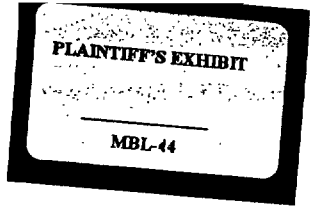

STATE OF MASSACHUSETTS

COUNTY OF MIDDLESEX, SS.

AFFIDAVIT

I, Edward T. Peters, being duly sworn according to law, hereby depose and says as follows:

1. I am a senior staff scientist in the Materials and Applied Physics Unit of the Product Technology Section of Arthur D. Little, Incorporated, Cambridge, Massachusetts. I have been a staff scientist at Arthur D. Little, Inc. since 1969.

2. Arthur D. Little, Incorporated, is a research firm experienced in the physical, structural and chemical characterization of materials.

3. I received undergraduate degrees from DePauw and Purdue Universities, a Master of Science degree from the University of Wisconsin and the degree of Doctor of Science in Metallurgy from the Massachusetts Institute of Technology.

4. I served as a member of the faculty in the Department of Metallurgical Engineering at the University of Wisconsin from 1958 to 1959.

5. From 1963 until 1969 I was employed by ManLabs Incorporated, in Cambridge, Massachusetts. At ManLabs, I specialized in the structural and physical characterization of materials.

6. I am a Registered Professional Engineer in the State of Massachusetts, a member of the American Society for Metals and the American Industrial Hygiene Association.

7. While at Arthur D. Little, Inc., I have been responsible for several laboratory based programs designed to evaluate and characterize materials as well as corporate responsibility for technical studies relating to asbestos.

8. I have written several papers on materials characterization as well as lectured numerous times on the subject.

9. Arthur D. Little, Inc., was retained by Mobil Oil Corporation to test an asbestos-containing product known as Hi-Heat Dum Dum to evaluate any occupational exposure during product application or removal.

10. The attached report describes the results of a study carried out under my direction to evaluate personal exposure to asbestos in working with Hi-Heat Dum Dum. The report accurately sets forth the methodology of the study and the conclusions I reached as a result of the experiments performed.

Edward T. Peters

Edward T. Peters

Sworn and subscribed to, before me, this 19th day of June, 1990.

Elaine M. Kenney

Elaine M. Kenney
Notary Public

My Commission Expires: 7/9/93

Evaluation of Asbestos Release from Chimney Weatherproofing Mastic During Application and Removal

By

Arthur D. Little, Inc.
Acorn Park
Cambridge, MA 02140-2390

1992

Reference No. 65191

Arthur D Little

Product Background

From the mid-1960's through the 1970's, Mobil Chemical Company manufactured and sold a line of mastic-type protective coatings under the name Dum Dum® Products. Chimney Dum Dum was a protective and waterproofing coating specially formulated for use on concrete and brick chimneys where heat resistance up to 210°F is required. The Mobil Chemical Product Catalog states:

> "Chimney Dum Dum/97 Series Chimney Dum Dum is a rugged heavy coating for the exterior of chimneys that provides flexible weatherproof protection. It fills and bridges hairline cracks with a flexible coating under a tough outer skin. Should the leathery skin become fractured, the soft under film will harden on contact with air. May be applied without completely cooling stack."

Chimney Dum Dum consists of a resinated vegetable oil vehicle, containing 41% pigments, including titanium dioxide, mica and the chrysotile form of asbestos; the total solids content is 63%. Application is by brush, or more typically, by spray. At 75°F, the surface skins over in 4-6 hours, and the under surface remains pliable. Resistance to chemical fumes and moisture is very good to excellent and the product is resistant to constant dry heat at 210°F.

Product Testing During Application and Removal

To determine if asbestos is released during the application or removal of Chimney Dum Dum, approximately 18 gallons of the product was prepared on the basis of the formula master and mixing instructions provided by Mobil. The oil base resin was no longer commercially available, and a special batch was prepared for us by McWhorter Corp. All other components were obtained commercially. The product was made with a Myers mixer in 6 gallon batches which were subsequently combined, blended and stored in 5 gallon pails. The prepared product was observed to be smooth and uniform in appearance and of mastic consistency. This work, as well as subsequent application and removal experiments, was conducted at our facilities in compliance with all current United States and Massachusetts rules and regulations relating to asbestos and in accordance with an approved Arthur D. Little, Inc. Health and Safety Plan.

A test plan was developed to simulate typical work practices for product application and removal[1]. In addition, a sampling and analysis protocol was developed to

[1]Although intended for exterior use, this product was tested in an interior (controlled) environment.

Table 1 Asbestos Exposures During Application and Removal of Chimney Dum Dum®			
Sample No.	Description	Sample Type	Exposure (s/cc)[4]
052802	Application	Personal	0.088
052803	Application	Personal (replicate)	0.024
052805	Application	Area	0.024
062001	Removal	Personal	<0.01
062002	Removal	Personal (replicate)	<0.01
062003	Removal	Area	<0.01

Conclusions

The conclusions reached in this study are as follows:

- Remanufactured Chimney Dum Dum was smooth and uniform with mastic-like consistency.
- Application to brick and concrete panels required heavy duty mastic spray apparatus.
- After 23 days of aging (14 days at 200-210°F), the product was skinned over but pliable and elastic when depressed with a tool.
- Results of worker exposure measurements during application of Chimney Dum Dum in a controlled environment were below the current OSHA action level[5].
- Results of worker exposure measurements during removal of Chimney Dum Dum in a controlled environment did not exceed the minimum detection limit of 0.01 structures/cc.
- Based upon the above results, there is insignificant occupational exposure to airborne fibers during the application of Chimney Dum Dum and virtually no exposure to airborne asbestos fibers during the removal of this product.

[4]Asbestos structures per unit volume of air. The structures observed were fibers (or fibers and bundles, corresponding to the EPA definition).

[5]OSHA defines action level as "an airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals, of 0.1 fiber per cubic centimeter (f/cc) of air calculated as an eight (8) hour time weighted average" (29 CFR 1910.1001, promulgated June 20, 1986).

Evaluation of Asbestos Release from Boiler Caulking During Application and Removal

By

Arthur D. Little, Inc.
Acorn Park
Cambridge, MA 02140

June 1990

C-65191

Arthur D Little

447856

06085

Product Background

High temperature resinous caulking materials of mastic (putty-like) consistency are used in sealing joints and crevices on furnaces and boilers to prevent heat loss. Mobil Chemical Company manufactured and sold such a caulking product from the mid-1960s through the 1970s called Hi-Heat Dum Dum. This product, No. 46-F-7, consisted of a linseed oil-base vehicle (resin) containing various solid fillers, including clay and the chrysotile variety of asbestos (added for its resiliency and bridging properties). The Mobil Chemical Products Catalog provides the following description:

> "Hi-Heat Dum Dum/46-F-7, a heavy semi-plastic fibred coating, which acts as a joint sealer and pliable gasket for boilers, furnaces and dry kilns. Improves boiler efficiency by preventing heat loss. Retains its elasticity at consistent heat up to 175° and intermittent heat to 350°. May be used as a complete cover to eliminate excess fuel consumption and can be painted over in 24 hours."

The purpose of a joint or crevice sealant is to bridge gaps between the furnace enclosure and attachments (doors, ports, flanges, etc.). This requires a product that is pliable and resilient (i.e., withstands shock without permanently deforming, tearing, rupturing or pulling away from the furnace surface), and does not degrade over time by becoming friable[1]. The resinous formulation of Hi-Heat Dum Dum provides these properties and also effectively encapsulates the asbestos component, preventing its release.

Product Testing During Application and Removal

Hi-Heat Dum Dum was tested by Arthur D. Little, Inc. to determine if asbestos was released during application or removal. Approximately 30 gallons of 46-F-7 Hi-Heat Dum Dum was remanufactured, as observed by Arthur D. Little, Inc. staff who provided chain-of-custody transmittal to our facility. Experiments (described below) were conducted at our facilities in compliance with all current United States and Massachusetts rules and regulations relating to asbestos and in accordance with an approved Arthur D. Little, Inc. Health and Safety Plan.

A test protocol was developed to simulate typical work practices for product application and removal. Since these experiments involved an asbestos containing product, precautions were taken so that experimenters and the ambient environment were fully protected from any potential release of asbestos fibers. A sampling and analysis protocol was developed to quantify the extent to which asbestos fibers may

---

[1]The U.S. Environmental Protection Agency defines friable as "capable of being crumbled, pulverized, or reduced to powder by hand pressure".

be released during the experimental application and removal activities[2]. This protocol was designed so that all applicable OSHA, NIOSH and EPA requirements were met or exceeded. The minimum detection limit for the analytical protocol was 0.01 fibers/cc[3].

To evaluate the release of asbestos during product application and removal, steel panels (1/32 inch thick 1040 steel, cleaned and degreased, measuring about 2 1/2 x 3 1/2 feet) were coated by troweling at an estimated thickness of 1/8" (and feathered at the panel edges). Approximately 15 panels were coated during each of two 80-minute application experiments. Personal exposure samples were collected during both experiments.

After product application, the Hi-Heat Dum Dum was heated to accelerate the natural aging process. During preliminary laboratory furnace experiments with coated steel coupons, we observed that the product discolored from a neutral grey to a dark chocolate brown after one day at 350°F and to a medium brown after four days at 265°F, indicating chemical modification of the resin by oxidation. Even after these exposures to temperatures which exceeded the recommended continuous use temperature, the product remained pliable and gummy when probed with a screwdriver. Although the product was designed for a continuous temperature of 175°F, a treatment of two weeks to dry, flowing air at 250°F was chosen to not only accelerate aging but also to account for intermittent temperatures greater than 175°F.

After accelerated aging (actual conditions were 225-250°F for 18 to 23 days), product removal experiments were conducted using a putty knife and scraper. Although the thicker, centrally coated area of each panel was very pliable and quite easily removed, the feathered edge regions were somewhat harder and required substantial mechanical effort to scrape down to the bare metal. Approximately 10 panels were cleaned in each of three, separate 80-minute experiments during which personal filter samples were collected.

The personal filter samples were prepared and analyzed by transmission electron microscopy. The results of these analyses are given in Table 1.

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[2]Fiber is defined as a particle 5μm or more in length with substantially parallel sides and an aspect ratio (length to width) of three or more.

[3]The minimum detection limit (MDL) is the concentration where occupational exposure can not be differentiated from general background.

Table 1

Asbestos Exposures During Application and Removal of Hi-Heat Dum Dum: Personal Samples Analyzed by Transmission Electron Microscopy

Sample No.	Description	Exposure (s/cc)[4]
042504	First Application	<0.01
042604	Second Application	<0.01
051703	First Removal	<0.01
051705	First Removal (replicate)	<0.01
052203	Second Removal	<0.01
052207	Third Removal	0.01

Conclusions

The conclusions reached in this study are as follows:

- Hi-Heat Dum Dum is non-friable and provides encapsulation of asbestos during application and removal experiments.
- Exposure of the product to 225-250°F for 18 days changes its color from a natural gray to a chocolate brown, indicating oxidation of the resin (overheating). Even so, the product was elastic and pliable except at the feathered, thin edges where it was hardened but not friable.
- Results of worker exposure measurements during use of Hi-Heat Dum Dum did not exceed the minimum detection limit of 0.01 asbestos structures/cc in either product application or product removal experiments.
- Based upon the above results, there is no potential for occupational exposure to free asbestos fibers during the application, removal or other use of Hi-Heat Dum Dum.

[4]Exposure represents asbestos structures per unit volume of air. Structures include fibers, bundles (an arrangement of parallel fibers that touch), clusters (an arrangement of random fibers that touch) and matrix (a fiber or fibers embedded in particulate).

Appendix A
Photographs

Exhibit No.	Description
1	Hi-Heat Dum Dum as Applied and Aged at Ambient Temperature for 20 Days.
2	Hi-Heat Dum Dum as Applied and Aged at 225-250°F for 20 Days.

Evaluation of Asbestos Release from Exterior Masonry Weatherproofing Mastic During Application and Removal

By

Arthur D. Little, Inc.
Acorn Park
Cambridge, MA 02140-2390

1992

Reference No. 65191

Arthur D Little

Product Background

From the mid-1960's through the 1970's, Mobil Chemical Company manufactured and sold a line of mastic-type protective coatings under the name Dum Dum® Products. Dum Dum Masonoc/Series 95 was a restoration product for weatherproofing masonry structures. The Mobil Chemical Product Catalog states:

> "Dum Dum Masonoc/95 Series Masonoc is a heavy bodied textured coating designed as a weather seal, waterproofing, and restoration coating for all types of masonry structures. Pliability and elasticity allow for building movement without cracking of the coating while a tough outer skins provides protection for normal usage. Its high build qualities permit hairline cracks to be bridged and sealed, and surface irregularities to be filled and uniformed.
>
> Masonoc also provides fine protection for steel with its high film build and impermeability. Its excellent surface wetting properties recommend use of this material in areas that cannot be cleaned too well, where there are numerous angles and edges to protect, or when a single coat application is all that can be provided."

Masonoc consists of a resinated vegetable oil vehicle with about 22% solid fillers (by weight), including titanium dioxide, the chrysotile form of asbestos and various coloring pigments; the total solids content is 42 percent by volume. After application, Masonoc skins over in 1 hour, but the undersurface remains pliable to allow for expansion and contraction. The Mobil Chemical Product Data Sheet for Dum Dum Masonoc claims excellent resistance to dry heat (to 150°F), weather extremes, chemical fumes, moisture and salt air.

Product Testing During Application and Removal

Three 5 gallon pails of Dum Dum Masonoc (soft white 95-W-9) were obtained from an electric utility seeking information on product disposal. A sample was taken from one pail, about a third full, and ashed at 500°C. Microscopic analysis of this ash confirmed the presence of the chrysotile form of asbestos. The other two pails were intact with no visible signs of having been opened. After thorough mixing and being satisfied that the product viscosity was in the range of a mastic, these two pails of Masonoc were used for application and removal experiments. This work was conducted at our facilities in compliance with United States and Massachusetts rules and regulations applying to asbestos and in accordance with an approved Arthur D. Little, Inc. Health and Safety Plan.

A test plan was developed to simulate typical work practices for product application and removal[1]. In addition, a sampling and analysis protocol was developed to

[1]Although intended for exterior use, this product was tested in an interior (controlled) environment.

quantify the extent to which asbestos structures[2] may be released during the experimental application and removal activities. This protocol was designed so that all applicable NIOSH and EPA requirements for analysis by transmission electron microscopy were met or exceeded. The minimum detection limit for the analytical protocol was 0.01 structures/cc[3].

To evaluate the release of asbestos during product application and removal, concrete panels 4 feet by 2-1/2 feet by 1-1/2 inch were prepared in wooden frames and cured for 42 days. The panels were then each coated with Masonoc Primer 47-W-21, "a clear 100 percent solid heat resistant penetrating primer", dried overnight and then coated with Dum Dum Masonoc, using a Binks 7E2 spray gun and 2 gallon pressure pot, to a thickness of approximately 30-40 mils. Approximately 15 panels were coated during each of two 80 minute application experiments. Personal exposure and area air samples were collected during both experiments. The area sample was located about 10 feet from the worker (sprayer) at an elevation of 5 feet.

After product application, the coated panels were stacked (with spacers), allowed to dry for 24 hours and were then moved to an oven and exposed to flowing dry air at 150°F (the maximum recommended use temperature) for 42 days to accelerate the aging process followed by an additional 67 days at ambient conditions.

After aging, the product was found to be pliable and elastic when pressed with a screwdriver blade. A product removal experiment was performed using a putty knife and scraper. Eight panels were cleaned over an approximately 80 minute period during which personal samples were collected. After a further ambient aging period of 168 days (a total of 278 days after application), and again observing the product to be pliable and elastic, a second replicate removal experiment was performed on ten panels.

The collected filter samples from these experiments were prepared and analyzed by transmission electron microscopy. The results of these analyses are given in Table 1. These results may be overstated compared to actual exposures which would occur in an open air environment. As such, they are considered to represent a "worst case" condition.

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[2]Asbestos structures are defined herein as particles 5μm or more in extent that satisfy the counting guidelines given in 40 CFR Part 763 Asbestos-Containing Materials in Schools, Appendix A, Figure 5 (Federal Register 52 (210) October 30, 1987, 41866-41867). Structures include fibers, bundles, clumps and matrix. OSHA regulates exposure to fibers, which are defined as "a particulate form of asbestos, tremolite, anthophyllite or actinolite, 5 micrometers or longer, with a length-to-diameter ratio of at least 3 to 1" (29 CFR 1910.1001).

[3]The minimum detection limit (MDL) for this experiment is the concentration where occupational exposure cannot be differentiated from general background.

Table 1 Asbestos Exposures During Application and Removal of Dum Dum Masonoc®			
Sample No.	Description	Sample Type	Exposure (s/cc)[4]
072701	First Application	Personal	0.01
072702	First Application	Area	<0.01
072703	Second Application	Personal	<0.01
072704	Second Application	Area	<0.01
111406	First Removal	Personal	<0.01
111407	First Removal (replicate)	Personal	<0.01
111403	First Removal	Area	<0.01
050104	Second Removal	Personal	<0.01
050107	Second Removal (replicate)	Personal	<0.01
050105	Second Removal	Area	<0.01

Conclusions

The conclusions reached in this study are as follows:

- After thorough mixing, the obtained pails of Dum Dum Masonoc®, confirmed to contain chrysotile asbestos, were smooth and of mastic consistency.
- Application to concrete panels required heavy duty mastic spray apparatus.
- After aging at 150°F for 42 days and additional periods of 67 and 168 days at ambient conditions, the product was observed to be pliable and elastic when depressed with a tool.
- Results of worker exposure measurements during application and removal of Dum Dum Masonoc® in a controlled environment did not exceed the minimum detection limit of 0.01 structures/cc.
- Based upon the above results, occupational exposure to airborne asbestos fibers during the application or removal of Dum Dum Masonoc® is virtually non-existent.

[4]Asbestos structures per unit volume of air.

removal activities[2]. This protocol was designed so that all applicable NIOSH and EPA requirements for analysis by transmission electron microscopy were met or exceeded. The minimum detection limit for the analytical protocol was 0.01 fibers/cc[3].

To evaluate the release of asbestos during product application and removal, steel panels (1/32 inch thick 1040 steel, cleaned and degreased, measuring about 2 1/2 x 3 1/2 feet) were coated by troweling at an estimated thickness of 1/8" (and feathered at the panel edges). Approximately 15 panels were coated during each of two 80-minute application experiments. Personal exposure samples were collected during both experiments.

After product application, the Hi-Heat Dum Dum was heated to accelerate the aging process[4]. The neutral gray of the as-applied coating changed in color to a chocolate brown (225-250°F for 20 days).

After aging, product removal experiments were conducted using a putty knife and scraper. Although the thicker, centrally coated area of each panel was very pliable and quite easily removed, the feathered edge regions were somewhat harder and required substantial mechanical effort to scrape down to the bare metal. Approximately 10 panels were cleaned in each of three, separate 80-minute experiments during which personal filter samples were collected.

The personal filter samples were prepared and analyzed by transmission electron microscopy. The results of these analyses are given in Table 1.

---

[2]Asbestos structures are defined herein as particles 5μm or more in extent that satisfy the counting guidelines given in 40 CFR Part 763 Asbestos-Containing Materials in Schools, Appendix A, Figure 5 (Federal Register 52 (210) October 30, 1987, 41866-41867). Structures include fibers, bundles, clumps and matrix. OSHA regulates exposure to fibers, which are defined as "a particulate form of asbestos, tremolite, anthophyllite or actinolite, 5 micrometers or longer, with a length to diameter ratio of at least 3 to 1" (29 CFR 1910.1001).

[3]The minimum detection limit (MDL) for this experiment is the concentration where occupational exposure can not be differentiated from general background.

[4]During preliminary laboratory furnace experiments with coated steel coupons, we observed that the product discolored from a neutral grey to a dark chocolate brown after one day at 350°F and to a medium brown after four days at 265°F. Even after these exposures to temperatures which exceeded the recommended continuous use temperature, the product remained pliable and gummy when probed with a screwdriver. Therefore, although the product was designed for a continuous temperature of 175°F, a treatment of two weeks to dry, flowing air at 250°F was chosen to not only accelerate aging but also to account for intermittent temperatures greater than 175°F. The actual conditions of exposure were 225-250°F for 18 to 23 days.

Table 1

Asbestos Exposures During Application and Removal of Hi-Heat Dum Dum: Personal Samples Analyzed by Transmission Electron Microscopy

Sample No.	Description	Exposure (s/cc)[5]
042504	First Application	<0.01
042604	Second Application	<0.01
051703	First Removal	<0.01
051705	First Removal (replicate)	<0.01
052203	Second Removal	<0.01
052207	Third Removal	0.01

Conclusions

The conclusions reached in this study are as follows:

- The Hi-Heat Dum Dum that was tested was found to be non-friable and provided encapsulation of asbestos during application and removal experiments.
- Exposure of the product to 225-250°F for 18 to 23 days changes its color from a neutral gray to a chocolate brown, indicating modification of the resin. Even so, the product was elastic and pliable except at the feathered, thin edges where it was hardened but not friable.
- Results of worker exposure measurements during use of Hi-Heat Dum Dum did not exceed the minimum detection limit of 0.01 asbestos structures/cc in either product application or product removal experiments.
- Based upon the above results, occupational exposure to airborne asbestos fibers during the application or removal of Hi-Heat Dum Dum is virtually non-existent.

[5]Exposure represents asbestos structures per unit volume of air.

Resiliency of Mobil Hi-Heat Dum Dum after High Temperature Exposure

By

Arthur D. Little, Inc.
Acorn Park
Cambridge, MA 02140-2390

1992

Reference No. 65191

Product Background

High temperature resinous materials of mastic (putty-like) consistency are used in sealing joints and crevices on furnaces and boilers to prevent heat loss. Mobil Chemical Company manufactured and sold such a caulking product from the mid-1960s through the 1970s called Hi-Heat Dum Dum. This product, No. 46-F-7, consisted of a linseed oil-base vehicle (resin) containing various solid fillers, including clay and the chrysotile variety of asbestos (added for its resiliency and bridging properties). The Mobil Chemical Products Catalog provides the following description:

> "Hi-Heat Dum Dum/46-F-7, a heavy semi-plastic fibred coating, which acts as a joint sealer and pliable gasket for boilers, furnaces and dry kilns. Improves boiler efficiency by preventing heat loss. Retains its elasticity at consistent heat up to 175° and intermittent heat to 350°. May be used as a complete cover to eliminate excess fuel consumption and can be painted over in 24 hours."

The purpose of a joint or crevice sealant is to bridge gaps between the furnace enclosure and attachments (doors, ports, flanges, etc.). This requires a product that is pliable and resilient (i.e., withstands shock without permanently deforming, tearing, rupturing or pulling away from the furnace surface), and does not degrade over time by becoming friable. The resinous formulation of Hi-Heat Dum Dum provides these properties and also effectively encapsulates the asbestos component, preventing its release.

Purpose of the Evaluation

The objective of the thermal exposure experiments was to determine the useful service life of Hi-Heat Dum Dum for temperatures within and above the recommended service temperature range described in the product literature.

Product Testing Experiments and Results

Approximately 30 gallons of 46-F-7 Hi-Heat Dum Dum was remanufactured, as observed by Arthur D. Little, Inc. staff who provided chain-of-custody transmittal to our facility. Approximately one pint was used for the tests described herein.

The aging experiments were conducted by filling steel fixtures with Dum Dum and placing the fixtures into ovens at different temperatures. The fixtures, consisting of a steel ring spotwelded to a piece of sheet steel, provided for a one inch diameter and three different thicknesses of the material - 0.062 inches, 0.125 inches and 0.187 inches. Fifteen fixtures of each thickness were prepared for a total of 45 fixtures, individually numbered by stamping.

Each fixture was tared on an analytical balance (scale) that measured the weight to 0.0001 grams. The fixtures were then filled with the Dum Dum product, reweighed to determine the

weight of the Dum Dum in the fixture and placed into ovens in triplicate at temperatures of: 175, 250, 350, 425 and 500 °F.

The three replicate samples at each thickness represented a total of nine samples at each temperature. At times of 22, 46, 70, 93.5, 133.5, 400.5 and 763 hours, the samples were removed from the ovens, allowed to cool to room temperature and again weighed. The percent change from initial weights are provided in Table 1.

All of the samples underwent a change in the original natural gray color after aging. The colors ranged from a darker gray (175°F) to chocolate brown (250°F) to dark brown (350°F) to black (425°F and 500°F). During the initial heating of the 500°F samples, smoke was emitted from the oven leading us to believe that the solvent within the sample ignited and burned. The surface of the 500°F samples became swollen and expanded out of the fixture in a spherical shape. This occurred to a lesser extent for the 425°F samples.

The samples also exhibited surface hardening. To determine any product brittleness or friability, we tested the flexibility of five samples aged for 763 hours by a bending experiment. For this purpose, a test sample was cut from the fixture such that there would be no interference from the fixture on the bend experiment. The tests were done using a three point bend fixture on an Instron 1332 mechanical testing machine with a 1000 pound load cell. A schematic representation of the bend condition is shown in Figure 1. Crosshead displacement control was used with a displacement rate of 0.1 inches/minute. The applied load and the crosshead displacement was continuously recorded. Test events such as the onset of surface cracking were noted. The experimental results of the bend tests are given in Table 2.

Discussion

Hi-Heat Dum Dum contains about 10 percent by weight mineral spirits, to provide a suitable viscosity for application, and a linseed oil blend as the vehicle which may have some volatiles; the solids content is stated as 85 percent by volume. Loss in weight of Hi-Heat Dum Dum exposed to elevated temperatures occurs by evaporation of the solvent and oxidation (ablation) of the resinous vehicle.

To estimate the useful life of the product, defined as retention of flexibility as demonstrated by a strain of 1 percent, the observed loss in initial weight as a result of furnace aging experiments is plotted in Figure 2, where the averages for three thicknesses tested are pooled. After 22 hours of high temperature exposure, much of the solvent has evaporated, more so as the exposure temperature increases. For longer exposures at elevated temperature, the 175, 250 and 350°F exposures demonstrate a linear change in weight loss when plotted against the logarithm of exposure time. The samples aged at 350°F for 763 hours still exhibit a 1 percent strain in bending (Table 2), having lost 12.5 percent of initial weight, representing essentially all of the non-solids content of Hi-Heat Dum Dum. From the data, product life at a sustained temperature of 250°F is conservatively estimated at more than 10 years.

Exposures of Hi-Heat Dum Dum at temperatures greater than 350°F results in rapid degradation due to both very rapid evaporation of the solvent and oxidation of the resin. Further, exposure of this product to sustained temperatures of 350°F could result in product life as short as one month. Accordingly, the use of this product under conditions where it is exposed to consistent heat of up to 175°F and intermittent heat of up to 350°F is considered prudent.

Conclusions

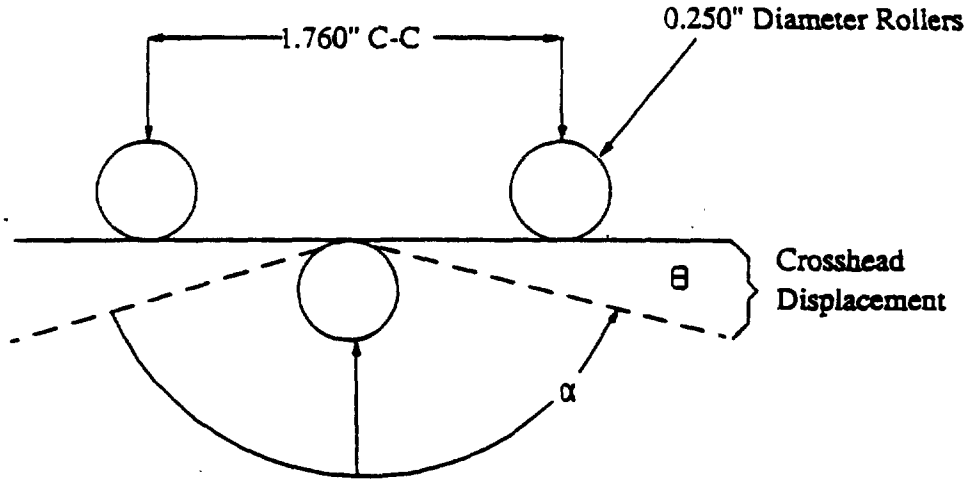
The conclusions reached in this study are as follows:

- Hi-Heat Dum Dum survives constant heating to 250°F and intermittent heating to 350°F and behaves as described in the product literature. Heating the Dum Dum above 350°F causes rapid loss in weight and probable failure of the product.
- After 763 hours of aging at 250 and 350°F, the product can be strained by one to one and a half percent, demonstrating that it has retained elasticity.
- Based upon extrapolation of the data, Hi-Heat Dum Dum is expected to retain its elasticity for more than 10 years when used in accordance with the manufacturers recommendations.

Table 1 Hi-Heat Dum Dum: Percent Weight Loss (Average of 3 Samples)							
Temp.	Time - Cumulative Hours at Temperature						
(°F)	22	46	70.5	93.5	133.5	400.5	763
Thickness = 0.063"							
175	8.90	8.95	8.87	8.87	8.94	9.52	8.99
250	9.47	9.50	9.55	9.57	9.65	9.93	9.75
350	9.91	10.67	10.91	11.00	11.39	12.10	12.18
425	10.96	11.73	12.07	12.34	12.74	14.65	16.11
500	14.60	18.39	21.36	23.98	28.47	40.41	45.53
Thickness = 0.125"							
175	7.86	8.92	9.27	9.43	8.94	9.52	9.79
250	8.88	9.51	9.71	9.73	9.65	9.93	9.95
350	10.24	10.86	11.02	11.13	11.39	12.10	12.10
425	11.04	11.55	12.17	12.80	12.74	14.65	18.98
500	15.08	17.35	22.28	24.98	28.47	40.41	45.24
Thickness = 0.183"							
175	6.25	7.79	8.52	8.90	9.31	10.13	10.00
250	7.79	9.21	9.71	9.82	10.05	10.27	10.27
350	9.68	10.50	10.75	10.90	11.15	11.90	13.31
425	11.21	11.70	12.25	12.68	13.94	16.42	18.28
500	14.15	16.87	19.41	21.75	24.22	37.88	44.30

Table 2 Hi-Heat Dum Dum: Flexibility after 763 Hours at Temperature					
			Angle of Deflection		
Sample	Thickness (inches)	Aging Temp. (°F)	Crack Starts at One End	Fully Cracked	Percent Strain
37	0.125	250	10	16	1.7
27	0.187	250	4	11	1.2
33	0.062	350	4	10	1.1
8	0.125	350	5	10	1.1
28	0.187	350*	N/A	N/A	N/A
* Material separated from steel holder.					

Figure 1
Schematic of Bend Test Conditions and Bend Angle Calculations



Crosshead Displacement

$\sin \theta = 0.5\ (1.760)$

$\alpha = 180° - 2\ \theta$

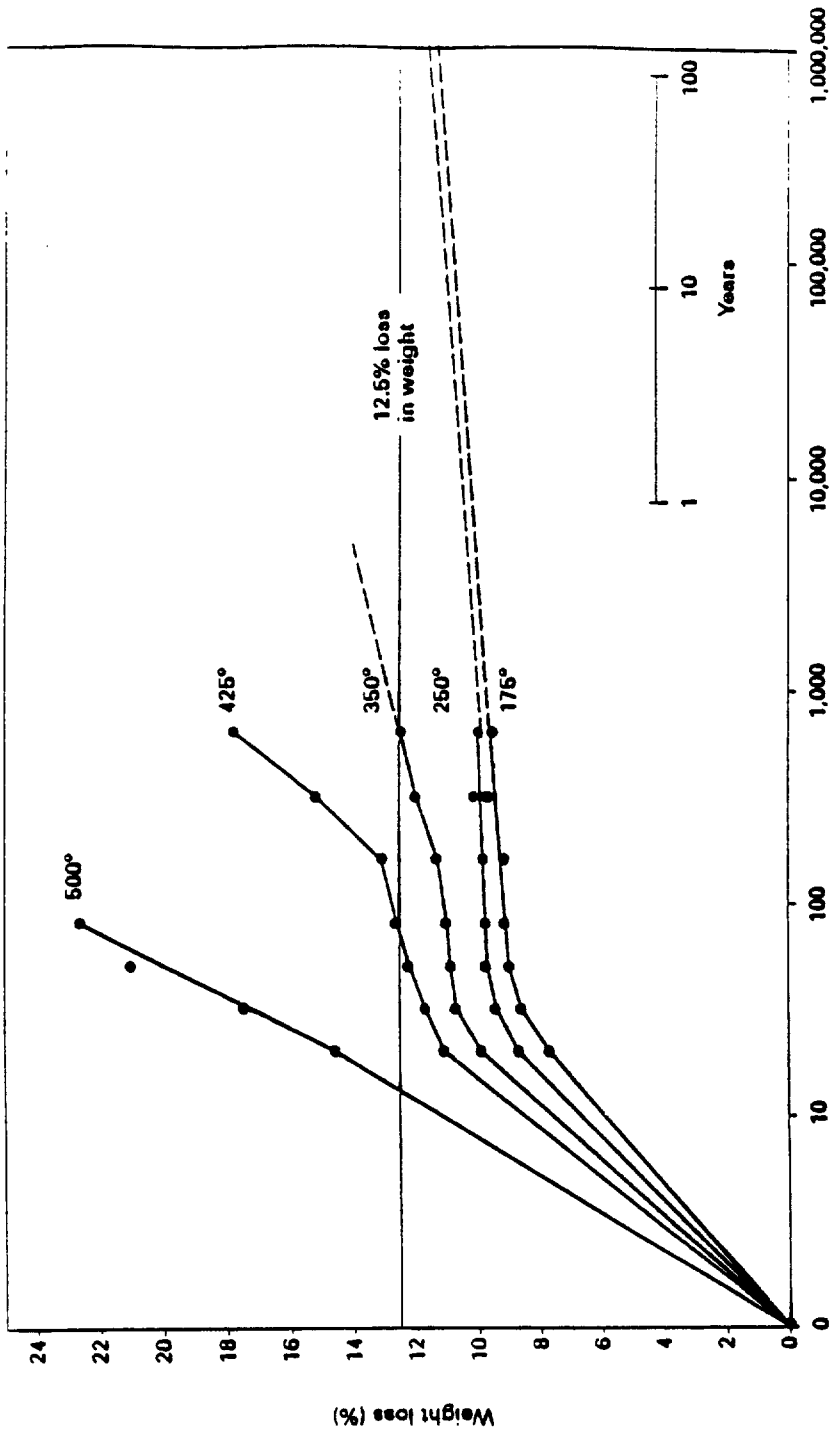


Figure 2. Hi-Heat Dum Dum Weight Loss with Time at Temperature

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