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DOW-727

R & D REPORT

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CRI NUMBER 73 3468

LABORATORY REPORT CODE: NCT-5517

DATE ISSUED: 6-28-73

DEPARTMENT: COMPUTATION RESEARCH - THERMAL RESEARCH

LAB. NO.: 5 8 1 PROBLEM NO.: 0 6 0 2 0 4 0

TITLE: Specific Heat of Asbestos - 15% Latex Sheet

PAGES IN FULL REPORT

AUTHOR(S): R. A. McDonald

AUTHOR(S) SIGNATURE(S): R A McDonald

REVIEWER'S SIGNATURE: R. Klimpel

This report is: [ ] INTERIM [x] FINAL and mainly: [x] NEW [ ] REVIEW

CRI NUMBER 73 3468

DESCRIPTIVE SUMMARY WITH CONCLUSIONS: (Include in this space references to data books, and to earlier related reports, patents and publications.)

D. M. Blake, Designed Products TS&D, requested the specific heat measurement at 150 and 180°F on a sample of an asbestos-latex sheet material supplied by Nicolet Industries, Inc. The 15% latex content was said to be Dow SD655 latex or a blend of that and XD8131 latex.

The specific heat was determined by comparison with standard reference α-Al_2O_3 in a differential scanning calorimeter. The values at 150 and 180°F are read from a curve through the plot of the experimental points. See the attached Figure 1.

°F	BTU/(lb. °F)
150	.295
180	.304

A slight weight loss and a slight exothermal drift were noticed during the measurement.

ST02843315

JUN 29 1973

[redacted]

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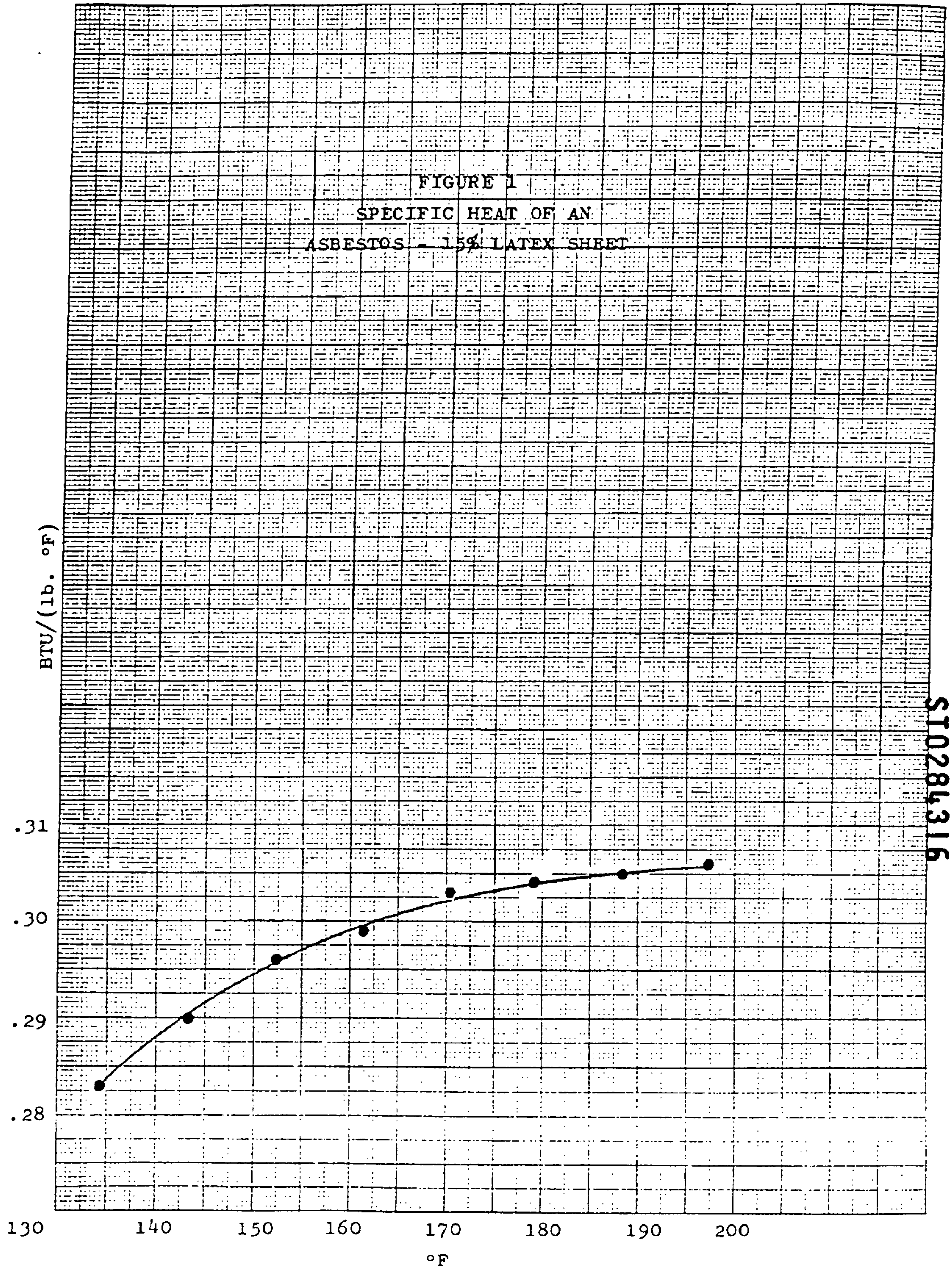
FIGURE 1
SPECIFIC HEAT OF AN
ASBESTOS - 15% LATEX SHEET
BTU/(lb. °F)
.31
.30
.29
.28
130
140
150
160
170
180
190
200
°F

16a. B- 16,339
PG. 1

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RELEASE OF TECHNICAL INFORMATION
(Numbers 1 - 15, 22 - 24 for originators of request; 16 - 21 for reviewers)

1a. Title of Proposed Talk, Publication or Release SIMULATED PLANT FIRE TESTING OF PIPE INSULATION SYSTEMS

1b. Request for release of ☐ Title only ☐ Abstract only ☒ Full text

2. Author(s) William J. McMillan

3. Return request to: Name W.J. McMillan Phone No. 6-3512
Address

4. Date submitted to sponsor May 23, 1973

5. Final release decision required no later than June 1, 1973

6-13. See page 2.

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Responsible line manager DLG Date

Indicate appropriate reviewers in (16b on page 2) and forward to ~~Corporate R&D, 2020~~ Bldg., Midland, Mich.

16c. Corporate R&D will assign B-number, and send to reviewers designated in 16b. CENTRAL REPORT INDEX

17-18. See page 2.

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☒ Approved for release, note comments if made
☐ Approved for limited release and/or only after revisions are made

describe

☐ Not approved for release
reasons

D L Graham 6/3/73
Signature Date

20. Classification: ☐ A, primarily research; ☐ B, non-research; ☐ C, Associated research, Rocky Flats; ☐ D, Analytical; ☐ E, Sales; ☐ F, General, review; ☐ G, other

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22. Final approved draft. I have complied with the conditions stated above; the originally submitted manuscript has been changed to this final form and will be submitted, published and/or presented in this form.

RECEIVED JUN 5 1973 CRI

Signature Date

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This Form replaces Stock Form C-10550, printed R-1-67 and R3-68.

Title SIMULATED PLANT FIRE TESTING OF PIPE INSULATION SYSTEMS
Authors W. J. McMillan

ST02843117

SIMULATED PLANT FIRE TESTING

OF

PIPE INSULATION SYSTEMS

by

William J. McMillan

In industrial plants, particularly in the petrochemical industries, accidental plant fires involve burning liquid hydrocarbons, many of them lighter than water. Thus, the consideration of a large flame area with rapid temperature rise and flame impingement directly on pipes is of paramount importance in pipe insulation systems design.

Small scale comparison tests of insulation materials may provide a rating for combustibility or fire resistance, but they will not establish the performance of pipe insulation in a fire. Recognizing the inadequacy of point impingement flame tests and radiant heat exposure to forecast pipe insulation behavior; the Union Carbide Corporation in the early sixties initiated an outdoor fire resistance test to simulate plant fire conditions. This test exposed pipes and insulation systems to approximately thirty square feet of flame area having temperatures tailored to the ASTM E-119 Standard Time-Temperature Curve. The results of these tests were reported[1] by Durbin H. Way and Carlos J. Hilado in 1968. During the past two years research at The Dow Chemical Company duplicated and modified the Union Carbide test procedure.

The fire resistance of pipe insulation systems is determined by suspending 20 feet of insulated 3" diameter steel pipe over a 4 x 12 foot steel fire pan containing water with burning gasoline on its surface. A schematic of the test apparatus is shown in Figure 1. Five insulated pipes may be tested simultaneously. The gasoline feed rate to the underwater sparger in the bottom of the fire pan is continuously monitored to produce a flame temperature rise which coincides with the ASTM E-119 Standard Fire Temperature Curve. After burning for one hour, the fire is allowed to burn out and the insulation inspected. The impact of water on the insulation is simulated by re-igniting the fire and after five minutes spraying the insulation with water from a fire hose until the fire is extinguished.

The pipe temperature rise is measured by a thermocouple in the pipe surface midway between the pipe ends. Although these tests were conducted within a specially designed building, the flame temperature and profile were sensitive to weather conditions and required constant monitoring and control by adjustment of the fuel flow and draft profile. The variation in flame profile and intensity also made it necessary to measure the flame temperature immediately adjacent to each pipe. The flame temperature thermocouples are mounted within a 4" length of stainless steel pipe to modulate the thermocouple sensitivity.

Fire resistance is expressed as the time required for the insulated pipe to reach a forecast failure temperature or as the pipe temperature after a given fire exposure time. The desired minimum fire resistance for pipe insulation for the petro-chemical industry has been arbitrarily selected as one hour for the pipe temperature to reach 1000°F. However, a specific fire resistance should be selected for each installation.

The variation in flame temperature from the ASTM E-119 Standard Time-Temperature Curve, from pipe to pipe and test to test, is corrected by application of a deviation factor to the temperature and or time. The deviation factor is expressed as the ratio of the area under the flame temperature curve to the area under the ASTM E-119 Standard Time-Temperature Curve. When computing the deviation correction only that portion of the Time-Temperature Curve for the time period under consideration is used. The test is considered invalid if the flame temperature curve for the duration of the test deviates from the ASTM E-119 curve by more than ten percent.

When five pipes were insulated with one inch of a calcium silicate insulation and a ten mil stainless steel jacket; the insulation system was found to provide essentially one hour of fire resistance. Figure 2 shows the test in progress and the fire resistance curve is shown in Figure 3. The average variation in flame temperature was 360°F. The pipe temperatures varied by 92°F.

Because "white goods" normally shrink when exposed to high temperatures a double layer pipe insulation system is usually specified to provide satisfactory fire protection against direct flame impingement or direct radiation from the jacket. However, since ceramic and glass foam insulations expand rather than shrink when heated; a single layer of these materials will provide the required protection provided they are secured on the pipe with steel jacketing or bands.

With an external temperature rise of 2000°F and a pipe temperature rise from ambient to 1000°F; calculations show that the expansion of the glass foam insulation exceeds that of the pipe and cracks for direct flame impingement are not formed. Also, in a three foot length of pipe the expansion of the pipe will not exceed that of ceramic foam insulation by more than 0.1". Past experience has shown the ceramic foam to fracture an average of each 6" under rapid external temperature rise; thus the potential crack due to a fire would be distributed over five fractures and would be approximately 0.02" which is insignificant for direct flame impingement consideration.

The difference in fire resistance between glass foam and ceramic foam becomes more obvious with increased flame exposure time. The glass foam, because of its lower softening temperature tends to sinter and shrink at temperatures where the ceramic foam remains essentially unchanged. The fire resistance of ceramic foam pipe insulation is shown in Figure 4. Ceramic foam pipe insulation 2" thick with proper covering will provide the desired one hour of fire resistance.

From the tabulated fire resistance shown in Table I of various high and low temperature jacketing systems for two inches of ceramic foam, the fire resistance is not very sensitive to the jacketing material. The ceramic foam pipe insulation without a jacket spalled due to the rapid temperature rise and flame impingement during the first 14 minutes of the test. The loss of material reduced the fire resistance. The vinyl acrylic mastic did not readily burn and left a cement-asbestos like residue which protected the ceramic foam from spalling and left it intact under the jacket residue. The asphaltic mastic burned and dripped from the pipe but left a light-weight expanded residue. Some spalling occurred. The aluminum jacket had melted from the insulation within 12 minutes into the test. Banding with steel bands 12" on center instead of 6" on center allowed fragments of the foam to become dislodged from the pipe. The foam under the steel and asbestos felt jackets, although fractured, was intact after the test.

The "after fire" integrity and functionality of an insulation system is very significant when selecting an insulation system to minimize processing or production "down time" after a fire. Three inches of ceramic foam pipe insulation with an asphalt impregnated asbestos felt jacket banded with steel bands 6 inches on center did not change its fire resistance when exposed to three consecutive fire tests. The insulation was rejacketed between tests.

In a single test, a 6" diameter pipe insulation system composed of 24 ceramic foam segments approximately 1.7" wide bonded to an asbestos felt jacket, when banded 6" on center; was found to remain functional after the fire resistance test in that despite the small size of the segments, they remained firmly secured on the pipe even when the jacket residue was scraped off.

Plastic foam insulation is not usually considered as providing fire protection. However, some fire retardant rigid polyurethane foams by virtue of their char forming characteristics, do provide fire resistance, especially when installed with steel jacketing. Most of these rigid foams, once converted to carbon char by a high temperature, contract and rupture leaving a part of the pipe exposed to direct heat radiation or flame impingement.

One rigid polyurethane foam is unique in that when exposed to high temperature it concurrently melts, carbonizes, and intumesces thereby providing an essentially continuous carbon char insulation. Variance in the fire resistance of four commercial rigid polyurethane foam pipe insulations is shown in Figure No. 5. Each foam was 3" thick and was jacketed with 10 mils of vinyl coated steel. The better resistance is provided by the non shrinking type foam previously described.

The characteristic to melt, carbonize, and intumesce applies to vertical as well as horizontal surfaces. A vertical pipe insulated with 3" of rigid polyurethane foam and a steel jacket was included in one of the fire resistance tests and is shown during the test in Figure 6. The char formation did not melt and run out and provided fire resistance for longer than one hour.

Some rigid polyurethane foams continued to "punk" 20 minutes after the fire was extinguished, even when the fire was extinguished with water. The punking was usually ajacent to the pipe where a high temperature could be maintained. A punking characteristic is undesirable where there is a potential for fire re-ignition.

Five jacket materials for three inches of fire retardant rigid polyurethane foam pipe insulation were tested simultaneously. The results shown in Table 2 indicate that the fire resistance of a rigid polyurethane foam pipe insulation system correlates directly with the fire resistance of the jacketing. The fire resistance as a function of the foam thickness for a steel jacket system is shown in Figure 7.

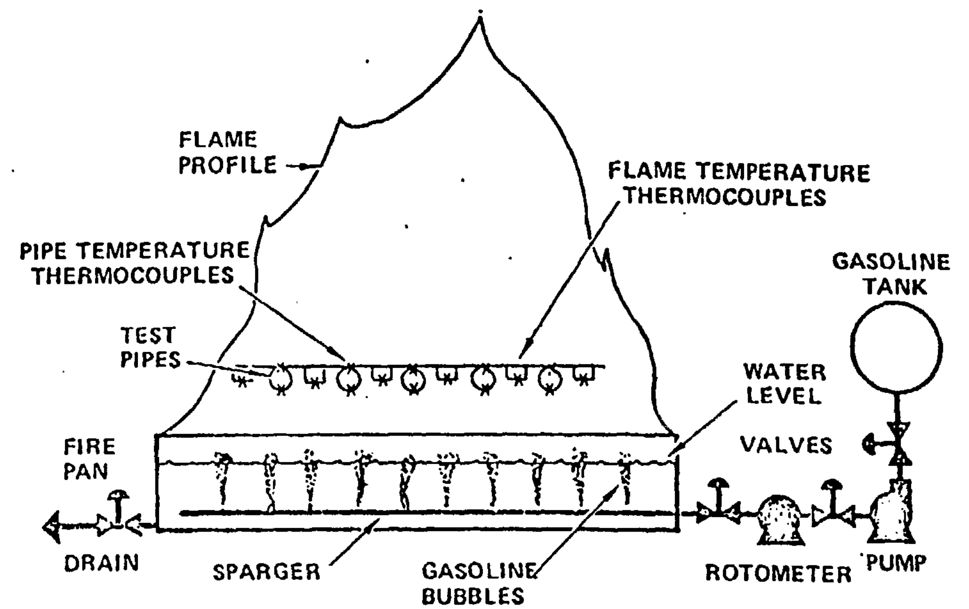
Since these fire resistance tests were run with empty pipes the fire resistance will be increased when the pipes are filled and should be extended considerably when the pipe contents are flowing. They should not be confused with established ASTM test procedures such as ASTM E-119 and ASTM E-84, nor should these test results be considered as guaranteeing pipe insulation performance in a fire. However, these test results can provide the basis for the selection of insulation materials and systems.

In summary, simulated plant fire testing of pipe insulation systems has shown that: (1) Rigid polyurethane foam insulation can provide fire resistance. (2) The fire resistance of polyurethane foam pipe insulation is a function of the jacketing material. (3) Single layer ceramic foam pipe insulation can provide fire resistance without flame impingement. (4) Ceramic foam pipe insulation can remain functional after a fire. The ability to forecast the insulation thickness required for fire protection becomes significant when the potential fire severity and heat insulation requirements are combined to determine the most economical thickness of insulation.

BIBLIOGRAPHY

1 - Durbin H. Way, and Carlos J. Hilado, Fire Technology 4:271-283 November 1968 and Journal of Cellular Plastics, 221-228 June 1968.

Figure 1



Equipment for Measuring Pipe Covering
Fire Resistance

(Not to Scale)

Figure 3

Fire Resistance of Calcium Silicate Pipe Insulation

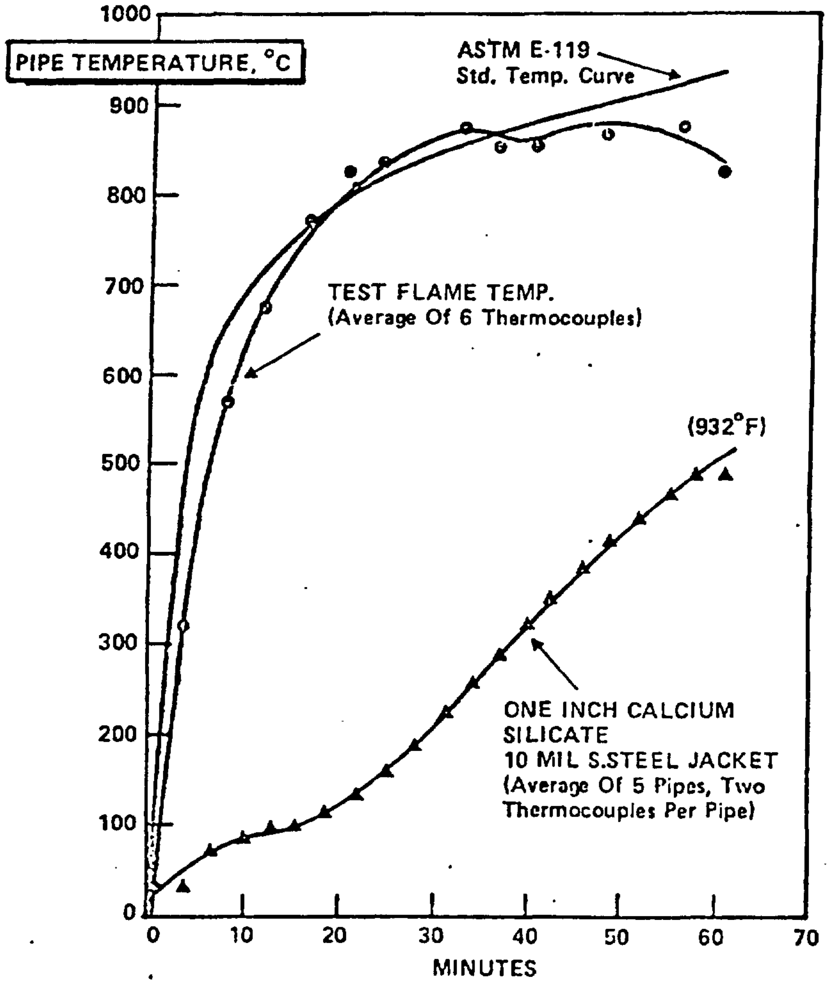


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Figure 4

Fire Resistance of Ceramic Foam Pipe Insulation

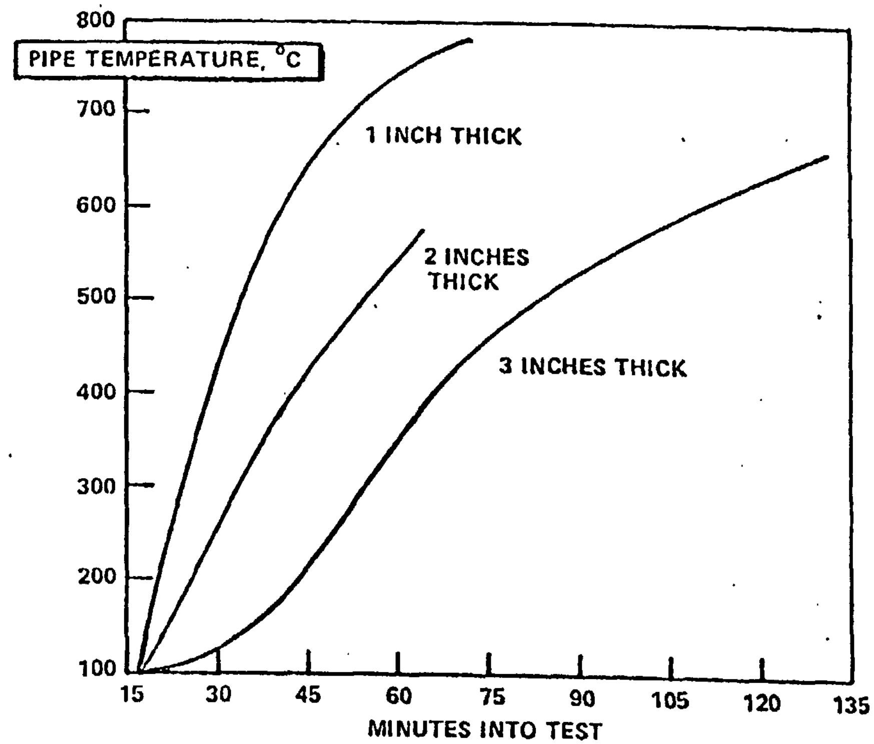

Table 1

FIRE RESISTANCE
TWO INCHES OF CERAMIC FOAM

System	Minutes To 1000°F Pipe Temperature
No Jacket	54
Vinyl-Acrylic-Mastic	65
Asphaltic Mastic	67
10 Mils Corrugated Aluminum	63
10 Mils Stainless Steel	66
Asbestos Felt	59

Figure 5

Fire Resistance of Three Inch Thick Rigid Polyurethane Foam Pipe Insulation

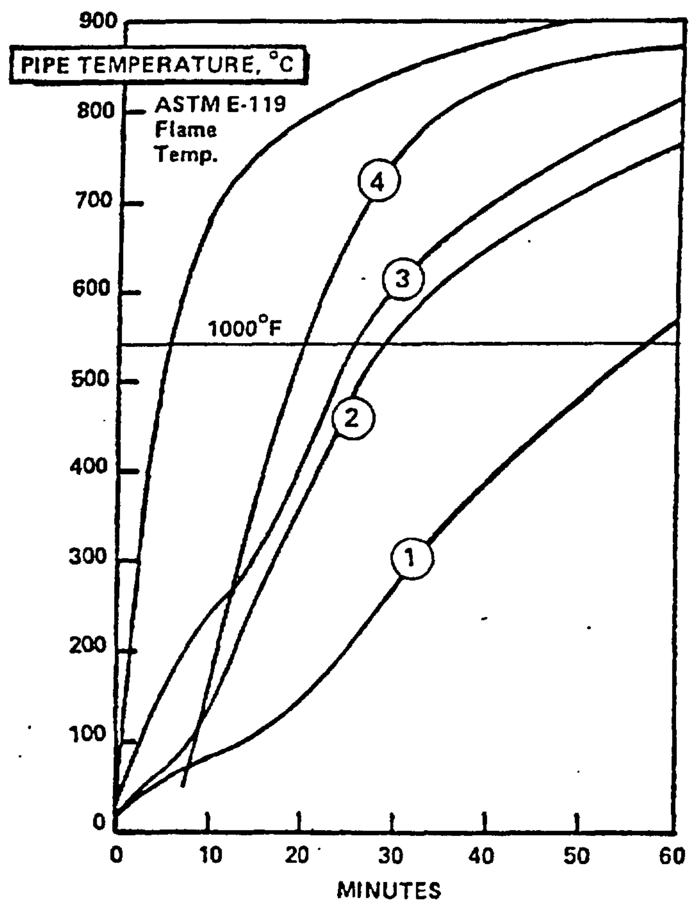

Table 2

Jacket	Minutes To 1000°F Pipe Temperature
10 Mil Polyvinyl Chloride	18
Paper/Aluminum Foil/ Skrim Laminate	22
26 Gage Aluminum	28
1/8" Reinforced Asphaltic Mastic	40
10 Mil Vinyl Coated Steel	58

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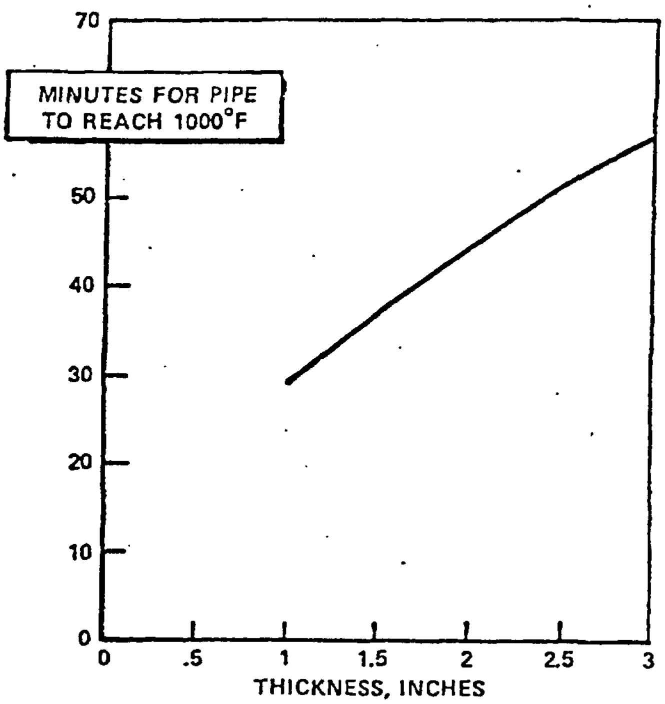
Figure 7

Fire Resistance as a Function of Polyurethane Foam Thickness



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☐ d. Tech. Center		☐	☐	☐		
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*Comments or limitations *With modification of p5 discussed with WJM 5 May 73* *RBI*

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