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NATIONAL BUREAU OF STANDARDS REPORT

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QUARTERLY REPORT

ON

EVALUATION OF REFRACTORY QUALITIES OF CONCRETES FOR JET AIRCRAFT WARM-UP, POWER CHECK, MAINTENANCE APRONS, AND RUNWAYS

by

James V. Ryan, E. C. Tuma, D. K. Ward

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U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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A complete listing of the Bureau's publications can be found in National Bureau of Standards Circular 460, Publications of the National Bureau of Standards, 1901 to June 1947 ($1.25), and the Supplement to National Bureau of Standards Circular 460, July 1947 to June 1957 ($1.50), and Miscellaneous Publication 240, July 1957 to June 1960 (Includes Titles of Papers Published in Outside Journals 1950 to 1959) ($2.25); available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

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Building Research Division

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1. INTRODUCTION

The purpose of this project is the development of criteria for the fabrication of jet exhaust resistant concretes. Concretes under development are evaluated by exposure to hot gases from a combustion chamber. The combustion chamber delivers these gases at velocities and temperatures approaching field conditions.

2. ACTIVITIES

Measurements and tests were made with ten concrete specimens during the quarter. Five were made with blast-furnace slag concrete (P-BF-10); the other five were made with diabase concrete (P-Di-18). The concretes are described below.

	P-BF-10	P-Di-18
Cement content, sacks/yd^3	7.6	10
Vinsol resin, % by wt of cement	.01	.01
Water content, gal/yd^3 of concrete	38.2	54.3
Air content, %, gravimetric	7.5	None
Slump, in.	3	4 1/2
Water/cement ratio by weight	.45	.48

Each set of five specimens included two 6 in. high truncated cones, as illustrated in NBS Report 7486 and three 2 1/2 by 4 1/2 by 9 in. bricks cast and vibrated in steel molds. One of the latter had thermocouples at the top surface and at 1/8, 1/4, 3/8, and 1/2 in. therefrom.

2.1 Steam Pressure Applied to Concrete

The truncated cone specimens were subjected to steam at 300 psi applied over the base. The pressure forced the specimens upward against a restrained rubber sleeve, thereby improving the seal and preventing leakage between the concrete and the sleeve. The temperature distributions were essentially the same in all four specimens but measurable internal pressures were observed in only one of each aggregate. Pressures as high as 225 psi were observed. No moisture came through the concrete of any specimen.

The fact that pressures were not observed during two of the tests was believed due to pinching of the pressure probe tubes as the conical specimens moved under the influence of the applied steam pressure.

2.2 Air Permeabilities

Measurements of air permeability of each of four brick-shaped specimens were made before and after being subjected to pressure differentials in the range 100, to 300 psi. The results indicate that the permeabilities of the particular diabase and blast furnace slag aggregate concrete cast specimens were appreciably lower after exposure to high pressures than before. This is contradictory to the results obtained with sawed specimens. The measurements were made a few hours after the high pressures were released. No attempt has been made to determine if the reduced permeability effect is permanent or temporary. The results also indicate that the permeability apparently changes as the air flow at low pressure differential is continued for several hours. Although an ultimate steady-state permeability may be reached, it is doubtful that it is directly applicable to the short times and rapid changes associated with jet-blast exposure.

2.3 Temperature Gradients

Two brick shaped specimens, one of diabase aggregate and one of slag aggregate concrete, were subjected to jet blast test. The temperature gradients were observed by thermocouples at 1/8 in. depth increments over the first 1/2 in. Following the jet-blast test and cooling, the blast furnace specimen was immersed in water for a period of 2 to 3 days, the surfaces wiped to remove excess water, and resubjected to jet blast test. The time-temperature curves (see fig. 1) from the test and retest did not show the characteristic flattening near 100°C due to changing of water to steam. This flattening had been observed in jet blast tests of 6 by 18 by 18 in. specimens soaked and retested. The diabase aggregate brick spalled in the initial exposure and was not retested. Figure 2 shows the temperatures versus depth at 15 second intervals until after the time at which the diabase specimen spalled.

2.4 Specimen Preparation

In view of the probability that movement and sealing of the truncated cone specimens lead to pinching of the pressure probe tubes, it was decided to modify the specimen design and the test method. Specimens were 6 in. thick by 13 1/2 in. diameter. Instrumentation consisted of probe tubes and thermocouples similar to those in the truncated cone specimens plus thermocouples at 1/8-in. depth increments for gradient measurements in the first 1/2 in. The specimens will be exposed to hot gases, at temperatures equal to the jet blast but not moving at high velocities, over the central 6 in. diameter area of one face. The greater diameter of the specimen was chosen to eliminate the need for sealing the periphery. The choice of hot gases rather than steam permits closer approximation to the jet blast test and precludes the introduction of extra moisture into the specimen.

It was believed that the surfaces of the permeability specimens, resulting from the use of steel molds, and the separation, resulting from vibration, may have affected the results obtained. Therefore, new specimens were prepared by casting oversize slabs from which 9 by 4 1/2 by 2 1/2 in. specimens were sawed.

Specimens were also prepared for drying shrinkage, thermal expansion, and shear strength tests. Specimens were prepared with diabase aggregate concrete and with blast furnace slag aggregate concrete. All specimens of a given concrete were cast at the same time from a single batch. Both slump (mix water) and vibration were held to minimum values.

The concretes are described below.

	BF-1	Di-1
Cement content, sacks/yd^3	6.9	6.8
Vinsol resin, % by wt of cement	.01	.01
Water content, gal/yd^3 of concrete	36.7	33.7
Air content, %, gravimetric	2.8	2.8
Slump, in.	2	1/4
Water/cement ratio, by wt.	.47	.45

2.5 Personnel

Mr. Wm. Pendergast, long time project leader retired as of the end of the quarter and was succeeded by Mr. J.V. Ryan.

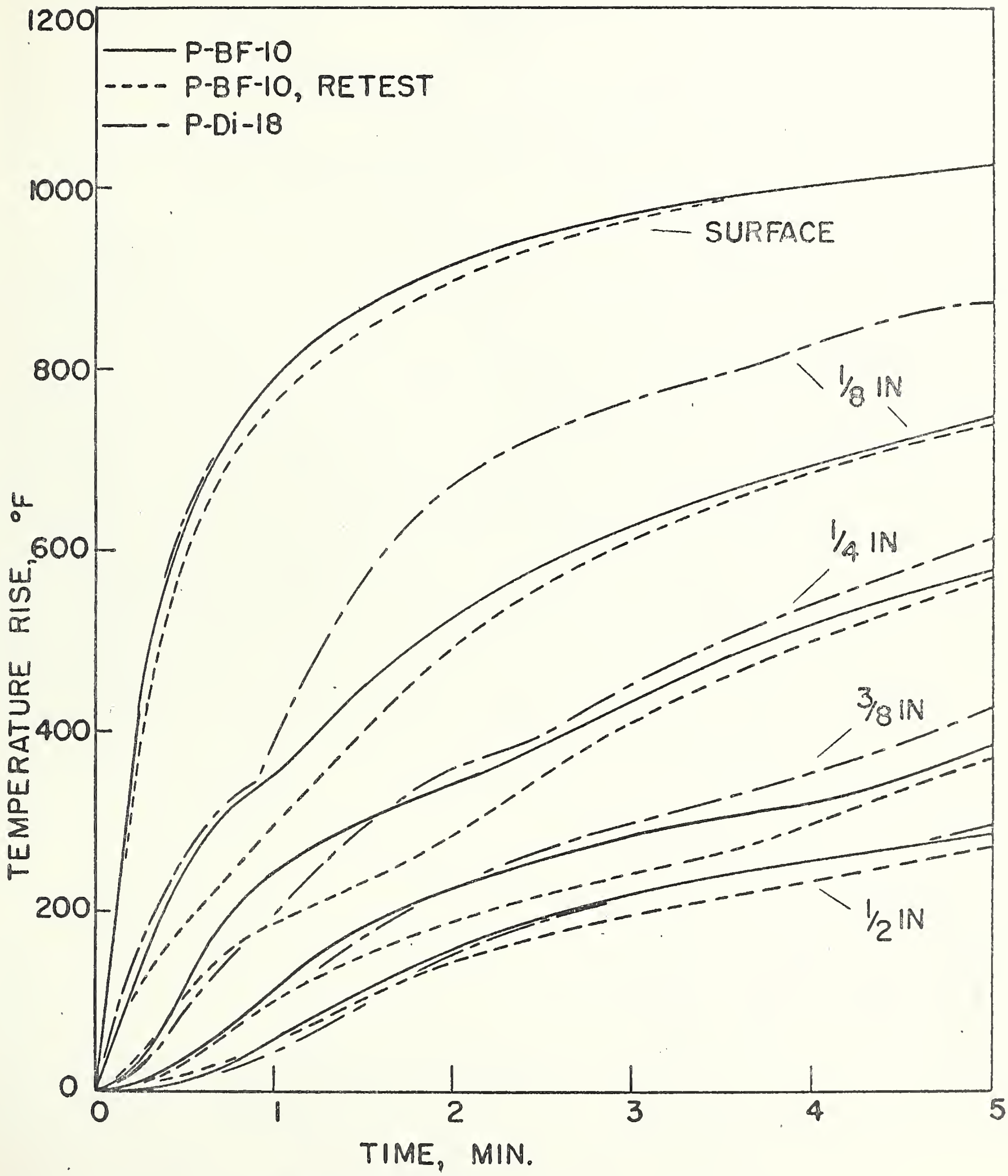

FIG 1. TEMPERATURE - TIME DATA

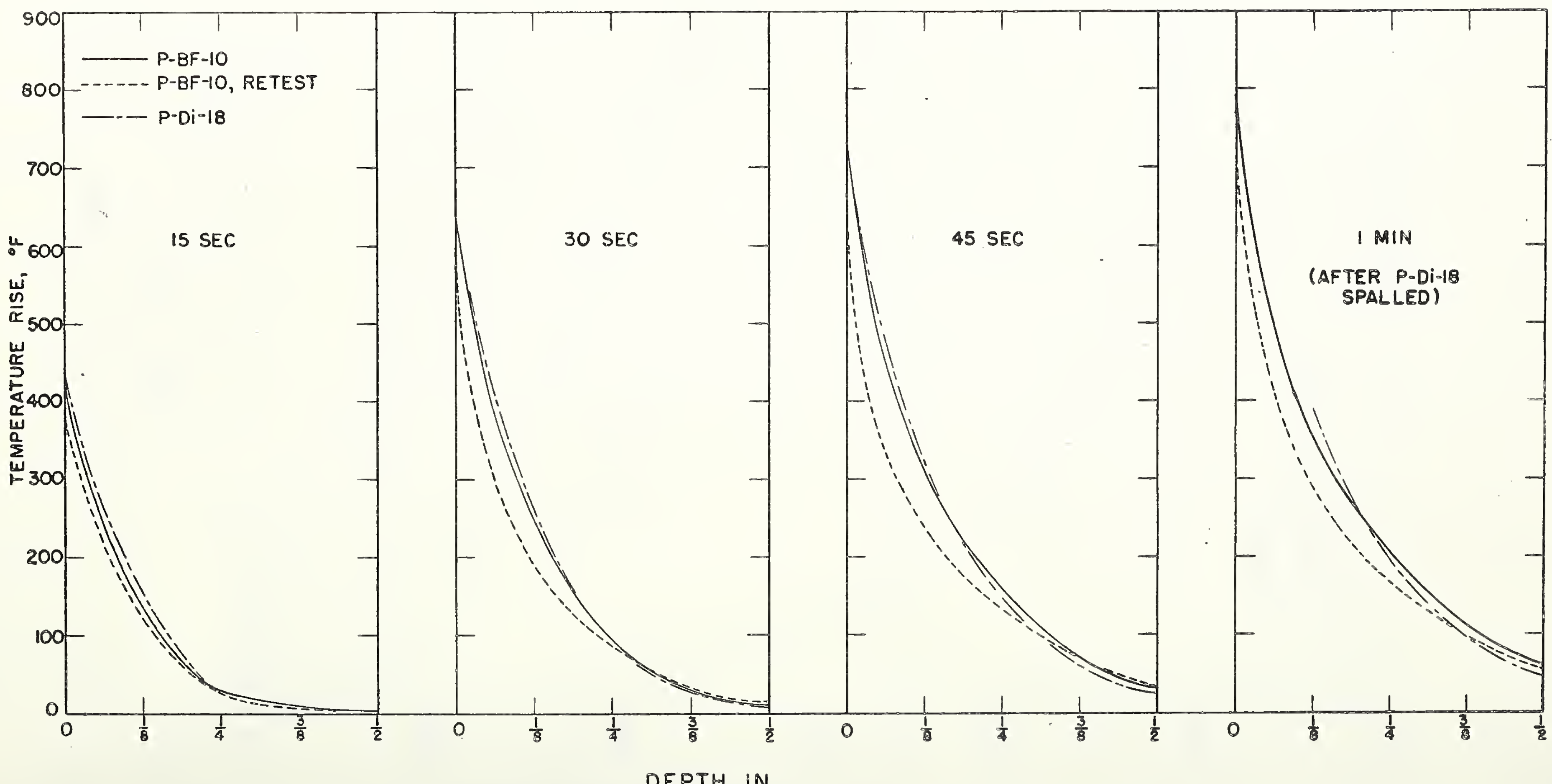

FIG 2. TEMPERATURE VERSUS DEPTH DURING FIRST MINUTE OF JET BLAST.

U. S. DEPARTMENT OF COMMERCE
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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. High Voltage.

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

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

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

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Microscopy and Diffraction. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

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

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Solid State Physics. Electron Physics. Atomic Physics.

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

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Molecular Kinetics. Mass Spectrometry.

Office of Weights and Measures.

BOULDER, COLO.

Cryogenic Engineering Laboratory. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Cryogenic Technical Services.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

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

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Physics. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Millimeter-Wave Research.

Circuit Standards. High Frequency Electrical Standards. Microwave Circuit Standards. Electronic Calibration Center.

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