NATIONAL BUREAU OF STANDARDS REPORT

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VISIT TO THREE GERMAN FIRE RESEARCH FACILITIES

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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The Bureau comprises the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Center for Radiation Research, the Center for Computer Sciences and Technology, and the Office for Information Programs.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of an Office of Measurement Services and the following technical divisions:

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Office of Standard Reference Data—Clearinghouse for Federal Scientific and Technical Information [3]—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Located at Boulder, Colorado 80302.
[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

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ABSTRACT

Three German fire research laboratories were visited in September 1970.

Budenstalt for Material Prufing - Berlin

Technische Universitat - Braunschweig

Institute for Holz Forchung und - Munich
Holztechnik

This report covers a description of the research facilities and their current research programs. A description is also given of the current German practice on materials control and fire endurance certification.

VISIT TO B. A. M. BERLIN

1.0 The fire section is in the division devoted to Building Protection, which contains sections on fire, heating, acoustics, and special problems and is under the direction of Dr. Ing P. Schneider. The fire section is under Dr. J. Stanke.

We reviewed in detail all the tests for fire safety now being used in Germany and covered in DIN 4102. Of particular interest were some new tests which are being used in Germany alone.

2.0 All materials are classified as follows:

Class	
A1	non-burning
A2	non-burning
B1	hard to burn
B2	normal burn
B3	easy to burn

2.1 A modified ISO non-combustibility apparatus is used for the class A materials. The apparatus does not have the cone on the bottom or the draft shield on top but uses a cover instead. In addition a pilot burner is placed above a small opening in the cover and any increase in the pilot flame is noted. Class A material must pass this modified ISO test.

2.2 Class A2 material must pass the modified ISO test with the furnace run for only 15 minutes and an exception for 20 seconds flaming. Also a new test called a Brand Schacht test (chimney) is used. In this test 4-19 cm wide by 1 m, long boards are arranged vertically to form a chimney. A burner about 20x20 cm square with 8 ports on each side is located at the bottom of the chimney. The assembly is placed in an 80x80 cm square box in which the walls are heated to 40°C. The burner is lighted and the vertical flame spread is measured on the vertical boards. The flame spread is limited to 650 cm for A2 materials and 850 cm for B1 materials.

Also, a thermocouple in the hood measures the temperature rise, which is limited to 125°C for class A2 materials and 250°C use for class B materials.

As an alternate for classifying A2 materials a potential heat test can be substituted for the modified ISO test. This is similar to our potential heat test except that the sample is burned from one side only in the small scale furnace described in 3.1, instead of the muffle furnace we use. The values are limited to 4000 Kcal/m^2 or 1000 Kcal/Kg.

2.3 The B2 materials are subject to another new test called the Kleinbrenner (small burner). This test consists of two parts: In both cases a small pilot is brought against the face of a vertical sample 90 mm wide and either 190 or 230 mm high. A mark is made on the sample 150 mm above the contact point of the flame, which for one test is at the bottom of the cut edge and for the second against the face about 40 mm above the bottom. The travel time up the face to the mark should be greater than 20 seconds. Also a piece of filter paper is placed on the bottom of the box and a determination is made as to whether the paper catches fire by dripping of the sample.

3.0 BAM runs fire endurance tests for walls, doors, floors and columns. Their facilities are relatively new (the building was completed in 1965.) They are now building a new floor furnace which will be 4x4 m. The furnace will not use any end restraint. They are planning a new column furnace in which they can vary the end fixity of the columns.

The German standard uses 5 classes of fire endurance: 30,60,90,120 and 180 minutes. The ISO recommendation is used for the fire tests. The DIN calls for oil burners to be used with an oil providing 10,000 cal/g fuel content. This gives a highly radiant flame.

3.1 They have two small scale furnaces which will test a 50 cm square sample in either the wall or floor position. These are fired by horizontal automatically controlled oil furnaces. Burners made by Korting-Hanover and cost $2,000 each. This furnace is used for the potential heat test.

3.2 The full scale and the small furnaces are controlled from a central room which contains both temperature programming and the feed back systems.

The wall furnace has a 3x3 m opening. Specimens are built into a steel frame which is moved in front of the opening. There are four vertical burners on the floor and a top draft is used. The nine TC's are horizontal and supported in a saddle from the top of the furnace so that they are located within 10 in. from the specimen.

They have been testing elevator doors and have a unique specification. When tested from the lobby side the door is subject to the standard ISO time-temperature curve. When tested from the shaft side they use a curve which reaches 270°C in 60 minutes, and 330° in 90 minutes.

3.3 The column furnace is 2x2x3 m high and the sample is on a power carriage which places it in the furnace. Burners are on the bottom in the four corners and a vertical-top draft is used. Six TC's are located 10 cm from the column face. The columns can be loaded

up to 200 tons by hydraulic jacks.

They have been doing considerable research on columns for the European steel community as well as actively testing commercial column protections: while there they had steel columns protected with 1" thick precast Vermiculite concrete slabs which are glued together with water glass and vermiculite dust mixture. Also, columns which had been sprayed with asbestos fibers - both wide flange and pipe columns.

3.4 The research work on columns has been devoted to studying structural failure and developed analytical methods for prediction. For steel columns they have been developing a program to predict temperature rise in the steel through the fire protection. By studies of the effect of the slenderness ratio, the ratio of surface to cross section area and the temperature rise they can predict the structural fire performance.

Studies of the rate of charring of wood columns and the effect of the slenderness ratio are being used to develop prediction formula for the performance of wood columns. BAM differs with some previous data, claiming the char rate is in the range of 0.6 to 0.8 mm per minute. They also mentioned that tests at Stuttgart have shown the rate is the same whether fire-retardent treated or not.

3.5 The test for roofing uses a 2x2 m sample which is placed both at an angle of 15° and 45° with the horizontal. An open wire basket containing 600 g of wood shavings is placed on top of the sample and lighted. They evaluate burn through and limit flame spread to 50 cm with natural draft.

3.6 The test for exterior curtain walls is a two part test. The ISO standard exposure is used for the inside face of the wall. For the exposure on the exterior face, the time-temperature curve goes to 650°C in 10 minutes and is then held constant.

3.7 The DIN allows tests to use standard constructions to develop ratings of ceilings independent of the construction. This practice is at variance with the US concept that the ceiling does not have a rating independent of the construction in which it is tested.

VISIT TO UNIVERSITY OF MUNICH INSTITUTE FOR WOOD RESEARCH

1.0 The fire research group of the institute is headed by Dr. Teichgraber and Mr. Topf, his deputy: They are part of an institute to promote wood and are comparable to F.P.L. in the US, with whom they maintain contact.

2.0 The facilities of the institute are brand new and some are still in the process of installation.

2.1 German Smoke Test. They conducted a smoke test for me to see the use of their apparatus. The sample to be tested is about 8 to 10"long and 1/8" wide and is put in a small glass boat inside a large glass tube. A furnace which can be set to provide a range of temperatures inside the boat encircles the tube and by means of lead screws passes over the tube and sample at a fixed speed. Air is moved through the tube and the air and smoke is collected and measured in a light transmission apparatus outside the tube. The test is very sensitive to small quantities of smoke - possibly too sensitive.

2.2 They have the Swedish fire box, the British fire propagation test and a radiant ignition device for measuring ease of ignition of coatings. The latter is no longer used.

2.3 They have built a new wall furnace-on the top floor of the lab building-to take a 2x2 1/2 m sample. This furnace can have 4 oil burners on either or both sides; four oil burners in the floor; or gas burners in the back. The exhaust can be taken out either near the floor or near the roof to give more flexibility on pressure distribution. This is an experimental furnace to study some of the variables in the fire endurance test and answer some of the questions in test method which have never been resolved.

2.4 They were building a new piece of Brandschaft equipment, provided with controlled air flow and weighing equipment to measure weight loss of the sample.

2.5 They have made provision for an 8 foot flame spread tunnel and a small scale furnace - neither of which is yet installed.

2.6 They have a large Aminco TGA piece of equipment which has been modified to do research on the decomposition of wood.

3.0 Their research program is devoted to the performance of wood; but their immediate job is to get a whole array of new facilities working. They contemplate the following:

- study of furnace performance under a variety of firing and draft conditions
- more work on smoke-trying either the new French test or the NBS

They seem to prefer the French test since it also measures smoke scatter.

- participate in ISO test development

- have papers coming out on self ignition and also on the pyrolysis of wood

- do routine acceptance testing for industry (of interest - I found that the styrofoam in Germany is color coded both as to density and fire retardence.)

VISIT TO TECHNICAL UNIVERSITY, BRAUNSCHWEIG

1.0 The institute is directed by Professor Kordina and has among its sections one on fire research headed by Mr. Meyer-Ottens, with whom I visited. The work at Braunschweig is devoted to structural fire research and does not involve material approvals.

2.0 Their current program is out-lined:

2.1 Concrete Research Program:

- studies of flow of heat in concrete members - both analytical and experimental - paper by Ehm to be published soon
- study of continuous beams - negative moment design, effect end tie down, and resistance the exposed compression zone to fire
- spalling of concrete, report to be given at FIP Congress at Prague
- performance of lightweight concrete
- performance of two way slabs

2.2 Steel Research Program:

- study of U/F ratio effect; this is the ratio of the exposed surface to the cross sectional area of a steel column and is being studied in several labs under the sponsorship of the European Steel Conven tion. This work provides a rational approach to the design steel beam and column fire protection and should be followed.
- moment capacity of continuous steel beams-experiments with fireproofing in selective areas.
- ceilings-effect fire in one room traveling to a second when a suspended ceiling is used
- columns with water; to study effect of column movements on a structure. Tested a building at Dusseldorf, using transportable oil burners and found temperature on outside face of the steel column up to 250° while the inside in contact with the water was at 105°C.

2.4 Special Studies

- Studies of the physical properties and conductivity of steel

and concrete at elevated temperatures

- fire-load effect of steel vs wood desks, and the type of drawer content on the effective fire load; see 4.7

- studies of structural behavior of columns when using other than the standard time-temperature curve.

- studies of structural fire models

3.0 The fire research section has 25 people and last year spent 600,000 DM up from 200,000 in 1965. The work is 1/2 tests for industry and 1/2 research. Under the German system one can run a test and get a report-but it takes two duplicate tests to get a certification. For doors the test is run once on each side. For classes F30 and F60 there are no material requirements, except that the wall must withstand an impact test if < 10 mm thickness is left in any component. F90 and F120 can have combustible materials but the structural members must be A1 or A2 materials. Floor tests and beam tests are unrestrained. Girders are differentiated from beams, in that the girder has a typical framing connection at midspan which also has to be protected.

4.0 Facilities

4.1 The floor furnace has a 4x10 m opening, with supports at 5x11.1 m. This is a most unusual furnace in that it can be divided into smaller units, e.g. 3x10 m, by means of portable insulated block walls. They can test several floor systems at the same time or test beams with 10 m length exposure (the facilities are designed so that they can load a beam about 15 m long. At the time of my visit they were testing a ceiling which spanned two rooms with the fire in only one. As in all German furnaces oil burners are used. They use 8 on each side and have 4 draft openings on the floor. They use 8-30T movable jacks.

Concrete constructions are tested when the concrete has reached constant weight. They have a scale that will weigh 5 tons with 200g accuracy for checking and drying. Where possible TC's in the furnace are hung from the deck to compensate for deflection. If this is not possible then they are brought in from the sides. The furnace can be run from -1 mm to +2 mm H_2O pressure.

4.2 All the furnace burners are controlled from a central control room where the time-temperature curve is automatically followed. They can also control by standardizing the oil flow rather than following the time-temperature curve.

4.3 The door and wall furnace is run with -1 mm bottom to +2 mm top pressure to get the neutral point at 1/3 height. The furnace has 3 burners on one side and the exhaust draft on the other. Three

TC's are supported from each side. On wall tests TC's are put over screw heads in the wall but the data is used only to check the maximum temperature and does not go into the calculation for the average.

4.4 They have an unusual small scale furnace which is 1 m x 1.50 m x 1.5 m high, with openings on the top and on both side walls. They can place two burners side by side in the front. They can fire one or both burners to study a walls performance. They can also load specimens in this furnace and are planning to use it for model work. They claim they can get a heating rate up to 5 times the time-temperature curve, which will allow adequate scaling for testing models.

4.5 They have a special furnace mounted in a testing machine for determining physical properties under elevated temperatures of specimens 15x15x50 cm.

4.6 There is another wall furnace outside the building for testing partitions which will give off a lot of smoke. This furnace will take a 3.5 x 4 m specimen.

4.7 They have a special furnace for testing safes which has a plan of 3.5 x 3.5 m. There are six oil burners on the floor, 3 each side of the safe which is mounted on a dolly and rolled into the furnace. After the test they use a 10 m drop test. This furnace has been used to evaluate the burnout of steel and wood desk contents by weighing and examining the fuel consumptions. A loading frame is built outside the furnace so that they can conduct studies on loaded steel columns outside of a building-to continue the work Kordina did earlier on this problem.

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