effect of the wood thickness. F.R. Note No. 474
CIB/CTF 61/58(I)	-	Resistenza al fuoco delle strutture Valutazione teorica - Controlli Sperimentali
CIB/CTF 61/59(UK)	-	United Kingdom Fire Statistics 1960
CIB/CTF 61/60(UK)	-	The projection of spray from fixed nozzles on to an outdoor risk. F.R. Note No. 465
CIB/CTF 61/61(C)	-	Small-Scale Fire Extinguishment Test on Mechanical Foam. Part II. D.B.R. Internal Report No. 230
CIB/CTF 61/62(C)	-	The value of a Fire Detector in the Home. D.B.R. Internal Report No. 237
CIB/CTF 61/63(UK)	-	References to Scientific Literature on Fire. Part XI. 1957-9
CIB/CTF 61/64(UK)	-	Effect of Restraint on Fire-Resistance of Concrete Floors. F.R. Note No. 460
CIB/CTF 61/65(UK)	-	A Comment on the Thermal Decomposition of Wood at High Temperatures. F.R. Note No. 471
CIB/CTF 61/66(F)	-	C.S.T.B. No. 52, Cahier 415. Essais de résistance au feu
CIB/CTF 62/1(UK)	-	The size of flames from two very large fires. F.R. Note No. 481
CIB/CTF 62/2(F)	-	C.S.T.B. No. 53, Cahier 424. Tableau récapitulatif général des classements relatifs a la résistance au feu
CIB/CTF 62/3(D)	-	Erhöhung der Feuerwiderstandsdauer von Stahlbetonrippendecken durch Verwendung von Holzwolleleichtbauplatten
CIB/CTF 62/4(C)	-	An Absolute Thermal Radiation Calorimeter. Research Paper No. 138
CIB/CTF 62/5(J)	-	Thermal Character of Concrete
CIB/CTF 62/6(J)	-	Study on the Reduction of Strength and of Modulus of Elasticity of Reinforced Concrete Beams subjected to Elevated Temperature
CIB/CTF 62/7(J)	-	The Effect of the Elevated Heat upon its Strength of the Corner of the Reinforced Concrete
CIB/CTF 62/8(UK)	-	On the Heights of Buoyant Flames. F.R. Note No. 489

CIB/CTF 62/9(C)	-	Fire Test of a Steel Column of 8in H Section, Protected with 4in Solid Haydite Blocks. Fire Study No. 6
CIB/CTF 62/10(I)	-	Il Laboratorio di Scienza delle Costruzioni del Centro Studi ed Esperienze Antincendi
CIB/CTF 62/11(UK)	-	Library Vocabulary No. 1/1961. English - German Vocabulary of Fire Protection Terms
CIB/CTF 62/12(UK)	-	Library Vocabulary No. 2/1961. German - English Vocabulary of Fire Protection Terms
CIB/CTF 62/13(UK)	-	On the Heights of Buoyant Flames. F.R. Note No. 489
CIB/CTF 62/14(J)	-	Estimation of Room Temperature and Fire Duration
CIB/CTF 62/15(UK)	-	Fire-Resistance of Concrete Block Walls. F.R. Note No. 501
CIB/CTF 62/16(C)	-	Stability of Numerical Heat Flow Calculations. Technical Note No. 339
CIB/CTF 62/17(C)	-	Variable-State Methods of Measuring the Thermal Properties of Solids. D.B.R. Internal Report No. 249
CIB/CTF 62/18(C)	-	A Treatise on Theoretical Fire Endurance Rating. Research Paper No. 153
CIB/CTF 62/19(J)	-	The Variation of Thermal Conductivity of Cement Mortar and Concrete under High Temperature
CIB/CTF 62/20(J)	-	Fire Tests on Mitsubishi Naka No. 15 Building
CIB/CTF 62/21(F)	-	C.S.T.B. No. 56, Cahier 445. Essais de résistance au feu (11e série)
CIB/CTF 62/22(C)	-	Performance Test on Foam-Compatible Dry Chemical Powders. D.B.R. Internal Report No. 258
CIB/CTF 62/23(F)	-	C.S.T.B. No. 58, Cahier 469. Les problèmes posés par les fumées en cas d'incendie. Essai d'incendie réel dans un immeuble-tour de 20 niveaux a maisons-alfort
CIB/CTF 63/1(UK)	-	Control of fires in large spaces with inert gas and foam produced by a turbo-jet engine. Part I - Introduction and properties of inert gas and foam. F.R. Note No. 507
CIB/CTF 63/2(UK)	-	Radiation from fires in spirit storage buildings. F.R. Note No. 508
CIB/CTF 63/3(F)	-	C.S.T.B. No. 59, Cahier 479. Essais de résistance au feu
CIB/CTF 63/4(F)	-	C.S.T.B. No. 59, Cahier 480. Essais de résistance au feu
CIB/CTF 63/5(UK)	-	Research Programme 1962/1963
CIB/CTF 63/6(UK)	-	Some observations of the effect of wind on line plumes. F.R. Note No. 510
CIB/CTF 63/7(C)	-	The value of a fire detector in the home. Fire Study No. 9, D.B.R. N.R.C. 7162
CIB/CTF 63/8(F)	-	C.S.T.B. No. 60, Cahier 493. Essais de reaction au feu - 2o serie
CIB/CTF 63/9(J)	-	Full Scale Fire Test on an Apartment House in Tokyo
CIB/CTF 63/10(UK)	-	Fire Research 1961

CIB/CTF 63/11(UK)	-	United Kingdom Fire Statistics 1961
CIB/CTF 63/12(UK)	-	Heat Radiation from Fires and Building Separation. Fire Research Technical Paper No. 5
CIB/CTF 63/13(UK)	-	Protection of structural steel against fire. Fire Note No. 2
CIB/CTF 63/14(UK)	-	Some observations of the effect of wind on line plumes. F.R. Note No. 510
CIB/CTF 63/15(UK)	-	English - French Vocabulary of Fire Protection Terms. Library Vocabulary 5/1963
CIB/CTF 63/16(J)	-	The Thermal Stress of Reinforced Concrete Frame at Fire of the Factory of Yokohama Bridge Stone Tire Company
CIB/CTF 63/17(J)	-	Report - Building Research Institute 1962
CIB/CTF 63/18(No)	-	Stability in fire of protected and unprotected glued laminated beams
CIB/CTF 63/19(F)	-	C.S.T.B. No. 60, Cahier 490. Mesures de rayonnement à la station du feu
CIB/CTF 63/20(UK)	-	Measurements of the transmission of radiation through water sprays. F.R. Note No. 520
CIB/CTF 63/21(UK)	-	The reduction of the fire hazard of thatched roofs. F.R. Note No. 525
CIB/CTF 63/22(F)	-	C.S.T.B. No. 62, Cahier 510. Essais de réaction au feu (3è série)
CIB/CTF 63/23(UK)	-	The relationship between the ignition of fires in buildings in England and Wales and climatological variations over the period 1951 to 1961. F.R. Note No. 522
CIB/CTF 63/24(J)	-	The theoretical calculation of temperature-rise of thermally protected steel column exposed to the fire. B.R.I. Occasional Report No. 10
CIB/CTF 63/25(J)	-	Estimation of fire temperature-time curve in rooms. B.R.I. Occasional Report No. 11
CIB/CTF 63/26(CA)	-	The approximate determination of the fire endurances of structural elements. UP No. 147
CIB/CTF 63/27(F)	-	C.S.T.B. No. 63, Cahier 521. Essais de résistance au feu. (13e série)
CIB/CTF 63/28(UK)	-	Investigations into the flow of hot gases in roof venting. Fire Research Technical Paper No. 7
CIB/CTF 63/29(UK)	-	Progress Report of the Director of Fire Research - 1st May to 31st August, 1963.
CIB/CTF 63/30(J)	-	On the heights of flames from burning cribs. B.R.I. Occasional Report No. 12
CIB/CTF 63/31(USA)	-	Early History of Fire Endurance Testing in the United States
CIB/CTF 63/32(USA)	-	Experiments on the Burning of Cross Piles of Wood
CIB/CTF 63/33(USA)	-	Fire Tests of Precast Cellular Concrete Floors and Roofs. N.B.S. Monograph 45
CIB/CTF 63/34(USA)	-	Study of Gypsum Plasters Exposed to Fire
CIB/CTF 63/35(USA)	-	Surface Flame Propagation on Cellulosic Materials Exposed to Thermal Radiation
CIB/CTF 63/36(D)	-	Das Verhalten von Stahlbetonund Spannbetonbauteilen unter Feuerangriff

CIB/CTF 63/37(C)	-	Flame Spread. Canadian Building Digest U.D.C. 614.841
CIB/CTF 63/38(UK)	-	An Instrument for Measuring Total Heat Fluxes within Flames. F.R. Note No. 531
CIB/CTF 63/39(J)	-	Effect of the Internal Linings on the Fire Behaviour in the Room
CIB/CTF 63/40(D)	-	Brandversuche an schlanken, stark bewehrten Stahlbetonsäulen hoher Betongüte
CIB/CTF 64/1(C)	-	A Remote Reading Anemometer Counter. N.R.C. D.B.R. Technical Note No. 403
CIB/CTF 64/2(F)	-	C.S.T.B. No. 65, Cahier 541. Essais de réaction au feu (4e série)
CIB/CTF 64/3(UK)	-	Temperatures within the walls of a compartment containing a fire. F.R. Note No. 524
CIB/CTF 64/4(UK)	-	Fire Resistance: Some unresolved problems
CIB/CTF 64/5(UK)	-	The Spread of Smoke and Toxic Gases in Buildings
CIB/CTF 64/6(UK)	-	Notes on Theme "The Desirable Limitations on the Size of Buildings and Compartments"
CIB/CTF 64/7(F)	-	Immeubles tres élevés
CIB/CTF 64/8(UK)	-	Causes of fires in dwellings in London, Birmingham and Manchester and their relationship with the climatic conditions during the first quarter of 1963. F.R. Note No. 538
CIB/CTF 64/9(D)	-	Feuerungsanlagen - Hausschornsteine; Bemessung und Ausführung
CIB/CTF 64/10(D)	-	Brandschutz Versuche an Baustoffen
CIB/CTF 64/11(N)	-	Brandproeven op steenachtige vloerconstructies. Rapport no. 16/1963
CIB/CTF 64/12(N)	-	Afzonderlijke verslagen van brandproeven op steenachtige vloerconstructies. Bijlage behorende bij rapport no. 16/1963
CIB/CTF 64/13(UK)	-	Some observations on the C.I.B. Models Programme
CIB/CTF 64/14(UK)	-	Complete list of papers circulated to delegates since October 1961 meeting

21st February, 1964.

Appendix C

Report of Group 1

The aim of the co-operation in the C.I.B. Commission is to compare the results received by each institute from fire tests on materials of structure. In order to realize this idea the Group 1 - Fire endurance - gives the following report:

1. The group were unanimous that the utilization and acceptance of fire resistance tests made in one country in other countries was not possible until some basic problems had been resolved. These problems relate to real differences in test conditions and procedures, although they will nominally be the same. Instead, therefore, of discussing the individual documents submitted on fire endurance, the group decided that a fruitful outcome could only be achieved by examining certain fundamental issues, and paper 64/4 (UK) was adopted as providing a basis for the day's discussions.

2. The group agreed that furnace design and operation were the most important factors affecting the results of fire resistance tests which required investigation first. Information should be obtained on the heating characteristics as affecting a test specimen of one type of furnace in the laboratories of the participating countries and it was agreed that the wall furnace would be most suitable for this study. The group proposes that small refractory elements should be designed containing thermocouples accurately located at specified distances from one face and these elements should be incorporated at selected positions in a brick wall. Repeat tests could be made with any time/temperature regime in the furnace and the heat transfer to a specimen determined, enabling a comparison to be made of existing equipments. Investigation of the effect of changing other factors, such as furnace pressure, or volume of the furnace chamber, might also be included. As the results of tests on constructions of combustible materials such as wood or wood-based products will be influenced by the furnace conditions, it is proposed that comparative tests should be made on bulkheads of particle board.

   In all experiments sampling the furnace atmosphere would give useful additional information for the interpretation of the results.

3. Members of the group were prepared to make a comparative study of the results of tests made in various countries on certain forms of construction, such as protected steel columns, reinforced concrete columns and combustible bulkheads, to obtain, if possible, data on furnace operation in different countries which will supplement the information from the research programme.

Ashton (UK) (Chariman)
Becker (G)
Fackler (F)
Helmrich (Interpreter)
Malmstedt (D)
van Sante (N)
Seekamp (G)
Westhoff (G)

Appendix D

Report of Group 2

The Spread of Smoke and Toxic Gases

It was agreed that the problem is to:

a) identify materials that will produce smoke and toxic and irritant gases and compare the level with levels produced by materials in common use in buildings and develop a test for comparison purposes. As the amount of smoke depends on the rate of burning of the specimen and the degree of ventilation any test method would have to take into account these factors. Acceptable levels of usage to be established.

b) develop methods for disposing of smoke or for preventing entry of smoke into escape passages and establish satisfactory levels. Escape passages should also serve as a basis for the fire fighting operations.

Dr. Yokoi said Dr. Saito had been carrying out measurements of smoke and toxic gases using model fires with different levels of ventilation and with different fire loads. The smoke density increased with fire load and decreased with ventilation. Dr. Saito is monitoring CO_2 and O_2. A paper will be available next year.

Dr. Robertson referred to some experiments with fires using a radiant ignition of wall finish materials in a small building CIB/CTF 64/24 (USA). He discussed smoke measurements referring to the January issue of NFPA Quarterly and ASTM Methods E-84 and E-162. He emphasized the importance of recognizing that the total quantity of absorbing material is more nearly linearly related to the optical density of the absorbing medium than to the absorption. The result is in considering the dispersal of smoke from a limited source to a large volume you have to base your measurements on the optical density of the absorbing medium. He recommended that in reporting optical density or absorption of smoke, such data should be based on a one meter path length.

Shorter reported that Canada will be doing work in the measurement of the products of combustion from plastics burning in free air and doing a chromatographic analysis.

Dr. Rumberg, Dortmund, and Mr. Lawson, J.F.R.O., stated that their laboratories would also be working in this field. It was agreed that they should discuss their programs with a view to avoiding duplication. Dr. Rumberg questioned whether it was possible to measure the adsorption in smoke by photometering deposited smoke on filterpapers. Dr. Robertson said he was looking into this question and would have some results in the near future.

Mr. Traverse described an experiment in a building in which wood and fabrics had been burnt CIB/CTF 62/23 (F) and supplement. They tried two methods of smoke clearance: (1) separate smoke exits from building into a multiple flue system and (2) smoke was extracted into a common flue, the exits from room being closed by dampers which were opened by thermal links. Fresh air was supplied to room at floor level from a duct also closed but which would open by fusing of a thermal link in a fire. The size of the ducts was 18" square and these had been found to be very effective.

Shorter reported on work being undertaken in the United States and Canada CIB/CTF/64/19 (C). He referred briefly to the work carried out by the Southwest Research Institute, the Underwriters Laboratories and the Los Angeles Fire Department. He referred to work carried out at the National Research Council of Canada related to the significance of the neutral pressure plane in a fire area. A technique is suggested whereby smoke could be confined to the immediate fire area in a building. CIB/CTF 64/23 (C).

Lawson described a series of experiments that were being carried out at J.F.R.O. in which the smoke from the fire in a compartment was measured as it escaped into a central escape loft CIB/CTF 64/5 (UK). Measurements were being made of visibility in relation to the absorption and measurements were also being made of the distortion of smoke check doors in fires. Experiments had also been made in a building in which the escape routes had been pressurized and it was found that a pressure of .05 to .1" watergauge was sufficient to prevent smoke leaking into escape routes. Surveys were also being made of the position of smoke stop doors in buildings under normal usage and fire brigades are to report on whether such doors had been closed when fires occured.

The task group recognized that while in some cases smoke could be measured, the toxic and irritant qualities were difficult to measure in a quantitative manner and the suggestion of the commission would be welcome.

Attendance

Haure (F)
Hoogstraten (N)
Lawson (UK)(Chairman)
Robertson (USA)
Rumberg (G)
Shorter (C)(Reporter)
Traverse (F)
Yokoi (J)

Appendix E

Report of Group 3

Fires in single compartments including the co-operative research programme on models

Co-operative Research Programme

The present state of the co-operative research programme is that the sets of experiments which were allocated to France and Italy have yet to be done and the tests on 1 1/2 m scale allocated to the NBS have been deferred. B.A.M. expect to complete their tests by the autumn of this year.

The UK tests on wind effects have been completed but the tests on shape (441) on 1/2 m and 1 1/2 m scale will be undertaken during 1964/5. Since no other tests on this shape are included in the programme an analysis of the data for (121) (211) and (221) shapes can be started. All other assignments were completed and the participating laboratories should be commended for their fine efforts.

Dr. Thomas said that JFRO would set up a programme of statistical analysis for the 1/2 m and 1 m scales. This would not need to be altered when data for those tests not yet done were available, but it was thought that those tests allocated to France, at least, ought preferably to be done by one laboratory. This would leave a minimum number of gaps in the analysis.

The data on 1 1/2 m scale already available could be incorporated at a later stage.

It was thought desirable that each laboratory should send a small (5 x 10 cm) sample of the material it had used in the box construction to each of the others since some differences between laboratories might be ascribed to this factor.

However, while there were some systematic differences, the few comparisons made so far on the basis of the results available earlier appeared more consistant than the first CIB experiments and the group was optimistic as to the outcome of the work. It is expected that the final results will be expressed in terms of "probable best values" for each measured variable and under each set of conditions studied.

It was thought that no programme, where experiments of one laboratory were formally related to those of another as in the present series, should be commenced before the present programme was analyzed.

Dr. Thomas strongly urged that any laboratory undertaking research using models should follow the example of TNO in their study of flashover and include models corresponding to one or other of the CIB sizes and shapes in their programme. Useful programmes for any laboratory wishing to continue experiments independently of other laboratories would be to study (a) the effect of different materials in the construction of the box, (b) the effect of the method of ignition and (c) the effect of baffles, shields or ground plates.

Dr. Thomas said that the effects of wind on the rate of burning was no more than to double it but the effects on flame position, etc. were probably more important. The effects of wind were complex and required studies in more detail than provided for in the CIB programme.

Fires in Compartments

Dr. Lie reported on his recent work on the correlation of flashover times in CIB enclosures of several shapes and sizes. Except for certain thin materials, the flashover times for a variety of lining materials were nearly identical if the ignition of the crib is adjusted to cause flashover with an incombustible lining in 20 minutes. It is planned to continue the study in a large enclosure of 3 x 4 x 3 meters size. This study using a continuous crib fuel extends and supplements prior work by Hird & Fischl (JFRO) using continuous fuel (mock furniture).

Mr. Christensen reported on full scale experiments on fire spread from a room containing wooden linings and furnishings through a corridor whose walls and ceiling were surfaced with various combustible and non-combustible linings. Preliminary results indicate that the generation of gases and heavy smoke precede flaming down the full length of the corridor, even when the corridor surfaces are noncombustible. The contribution of conbustible linings and the effect of surface treatments are to be evaluated and a complete report may be available in several months. Since the entire room was supported on a weighing device, measured rates of burning were obtained which were in very good agreement with available data from the UK and Japan from model and full scale enclosure tests.

Mr. Gross reported on NBS work on the burning of crosspiles of wood in the open and on fires in geometrically similar enclosures of three sizes. It was suggested that interpretation of the porosity factor for the cross-piles in terms of a void space parameter would enable data for fuel beds of random construction to be analyzed also. The appropriateness of the Froude number in interpreting burning rates of open piles, of cribs within enclosures, and of conventional fuels in furnaces was commented upon. For piles in the open, the transition point between the diffusion-limited region and the free combustion region was suggested as a good point for the evaluation of the effectiveness of extinguishing agents.

Appendix E (concl'd)

Dr. Magnus led a discussion on the desirability and suitability of idealizing experiments in enclosures by using liquid or gaseous fuels in place of solid fuels. It was concluded that the resultant differences in floor patterns, flame emissivity and combustion products would have to be considered.

A discussion was held on the impprtance of burning rate data, modified by wind, fire load, ventilation, etc. on the penetration of heat into structural elements and their fire endurance. Test data in this area is needed and theoretical calculations, such as those performed by Kawagoe, Lie and others should be extremely valuable.

Attendance:

Christensen (D)
Magnus (G)
Lie (N)
Fry (UK)
Thomas (UK)
Gross (USA)

Appendix F

BUNDESANSTALT FÜR MATERIALPRÜFUNG
(BAM)

Berlin-Dahlem

Leitung

Abteilung 1
Metalle und Metallkonstruktionen

Fachgruppe 1.1
Metallkunde und Metalltechnologie
- 1.11 Metallurgie und Metalltechnologie
- 1.12 Metallographie und Elektronenmikroskopie
- 1.13 Sonderverfahren der Metallkunde
- 1.14 Spektrochemie

Fachgruppe 1.2
Mech.-technolog. Prüfung der Metalle und Konstruktionen
- 1.21 Technologische Prüfungen der Metalle
- 1.22 Schwingprüfung
- 1.23 Triebelemente
- 1.24 Festigkeitsforschung und Behälterbau

Fachgruppe 1.3
Anorganisch-chemische Untersuchungen
- 1.31 Analyse von Eisen und Stahl
- 1.32 Analyse der Nichteisenmetalle
- 1.33 Analyse sonstiger anorganischer Stoffe
- 1.34 Physikochemische Analysenverfahren

Fachgruppe 1.4
Korrosion und Korrosionsschutz
- 1.41 Korrosion und Elektrochemie
- 1.42 Korrosionsprüfung
- 1.43 Korrosionsschutz
- 1.44 Galvanotechnik

Abteilung 2
Baustoffe und Baukonstruktionen

Fachgruppe 2.1
Prüfung von mineralischen Baustoffen
- 2.11 Chemische Prüfung der Baustoffe
- 2.12 Mechanische Prüfung der Baustoffe und Natursteine
- 2.13 Technologische Prüfung und Sonderfragen der Baustoffe

Fachgruppe 2.2
Unterschung der Baukonstruktionen
- 2.21 Mechanische Prüfung der Baukonstruktionen
- 2.22 Tragfähigkeitsuntersuchung von Bauwerken

Fachgruppe 2.3
Bautenschutz
- 2.31 Feuer- und Brandschutz
- 2.32 Wärme- und Kälteschutz
- 2.33 Schallschutz im Bauwesen

Fachgruppe 2.4
Biologische Materialprüfung, Holzschutz- u. Holztechnologie
- 2.41 Biologische Materialuntersuchung
- 2.42 Biologisch-technische Holzschutzuntersuchung
- 2.43 Chemisch-technische Holzschutzuntersuchung
- 2.44 Technologische Holzuntersuchung

Abteilung 3
Organische Stoffe

Fachgruppe 3.1
Kautschuk, Kunst- und Anstrichstoffe
- 3.11 Kautschuk und Kautschuk-Erzeugnisse
- 3.12 Kunststoffe und Kunststoff-Erzeugnisse
- 3.13 Fußbodenbeläge
- 3.14 Anstrichstoffe und Klebstoffe
- 3.15 Organisch-chemische Analyse

Fachgruppe 3.2
Textilien und Leder
- 3.21 Mechanisch-technolog. Textilprüfungen
- 3.22 Textilchemische Prüfungen
- 3.23 Versuchswäscherei
- 3.24 Lederprüfung

Fachgruppe 3.3
Zellstoff und Papier
- 3.31 Zellstoff
- 3.32 Papier und Pappe
- 3.33 Drucktechnische Papierprüfung

Fachgruppe 3.4
Erdöl- und Kohleerzeugnisse
- 3.41 Heiz-, Kraft- und Schmierstoffe
- 3.42 Bituminöse Stoffe

Abteilung 4
Technische Gase, feuergefährliche und explosive Stoffe

Fachgruppe 4.1
Chemie und Technologie des Azetylens, Unfallschutz
- 4.11 Untersuchung der Eigenschaften und Reaktionen des Azetylens
- 4.12 Herstellung des Azetylens, Apparate und Sicherheitseinrichtungen für Gase
- 4.13 Speicherung und technische Anwendung des Azetylens

Fachgruppe 4.2
Chemie und Technologie der Gase
- 4.21 Eigenschaften der Gase – Gasanalyse
- 4.22 Reaktionsvorgänge in Gasen
- 4.23 Herstellung und technische Anwendung der Gase; Gasschutz

Fachgruppe 4.3
Explosive, leicht- und selbstentzündliche Stoffe
- 4.31 Explosive und andere exotherm zerfallende Stoffe
- 4.32 Explosive Stoffe mit kleiner Grenzladung
- 4.33 Nitrocellulose und daraus hergestellte Produkte
- 4.34 Pyrotechnische Gegenstände

Fachgruppe 4.4
Thermochemie der brennbaren und der explosiven Stoffe
- 4.41 Brennbare und autoxydationsfähige Stoffe
- 4.42 Zündgefährliche Stäube
- 4.43 Kalorimetrie und Entzündungskinetik
- 4.44 Verbrennungs- und Explosionsdynamik

Fachgruppe 4.5
Schweißtechnik
- 4.51 Schmelzschweißen
- 4.52 Preßschweißen und Sondergebiete der Schweißtechnik

Abteilung 5
Sonderverfahren in der Materialprüfung

Fachgruppe 5.1
Zerstörungsfreie Prüfverfahren und Strahlentechnik in der Materialprüfung
- 5.11 Entwicklung zerstörungsfreier Prüfverfahren, Rö-Feinstruktur, Prüfdienst, Strahlenschutzmessung
- 5.12 Kerntechnik in der Materialprüfung

Fachgruppe 5.2
Meßwesen für die Materialprüfung
- 5.21 Mechanische Meßtechnik
- 5.22 Elektrische Meßtechnik
- 5.23 Überwachung von Materialprüfmaschinen; Sonderverfahren der Meßtechnik

Fachgruppe 5.3
Rheologie (Fließkunde)
- 5.31 Rheometrie und Strukturmechanik
- 5.32 Schmiertechnik, Reibung und Verschleiß

Fachgruppe 5.4
Sonderverfahren der Elektrochemie
- 5.41 Elektrochemische Meßtechnik
- 5.42 Elektrochemie und Anwendung der elektrochem. Sauerstoffmessung in der Technik
- 5.43 Anwendung der elektrochemischen Sauerstoffmessung in der Biologie

Fachgruppe 5.5
Angewandte Farbforschung
- 5.51 Farbmessung
- 5.52 Farbmuster

0
Dienststellen

0.1
Schrift-, Bild- und Vortragswesen

0.2
Technische Dienststelle

0.3
Verwaltung

Appendix G

Organization Chart Joint Fire Research Organization

Director of Fire Research

D. I. Lawson

Assistant Director

R. G. Silversides

Ignition and Growth

- P. H. Thomas
- D. L. Simms
- H. L. Heselden
- R. Balwin

Building Materials and Structures

- L. A. Ashton
- H. L. Malhotra
- G. J. Langdon Thomas

Administrative Services

Senior Principal Scientific Officer

F. E. T. Kingman

Operational Research

- J. F. Fry
- Mrs. Hogg
- Miss Gannt
- Miss Shakeshaft

Chemistry & Chemical Engineering

- D. J. Rasbash
- K. N. Palmer
- P. C. Bowes
- G. W. V. Stark
- McLintock

Extinguishing Materials

- P. Nash
- R. W. Pickard
- J. A. Gordon

DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS