THE FIRE SAFETY OF LS NEOPRENE MATTRESSES IN INSTITUTIONS

by

R. H. Morford
Toyad Corporation
Latrobe, Pa.

Presented at:

International Conference
on Fire Safety

University of San Francisco
January 15, 1979

FIRE SAFETY OF NEOPRENE MATTRESSES IN PENAL INSTITUTIONS

There have been large numbers of fires caused by vandalism and arson of foam products such as mattresses in various institutions such as prisons, jails and mental institutions. These fires that have been responsible for many deaths, injuries and large property loss, have been the basis for many legal actions against the authorities responsible for the maintenance of the various institutions.

The following are some of those fires: Stratford Jail Canada, 5 deaths; Danbury Connecticut Federal Prison, 5 deaths, 66 injuries; Maury County Jail, 42 deaths; Prince George's County Jail, 15 injured.

The above factors have been responsible for many institutions and many agencies searching for a safer mattress material for institutional use. After much testing, both small and large scale, Neoprene foam has been selected for use in mattresses in many institutions.

The Toyad Corporation, a pioneer in manufacturing Neoprene foam, has developed a new Neoprene foam for this market. Toyad LS™ foam generates less smoke than the conventional RP foam without sacrificing any of the physical properties required for good mattress performance.

The base latex for this formula is an anionic chloroprene latex produced by Du Pont. The polymer in this latex is produced by an emulsion polymerization process with soaps formed "in situ" from the interaction of a resin-derived acid and an alkali metal hydroxide.(1)

The base chloroprene polymer is composed of carbon, hydrogen and chlorine of an approximate composition of 55% to 5% to 40%. Chloroprene polymers are difficult to ignite when subjected to an ignition source but they start to decompose when the temperature reaches approximately 240°C to produce carbon particles (smoke or char), H_2O, HCL, CO and CO_2. The burning characteristics of polychloropren are altered and improved by the presence of fillers and chemical additives. Thus, Neoprene foam compositions generally contain antimony oxide as a flame retardant and hydrated aluminum oxide to release water vapor to cool and delay ignition.(2). The use of compounding chemicals, and methods of compounding and curing have greatly reduced the potential for smoke production of LS Neoprene foam.

The conversion of this latex to a useful foam product involves the use of techniques adapted from natural rubber technology or more specifically the Dunlop process. Toyad uses a modified version of this process. The collodial system is sensitized and compounded with additives then frothed to the desired density for the finished product. The froth is poured into a mold and caused to gel to a permanent state by time controlled reaction of gelling agents. After gelation, the foam is dried and cured in a carefully controlled hot air atmosphere. The recipe can be varied within limits to produce products meeting a variety of specifications. This commercial product LS Neoprene foam is the subject of the remaining discussion.

In comparison to other products such as cotton and urethane foam used in institutional mattresses, LS Neoprene foam is more costly, but because of the excellent flammability characteristics, comfort and increased service life, the higher cost of the LS Product is justified in the opinion of many agencies.

Small-Scale Flammability Tests

Toyad's LS™ Neoprene foam has been subjected to the many laboratory or small-scale tests. The most common small-scale test used by many agencies is the Radiant Panel test, (ASTM E162-76). A one inch hexagonal screen is used in front of the sample and the sample is wrapped on sides and back with aluminum foil. A six inch pilot flame is used as an open flame ignition source. For a sample to qualify, there is a stipulation that there shall be no running or dripping of the sample during the test.

LS Neoprene foam is tested daily in the Toyad Laboratory and averages 4 to 8 Flame Spread Index.* Samples are sent to outside laboratories for certification and their results agree with the results obtained in the Toyad Laboratory. Toyad certifies that the rating on the foam will be maximum of 25 which is the number used by the various agencies. LS Neoprene foam has been tested in thicknesses up to 4 inches and while the index obtained is greated than obtained in the standard test, it is always below 25. The higher flame spread index is due to the greater mass of foam which causes an increase in stack temperature of the apparatus, but we have never seen a flame front on the samples we have tested.

Smoke Density Tests

The National Bureau of Standards Smoke Density Chamber is used by the Toyad Corporation as a quality control tool and to evaluate developmental materials.

It is our objective to produce foam with the lowest potential for smoke production during fire, that it is possible to produce. Our immediate target is a maximum smoke value of 200 but we have reached this only with development materials.

All testing in the NBS smoke chamber is in the flaming mode since our worst results are obtained in this mode. The average smoke density values for foam samples from our quality control data, taken over the past six months are shown in Table 2.

NBS SMOKE CHAMBER

TIME, MIN.	OPTICAL DENSITY
1-1/2	140
4	280 (Max.)

TABLE 2

These optical density values bear little relation to real fire situations. We will discuss smoke generation from Neoprene in large-scale burn tests later.

*The results of testing in this paper are not intended to reflect hazards of any material under actual fire conditions.

Toxicity Testing

The established chemistry of polychloroprene combustion indicates that in addition to the normally expected oxides of carbon, CO and CO_2, hydrogen chloride and water vapor are produced. The possibility of phosgene production has been studied by the Du Pont Company. No evidence of phosgene has been obtained in rigorous experiments.

To evaluate the composition of combustion gases, the gases produced in the NBS Smoke Chamber were sampled by the use of Detector tubes from Mine Safety Appliances. Tests were made for HCl and CO. The HCl averaged 200 ppm while the CO was 100 ppm. These results are a function of the amount of material burned and the volume of the capture space. Full scale test results more nearly like actual fire conditions do not produce numbers this large. LS Neoprene foam was tested at the University of San Francisco (4) using the USF Toxicity Screening Test Method, Procedure B. This method uses a 1 gram sample, employs a rising temperature program at 40°C/min. from 200 to 800° C without forced air flow. Four free moving Swiss Albino mice are subjected to the fumes from the LS foam. The average time to death was 26 minutes, compared to 12-14 minutes for urethane foam.

Full Scale Testing

A full scale test was run at the National Bureau of Standards for the Coast Guard. (5) The room used for this test was constructed to roughly simulate a shipboard bunk space. The size of this is roughly the same as a cell or hospital room. Double deck bunks were used and a fire was set on the bottom bunk.

Four mattresses were tested: (1) Polyurethane foam mattress, (2) a Neoprene foam mattress that had been in service, (the date of manufacture was unknown but it is believed to have been made prior to 1972), (3) a new mattress meeting the requirements of MIL-R-20092H, (4) a new LS Neoprene mattress. All four mattresses were covered with Government approved cotton fabric.

The test bedding consisted of a polyurethane pillow, pillowcase and sheets of 50% cotton/50% polyester and a wool blanket. The blanket and the top sheet were pulled down about halfway and loosely doubled back. The ignition source was two sheets of newsprint loosely doubled and placed under the pillows. An electric match was placed next to the two crumpled double newsprint sheets. This method of ignition contributed negligible fuel to the fire but did insure a predictable start.

The results of these tests are shown in Table 3.

The following general observations were made from this test:

The combustion gas concentration maximum values of the Neoprene mattresses did not show levels considered hazardous with the LS Neoprene having the best results. The urethane mattress exceeded the gas concentration tenability levels.

The urethane mattress produced a compartment fire hot enough to be a serious life hazard while the LS Neoprene did not reach a critical heat flux level.

Smoke obscuration is an important element in any fire. It is considered that an extinction coefficient, k, of 1.2 $m.^{-1}$ is sufficient to preclude visibility for escape. The critical smoke level, or k, for the urethane mattress was reached in 190 seconds and remained above this level for the remainder of the test. The LS Neoprene reached the critical level in 570 seconds and was above this value for only 60 seconds.

ts.

TABLE 3

Results of Measurements*

Specimen	TEST 1 Urethane	TEST 2 Used Neoprene	TEST 3 RP Neoprene	TEST 4 LS Neoprene
Weight Loss at 1800 s (kg) & %	5.14 54.7%	1.91 12.4%	0.97 9.3%	0.68 4.4%
Maximum Temperature - TC63 (^{o}C)	495	243	79	100
Time at Maximum Temperature (s)	450	300	380	370
Maximum Radiant Heat Flux 0.72 m Above Floor (kW/m^2)	25.97	3.38	0.22	0.30
Time at Maximum Flux (s)	320	300	580	350
Time to Reach $k = 1.2\ m^{-1}$ at 0.3 m Below Doorway Top (s)	190	120	140	570
Time to Activate Tell-Tale Sprinkler (s) 74^{o}C (165^{o}F) Head 57^{o}C (135^{o}F) Head	229 N.A.	283 222	— —	— 317
Temperature at TC64 When Sprinkler Activated (c) 74^{o}C Head 57^{o}C Head	183 —	210 ;39	— —	— 96
Gas Concentrations, 0.30 m Below Doorway Top O_2 minimum (4%) CO_2 maximum (%) CO maximum (ppm)	 9.8 8.8 3700	 16.9 2.4 2100	 19.8 0.53 350	 19.8 0.79 180
Time to Reach Gas Peaks (s) O_2 Peak CO_2 Peak CO Peak	 350 350 350	 340 340 340	 620 620 630	 390 360 500

* The results of these tests are not intended to reflect hazards of any material under actual fire conditions.

Toyad was invited to send a representative to observe a comparison fire test of a urethane mattress and a Toyad LS Neoprene mattress, conducted at the Madison Fire Training Center at Madison, Wisconsin. The urethane mattress was a 4" x 32" x 74" unit with an HR20 Staphchek cover. The Toyad mattress was a 3" x 28" x 74" LS with HR20 Staphchek cover taken from stock at the Wisconsin State Use Industries.

The tests were conducted by placing the mattresses on a steel spring cot inclined at 30° to the wall. The mattress cover was slit three times from the middle of the unit to the bottom. The foam was also gouged and torn in several places at the slits. Two pounds of newsprint were used with individual sheets being crumpled loosely and placed under the cover and in the tears in the mattress. The remainder, approximately 75%, was crumpled and placed at the bottom of the mattress. The following items were placed on top of the paper: part of a wool blanket, one lightweight cloth spread, one sheet, one pillowcase, one work shirt and one pair work pants. These items would be available to an inmate. One 10 oz. can of lighter fluid was then poured over the above materials and immediately lit with a match.

In the test with the urethane mattress, flames immediately covered the mattress. The cover melted away and the mattress core became involved. Heavy black smoke was produced and at 1 minute the room was obscured. The flames went over the top of the mattress at 1 minute and involved the wooden rafters at this time. The fire was extinguished in 1-1/2 minutes to prevent damage to the building. The mattress core was approximately 1/3 consumed. The foam had charred and formed a wave pattern on the surface with no dripping on the floor.

In the test with the LS Neoprene mattress, the flames scorched approximately 3/4 of the unit, the cover melted but the mattress core did not flame. The smoke produced was much lighter and did not obscure the room although smoke was down to approximately 5 feet from the floor. The test ran 5-1/2 minutes before being extinguished. The mattress core was charred approximately 1-1/2 inches deep at the point of the fire. The char was unbroken and became much less up the face of the unit with the top 20 inches of the mattress having no char.

Full scale testing was performed by Ben Gazzaway, Safety Officer of Pima County, Arizona [b]. This testing program was undertaken because of 15 incidents of fires in urethane mattresses at the Pima County Jail in Tucson, Arizona. These fires were shown to be deliberately caused by jail inmates. Mr. Gazzaway obtained information concerning various fire tests and evaluations from a number of agencies. After studying the data, he decided to run the following six tests on LS Neoprene mattresses. The tests and results are as follows:

TEST NUMBER 1 - CIGARETTE TEST.

Nine Pall Mall (non-filter) cigarettes were lighted and placed on the top of the mattress. Burn time 14 minutes 54 seconds.

Results - Cigarette burn melted cover beneath cigarette, but did not spread, removal of ash and cutting cover found only a minor scorched area equal the size of the cigarette on the mattress.

TEST NUMBER 2 - BOOK MATCHES TEST

A book of safety matches was placed on top of the mattress and the cover of the book of matches was lighted. Flame ignited the matches and burned for 3 minut Only a portion of the safety match cover burned before the flame went out.

Results - Mattress cover melted beneath burn area. The mattress had only a minor scorched area beneath the cover of the burn area.

TEST NUMBER 3 - NEWSPAPER TEST

Seven and one half pages of newspaper lightly crumpled were placed on top of the mattress and ignited with a cigarette lighter. Burn time was 11 minutes 5 sec with a maximum temperature of 700 degrees Farenheit.

Results.- Bare hand held beneath mattress felt no heat effect. Mattress cove melted around the immediate circumference of fire only and the mattress sustained a char, like burned toast, to a maximum depth of 1/4 inch; the mattress did not sustain combustion.

TEST NUMBER 4 - NEWSPAPER BURN BENEATH MATTRESS

22 pages of newspaper were crumpled and placed under the mattress (entire length of mattress). Burn time 10 minutes 30 seconds.

Results - Not all the newspaper burned before fire went out. Damage to mattress was char, like burned toast, to maximum of 1/4 inch deep. Again the mattress did not sustain combustion.

TEST NUMBER 5 - NEWSPAPER BURN WITH MATTRESS IN VERTICAL POSITION

Two pages of newspaper and one page of note paper 8-1/2 x 14 inches were ignited. Burn time 3 minutes.

Results - Fire went out leaving maximum char-like toast to depth of 1/4 inch.

TEST NUMBER 6 - RIP AND INSERT BURN

Two pages of newspaper and four sheets of note paper, 8-1/2 x 14 inches, were placed inside a ripped section of mattress edge and ignited. Burn time 5 minutes.

Results - Fire went out at mattress edge and newspaper in ripped section did not burn. The mattress did not sustain combustion and had only minor scorch damage.

The following conclusions were made by Mr. Gazzaway at the completion of the tests and evaluation of the results:

1. The Neoprene mattress tested did not support combustion.

2. After combustibles placed on the mattress were consumed in the fire, only minor "char" damage resulted to the mattress.

3. By the use of the Neoprene mattress, our fire source is limited to newspaper and minor combustibles in a jail cell.

actual fire conditions.

On the basis of the tests conducted, Neoprene mattresses have been ordered for the Pima County Jail, to replace all existing mattresses.

Rafael J. Nieves, Bureau Chief of Fire Prevention of Prince Georges County of Maryland, conducted full scale tests on polyurethane mattresses and LS mattresses at the University of Maryland Fire Extension Service in July of 1977 (7).

The test set-up for all tests was a room comparable to what would be found in a detention center. Each of the mattresses were propped against the wall, six double sheets of newspaper, balled up and one tee shirt were placed against the bottom of the mattress. These combustibles were lighted with a match.

TEST I - The test used a polyurethane mattress obtained from the Detention Center. The mattress itself caught fire one minute after ignition. The entire mattress was engulfed in flames in one minute and forty-two seconds after ignition occurred and produced extreme heat and toxic gasses in the room. The test was terminated after two minutes and thirty-five seconds because of the intensity of the fire and the volume of dense black smoke produced by the mattress fire.

TEST II - This test used a LS Neoprene mattress. The test set-up was identical to Test I. This test was halted after five minutes. The only damage to the mattress was the melting of the covering and blackening of the foam nearest the paper and tee-shirt, no additional heat, smoke or fuel contribution can be attributed to the LS foam core.

TEST III - This test used the LS Neoprene mattress in a more severe scenario. The covering was slit and newspaper was stuffed into it. A sheet, blanket and a pillow were added, and lighter fluid was sprayed onto them. Upon ignition, a severe amount of fire and smoke developed. It was estimated that the large fire and heavier smoke came from the extra ignition fuel, especially the blanket. The test was halted after about four and one-half minutes. The covering was melted and the foam charred. However, at no time did the cover or foam appear to burn, even though this mattress was exposed to greater amounts of combustible materials and flammable liquid. Again, the Neoprene mattress did not add any heat, smoke or fuel to the fire, nor did it ignite from the exposure. All ignition materials were consumed without significant damage to the mattress.

TEST IV - This test was conducted using the blanket alone, because of observations of its flammability in Test III. The blanket was dropped onto the floor and ignited in two places with a single match. Within one minute the entire blanket was involved in flames with heat and smoke so intense that all observers had to quickly back away.

Mr. Nieves made the following comments and recommendations following completion of the tests:

TESTS I AND IV - Demonstrated that the heat and smoke generated by urethane mattresses and similar materials are so severe that they pose an unreasonable risk to the life safety of all persons within the Detention Center and anywhere else similar to it such as the Hyattsville lock-up. As such, the continued use of urethane mattresses was deemed unacceptable and they must be replaced immediately.

The tests revealed that the fire and smoke conditions observed are so great that control of the fire and successful rescue of the detainees and deputies might not be successfully carried out.

Furthermore, we do not mean to say that of the mattress used in Tests II and III, LS Neoprene, is the only one acceptable to us, we do state that today's tests constitute a test standard. Any other mattress or other bedding must be subjected to the same test and must behave comparably before it will be accepted.

I know of one actual incident of vandalism with a LS mattress which occurred in the City of Philadelphia which has not been immune to such acts. Just recently, a resident deliberately ignited a polyurethane mattress. Although the mattress met the Consumer Product Safety Commission standard, it proved impractical in use. The resulting fire caused an inmate to suffer severe burns. A subsequent class action suit -- Jackson vs. the City of Philadelphia -- resulted in an interim decree of $500,000 against the city. While prison administrators and the City's Department of Standards and Specifications had been investigating the improved mattresses before the suit, the incident focused attention on the seriousness of the problem and expedited the use of LS mattresses.

The first practical test of the new mattress occurred last March when an inmate of the House of Corrections attempted to set the mattress in his cell afire by igniting it with newspapers and toilet tissue. Deputy Warden Thomas J. Kelly investigated the incident and turned in the following report:

"On March 6, 1978, at approximately 12:55 A.M., a resident deliberately set fire to his new Neoprene mattress. The only result of this fire was that the mattress cover did burn and cause a small amount of smoke on the complete wing. The new mattress did char but did not burst into flames or cause any appreciable amount of smoke."

In this first practical test, the Toyad "LS" mattress proved difficult to ignite in sharp contrast to similar incidents encountered with polyurethane constructions.

It was stated at the beginning of this paper that treated cotton was used in institutions. The next section of the paper discusses cotton and comparative testing with LS Neoprene.

New FR cotton mattresses with eight percent or more boric acid on the cotton batting is fire resistant - a fire will self-extinguish when the fuel source is removed. This product is produced by spraying an oil or other binder onto the cotton as it is picked (pre-opened) prior to garnetting. The boric acid powder is dusted (vibrating shaker) onto the web after the fiber leaves the garnett and is in the process of being transported by the cross-lapper. The boric acid powder is held to the web by the binder material.

It has been suggested by various authorities that the boric acid will sift from the surface layers of the batting during use, thus reducing (or losing) fire resistance. Recent studies [8] have also shown that the boric acid on cotton batting is gradually lost in storage. Of concern in the use of the borate salts or boric acid for preventing smoldering combustion is their instability when exposed to elevated temperature and high relative humidity. It is well known

that boric acid is volatile, exhibiting significant vapor pressure in its solid state as well as in water solutions. Researchers have pointed out that borax-boric acid treatments are not durable and should not be used when service for more than one year is required. (9) The present commercial methods of application of boric acid produce products with uneven add-on. Titration tests on samples of treated cotton taken from new mattresses have given a percent of boric acid in the cotton varying from a low of 3.8 to a high of 11.6. Samples from a used mattress, one year service, had 3.7 to 5.9 percent boric acid remaining in the cotton.

Boric acid treated cotton has been subjected to small scale testing in the Toyad Corporation laboratory. These included Radiant Panel and NBS Smoke Chamber. The treated cotton had a flame spread index of 716 on the Radiant Panel (ASTM E162) but is very low on smoke production in the NBS Smoke Chamber with a value of 36 D's in four minutes. The CO produced by the LS Neoprene compared to the treated cotton gave the following results:

TIME	3'	6'	9'	12'	15'
Cotton	400 ppm	750 ppm	1,000 ppm	1,100 ppm	1,100 ppm
Neoprene	100 ppm	250 ppm	500 ppm	900 ppm	900 ppm

The cotton used for these tests had an 8% add-on. Nine gram samples were used for the Smoke Chamber test. The cotton sample was 86% consumed and the neoprene 81% consumed.

Full scale tests on treated cotton mattresses have been run with various burn scenarios. The results of these tests are listed as follows:

The first full scale test compared a polyurethane, a treated cotton (new), a treated cotton with six months service and a LS mattress (new). Two mattresses were placed on a steel cot in a "teepee" form leaning against the wall. Twenty double sheets of newsprint were lightly crumpled and sat behind and between the mattresses. The newspapers were ignited with a match.

The conclusions were:

Both the FR Cotton and Neoprene mattresses offer superior performance over commercial polyurethane mattresses as judged by burn characteristics. The polyurethane foam was the only type that was consumed by fire and generated toxic gas concentrations exceeding critical escape conditions.

New treated cotton mattresses out performed new LS neoprene foam mattresses from a smoke envolvement standpoint; however, the used treated cotton mattress produced more smoke than all mattresses except the urethane unit.

A second series of full scale tests were run with the units in what has been called the Michigan configuration. This consists of rolling the mattress end to end with a ten to twelve inch opening or chimney in the center. The mattress is secured in this shape with wire. The rolled mattress is then set on end and tilted slightly from vertical by placing one side on a four inch block. These tests used eight double sheets of newsprint lightly crumpled and placed from end

to end in the opening in the center of the rolled unit. The newspapers are ignited at the bottom.

The description and results of these tests are as follows:

Test #1 - A new boric acid treated cotton mattress with Staphchek cover was used. There was 5.1% boric acid add-on in a sample of the cotton taken prior to the test. This unit flamed from 30 seconds into the test to 9 minutes, smoke was heavy and the mattress was completely obscured at 3 minutes into the test. Test was ended at 15 minutes. Unit was burned from two inches deep at bottom to one inch deep at top of unit.

Test #2 - A one year old, used boric acid treated cotton was used. Prior to the test two checks on boric acid concentration showed the center of the mattress had 3.7% boric acid and a corner had 5.9% boric acid. This mattress produced a lot of flame and smoke. Smoke filled the room completely and obscured the mattress at two minutes into test. The test ended at 15 minutes and the mattress was burned uniformly to depth of two inches.

Test #3 - A used boric acid treated cotton mattress one year old was used. No boric acid concentration checks were made. Smoke was produced in 30 seconds from ignition. At 3 minutes there was nearly total obscuration. The smoke began to lift at 8-1/2 minutes, and mattress had 6 inch flames at one edge. Smoke continued to decrease until 14 minutes when flame went out but stuffing was glowing. This test was continued to 22 minutes and as the unit continued to smoulder, smoke increased significantly. The mattress was burned approximately halfway through.

Test #4 - A LS Neoprene mattress with Staphchek cover was used. Smoke appeared at one minute from ignition and flamed from 1-1/2 minutes to 3 minutes. Smoke continued to build up and at 6 minutes the mattress was totally obscured. Smoke lifted at 8-1/2 minutes and mattress was visible from 10 feet. Fire was out at 13 minutes and there was little smoke. Char on the core varied from 1 inch to 1/2 inch deep over the side.

An effort was made to obtain a used LS neoprene mattress prior to these tests but the unit did not arrive until the tests were completed. This unit has been in service for one year. Physical tests were run in the Toyad laboratory and these were approximately the same as a new unit. Radiant Panel results were under 10 and the results on the NBS Smoke Chamber were within specification. The mattress core had taken very little "set", (loss of height), and the ILD was within the specification for new units.

The LS neoprene foam, as used in these tests and as used widely in the institutional bedding industries, is not without recognizable deficiencies. The LS foam is used because of its superior resistance to ignition, comparatively low rate of burning and reduced smoke generation. However, its potential for smoke evolution is still too high under the influence of very strong ignition sources where large quantities of LS neoprene foam become involved.

A new foam formulation is under development by the Toyad Corporation. Development samples have been tested in the NASA Fireman Program (10) and found acceptable for testing in Phase III, the full scale test phase.

CONCLUSIONS

It has been my primary purpose to inform you of the extent of flammability testing and results obtained with the LS Neoprene foam. The chemical composition of the Neoprene polymer in conjunction with carefully balanced compounding ingredients is responsible for its strong resistance to burning and reduced smoke evolution. These properties have been clearly demonstrated by the various testing programs carried out by various officials and by Toyad. The large scale fire tests on LS Neoprene foam mattresses coupled with its proven comfort and durability indicate it to be the preferred mattress for institutional use.

ACKNOWLEDGEMENTS

The author would like to acknowledge Esther Gardner and Al Fredericks for their held in the writing of this paper, Joe Siko for testing the material and the office staff for typing the paper.

(1) P. R. Johnson - Rubber Chemistry and Technology. Vol. 49, No. 3, July - August 1976.

(2) R. H. Morford - The Flammability of Neoprene Cushioning Foam, International Conference on Fire Safety, U. of S.F., January, 1977.

(3) Edwin E. Smith - Private communications.

(4) Carlos Hilado - Private communications.

(5) Vytenis Babrauskas - Fire Behavior of Three Neoprene Mattresses, Report No. FR3939.

(6) Ben Gazzaway - Fight Fire with Fire Professional Safety, June 1978.

(7) Rafael J. Nieves - Communication with Don E. Ansell, Sheriff, 8/3/77.

(8) - Bedding and Furniture Materials, Vol. 14

(9) N. B. Knoepfler et. al - Storage Stability of Boron Treated Cotton Batting Products that Meet Mattress Flammability Standard FF4-72, 1974 AATCC National Technical Conference Oct., 1974.

(10) Larry L. Fewell et. al - Fire Resistivity and Toxicity Studies of Candidate Aircraft Passenger Seat Materials Journal of Fire & Flammability, Vol. 9 (July 1978) p. 377.