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NATIONAL BUREAU OF STANDARDS REPORT

5655

FIELD TEST OF HYLAG UNDERGROUND PIPE INSULATION AT
PHILADELPHIA NAVY YARD

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

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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FIELD TEST OF HYLAG UNDERGROUND PIPE INSULATION AT PHILADELPHIA NAVY YARD

by

Selden D. Cole
and
Paul R. Achenbach
Air Conditioning, Heating and Refrigeration Section
Building Technology Division

to

Office of the Chief of Engineers
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ABSTRACT

A field test was made of a section of underground steam pipe, at the Philadelphia Navy Yard, insulated with Hylag by collecting and weighing the condensate. Investigation was also made of the moisture content of the insulation and earth around and above the steam pipe. The results showed that the heat loss per linear foot of pipe can be determined by this method when the condensate is cooled before drainage, if there is a negligible pressure drop in the section under test. The observed heat loss per foot of eight-inch pipe was 397 Btu/hr at 59 psig steam pressure on the first day and 513 Btu/hr at 44 psig steam pressure on the second day. A rainstorm that occurred between the two tests is the only known variable that could have increased the heat loss rate on the second day. The moisture content of the insulation was 1.08 percent and that of the earth was 13.1 percent near the surface and 9.7 percent adjacent to the pipe insulation on the side of the pipe three feet below the surface at the conclusion of the second test. The wire mesh outside the insulation was badly corroded and the bituminous coating had a porous, granular, carbonaceous appearance. Air spaces as wide as 1 1/2 inches were observed between the pipe and insulation at the area of excavation.

Introduction

At the request of the Office of the Chief of Engineers, Department of the Army, a field test was made of a section of underground steam pipe, insulated with Hylag, in operation at the Philadelphia Navy Yard. The amount of condensate produced in a measured length of pipe was measured; a section of the insulated pipe was inspected; temperatures were observed in the earth and on the insulation; and samples of insulation and earth were taken for moisture determinations.

Description of Test Specimen

Hylag pipe insulation is produced by the Continental Coatings Corporation of 10 East 52nd Street, New York 22, New York. The specimen for this test consisted of about 230 feet of eight-inch steam pipe insulated with a covering of Hylag. The Hylag was reinforced with 1/2-in. hardware cloth and the surface was covered with a bituminous material for waterproofing purposes. The test section extended from manhole to manhole and had an offset expansion loop as part of its length. In the manhole at either end there was a suitable bucket type steam trap. The condensate was released to the atmosphere rather than to a return condensate line. See Fig. 1 for location of the expansion loop in relation to the manholes. The manhole nearest the power plant will be considered the inlet end of the length of pipe under test, while the other manhole will be considered the outlet end. The pipe was buried in filled ground with an earth cover of about 36 inches.

Test Equipment and Procedure

Each end of the pipe was fitted with a calibrated pressure gage six inches in diameter. The gages were installed in both cases in the horizontal 3/4-inch condensate line ahead of the steam trap. The scale of both gages ranged from 0 to 300 pounds; that at the inlet end was graduated in five-pound intervals and the one at the outlet end in two-pound intervals. In each case there was a loop between the 3/4-inch pipe and the gage.

Thermocouples of copper-constantan wire were used with a Rubicon portable precision potentiometer to indicate temperatures. The temperature of the pipe was observed at the inlet and outlet end. The temperatures of the earth, and of the insulation, were recorded during the time of excavating a hole for the purpose of observing the insulated pipe.

The condensate was collected in a 24-gallon container resting on a scale. A 50-foot coil of 1/2-inch copper tubing was connected to the 3/4-inch pipe at the outlet of the steam trap and was immersed in a container supplied constantly with tap water at a temperature of about 66°F. This coil cooled the condensate and thereby prevented evaporation by flashing or boiling.

For the first test the condensate was collected for a period of three hours. For the second test on the following day, the condensate was collected for a period of four hours. At regular intervals the gage pressure at the inlet and outlet ends , condensate weight and thermocouple indication were recorded. A preliminary time was devoted to checking the operation of each of the several parts before the test period started.

Prior to the first test, the steam trap in the system, about 100 feet ahead of the inlet end, was bypassed and the condensate blown to the atmosphere to assure the steam pipe was dry, and prior to the second test the condensate line at the inlet end of the test section was blown. In each case the results indicated a dry line. A rainstorm occurred during the 24 hours that elapsed between the two tests.

At the end of the second test, a hole about 3 x 5 feet was dug to expose the pipe and insulation. This excavation was about 1/3 the length from the inlet end, on the long leg of the expansion loop. See Fig. 1. Temperatures were recorded of the surface of the earth and at several stations above the pipe as the hole deepened. Specimens of the earth and insulation were placed in weighed containers as rapidly as possible after exposure and the containers immediately sealed air tight. Moisture content was determined by (1) weighing container and contents, (2) opening container and heating at 214 F until constant weight obtained.

The length of the specimen pipe under investigation was measured with a 50-ft steel tape and found to check in length with the figures indicated on the blueprints of the installation.

Test Results

The gage pressures observed at the two ends of the test specimen during two tests indicated no measurable drop in pressure for the length of the test specimen. The thermocouple readings indicated temperatures corresponding to saturation temperatures of steam at the observed steam pressures.

The results of the two condensate tests on successive days were as follows:

Test	Average Condensate Collected lb/hr	Steam Pressure at Outlet psig	Saturation Steam Temp. °F	Computed Heat Loss per Sq Ft Pipe Surface Btu/hr	Computed Heat Loss per Linear Foot Btu/hr
1	102.7	59.0	306.9	176	397
2	131.2	44.5	291.8	227	513

The heat loss per foot was obtained by multiplying the condensate collected per hour by the latent heat of the steam at the corresponding steam pressure and dividing by the total length of the test specimen in feet.

The temperatures in the earth during excavation were as follows:

72 in. from edge of hole at the earth's surface	55 F
12 in. deep over pipe	100 F
24 in. deep over pipe	114 F
32 in. deep to one side of the pipe	114 F
36 in. deep on exposed insulation surface where an air space existed between pipe and insulation	155 F
36 in. deep between insulation and earth	183 F
Between pipe and insulation in 1" air space	253 F
Between pipe and insulation in 1" air space	249 F
Between pipe and insulation, no air space	258 F
Saturation temperature by gage pressure	292 F

The temperatures near the outlet end at the earth's surface were:

2 in. deep and over the pipe	60 F
2 in. deep and 6 ft laterally from pipe	54 F

The specimens of earth and insulation as taken from the hole during excavation contained percentages of moisture related to dry weight as follows:

Surface (8-in. layer)	13.1%
At top of insulation (8-in. layer)	12.1%
At side of pipe (8-in. layer)	9.7%
Insulation (entire layer)	1.08%

About 1 1/2 inches of the earth adjacent to the insulation had a light color, was dusty, and appeared to be dry compared to the surrounding earth.

The bituminous coating on the surface of the insulation was hard even under heat, and had a porous, granular, carbonaceous appearance. It appeared to have little waterproofing quality. The wire mesh underneath the bituminous coating had rusted through in places and was so brittle that it could be readily broken with the fingers.

The Hylag insulation was not in contact with the pipe around the entire circumference of the pipe at the area of inspection. The approximate fit of the insulation envelope is indicated in the lower diagram of Fig. 1. The portion of the envelope indicated by the dotted lines in Fig. 1 was removed for moisture determination. The air space between pipe and insulation approximated 1 1/2 inches in some places. The insulation was from 1 1/2 to 1 3/4 inches thick in most places, but was as thin as 1/2 inch in a few places. Only about two feet of the pipe were uncovered for inspection.

Discussion

The heat loss of the test specimen can be compared with the requirements of the current interim OCE Guide Specification by correcting the observed values to a pipe surface temperature of 350°F and evaluating the resulting heat loss rate per square foot of exterior pipe surface. The heat loss through an envelope of insulation and earth is proportional to the temperature difference across the envelope if the thermal conductivities of the materials remain constant for the two conditions. This would be approximately true for a change in pipe temperature of 50 degrees.

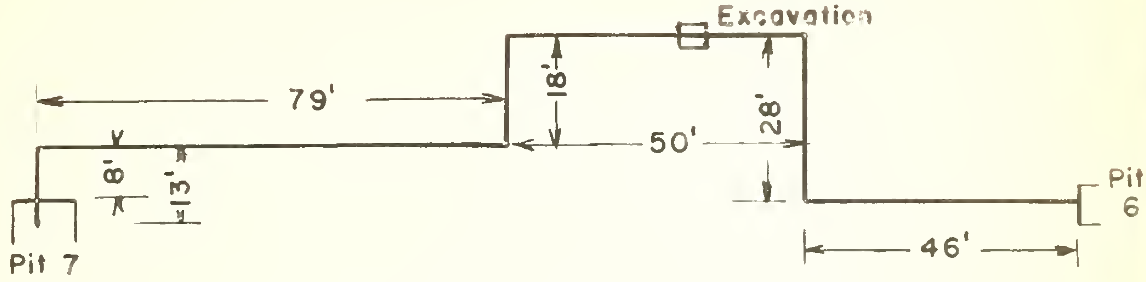
Correcting the observed heat loss values for a pipe temperature of 350°F the heat loss per linear foot would be 466 Btu/hr and 640 Btu/hr and the heat loss per square foot of exterior pipe surface would be 206 Btu/hr and 283 Btu/hr for Tests 1 and 2 respectively under conditions otherwise like those existing during the tests.

The low moisture content of the insulation shows that the Hylag insulation was quite dry, as would be expected for the temperatures observed on the inner and outer surfaces of the insulation.

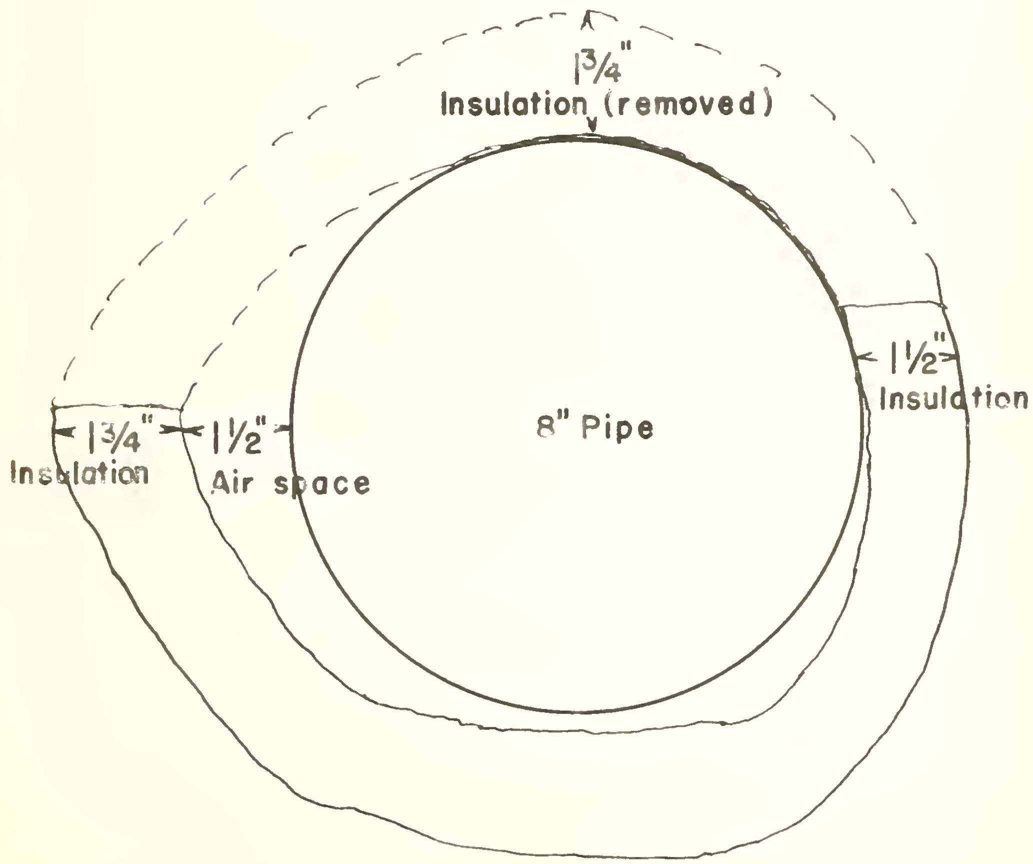
Apparently, the heat loss per unit length of pipe was increased 29 percent by the rainstorm that occurred between the two tests. There is no direct corroborative evidence for this conclusion, however, since the moisture content of the soil was not observed before the rain. The earth fill over the pipe was a very porous soil that readily absorbed water. Handbook data on the effect of moisture content on the thermal conductivity of soils indicate that the observed increase in condensate rates between tests 1 and 2 could have been caused by a 5 to 7 percent increase in the average moisture content of the envelope around the steam pipe.

According to information obtained from the Public Works Office at the Philadelphia Navy Yard this installation was made between three and four years ago. Inspection of the insulation at this one location indicated that the bituminous coating had very little waterproofing value at this time.

FIELD TEST OF HYLAG INSULATION AT PHILADELPHIA NAVY YARD



TEST SECTION OF PIPING SYSTEM



CROSS SECTION OF SPECIMEN AT POINT OF EXCAVATION

FIG. 1

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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.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

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Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Heating and Air Conditioning. Floor, Roof, and Wall Coverings. Codes and Specifications.

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Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analogue Systems. Application Engineering.

- Office of Basic Instrumentation
- Office of Weights and Measures

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering.

Radio Standards. Radio Frequencies. Microwave Frequencies. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.

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