NATIONAL BUREAU OF STANDARDS REPORT

7061

FIRE TESTS OF A STEEL COLUMN and SUPPLEMENTARY SPECIMENS PROTECTED with GLASS-FIBER REINFORCED PAINT

by

J. V. Ryan

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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by

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Report to
Office of the Chief of Engineers
Bureau of Yards and Docks
Headquarters, U. S. Air Force

NBS

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ABSTRACT

A system consisting of a blend of paint and glass fibers for use as a fire protective material sprayed on structural steel was evaluated by five small-scale tests plus one standard fire test of a 13-ft column. The effects of thickness and of an overcoat of paint alone were shown in the small tests.

The particular column tested, with 3/16 in. thickness of protective material, exhibited 57 min. fire endurance.

1. INTRODUCTION

Many large buildings consist of a steel frame plus an enclosing shell, with few, if any, partitions or columns other than those making up the enclosing structure. Recent fires have shown the severe damage to unprotected steel columns and roof trusses that may result from fires in buildings of this general design. This construction is particularly suitable, and widely used, for airplane hangars. This report gives the results of tests to evaluate the effectiveness of a protective material that may be applied directly to steel members by spray techniques.

2. MATERIAL

The protective materials consisted of glass fibers and two paints. The first paint was SAF 303 Resin base Fire Retardant Paint. One sample was found to weigh 12.1 lb/gal. The second paint was SAF 202. One sample was found to weigh 11.4 lb/gal. The glass fiber was provided by the applicator and no technical data were obtained.

The SAF 303 paint was applied by a special double-nozzle gun that also chopped the glass fibers to lengths intended to be about 1-1/4 in. long and fed them into the paint just after it left the sprayer. It was possible to spray paint without glass fibers. The application to the specimens wad done by a professional painter.

He first wet the surface with paint and then built up the desired thickness of the paint-glass fiber mixture by repeated coats. The material was tamped lightly between coats. The successive coats were applied as rapidly as the skill of the painter permitted, with no intentional delays to allow drying between coats.

On two specimens, an overcoat of SAF 202 was applied within one week after the 303-fiber mixture had been built up to the desired thickness. The SAF 202 paint was sprayed on without the inclusion of glass fibers.

3. SPECIMENS

Six specimens were prepared consecutively by the same craftsmen. The specimens were one steel column and five steel plates. The column was a 6H20 section 13 ft long with flange stiffeners in the upper 3 ft. The steel plates were 2 ft square, of 16 gage hot rolled steel, spot-welded to a grid of 3/4 in. cold rolled steel plasterers' channels. The protective material was applied to the face of the plate opposite to that welded to the channel grid. The overcoat of SAF 202 was applied over the SAF 303-glass fiber coat on two of these plate specimens, only, but not to the column.

The thicknesses of the protective coats were measured, as were the weight per sq ft of the material on the flat plate specimens:

Specimen	Col	Plate 1	Pl 2	Pl 3	Pl 4	Pl 5
Thickness, in.	3/16	.094	.112	.082	.083	.231
Weight, lb/ft^2	--	.54	.75	.52	.54	1.49

Note: Plates 1 and 3 were overcoated with SAF 202.

The steel plate specimens were stored in a room maintained at 73°F and 50 per cent relative humidity until they reached constant weight. The first specimen was tested 53 days after the application of the protective material, and the other four during the following week.

The column specimen was stored in a room heated, when necessary, to comfort conditions for 104 days before test. It was not practical to determine the period of aging by weight measurements, but, based on the time required for the plate specimens, the column's protective coating was assumed to have been aged for a satisfactory period.

4. TEST METHODS

Each specimen was tested in an appropriate furnace. The furnaces were gas fired and the fuel flow regulated automatically so that the average temperatures measured in the furnace chambers were as close as feasible to those specified in the standard time-temperature curve prescribed in ASTM E-119, which include: 1000°F at 5 min, 1300°F at 10 min, 1550°F at 30 min, 1700°F at 1 hr.

4.1 Steel Plate Specimens

Before each fire test, the protective coating on the steel plate was cut with a knife through to the plate at about 1 in. from the edges. This was done so that the tendency of the material to fall or to stay in place would not be affected by the edge support by the furnace.

Each specimen was placed coated face down, to close the top of a small furnace designed to expose an area about 23 by 23 in. Each was backed by a firebrick transducer and asbestos millboard laid on the steel channel grid. The edges of this assembly were insulated. Temperatures were measured by means of chromel-alumel thermocouples connected to self-balancing potentiometers. Thermocouples were attached to both faces of the transducer and the upper face of the steel plate specimen.

The end point of each test was established as the attainment of 1000°F temperature at the thermocouple junction attached to the steel plate.

4.2 Column

The column specimen was placed in a furnace specifically designed for the fire exposure of such specimens. All but about the top 3 ft of the 13-ft specimen was exposed to fire. The column was subjected to a load of 80750 lb, computed on the basis of a stress of 17000 psi reduced for the actual length-to-radius ratio. Temperatures were measured by chromel-alumel thermocouples attached to the steel column before the protective materials were applied. Observations were made of the thermal elongation of the column and its subsequent deformation under load. The only applicable end point in such a test is failure of the column to sustain the applied load.

5. RESULTS

5.1 Steel Plate Specimens

The data from these tests consisted of temperature readings at 5 min intervals throughout each test. The results are simply the times at which 1000°F was reached on the steel plate. These times are tabulated below:

Plate No.	1	2	3	4	5
Failure, min	47	59	47	44	70

Examination after test indicated that the protective coatings had puffed up somewhat and had remained in place throughout each test.

5.2 Column

The protective coating on the column turned black within the first minute. It puffed up, continuing to do so until about 20 min, at which time the maximum thickness was estimated at 2 in. The development of cracks in the coating accompanied the puffing. The column expanded as the temperature increased until the average at one level reached 1000°F, at 50 min. The column yielded under the load gradually for a few minutes and then rapidly. It was judged to have failed at 56 min. The applied load was removed then and the test stopped after the 1 hr temperature readings.

Examination after test showed the protective material still in place. The column was bowed along most of its exposed length.

The fire endurance of the column was limited by load failure at 56 min. The highest section average temperature was about 1125°F and the one point maximum about 1190°F. The control of the furnace was such that a correction of +1 min was applicable to the failure time.

6. DISCUSSION

Comparison among the steel plate specimens indicated that increased thickness of protective material lead to later failure by the criterion applied. The use of the SAF 202 overcoat lead to a slightly later failure than for a specimen without it, having essentially the same total thickness.

7. SUMMARY

The results of the tests indicated that the material remained in place throughout fire exposure up to 1 hr 10 min; gave greater protection for greater thickness; and that the fire endurance of the particular column tested was 57 min.

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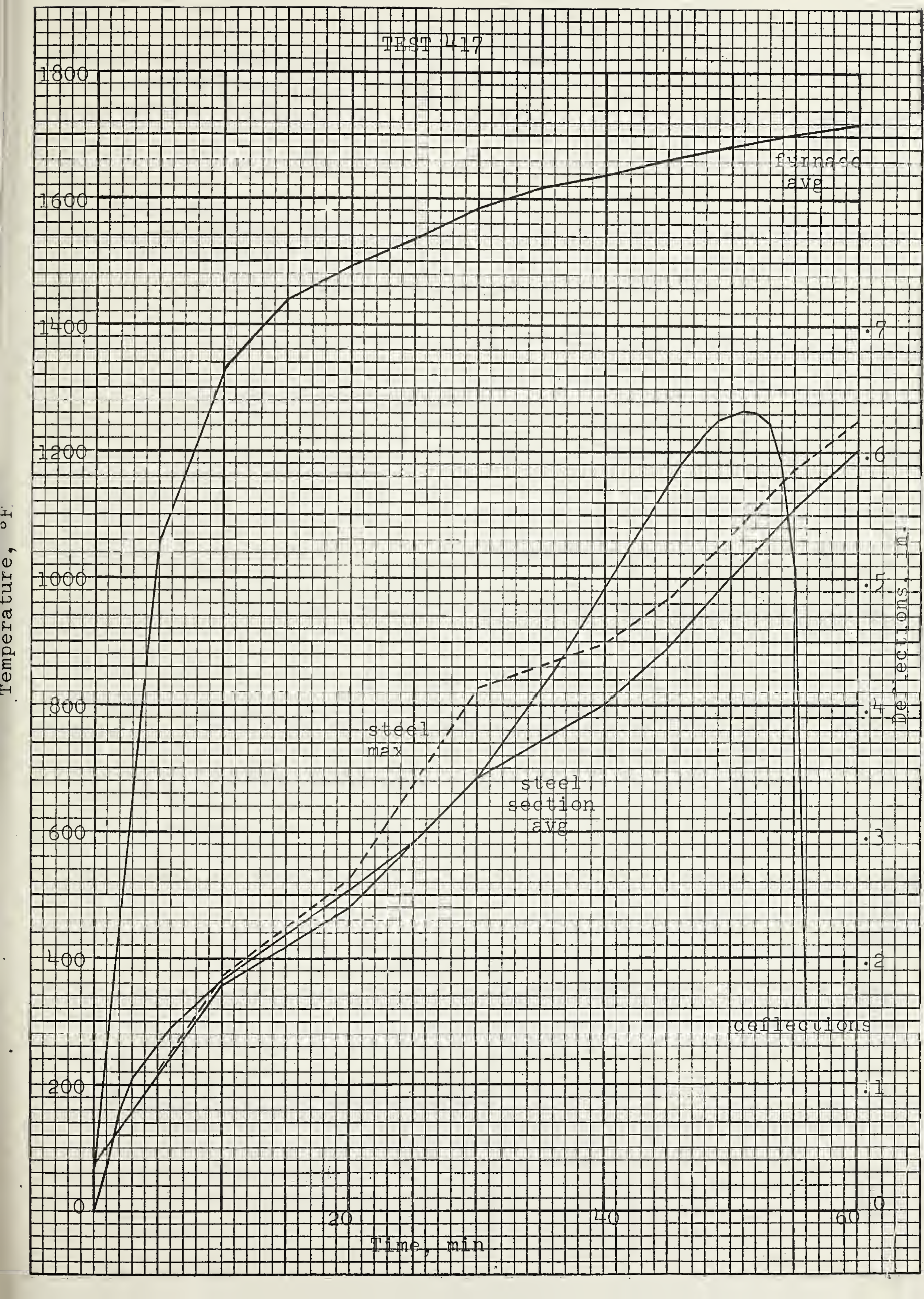
TEST 417
Temperature, °F
1800
1600
1400
1200
1000
800
600
400
200
0
furnace
avg
steel
max
steel
section
avg
deflections
Deflections, in.
.7
.6
.5
.4
.3
.2
.1
0
20
40
60
Time, min

U.S. DEPARTMENT OF COMMERCE
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NATIONAL BUREAU OF STANDARDS
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THE NATIONAL BUREAU OF STANDARDS

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WASHINGTON, D.C.

ELECTRICITY. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics.

METROLOGY. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

HEAT. Temperature Physics. Heat Measurements, Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research. Equation of State. Statistical Physics. Molecular Spectroscopy.

RADIATION PHYSICS. X-Ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

CHEMISTRY. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

MECHANICS. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Combustion Controls.

ORGANIC AND FIBROUS MATERIALS. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

METALLURGY. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

MINERAL PRODUCTS. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

BUILDING RESEARCH. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials.

APPLIED MATHEMATICS. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

DATA PROCESSING SYSTEMS. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Applications Engineering.

ATOMIC PHYSICS. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics.

INSTRUMENTATION. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

IONOSPHERE RESEARCH AND PROPAGATION. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services.

RADIO PROPAGATION ENGINEERING. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

RADIO STANDARDS. High frequency Electrical Standards. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time Standards. Electronic Calibration Center. Millimeter-Wave Research. Microwave Circuit Standards.

RADIO SYSTEMS. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Space Telecommunications.

UPPER ATMOSPHERE AND SPACE PHYSICS. Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

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