5631

NATIONAL BUREAU OF STANDARDS REPORT

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SIMULATED FIELD TESTS OF DURANT INSULATED PIPE

by

Selden D. Cole
and
Paul R. Achenbach

Report to
Office of the Chief of Engineers
Department of the Army
Washington, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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Building Technology Division

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ABSTRACT

Simulated field tests were made of several specimens of Durant Insulated Pipe primarily to study the effect of operating an underground steam system of this type when the unibestos insulation became wetted during installation or at a later time. The unibestos was deliberately wetted for these tests. Some specimens were buried in a trench, others were tested above ground, and the metal jackets were removed from some specimens to simulate the conditions that would exist after the sheet metal had rusted away.

Investigation was also made of the effect of pouring the asphalt in the field at other than the recommended asphalt temperature and in low ambient temperatures such as occur during winter weather.

The results showed that steam would be formed in the wet unibestos insulation when steam at a temperature above 212 F was admitted to the pipe and that enough pressure could be built up in the insulation to rupture the asphalt covering. The asphalt reached temperatures up to 216 F around the wet insulation and softened enough to settle to the sides and bottom of the pipe to a noticeable degree when buried in a trench and it slipped off the unibestos entirely when it was not restrained by the surrounding earth or the metal jacket. Continued heating of the pipe with steam at a temperature of 375 F dried the unibestos covering to a distance of 3/4 inch to one inch from the pipe in two weeks time. There was evidence that a steady state moisture distribution in the unibestos was approached during this time with dry insulation near the pipe and free water in evidence at the inner surface of the asphalt jacket. Asphalt poured at temperatures ranging from 350 F to 500 F and in ambient temperatures down to 12 F appeared to produce a jacket free of voids, fissures, or lines of cleavage. Measurements of heat loss from the specimens were not made during these tests.

Introduction

At the request of the Office of the Chief of Engineers, Department of the Army, tests were made on several specimens of Durant Insulated Pipe to study the temperature gradients in the insulation as received, to study the effects of wetting the molded pipe insulation, and to evaluate the effect of applying the asphalt in the field during severe winter weather. The specimens were buried in earth for a part of the tests, but no measurements were made of the heat loss through the pipe insulation.

Description of Test Specimens

Durant Insulated Pipe is manufactured by Durant International Corporation, Williamstown, N. J. The prefabricated specimens submitted for the tests consisted of 20-foot lengths of four-inch diameter black steel pipe encased in a two-inch thickness of molded Unibestos insulation, a one-inch layer of asphalt waterproofing and a sheet metal casing of 26-gage galvanized steel. Load-bearing spacers rings, one-inch in radial depth, were placed around the molded insulation to support the pipe in the sheet metal jacket. The one-inch annular space between insulation and jacket was filled by pouring high-melting-point asphalt at a temperature of 450 F through holes in the jacket spaced 15 in. apart. The insulation spaces of these specimens were sealed at the ends by steel plates welded to the pipe and to the jacket. Pipe sections prefabricated for field installation do not have these welded end plates, but had the ends of the insulation on each section covered with a waterproof fabric. This fabric is removed after adjacent lengths of pipe are welded together in the field and sections of molded insulation and waterproofing are applied to complete the joint. The welded steel end plates are used only in manholes and in buildings.

One of the three test specimens was submitted without the asphalt waterproofing between the molded insulation and the sheet metal jacket. A quantity of asphalt was furnished so information could be obtained on the effect of pouring the material when heated to different temperatures and in different ambient temperatures.

Test Equipment and Procedure

Each of the three specimens was fitted with a steam supply connection and a condensate drain. Steel plates, 1/2-inch thick, were welded over the ends of the four-inch pipe. A

piece of 3/4-inch pipe, 18 inches long, had been welded into the plate at the inlet end with nine inches projecting on each side. The inner end of the 3/4-inch pipe was capped and enough 1/4-inch holes were drilled into the sides of the pipe to provide an aggregate area equal to the area of the 3/4-inch pipe. This arrangement caused the steam to be sprayed against the inner walls of the four-inch pipe at its inlet end. At the outlet end, a 1/2-inch pipe nipple was welded into the bottom of the four-inch pipe and connected to a high pressure bucket-type steam trap.

Steam was generated in a thermostatically controlled boiler of ten-gallon capacity and 11-KW electric energy input. A float, located in a vertical by-pass line at the side of the boiler, actuated a solenoid valve to admit cold water to the boiler as required to maintain a constant water level. Adequate pressure was maintained on the cold water supply by means of a turbine type pump.

Thermocouples of 26-gage copper-constantan wire were used with a Rubicon portable precision potentiometer to indicate temperatures. The steam temperature was observed in the supply pipe and in the condensate outlet. Stations for temperature observation on the pipe covering were located (1) at the center of the pipe, on the top and bottom, (2) approximately four feet from each end of the specimen missing the spacer ring, and (3) on the spacer ring adjacent to the station at the inlet end of the pipe. Two thermocouples were used at each station, one on the outer surface of the Unibestos and the other on the outer surface of the asphalt. The stations of temperature measurement are indicated on the diagram at the top of Fig. 1.

The asphalt used to complete the unfinished specimen was heated in a metal container equipped with a built-in immersion electric heater. When the asphalt reached the desired temperature for a particular pouring, it was ladled into a two-gallon sprinkling can, from which the spray nozzle had been removed, and immediately poured into one of the pour holes in the metal jacket. This procedure was repeated with quantities of asphalt heated to 350 F, 400 F, 450 F, and 500 F using a different pour hole with each temperature. The first round of pourings filled one half the void circumferentially, the second round of pourings nearly filled the void, and the third round completed the asphalt jacket. One half the length of the specimen was poured with the specimen in equilibrium with an ambient temperature of 70 F; the other half was poured after the specimen had been cooled to 12 F.

Several two-inch cubes of asphalt were poured from one of the several batches to be used later for studying the softening point of the material. A chromatographic analysis of the asphalt was made in accordance with the method described in NBS Research Paper 2577 to determine its composition.

The first specimen was buried in a trench 18 inches deep and covered with six inches of dirt after first removing the sheet metal jacket. The pipe was heated with steam at a temperature of 375 F for a week with one or more observations of the temperatures on the pipe covering being taken each day. The results are plotted in Fig. 1.

At the conclusion of the first test made with the insulation in the condition received from the factory, the specimen was removed from the trench and the unibestos was saturated with water through two holes, one at each end, cut in the asphalt covering. The holes were sealed with hot asphalt after wetting the insulation and the specimen was buried in the trench again. The pipe was heated with steam at an average temperature of 375 F for two weeks. The temperatures observed during this test are plotted in Fig. 2.

The unibestos of the second specimen was wetted like the first after removing the sheet metal jacket and was supported above ground by a pipe support at either end while it was heated for 11 days with steam at a temperature of 373°F.

The welded caps were removed from the ends of the insulated jacket on the third specimen and the unibestos was saturated by immersing the specimen in a trench full of water for two days. The excess water was drained from the unibestos before heating and the specimen was supported above ground during the heating period of 15 days.

Results and Discussion

First specimen with dry insulation

The highest temperature observed on the surface of the unibestos was 138 F and the highest temperature observed on the surface of the asphalt was 95 F during the seven days of heating. Fig. 1 shows that the unibestos surface reached its maximum temperature in a little over 24 hours whereas the temperature of the asphalt surface was still rising slowly after seven days. The latter condition may have resulted because the temperature gradient in the earth over the pipe had not become stable or because the outdoor temperature was rising.

The jacket was removed from this specimen to simulate conditions that would exist in use after the jacket was rusted away. The asphalt showed a slight tendency toward plastic flow when the specimen pipe was heated in the earth without the metal covering. The plastic deformation was a little more pronounced near the metal caps at the ends and at the spacer rings.

First specimen with wetted insulation

The unibestos insulation absorbed a maximum of 10 to 12 lb of water per running foot. About two-thirds of the original quantity of water introduced into the insulation was evaporated during two weeks of heating the pipe with steam at a temperature of 373 F. Inspection showed that approximately the inner half of the unibestos covering had been dried, and there were pockets of free water on the inside surface of the asphalt covering. There was evidence that the moisture distribution in the unibestos had approached a steady state during the two-week test. Fig. 2 shows the temperatures observed at various stations during this test. The stations of temperature observation were the same as those shown on the diagram in Fig. 1.

The temperatures on the inner and outer surfaces of the asphalt reached 212 F and 216 F at two stations during the first three hours after admitting steam to the pipe as shown in Fig. 2. After two weeks operation temperatures as high as 151 F were observed on the outer surface of the asphalt and temperatures up to 198 F were observed at the interface between the unibestos and the asphalt. Inspection showed that the steam generated in the unibestos had ruptured the asphalt covering in several places. Fig. 3 shows the temperatures observed at stations 2 and 3 during the first seven hours of the test on an expanded time scale. This figure indicates that steam penetrated the asphalt covering at thermocouple No.3.

Fig. 4 shows specimen No. 1 after removal from the trench and after inspection.

Apparently water was continuously evaporated at the 212 F isotherm in the insulation, but the vapor condensed to water again in the cooler regions farther from the pipe. Since the total pressure inside the asphalt covering did not exceed atmospheric pressure, additional water vapor could be lost from specimen only by diffusion through the fissures in the asphalt covering. This would be a very slow process. The asphalt became quite soft and there was plastic flow of the asphalt away from the top side especially near the metal caps. In some sections the asphalt had flowed to the sides of the

pipe and in others the asphalt thickness was greater on the bottom than on either the top or sides at the conclusion of the test. Presumably this plastic flow would not occur as long as the metal pipe covering was intact. The metal casing was removed before burying the specimen for the purposes of these tests.

Second specimen with wetted insulation

The second specimen was tested above ground with the metal jacket removed to observe what might happen if movement of the asphalt were not restrained by the surrounding earth.

With steam at temperatures increasing from 275 F to 345 F during an eight-hour period, the asphalt covering softened and fell off the pipe leaving a thin asphalt film on the unibestos and leaving the surface of the spacer rings bare. After ten days heating with steam at a temperature of 373 F the unibestos was dried from the pipe surface outward for about one half its total thickness. The remainder was quite wet to the touch.

Third specimen with wetted insulation

The third specimen was tested above ground. The metal jacket was left on this specimen but the end caps had been removed to expose the ends of the unibestos insulation.

With the ends of the unibestos insulation open to the atmosphere about one third of the unibestos adjacent to the steam pipe was dried in 15 days with steam in the pipe at a temperature of 373 F. The outer two-thirds of the unibestos was wet. Steam was emitted from the open ends of the unibestos during the early part of the drying period, but none was visible at the end. A column of water vapor was ejected from the unibestos when the asphalt was ruptured for inspection at the end of the test. The asphalt showed no deformation except conformation to the sheet metal enclosure.

The asphalt jacket poured at the National Bureau of Standards using asphalt at different temperatures ranging from 350 F to 500 F and under winter and summer ambient conditions was continuous in appearance and contained no voids, fissures, or lines of cleavage.

Fig. 5 shows the effect of heating small cubes of the asphalt, like the sample in the upper left of the figure, at various temperatures for selected periods of time. The asphalt slumped some in two hours at a temperature of 200 F and it flowed outward to a smooth flat mass in 35 minutes at a temperature of 248 F.

The chromatographic analysis of the asphalt used on Durant Insulated pipe showed the following percentages:

Asphaltenes	42.8
Water White Oils	24.6
Dark Oils	23.9
Asphaltic Resins	8.6
Chloroform Desorbed	0.5
Total	100.4
Softening Point	235°F
Penetration at 77 F	13

The composition and physical characteristics of this blown petroleum asphalt is typical of this class of bitumens in the 220 to 240 F softening point range. Blown petroleum asphalts, when subjected to heat, will show an increase in asphaltenes due to changes occurring mainly in the dark oils and asphaltic resins rather than to volatile losses. The lower the ratio of asphaltenes (black solids) to the petrolenes (combination of water white oils, dark oils, and asphaltic resins) the lower will be the softening point and the more easily fusible will be the bitumen.

Conclusions

Knowledge of the insulating characteristics of dry unibestos insulation indicates that Durant Insulated Pipe would not have excessive heat loss as long as the insulation were dry throughout its entire thickness, even though no measurements of heat loss were made during these tests.

These tests show that unibestos will absorb large quantities of water. When the insulation is thoroughly wetted and steam at a temperature above 212 F exists in the pipe, steam will be formed in the insulation near the pipe and will probably rupture the asphalt jacket to relieve the pressure unless some means are available for the escape of steam. After initially wetting the unibestos, about half the thickness of the unibestos insulation dried out in a two-week period when steam at a temperature of 375 F was supplied to the pipe. It is doubtful that the outer layers of the unibestos would dry out during the useful life of the system once it became wet in an actual installation.

The metal cover will contain the asphalt as long as it is intact, but prolonged corrosion might eliminate this support permitting some plastic flow of the asphalt, especially if the insulation were wet.

The integrity of the asphalt jacket does not appear to be adversely affected by using asphalt temperatures in the range from 350 F to 500 F or by ambient temperatures down to 12 F during the pouring operation.

INSULATION TEMPERATURE, °F

ASPHALT AND UNIBESTOS TEMPERATURES ON DRY SPECIMEN OF DURANT INSULATED PIPE

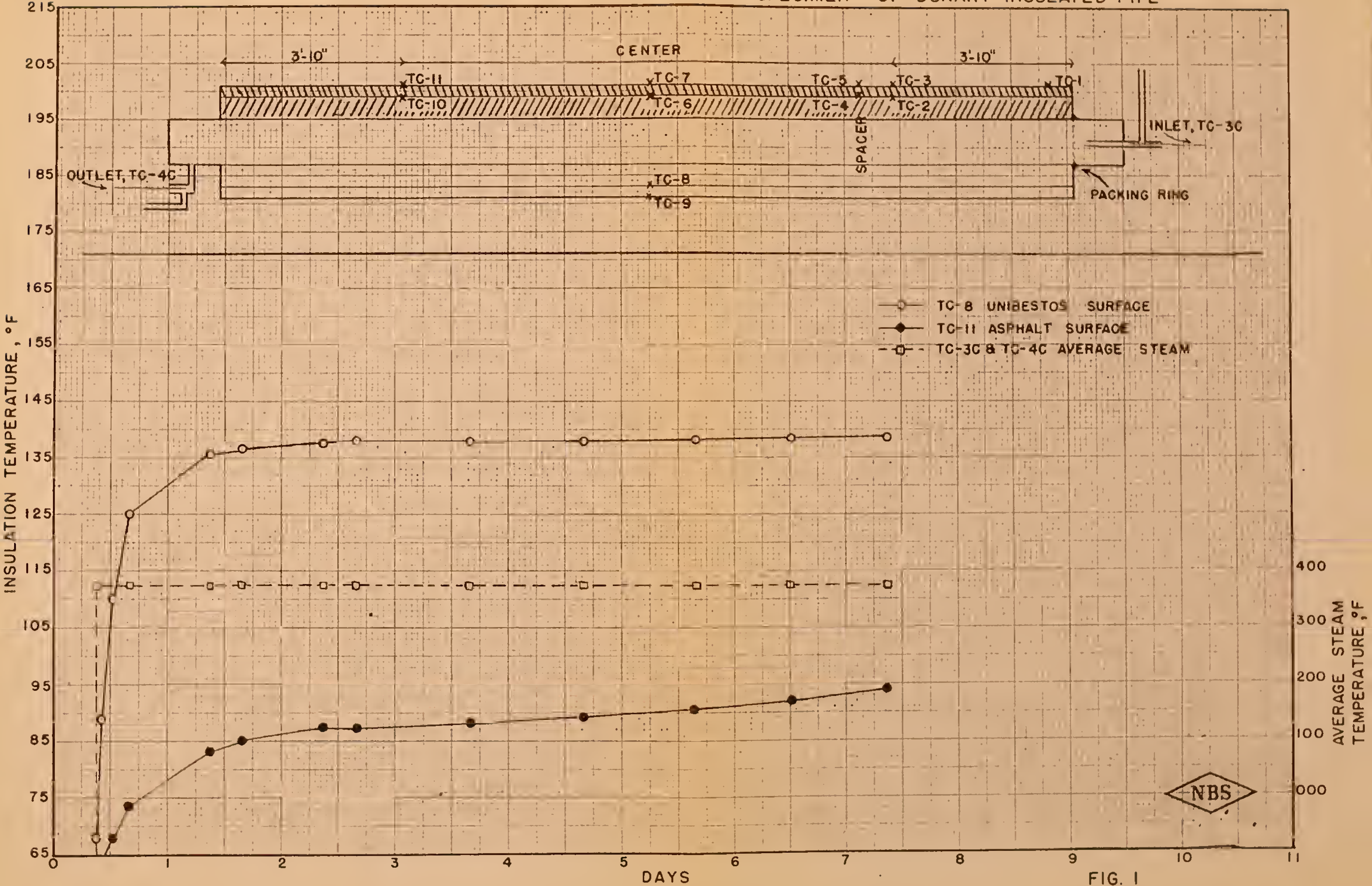
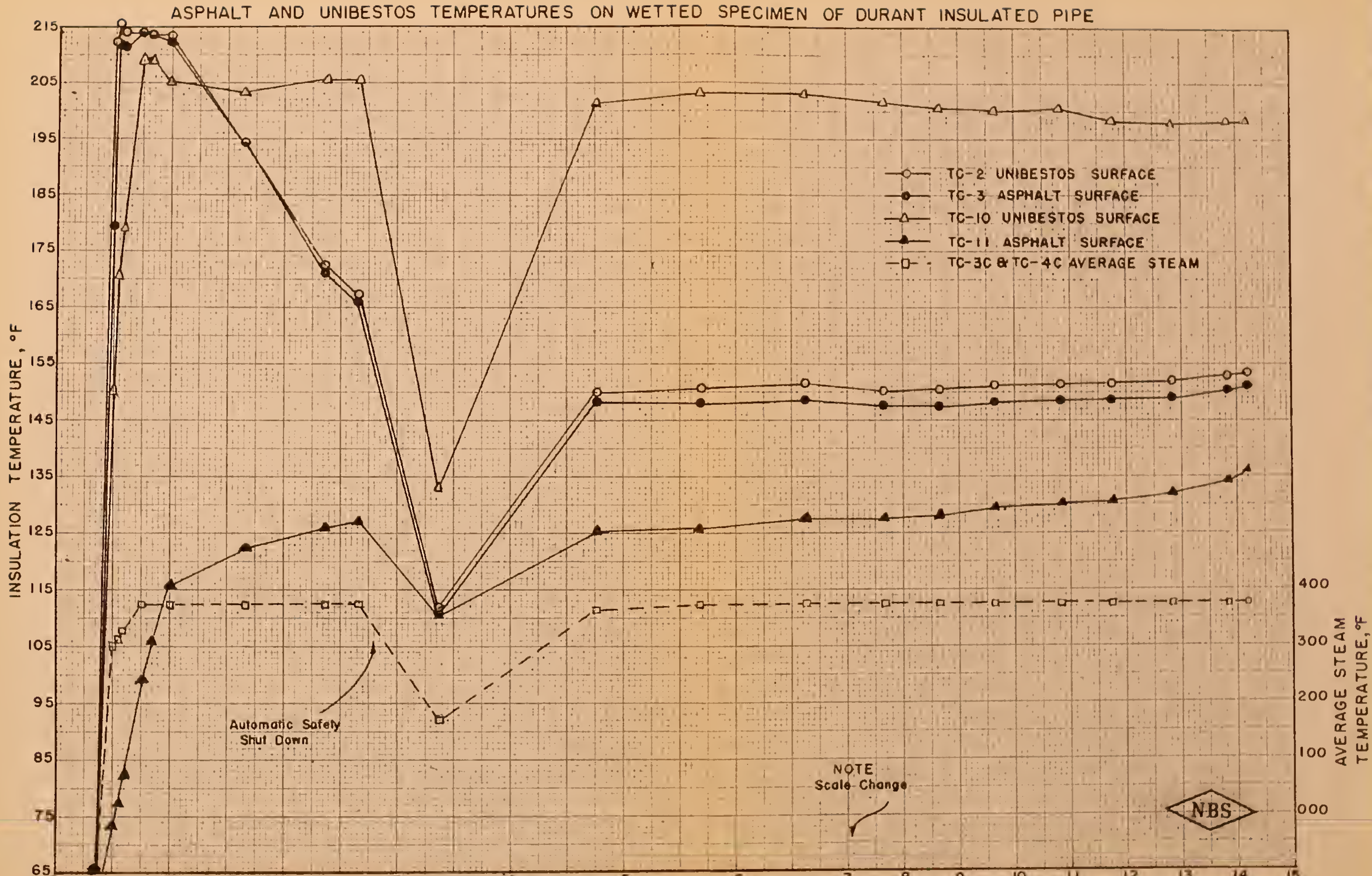


FIG. 1

INSULATION TEMPERATURE, °F



ASPHALT AND UNIBESTOS TEMPERATURES ON WETTED SPECIMEN OF DURANT INSULATED PIPE
INSULATION TEMPERATURE, °F
215
205
195
185
175
165
155
145
135
125
115
105
95
85
75
65
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
DAYS
AVERAGE STEAM TEMPERATURE, °F
400
300
200
100
000
TC-2 UNIBESTOS SURFACE
TC-3 ASPHALT SURFACE
TC-10 UNIBESTOS SURFACE
TC-11 ASPHALT SURFACE
TC-3C & TC-4C AVERAGE STEAM
Automatic Safety Shut Down
NOTE Scale Change
NBS

FIG. 2

TEMPERATURES ON WETTED SPECIMEN OF DURANT INSULATED PIPE

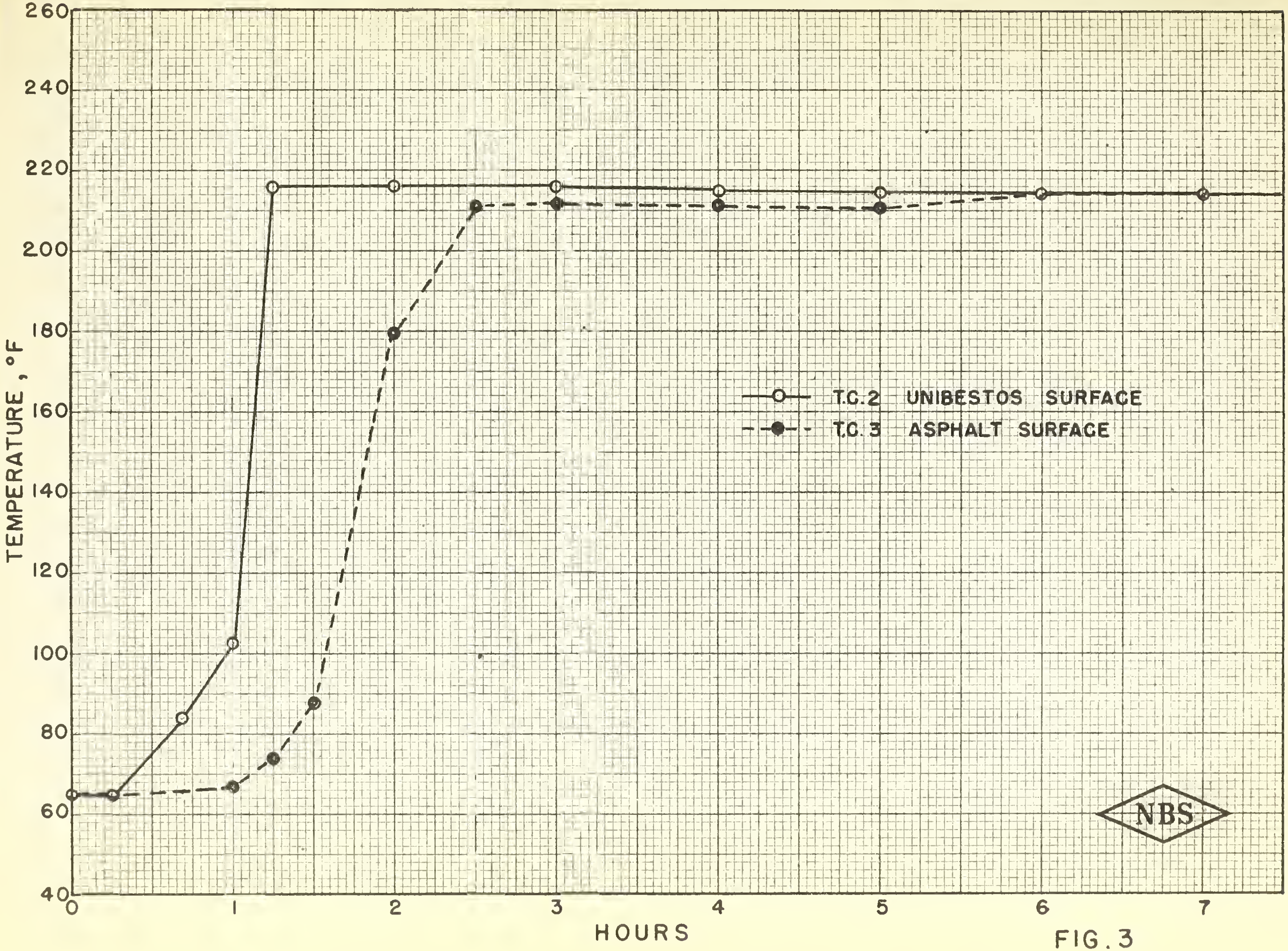
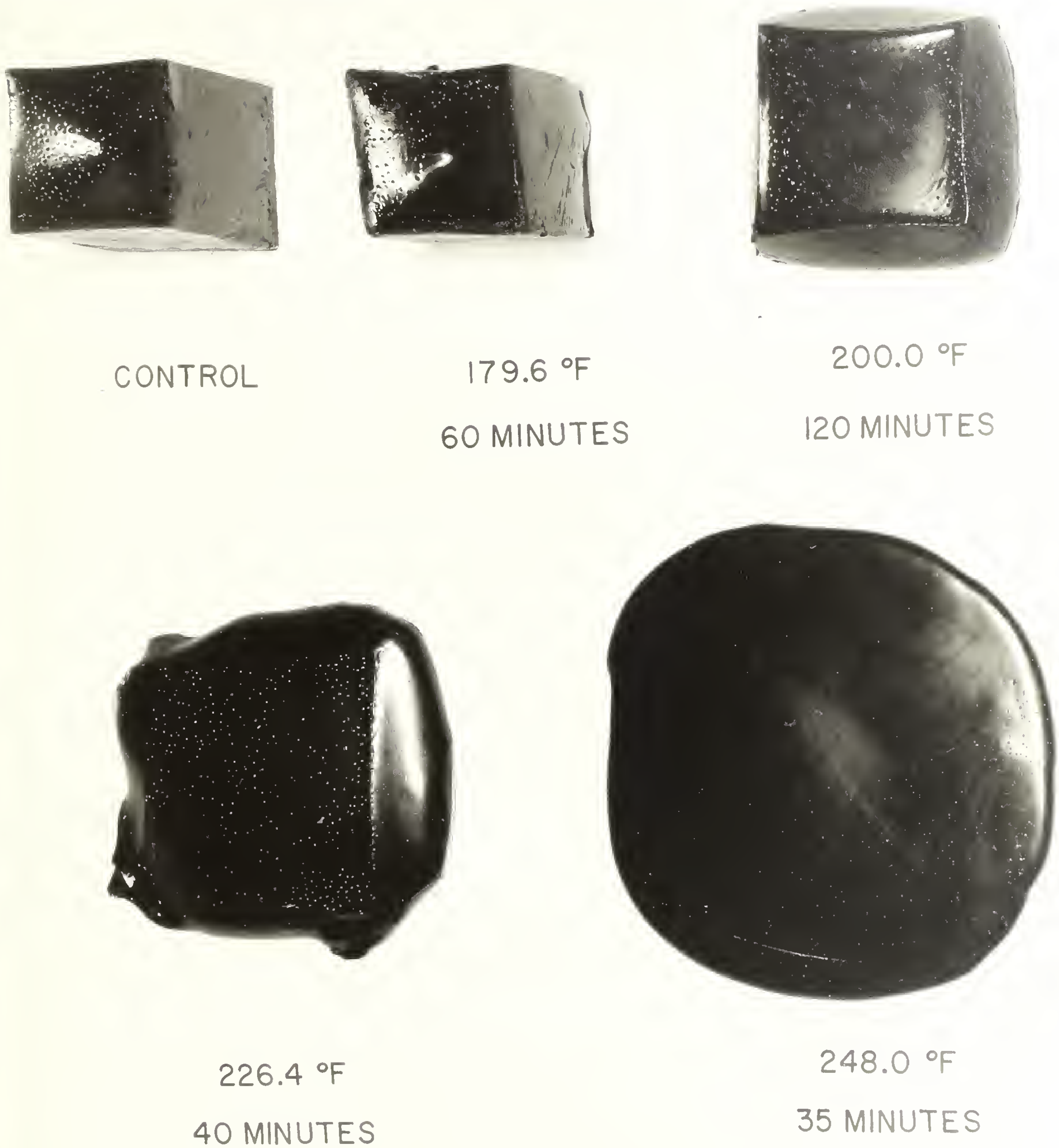


FIG. 3

Fig. 4



DURANT ASPHALT SPECIMENS

Fig. 5

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Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

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WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Tubes. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology and Lubrication. Engine Fuels.

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- Office of Basic Instrumentation
- Office of Weights and Measures

BOULDER, COLORADO

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