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DIVISION 601

NATIONAL BUREAU OF STANDARDS REPORT

6205

AN INTERIM REPORT ON BOILING TESTS
OF
INSULATIONS FOR UNDERGROUND HEAT DISTRIBUTION SYSTEMS

by

Selden D. Cole and Paul R. Achenbach

to
Office of the Chief of Engineers
Bureau of Yards and Docks
Department of the Air Force



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

NBS PROJECT
1003-20-4881

NBS REPORT
6205

October 28, 1958

AN INTERIM REPORT ON BOILING TESTS OF INSULATION FOR UNDERGROUND HEAT DISTRIBUTION SYSTEMS

by

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Air Conditioning, Heating, and Refrigeration Section
Building Technology Division

to

Office of the Chief of Engineers
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AN INTERIM REPORT ON BOILING TESTS OF
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1. Introduction

As part of a research program on the characteristics required of insulations to be used in underground heat distribution systems, boiling tests were made of selected insulating materials that have been used in this application. The boiling test procedures followed those incorporated in the new specification of the Office of the Chief of Engineers dated March 24, 1958, based on the recommendations contained in Federal Construction Council Technical Report No. 30, prepared by the Building Research Advisory Board.

The test procedure requires that an 8-foot specimen of the insulation be applied to a nominal 4-inch pipe in a tank, submerged with water, and boiled for 72 hours by maintaining 125 psig steam pressure on the 4-inch pipe. After drying for 24 hours, the specimen is to be evaluated in terms of eccentricity, cracking, rupturing, swelling, fraying, material fallen from the pipe, and separation of the joints.

2. Specimens Tested

Five materials have been subjected to this boiling test: Kaylo, Thermobestos, Unibestos, Foam-Sil, and Fiberglas. Some have been tested more than once and Fiberglas has been tested in blanket, loose fill, and premolded forms. Loose fill Fiberglas has also been boiled for 72 hours inside a clay tile conduit system. Some experimentation has been conducted on methods for covering the insulating material and for securing it on the pipe. The specimens that have been tested are summarized in the following table.

SPECIMEN IDENTIFICATION

SPECIMEN	NAME	THICKNESS	HOURS OF BOILING
1	Molded fiberglass, Standard	1 in.	72
2	Kaylo	1 in.	72
3	Foam-Sil	3 in.	72
4	Unibestos	1.5 in.	72
5	Fiberglas-Ric-Wil	1.5 in.	72 + 72
6	Fiberglas-1/4 mesh, loose fill	1.5 in.	72
7	Thermobestos	1.5 in.	72
8	Molded fiberglass, Low Temperature	1.5 in.	48 + 72
9	Molded fiberglass, Low Temperature	1.5 in.	72
10	Foam-Sil	1.5 in.	72 + 72
11	Thermobestos	1.5 in.	72 + 72
12	Fiberglas-1/4 mesh, loose fill	1.5 in.	72
13	Fiberglas-16 mesh, loose fill	1.5 in.	72
14	Kaylo	1.5 in.	72 + 72
15	Molded fiberglass, Standard	1.5 in.	72 + 72
16	Fiberglas-Stillwater, Conduit - loose fill	1.7 in. min.	72

3. Discussion and Conclusions

The conclusions drawn regarding the effect of boiling on five types of insulation, as indicated by the results of the tests, are summarized below, followed by some general conclusions regarding the application of insulations to underground piping. These conclusions are based on the test results summarized in Section 4 of this report. The results in successive tests of the same material were not always consistent. Thus, a more comprehensive study might lead to some modifications in the conclusions.

Effect of Boiling on Five Types of Insulation

Kaylo: This insulation will probably withstand 72 hours or more of boiling without falling off the pipe or being cut into pieces if straps are used to secure it to the pipe. Appreciable erosion occurs at the joints in 3 to 6 days of boiling, such that a gap of an inch or more may develop at the joints.

Thermobestos: This insulation appears to swell some during boiling, placing straps under tension. Light gage aluminum straps were sheared at the eye on this material. Longitudinal joints tend to open a little during boiling, perhaps due to swelling, and a slight erosion occurred at the joints. In one test, none of the insulation fell off the pipe in 72 hours, when supported by straps or wires. In a second test, three sections in succession broke and each fell off within 72 hours, using straps for support in each case.

Unibestos: Based on the results of one test only, it appears that this material will remain on the pipe for 72 hours, under boiling conditions, with appreciable spalling or sloughing off of the outer layers. The binder is leached out, leaving the outer surface soft and spongy as contrasted to its hard character when new. There appears to be no swelling of the material. It adheres to the pipe after boiling.

Foam-Sil: The Foam-Sil material itself does not appear to be affected by boiling water. There is virtually no erosion or other loss of material. The cement used to seal the layers together in manufacture is weakened in 144 hours of boiling and some sections could be pulled apart by hand, although none came apart during the 144-hour boiling test. It is a brittle, friable material and can be cut by the supporting straps if a section becomes slightly loose on the pipe and starts to vibrate as a result of the boiling action. Binding the material too tightly to the pipe may cause it to crack when the pipe expands. This is a closed-cell insulation which limits the access of water to the steam pipe somewhat under flooded conditions.

Fiberglas: This material has been subjected to boiling water under the following conditions and in the following forms:

- a. Loose fill supported on a pipe with 1/4-inch hardware cloth.
- b. Loose fill supported on a pipe with 16-mesh wire screen.
- c. Loose fill in the Stillwater Clay Products conduit.
- d. Molded 1" thick supported by straps and wires.
- e. Molded 1-1/2" thick supported by straps and wires.
- f. Molded 1-1/2" thick supported by 16-mesh screen.
- g. Blanket wrap 1-1/2" thick, Ric-Wil, supported by plastic mesh.

In all forms of Fiberglas, the boiling water causes a leaching action in the glass fibers which weakens them and causes them to break into short pieces. This action progresses more rapidly near the pipe than at greater distances. At the end of 72 hours of boiling, an appreciable amount of the material near the pipe appears to the naked eye to be pulverized to a consistency of dust, but a microscopic examination shows that it still has a fibrous character although there is a tangled appearance to the fibers. Somewhat farther out from the pipe, the individual fibers are covered with translucent blisters or even clusters of such blisters. The nature of these blisters is not known unless it is the products of the leaching action of water on the glass.

the 1970s, the number of foreign visitors increased from 1.2 million to 1.5 million, while the number of tourists increased from 0.8 million to 1.1 million. The number of foreign tourists increased from 0.5 million to 0.6 million, while the number of Chinese tourists increased from 0.3 million to 0.4 million. The number of foreign tourists increased from 0.2 million to 0.3 million, while the number of Chinese tourists increased from 0.1 million to 0.2 million. The number of foreign tourists increased from 0.1 million to 0.2 million, while the number of Chinese tourists increased from 0.05 million to 0.1 million. The number of foreign tourists increased from 0.05 million to 0.1 million, while the number of Chinese tourists increased from 0.02 million to 0.05 million.

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The effectiveness of the material as an insulation does not appear to be greatly reduced by boiling as long as the insulation remains on the pipe in its original thickness and without voids.

Prolonged boiling of the insulation in a tank appears to progressively break up the fibers and eventually substantial amounts of the material are lost by falling into the bottom of the tank. The rate at which this loss occurs, appears to be related to the uniformity of packing the fibers, the density of the pack, whether or not a binder is used, and the size of openings in the covering material. Generally speaking, a factory-made insulation envelope consisting of compressed blankets of Fiberglas will not deteriorate as rapidly as loose fill material applied to the pipe by hand. Insulation, wrapped in a 16-mesh plastic or metal screen, will not be lost as rapidly as the same material wrapped in 1/4-inch hardware cloth.

Factory-made envelopes using blanket Fiberglas insulation, as made by the Ric-Wil Company, premolded Fiberglas 1-1/2 inches thick and wrapped with 16-mesh screen, and premolded Fiberglas 1-1/2 inches thick, secured with steel bands at 1-foot intervals, will all withstand 72 hours of boiling without appreciable loss of material. Loose fill Fiberglas hand packed to a density of 7-1/2 pounds will suffer appreciable loss in 72 hours boiling with either 16-mesh or 1/4-inch mesh wrapper. The factory-made blanket envelope and the premolded envelope wrapped in wire mesh both suffer noticeable loss of material after boiling 144 hours whereas, a section of the premolded material, supported by straps, fell off the pipe during 144 hours of boiling.

Boiling loose fill Fiberglas insulation inside a clay tile conduit system of the type manufactured by the Stillwater Clay Products Company resulted in the loss of an appreciable amount of material within 3 feet of the vent pipe at one end, and very little loss in the remainder of the test specimen during a 72-hour boiling period. The vent pipes were attached to the conduit at the top of the arch tile. The insulation was packed to a density of 5.5 lb/cu ft.

In a typical installation, such a system would probably be vented from the side blocks instead of at the top of the arch. In this case, the steam would leave the insulation cavity through the upper holes of each of the ventilated side blocks and the water level would be at about this same height. The presence of a steam space in the upper part of the arch tile would probably reduce the mechanical agitation within the insulation as compared to that when the conduit was completely filled with water. By using 16-mesh screen over the openings in the side block, the loss of material at these openings could be reduced. It is probable that a solid enclosure for loose fill insulation, such as that used in the clay tile system, would prevent loss of fibrous material during a boiling period of 72 hours as effectively as a screen mesh wrapper in the boiling tank, if not more so.

On the other hand, it is also probable that prolonged boiling of Fiberglas insulation over a period of many days in a clay tile system would seriously deteriorate the insulation, so such a system should not be used where frequent flooding could occur.

General Conclusions

Wire bands should not be used to secure insulation on pipes underground.

Straps should not be made of light-gage metal. Expansion of the insulation can cause the eyes to cut light-gage straps.

Molded insulation should fit the pipes snugly. Loose sections of insulation will often vibrate on the pipe during boiling and cause the straps to cut the insulation into pieces.

Brittle materials should not be strapped so tightly, that pipe expansion will put tension on the insulation.

Except for the cellular glass, the boiling water will cause some erosion at the longitudinal joints and the butt joints between adjacent lengths. It will also erode channels or holes through the body of fibrous insulations.

Complete wrappers of wire mesh or suitable plastic mesh (16-mesh or smaller) will probably minimize spalling and sloughing off of insulation on an underground pipe more effectively than straps under boiling conditions.

The boiling tests made thus far indicate that all five of the materials tested will probably deteriorate significantly if boiling continues indefinitely. Foam-Sil was probably the least affected by boiling, but the fit of the material on the pipe may determine the likelihood of cracking the insulation or its tendency to vibrate on the pipe.

The deleterious effect of boiling water on most insulating material now used for underground piping systems, as revealed by these tests, emphasizes the need for continuous effort to design such systems so they will function many years before water gains access to the insulation, no matter what the nature of the terrain.

4. Test Results

The results observed during each boiling test are summarized separately in this section. The summary identifies the material and its dimensions, the method of application, the condition of the insulation at the conclusion of the boiling test, and one or more photographs of each specimen.

BOILING TEST OF PIPE INSULATION

Specimen 1

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Pre-molded Fiberglas PF, Standard

Binder used: Organic thermosetting resin

Length of section: 3 ft

Thickness of insulation: 1 in.

Covering: Light cloth fabric

Pipe diameter: 4 in.

Method of Application

Position of joints: 1st section - Joints vertical
2nd section - Joints horizontal

Covering used: Light cloth fabric

Other features: Fourth strap on 1st section covered lapped fabric at joint between sections

Test Results

Amount fallen from pipe: Top half of 1st section fell off.
Bottom half dropped down and resting
on straps. 2nd section intact.

Eccentricity: None on 2nd section

Separation at joints: None on 2nd section

Cracks and ruptures: None on 2nd section

Fraying: None

Swelling: Slight swelling on 2nd section

Erosion: Some erosion on interior surface and at joints

Other damage: None

Moisture retention: Not measured
Percent

Reference to photographs: Fig 1 shows initial appearance; right specimen.

Fig 3 shows 1st section gone after
72 hours; right specimen.

Swelled appearance of 2nd section is
primarily the stretched fabric covering.

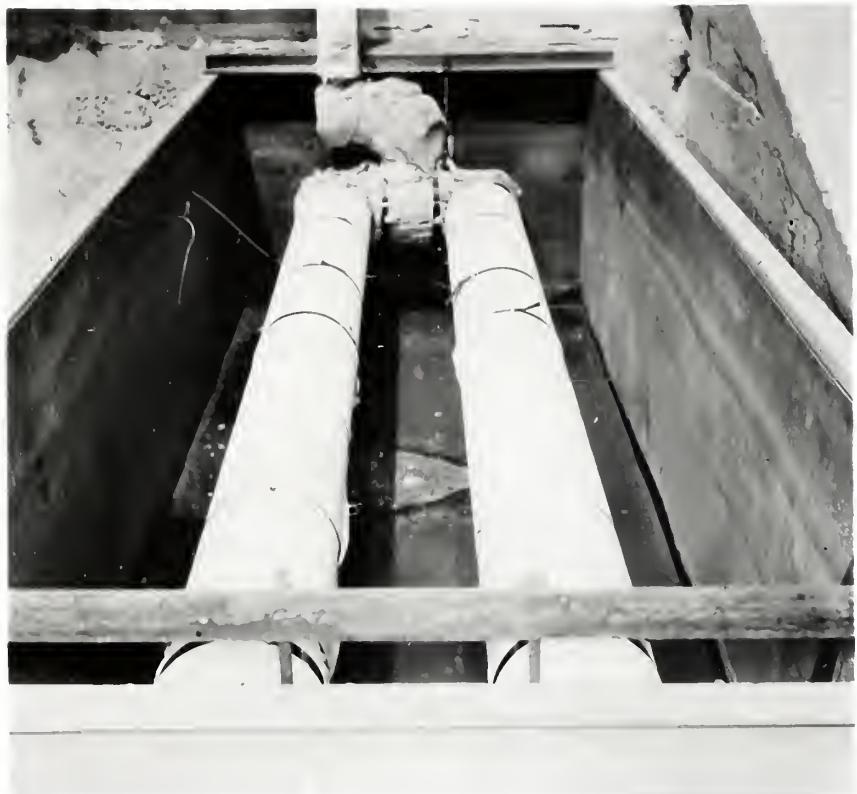


Figure 1



Figure 3

BOILING TEST OF PIPE INSULATION

Specimen 2

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Kaylo - Pre-molded calcium silicate and asbestos fibers

Binder used: Calcium silicate

Length of section: 3 ft

Thickness of insulation: 1 in.

Covering: Light cloth fabric

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section - Four 3/4-in. straps, 1 ft apart
2nd section - Four No. 12 copper wires,
1 ft apart

Position of joints: 1st section - joints vertical
2nd section - joints horizontal

Covering used: Light cloth fabric

Other features: Fourth strap on 1st section covered lapped
fabric at joint between sections

Algorithmic methods for SMT

Decision procedures

Decision procedure

Given a formula φ and a set of constraints C , decide whether $\varphi \wedge C$ is satisfiable.

• If $\varphi \wedge C$ is satisfiable, then there is a model m such that $m \models \varphi \wedge C$.

Satisfiability modulo theories

Given a formula φ and a set of constraints C , decide whether $\varphi \wedge C$ is satisfiable.

• If $\varphi \wedge C$ is satisfiable, then there is a model m such that $m \models \varphi \wedge C$.

Test Results

Amount fallen from pipe: Parts of 2nd section. See Fig 3; left specimen. 1st section intact.

Eccentricity: None.

Separation at joints: None

Cracks and ruptures: Insulation cut by wires on 2nd section and broken into pieces. Top half of 2nd section dislocated. See Fig 3; left specimen.

Fraying: None

Swelling: None

Erosion: Some erosion at joints

Other damage: Cloth fabric torn on 2nd section

Moisture retention: Not measured
Percent

Reference to photographs: Fig 1 shows initial appearance; left specimen.

Fig 3 shows rupture of 2nd section as it appeared after 72 hr of boiling; left specimen.

BOILING TEST OF PIPE INSULATION

Specimen 3

Description of Material

Manufacturer: Pittsburgh Corning Company

Identification name or symbol: Foam-Sil. Pre-molded closed cell glass foam.

Binder used: None. Fused material. Each piece made of two layers cemented together longitudinally.

Length of section: 17 in.

Thickness of insulation: 3 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st and 2nd sections - Two 3/4-in. straps, 2 in. from ends.

3rd section - One strap and one wire,
2 in. from ends.

4th and 5th sections - Two No. 12 copper
wires, 2 in. from ends.

Position of joints: 1st, 3rd, 5th sections - joints vertical
2nd, 4th sections - joints horizontal

Covering used: None

Other features: None

INTERVIEW WITH THE DIRECTOR

Introduction

INTERVIEWER'S QUESTIONS

1. Could you describe your background? Your education, your interests, what you do now, what you have done in the past.

2. What are your main goals? What do you want to accomplish with your work?

3. What is your role in the project?

4. What is your relationship to the other members?

5. Who is involved?

6. What is your role in the project?

INTERVIEWER'S QUESTIONS

7. What do you think is the most important thing about the project?

8. What do you think is the most difficult part of the project?

9. What do you think is the most interesting part of the project?

10. What do you think is the most important thing about the project?

11. What do you think is the most important thing about the project?

12. What do you think is the most important thing about the project?

Test Results

Amount fallen from pipe: None

eccentricity: 4th section cut by wire bands. Lower half dropped slightly from slack in wires.

Separation at joints: None

Cracks and ruptures: Vibration of fourth section caused it to cut into insulation, but it was not severed. See Fig 4; left specimen.

Fraying: None

Swelling: None

Erosion: Negligible

Other damage: None

Moisture retention: Not measured. Non-hygrometric material.
Percent

Reference to photographs: Fig 2 shows initial appearance; left specimen.

Fig 4 shows appearance after 7½ hr boiling. Dislocation of 4th section from cutting by wires shown in left specimen.

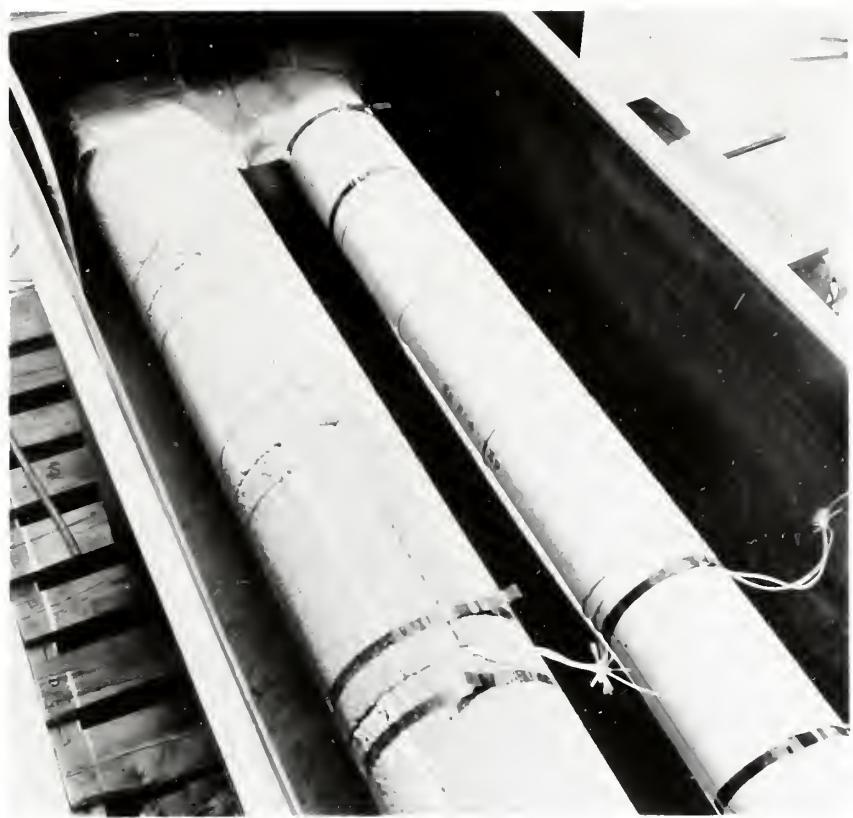


Figure 2



Figure 4

100%
COTTON

BOILING TEST OF PIPE INSULATION

Specimen 4

Description of Material

Manufacturer: Union Asbestos and Rubber Company

Identification name or symbol: Unibeston. Pre-molded asbestos fibers.

Binder used: Silicate

Length of section: 3 ft

Thickness of insulation: 1 1/2 in.

Covering: None. Exterior surface made quite hard with binder material.

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section - Four 3/4-in. straps, 1 ft apart
2nd section - Four No. 12 copper wires,
 1 ft apart

Position of joints: 1st section - joints horizontal
2nd section - joints vertical

Other features: None

connected with the party chairman

in particular.

Political Party Organization

presently there are approximately 100,000 members in the party organization, which includes approximately 10,000 members in the Central Committee and 10,000 members in the Central Control Commission.

Central Committee members

are elected by the National Congress

and by the Central Control Commission

and are serving three-year terms. The Central Control Commission consists entirely of members of the Central Committee.

Local Party Committees

Local Party Committees

Local Party Committees consist of members and representatives from districts, towns, and villages. There are approximately 10,000 members in the local Party Committees.

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Test Results

Amount fallen from pipe: None

Eccentricity: None

Separation at joints: None

Cracks and ruptures: None

Fraying: Slight

Swelling: Negligible

Erosion: About 1/4 of material was lost from outer surface of top half of 1st section. See Fig 4, right specimen.

Other damage: Binder leached out of insulation. Surface appreciably softened.

Moisture retention: 0.7 percent

Reference to photographs: Fig 2 shows initial appearance; right specimen.

Fig 4 shows loss of material on top of 1st section; right specimen in foreground.

Comments: Both sections adhered to the pipe at the end of the test. A scraper had to be used to loosen the insulation.

STATION 207

soil being well mixed around

the root system.

Soil mixture is composed
with charcoal and sand.

Soil mixture is composed

with charcoal and sand.

Soil mixture is composed

with charcoal and sand.

Soil mixture is composed

with charcoal and sand.

Soil mixture is composed

with charcoal and sand.

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with charcoal and sand.

Soil mixture is composed

BOILING TEST OF PIPE INSULATION

Specimen 5

Description of Material

Manufacturer: Ric-Wil - Sectional Fiberglas Pipe Insulation

Identification name or symbol: - Blanket Fiberglas as used
by Ric-Wil.

Binder used: Fiberglas oiled treatment only

Length of section: 2 ft with overlapping screen joints

Thickness of insulation: 1-1/2 inches - 7-1/2 lbs density

Covering: 14 x 16 mesh fiberglas strands plastic coated.

Pipe diameter: 4 in.

Method of Application

Method of fastening: Prepared sections slipped on pipe

Position of joints: Only butt joints in this construction

Covering used: Fiberglas screen held with metal staples.

Other features: 2 in. lap of covering at butt joints.

Міжнародні зв'язки та їх роль

І) міжнародні

Дипломатичні зв'язки

Міжнародні зв'язки відповідають терміну – дипломатичні зв'язки між державами – дипломатія. Існує також посередництво

Інші зовнішньополітичні зв'язки – зовнішньоекономічні зв'язки, зовнішньо-культурні зв'язки тощо. Це зв'язки, які виникають в результаті діяльності держави та її подій та не є дипломатичними зв'язками. Важко відрізняти міжнародні зв'язки та зовнішньоекономічні зв'язки, оскільки вони виникають в результаті діяльності держави та її подій та не є дипломатичними зв'язками.

Інформаційні зв'язки

Інформаційні зв'язки – це зв'язки, які виникають в результаті діяльності держави та її подій та не є дипломатичними зв'язками. Важко відрізняти міжнародні зв'язки та зовнішньоекономічні зв'язки, оскільки вони виникають в результаті діяльності держави та її подій та не є дипломатичними зв'язками.

Test Results

Amount fallen from pipe: Slight loss after 72 hr.

Eccentricity: Slight

Separation at joints: None after 72 hrs - open after 144

Cracks and ruptures: None after 72 hrs.

Fraying: None

Swelling: None after 72 hrs.

Erosion: Slight after 72 hrs.

Other damage: Plastic covering brittle after 144 hrs.

Moisture retention (percent): Dry

Reference to photographs: Fig 5 - after 72 hrs boiling

Fig 6 - butt joint uncovered to show negligible loss of wool

Fig 7 - after 144 hrs boiling shows some loss of Fiberglas wool



Figure 5



Figure 6



Figure 7

BOILING TEST OF PIPE INSULATION

Specimen 6

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Loose-fill Fiberglas

Binder used: None

Length of section: 7'-2"

Thickness of insulation: 1.5 in.

Covering: 1/4 in. mesh galvanized hardware cloth used to retain loose fill insulation on pipe

Pipe diameter: 4 in.

Method of Application

Method of fastening: A weighed amount of loose fill Fiberglas was spread as evenly as possible on a flat piece of 1/4 in. mesh hardware cloth and held in place with big stitches of cotton string. See Fig 8 and 9. Even though the insulation was spread as evenly as possible, there was an appearance of clumps in the layer and probable variations in density. The width of the mesh wrapper and the amount of insulation used was such that the insulation would be compressed to a density of 7lb/cu ft and a thickness of 1-1/2 in. when wrapped around the pipe with the wire mesh overlapping one inch at the edges. The wire mesh wrapper was held in place with 3/4 in. bands spaced 12 in. apart.

QUESTIONNAIRE ITEMS TO TEST OUTLINE

8 questions

1. Attitudes to inflation

Answers to questions below should indicate how well you think the following statements reflect your views.

"True" indicates the statement reflects your views;
"False" indicates the statement does not reflect your views.
and 8.2 are intended to complement
ability of your ability to evaluate statements about the economy
which are not included in the main

and 8.3 represent very

and thus does not reflect

the following items to answer following 8
items will be no reflection of either an average
or what some people consider their P.A. to
reflects position the majority of the society would
have and will reflect the view of the 95% and
99% majority. Following are attempts to measure some
less weight with which to accommodate the
above and reflect the average attitude
toward the trouble and suggestion above will be
more representative with much closer to the actual
than the majority to indicate a very broad
and general support made up of all the people
in the country who understand more easily than others
that the views expressed above will provide
them with all they need about what they believe

represented by society

Test Results

Amount fallen from pipe: About 30 percent as weighed dry before
and after boiling

Other damage: 4 in. pipe exposed in many places as voids appeared
in an irregular pattern in the insulation

Reference to photographs: Fig 8, left specimen, shows appearance
after 72 hrs boiling
Fig 9 shows close-up view of voids in the
insulation

ANSWER

Answers will be given on request. Please send your answers
and I will give you mine.

Remember always to send your answers in a separate envelope and to keep them
until I have given you my answers. If you do not receive my answers
within two weeks, please write again and ask for them.



Figure 8



Figure 9

BOILING TEST OF PIPE INSULATION

Specimen 7

Description of Material

Manufacturer: Johns-Manville

Identification name or symbol: Thermobestos

Binder used: A calcium silicate product with asbestos fibers

Length of section: 36 in.

Thickness of insulation: 1-1/2 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section - 4 straps

2nd section - #12 copper wire

3rd section - strapped

Position of joints: 1st section - Joints horizontal

2nd section - Joints vertical

3rd section - Joints horizontal

Covering used: None

Other features: 3rd section - was about 15 in. long.

INTERVIEW WITH SCIENTIFIC DIRECTOR

7 meetings

INTERVIEW WITH SCIENTIFIC DIRECTOR

QUESTION: What is your understanding

of the following? Listings of your publications

should include the following: authorship, title, journal, date, place, institution, and agreement.

ANSWER: I have agreed to sign

the following publications to my editor

and agree to sign them to my editor

and agree to sign them to my editor

INTERVIEW WITH SCIENTIFIC DIRECTOR

ANSWER: I have agreed to sign the following

publications to my editor and agree to sign them to my editor

and agree to sign them to my editor

and agree to sign them to my editor

and agree to sign them to my editor

and agree to sign them to my editor

and agree to sign them to my editor

and agree to sign them to my editor

Test Results

Amount fallen from pipe: None

Eccentricity: None

Separation at joints: Slight, except short piece which opened up so that pipe was exposed.

Cracks and ruptures: None

Fraying: None

Swelling: None

Erosion: Slight outside edge of all joints

Other damage: Wire cut into insulation a distance equal to its diameter in some places

Reference to photographs: Fig 8, right specimen, shows appearance after 72 hrs boiling. Note slight separation of longitudinal joint and slight embedment of wire at farther end of the middle section

www.ams.org/journals/mosco — A monthly journal of Soviet mathematics

With a large amount of material available, it is difficult to make a generalization about the effect of frequency upon the results.

BOILING TEST OF PIPE INSULATION

Specimen 8

Description of Material

Manufacturer: Owens-Corning Fiberglas

Identification name or symbol: Preformed 1.5 in. Fiberglas
(low temperature)

Binder used: Organic thermosetting resin

Length of section: 7 ft - 1 in.

Thickness of insulation: 1.5 in.

Covering: Vapor barrier paper removed from original product. 16-mesh galvanized screen wrapper applied in the laboratory.

Pipe diameter: 4 in.

Method of Application

Method of fastening: 16 mesh galvanized wire fastened every 2 in.
at the longitudinal joint with #22 copper wire

Position of joints: 1st section - Joints horizontal
2nd section - Joints vertical
3rd section - Joints horizontal

Other features: Wire mesh wrapper in one piece with 1 in. lapped seam.

INTERVIEW WITH THE PASTOR

Q What does

Lutheran mean to you?

It means that I believe in the scriptures and the word of God as the truth and the way to salvation (Matthew 10:12)

When you go to church what do you do?

I listen to the sermon and I pray for the people

and I ask God to help them

What is the most important thing you have learned from your pastor?

That God is good and he wants us to be good

Q What does

God mean to you?

He is my savior, my father, my best friend and he wants me to be a good person.

What are the three things you like best?

God, my family and my friends.

What is the best part of being a Christian?

That I can go to God anytime and he will listen to me and help me.

What is the worst part of being a Christian?

That I can't go to God anytime and he will listen to me and help me.

Test Results

Amount fallen from pipe: None

Eccentricity: None

Separation at joints: Only slightly at butt joints after 120 hrs.

Cracks and ruptures: None after 48 hrs.

Fraying: None after 48 hrs.

Swelling: None

Erosion: None after 48 hrs. Slight erosion at butt joints after 120 hrs.

Other damage: No damage that could be observed after 72 hrs. Except for the slight erosion at the joints and the usual embrittlement of the glass fibers, this specimen was in good condition after 120 hrs of boiling.

Moisture retention (percent): Not measured

Reference to photographs: Fig 10 is a view of the specimen after 120 hrs of boiling.

Books Received

and their work cannot stand

out of its context.

With this simple insight, one begins to understand the political process in a new way.

Thus, the author's insights into politics are valuable, but his emphasis

on the role of the state in politics is misleading.

It is also misleading to emphasize

the role of the state in politics.

While the author's analysis of politics is useful, it is not the whole story.

The author's emphasis on the

role of the state in politics is misleading, but the author's emphasis on the role of the state in politics is useful.

Thus, the author's insights into politics are valuable, but his emphasis

on the role of the state in politics is misleading.

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on the role of the state in politics is misleading.

Thus, the author's insights into politics are valuable, but his emphasis



Figure 10

BOILING TEST OF PIPE INSULATION

Specimen 9

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Preformed 1.5 in, Fiberglas
(low temperature)

Binder used: Organic thermosetting resin

Length of section: 3 ft

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section - 4-3/4 in. straps
2nd section - 4-#12 copper wire
3rd section - 2-#12 copper wire

Position of joints: 1st section - Joints vertical
2nd section - Joints horizontal
3rd section - 45°

QUESTIONNAIRE WITH THE WORKERS

C. intensity

Intensity of motivation

present intensity of job-related goals - motivation
of workers to work according to their individual
characteristics and

intensity of motivation among those workers

1. 2% C. intensity in physical

and 2.5% motivation to accomplish
work requirements

and 3. 5% motivation to work

intensity of motivation

intensity of physical motivation 0.5% (intensity to fulfill
physical needs - motivation 0.5%
and 0.5% - motivation 0.5%

intensity of mental - motivation 0.5% (intensity to fulfill
mental needs - motivation 0.5%
and 0.5% - motivation 0.5%)

Test Results

Amount fallen from pipe: None as pieces

Eccentricity: Insulation layers flared out at seams

Separation at joints: Joints opened from 1/8 in. to more than 1 in.

Cracks and ruptures: No cracks or complete ruptures but surface cut by wires

Fraying: All joints showed fraying. Fraying more extensive on second section with joints located horizontally. See Fig 11

Swelling: Slight

Erosion: All seams showed erosion with delamination evident

Other damage: Wires cut into insulation. See Fig 12

Moisture retention (percent): Not measured

Reference to photographs: Fig 11 shows appearance after 72 hrs boiling

Fig 12 shows closeup of sections 2 and 3 fastened with wires. Mirrored view of second section shows nature of the fraying and delamination at the horizontal joint

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Figure 11

BOILING TEST OF PIPE INSULATION

Specimen 10

Description of Material

Manufacturer: Pittsburgh Corning Glass Company

Identification name or symbol: Foam-Sil - A cellular silicate

Binder used: 99 + % pure silica

Length of section: 17 in.

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: With clamps screw thread tightened

Position of joints: 1st section - Joints horizontal
2nd section - Joints vertical
3rd section - 45°
4th section - Joints horizontal
5th section - Joints vertical

Covering used: None

Other features: All joints tight to slight crushing

DISCUSSION DUE TO PESTS

1. *Monocots*

1.1. *Gramineae*

Gramineae plants generally withstands predation well. However, it is difficult to estimate the exact number of species that are affected by herbivores. In general, the species that are affected are those that have a low seed production rate and/or a short life-span.

1.2. *Cyperaceae*

Gramineae species seems to be affected by herbivores. The following are some examples:

- *Setaria viridis* - eaten by *Setaria viridis*
- *Pennisetum polystachyon* - eaten by *Pennisetum polystachyon*
- *Zizaniopsis miliacea* - eaten by *Zizaniopsis miliacea*
- *Echinochloa crusgalli* - eaten by *Echinochloa crusgalli*

Gramineae species are also affected by other factors such as flooding, drought, and temperature.

Test Results

Amount fallen from pipe: None

Eccentricity: None

Separation at joints: Slightly at butt joints

Cracks and ruptures: About half of the individual pieces cracked circumferentially when steam was first turned on. No additional cracks developed during the test.

Fraying: None

Swelling: None

Erosion: Some of the cement used in fabrication of sections disappeared but not to point of unsealing joints after 144 hrs.

Other damage: Sections cracked on initial heating but cracks had not changed after 144 hrs. Cracks may have been caused by tight banding and pipe expansion on heating.

Moisture retention (percent): None

Reference to photographs: Fig 13 shows appearance of Foam-Sil after 72 hrs boiling

Annual Audit

and single unit utility services

and transportation

and other areas of responsibility.

Annual audits shall be filed with the Board of Education by the first day of October each year and shall be made available to the Board of Education and the public during the month of October.

and language

and personnel

The auditor is authorized to hear claims and to make investigations for such stated purposes as may be directed by the Board of Education. The auditor shall not be liable for any damages or expenses which may be incurred in the course of his duties. The auditor shall not be liable for any damages or expenses which may be incurred in the course of his duties.

and (annual) policies and practices

and allowed to become effective on January first of each year.



Figure 13

BOILING TEST OF PIPE INSULATION

Specimen 11

Description of Material

Manufacturer: Johns-Manville Company

Identification name or symbol: Thermobestos, Premolded Calcium silicate and asbestos fibers

Binder used: Calcium silicate

Length of sections: 36 in.

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section - Four 3/4 in. straps of aluminum
2nd section - Fiberglas mesh initially sewed at the longitudinal joint. Two metal straps added after 72 hrs because plastic mesh had stretched.

Position of joints: 1st section - Joints horizontal
2nd section - Joints vertical

Covering used: None except fiberglas mesh on second section

Other features: Aluminum straps replaced with steel straps after 24 hours

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J.L. Woodruff

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Test Results

- Amount fallen from pipe: 1st section fell off in less than 24 hrs when aluminum straps sheared.
1st section replaced and steel straps used.
1st section off again after 48 hours boiling. Replaced and boiled for an additional 72 hours with one piece breaking off.
- Cracks and ruptures: At 72 hours, seams of mesh-covered sections had opened about 2 in. 2 straps were added to the second section and after 72 hours of additional boiling, the seam opening had not increased in the second section but had in the short unstrapped section.
- Other damage: Some erosion at joints after 144 hours of boiling.
- Moisture retention (percent): Not measured
- Reference to photographs: Fig 14 shows condition of mesh-covered section after 144 hours of boiling.

REVIEW OF THE EVIDENCE

Evidence 100

and the same level as the 100% institutional
group reported. The two matched control groups
had approximately 10% higher rates than the 100% insti-
tutional group, reflecting their lower level of
institutionalization.

Additional accommodations by some participants in the 'non-living' care system
to avoid a 'living' care position seems to have been
the best predictor with the controlled variables
that we had. The highest scores were all associated
with those respondents who

denied the need for medical support, as indicated by having their
housemates pull a (known) participant outside

accommodations for extended periods of time. Indications of concern
regarding the extent of social isolation



Figure 14

BOILING TEST OF PIPE INSULATION

Specimen 12

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Loose fill Fiberglas wool

Binder used: None

Length of section: 7 ft - 2 in.

Thickness of insulation: 1.5 in.

Covering: 1/4 in. mesh galvanized hardware cloth to retain loose fill insulation on pipe

Pipe diameter: 4 in.

Method of Application

Method of fastening: A weighed amount of loose fill Fiberglas was spread as evenly as possible on a flat piece of 1/4 in. mesh hardware cloth and held in place with big stitches of cotton string. See Fig 15 and 16. Even though the insulation was spread as evenly as possible, there was an appearance of clumps in the layer and probably variations in density. The width of the mesh wrapper and the amount of insulation used was such that the insulation would be compressed to a density of 7 lb/cu ft and a thickness of 1-1/2 in. when wrapped around the pipe with the wire mesh overlapping one inch at the edges. The wire mesh wrapper was held in place with 3/4 in. bands spaced 12 in. apart.

INTERVIEW WITH THE CHIEF POLICEMAN

(Continued)

INTERVIEW WITH POLICEMAN

Ques. You have been asked to give your information about the incident.

Ans. I am a police officer and I have been asked to give my information about the incident.

Ques. When did you receive the information?

Ans. On 1st January 1997.

Ques. Who informed you about the information?

Ans. A man who was walking on the road.

Ques. What was he doing?

INTERVIEW WITH POLICEMAN

Ques. You have been asked to give your information about the incident.

Ans. I am a police officer and I have been asked to give my information about the incident.

Ques. Who informed you about the information?

Ans. A man who was walking on the road.

Ques. What was he doing?

Ans. He was walking on the road.

Ques. Who informed you about the information?

Ans. A man who was walking on the road.

Ques. What was he doing?

Ans. He was walking on the road.

Ques. Who informed you about the information?

Ans. A man who was walking on the road.

Ques. What was he doing?

Ans. He was walking on the road.

Ques. Who informed you about the information?

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Ans. A man who was walking on the road.

Ques. What was he doing?

Ans. He was walking on the road.

Ques. Who informed you about the information?

Ans. A man who was walking on the road.

Ques. What was he doing?

Ans. He was walking on the road.

Ques. Who informed you about the information?

Ans. A man who was walking on the road.

Ques. What was he doing?

Ans. He was walking on the road.

Ques. Who informed you about the information?

Ans. A man who was walking on the road.

Ques. What was he doing?

Ans. He was walking on the road.

Test Results

Amount fallen from pipe: About 20 percent as weighed dry before and after boiling.

Other damage: Pipe exposed in many places as voids in an irregular pattern formed in the insulation.

Moisture retention (percent): None

Reference to photographs: Fig 15, left specimen, shows appearance after 72 hours boiling

Fig 16, bottom specimen, shows closeup of voids with a mirror image of the underneath portion.

Microscopic Examinations of Insulation: Samples of insulation were taken from the specimen at several locations after the test for microscopic examination. Microphotographs were taken of the glass fibers before and after boiling. Fig 16a shows the smooth, transparent, cylindrical appearance of the fibers when new. Fig 16b shows the appearance of the material near the surface of the envelope after boiling. It was broken into many short pieces, and appeared brown to the naked eye (perhaps the effect of the boiling water and steam on the oil treatment of the original material). Fig 16a and 16b are about 400 to 1 magnifications.

Now I want you to imagine the same people with different dreams.



Figure 15



Figure 16



Figure 16a

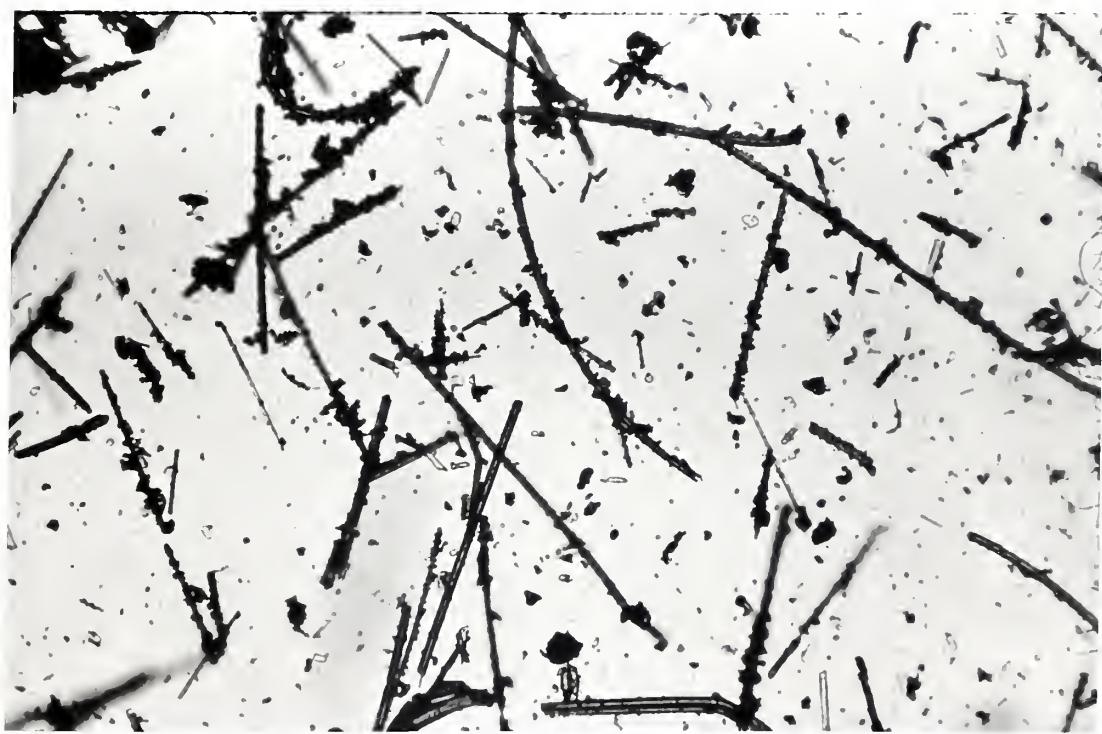


Figure 16b

BOILING TEST OF PIPE INSULATION

Specimen 13

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Loose fill Fiberglas wool

Binder used: None

Length of section: 7 ft - 2 in.

Thickness of insulation: 1.5 in.

Covering: 16-mesh galvanized screen wire used to retain loose fill insulation in the pipe.

Pipe diameter: 4 in.

Method of Application

Method of fastening: A weighed amount of loose fill Fiberglas was spread evenly on a flat piece of 16-mesh galvanized screen wire and held in place by stitches of cotton string. Even though the insulation was spread as evenly as possible, there was an appearance of clumps in the layer and probable variations in density. The width of the screen wrapper and the amount of insulation used was such that the insulation would be compressed to a density of 7 lb/cu ft and a thickness of 1-1/2 in. when wrapped around the pipe with the wire mesh overlapping two in. at the edges. The screen wrapper was held in place with 3/4 in. bands spaced 8 in. apart. See Fig 15.

Test Results

Amount fallen from pipe: About 10 percent of glass wool as weighed dry before and after boiling.

Other damage: Pipe exposed at several small spots and some local loss of fibrous material

Reference to photographs: Fig 15, right specimen, shows appearance after 72 hours boiling

Fig 16, top specimen, shows one spot where pipe exposed. 16-mesh screen wire provided a sort of flexible wrapping that tended to bulge slightly between straps

WILSON'S SPARROW AND WREN

INTERVIEW

QUESTION BY JOHN WOOD: 16. DESCRIBE BIRDS YOU'VE HAD WHICH YOU COULD NOT IDENTIFY WITH CONFIDENCE.

ANSWER BY JOHN WOOD: "I have known two birds which I could not identify with confidence."

QUESTION BY JOHN WOOD: "WHAT BIRDS HAVE BEEN THE MOST DIFFICULT TO IDENTIFY?"

ANSWER BY JOHN WOOD: "I have known two birds which I could not identify with confidence."

QUESTION BY JOHN WOOD: "WHAT BIRDS HAVE BEEN THE EASIEST TO IDENTIFY?"

ANSWER BY JOHN WOOD: "I have known two birds which I could not identify with confidence."

QUESTION BY JOHN WOOD: "WHAT BIRDS HAVE BEEN THE MOST UNUSUAL TO IDENTIFY?"

ANSWER BY JOHN WOOD: "I have known two birds which I could not identify with confidence."

QUESTION BY JOHN WOOD: "WHAT BIRDS HAVE BEEN THE EASIEST TO IDENTIFY?"

ANSWER BY JOHN WOOD: "I have known two birds which I could not identify with confidence."

QUESTION BY JOHN WOOD: "WHAT BIRDS HAVE BEEN THE MOST UNUSUAL TO IDENTIFY?"

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ANSWER BY JOHN WOOD: "I have known two birds which I could not identify with confidence."

QUESTION BY JOHN WOOD: "WHAT BIRDS HAVE BEEN THE EASIEST TO IDENTIFY?"

ANSWER BY JOHN WOOD: "I have known two birds which I could not identify with confidence."

QUESTION BY JOHN WOOD: "WHAT BIRDS HAVE BEEN THE MOST UNUSUAL TO IDENTIFY?"

ANSWER BY JOHN WOOD: "I have known two birds which I could not identify with confidence."

BOILING TEST OF PIPE INSULATION

Specimen 14

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Kaylo

Binder used: Silicate

Length of section: 3 ft

Thickness of insulation: 1-1/2 in.

Covering: Canvas on 1st and short sections

Pipe diameter: 4 in.

Method of Application

Method of fastening: 3/4 pipe straps spaced 12 in. apart

Position of joints: 1st section - Joints horizontal
2nd section - Joints vertical
3rd section - Joints horizontal

Covering used: Canvas on 1st section and short section

Other features: Longitudinal joints did not close by 1/8 in. when insulation was tightly fitted to the 4 in. pipe.
Insulation cavity was a little too small in diameter.

RECOMMENDATION FOR FURTHER ACTION

1. Recommendation

Establish a task force

The most significant problem areas identified by the study are the following:
1. The lack of communication between the various agencies involved in the delivery of services to the mentally ill.
2. The lack of communication between the mental health professionals and the public.
3. The lack of communication between the mental health professionals and the public.
4. The lack of communication between the mental health professionals and the public.

RECOMMENDATION FOR ACTION

1. Establish a task force consisting of mental health professionals, mental health consumers, and mental health advocates to develop recommendations for improving communication between the mental health professionals and the public.
2. Establish a task force consisting of mental health professionals, mental health consumers, and mental health advocates to develop recommendations for improving communication between the mental health professionals and the public.
3. Establish a task force consisting of mental health professionals, mental health consumers, and mental health advocates to develop recommendations for improving communication between the mental health professionals and the public.

Test Results

Amount fallen from pipe: None after 72 hours

Eccentricity: None

Separation at joints: All joints opened up about 3/4 in. Insulation moved slightly on 4 in. pipe

Cracks and ruptures: None

Praying: None

Erosion: Edges of vertical joints eroded so that circumference of two half sections lost about 1 in. after 144 hours boiling.

Reference to photographs: Fig 17 shows appearance after 72 hours boiling



Figure 17

27634 2

BOILING TEST OF PIPE INSULATION

Specimen 15

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Premolded Fiberglas, Standard

Binder used: Phenolic

Length of section: 3 ft.

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section, 4 straps - 72 hrs + 72 hrs.
2nd section, 4 copper wires - 72 hrs - new
section, 4 straps 72 hrs.
3rd section, 2 straps - 72 hrs + 72 hrs

Position of joints: 1st section - Joints vertical
2nd section - Joints horizontal
3rd section - Joints vertical

Other features: None

RECOMMENDATION TO YOUR COUNCIL

(A) CONTINUATION

Establish the recommended

proposed additional 2% general-local referendum.
However, a proposed 1% local option election may now be recommended.
In addition, regular taxation
of 1% will continue to apply
and B.L. contributions to continue
with reductions
at the maximum rate.

Establish the local

local 2% - 2014 ST - option to continue per capita reduction by another
local 2% ST - option to propose 2% reduction and
local ST - local ST - option to 2% reduction and
local 2% - reduction and remain as existing
local tax and option to reduce by
local 2% - reduction and
local 2% - reduction and

Test Results

Amount fallen from pipe: After 72 hrs.
1st section, none.
2nd section, top half off pipe, part of
bottom half hanging by wires.
Replaced with a new length.
3rd section, none

Separation at joints: 1st and 3rd sections tight at longitudinal
joints, 2nd section not on pipe so no butt
joints.

Cracks and ruptures: None

Fraying: Very slight fraying at all joints.

Swelling: Very slight

Erosion: Butt joint end eroded to a concave shape on sections 1
and 3. Longitudinal joints eroded slightly at surface.

Other damage: After 144 hrs; 1st section; right side off pipe;
part of left side hanging at bottom by straps.
After 72 hrs; replaced 2nd section; joints tight;
joints show slight erosion at surface.
After 144 hrs; 3rd section; longitudinal joint
tight.

Reference to photographs: Fig 18 shows the appearance of the ins-
ulation after 72 hours boiling. The
first section, secured with straps, shows
slight erosion and fraying. The second
section, secured with wires, had separated
from the pipe and a part had fallen into
the bottom of the tank.

and the original or older version has not yet been published, it will be nothing but a copy of what the other author has written.

E. amboinicus en beide gevallen is dit deel van de vleugel niet goed te bestuderen.

using the white-shade technique and green-dot media. Two methods were used to compare white and green dot media.



Figure 18

Specimen 16

BOILING TEST OF LOOSE FILL FIBERGLAS IN STILLWATER CLAY PRODUCTS CERT-A-BAR SYSTEM

Description of Test Specimen

Loose fill Fiberglas insulation, manufactured by Owens-Corning Fiberglas Company, was boiled inside a 14-ft test specimen of the Cert-a-Bar Clay Tile Conduit as manufactured by the Stillwater Clay Products Company. The insulation was packed to an average density of 5.5 lb/cu ft around a 4-inch pipe over a 2-inch pipe, both located inside a clay tile conduit made of 8-inch high side blocks and 8-inch semi-cylindrical arch tile.

The thickness of the insulation varied from a minimum of about 1.72 inches around the top half of the 4-inch pipe to a maximum of approximately 4.75 inches at some places underneath the 4-inch pipe.

The insulation had been subjected, during earlier tests, to several lengthy heating and cooling cycles, and to numerous wetting and drying cycles without boiling the insulation. The insulation had a semi-rigid molded characteristic before the boiling test and the fibers were brittle and broken into short pieces near the pipe.

Boiling Procedure

The ends of the system were sealed so it could be filled with water. The water level was indicated by an external sight glass and makeup water was added to replace that evaporated to maintain the water level at the top of the insulation space. Steam was introduced into the 4-inch pipe at a pressure of 125 psig and the pressure was maintained for 72 hours. The steam generated inside the conduit was vented to the atmosphere through two vertical 2 x 3-inch ducts placed, one at each end of the test specimen, at the top of the cylindrical arch tile forming the top of the conduit. The vertical leg of the two vents was about 4 feet long.

mostre la capacità di avere buone relazioni con le autorità e di non essere un pericolo per la sicurezza pubblica. Se invece quel che è in gioco sono i diritti civili, il giudizio deve essere fatto sulla base della legge.

of Alfred Walling's original publications and their modifications will indicate somewhat of his "methodology" for obtaining biological knowledge. He believed in self-education and utilized available native plants, animals and published and recorded aboriginal accounts alongside a few rare books among those used for fine studies were standard self-teach-

Test Results

Fig 19 shows the appearance of the insulation in the conduit after boiling 72 hours. The dark streak at top center is a copper tube used at one time to introduce water to the insulation.

Fig 20 shows the appearance, at the downstream end, of the insulation. The 4 in. pipe is exposed for about 1/2 of its circumference on the lower side. There was considerable loss of insulation only near the outlet end for a distance of about 3 ft. A small amount was also lost at the inlet end. Apparently the insulation was carried out of the vertical vent pipes by the surging water and steam. Some pulverized glass fibers were found in the vent pipe at the end of the test. Except for the loss indicated above, there was little evidence of any voids in the remainder of the insulation.

Companies will be established with no shareholders and shares of 100 million each. The new shareholders will be the state and a fund of billion rupees which will be used to implement the new law by April 2014.



Figure 19



Figure 20

U. S. DEPARTMENT OF COMMERCE

Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. Astin, *Director*



THE NATIONAL BUREAU OF STANDARDS

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

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

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

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

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. 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. Plastics. Dental Research.

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

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

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer.

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

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog 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. VHF Research.

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

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

