The Navy and Asbestos Thermal Insulation

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Abstract

Asbestos was once used in U. S. Navy shipboard pipe and machinery thermal insulation and in many other shipboard products. It was also used throughout the country in thousands of commercial products and in some products it remains in use today. The health hazards of asbestos have resulted in an increasing number of lawsuits that involve, among many others, manufacturers of Navy hardware. The plaintiffs in these lawsuits include many who were exposed to asbestos while serving in Navy ships built during and following WWII. Because the materials are dry, friable, and easily accessible, the most likely source of their Navy shipboard exposures was thermal insulation. In this article the evolution of thermal insulation systems in WWII and post-WWII ships is described, Navy and national asbestos consumption patterns are compared, the asbestos industrial hygiene environment of the times are described, and a perspective on asbestos concerns from a hardware manufacturers' standpoint is provided. The liability situation regarding asbestos may be seen as a pattern causing Navy manufacturers to seek some form of waiver of liability or other relief from the Government for all hazards arising from their Navy work. Naval engineers have a responsibility to understand the background surrounding the use of asbestos, particularly as they continue to deal with new systems and materials that could potentially impact the future health of those who come in contact with them.

Introduction

Asbestos was once an industrial material widely used through much of the 20th century in thousands of products including thermal insulation in Navy ships. During the past thirty years, there has been a great deal of litigation regarding such products.

The health hazards of asbestos as used in certain industries were first reported as early as the 1930's and were more generally established by the early 1970's. At about the same time, a large number of lawsuits were initiated to seek compensation for those injured. These cases first focused on the manufacturers of asbestos products such as thermal insulation and textiles. The cases were supported by documents dating from as early as the 1930's reporting asbestos-related fibrosis hazards to the professional occupational health community. Other documents suggested that some manufacturers of asbestos products might have concealed information about the dangers of the asbestos fiber from their customers and the public. Many if not all of these manufacturers were bankrupted as a result of perceived or litigation-enforced liability.

In recent years, the legal focus of Navy-related asbestos litigation has shifted to manufacturers of hardware such as pumps and valves that used small amounts of asbestos packing or gaskets and which may have carried thermal insulation once installed. The Navy, usually exercising its right to immunity to liability because of its status as a sovereign agency, has avoided liability claimed against it.

A recent New York case promises to take asbestos liability a step further. The case involved a sailor who served aboard a WWII ship during the 1960's who asserted that his work near insulated pumps in his ship caused his injuries. The court suggested that the pump whose manufacturer was subject to potential liability because it failed to warn of the dangers of asbestos insulation that the shipyard, not the pump manufacturer, applied to the pumps. Asbestos was once so widely used that under this judicial

ruling, manufacturers of nearly anything that went into a Navy ship during and following WWII could be held liable for asbestos injuries. Should the rational of the New York decision spread; the Navy may be confronted with a whole new series of demands from its equipment manufacturers for legal pro tections such as full indemnity for damages paid to plaintiffs.

In this paper, the industrial environment surrounding the past use of asbestos thermal insulation in the Navy is explained, and how the court's requirement that the defendant warn users of its products could not reasonably have been implemented is explored. The article is written so that naval engineers can understand what equipment manufacturers and other contractors facing asbestos-related liability may need or demand in the future from the Navy. It is also written as an object lesson teaching that materials, however benign they may appear, can be problematic in the future in wholly unexpected ways.

Background

During WWII, large numbers of Navy ships were built which served through the next four decades. Some sailors and maintenance workers who served aboard these ships during their lifetimes have become the source of much current Navy-related asbestos litigation. Therefore, it is useful to review the situation regarding thermal insulation in these ships.

Asbestos Was Once a Common But Not Universal Insulator in Navy Ships

It is likely that the most abundant asbestos product used in Navy ships was thermal insulation. Asbestos consumption data from WWII suggests that there may be more asbestos in a ship's electric cable than in her thermal insulation. The U.S. Navy ceased using asbestos thermal insulation in the 1970's and in cables about the same time. Asbestos, however, contrary to a popular belief, was not the universal insulator. Even during WWII, many asbestos-free products such as fibrous glass and mineral wool were used, particularly for hull and bulkhead insulation. But asbestos products dominated as piping and machinery insulation simply because they were the best insulators then available. Among eleven different classes of WWII era ships which we have evaluated, including the prewar *Fletcher* and wartime *Sumner* and *Gearing* class destroyers and the wartime *Essex* class aircraft carriers, up to 88% by weight of the thermal insulation products used on pipes and machinery in these ships contained asbestos.

Thermal Insulation Systems Built from Four Types of Products

Thermal insulation systems were constructed from four general kinds of products: 1) flexible thick felt pads, 2) rigid preformed shapes in a wide variety of sizes and dimensions, 3) cloth, tape, and thread and 4) troweling cement to fill cracks and form smooth surfaces and adhesives. Felts were used in concert with cloth and thread to form pads to fit around irregular components such as steam turbines or pipe flanges. Rigid preformed shapes were fitted around pipes and regularly shaped objects and then covered with cloth and adhesive. Troweling cement filled cracks and provided smooth damage-resistant surfaces. A coat or two of paint on the outer surface finished an installation.

Each Ship Carried Many Tons of Insulation

Each WWII *USS Fletcher* class destroyer bore nearly 30 long tons of thermal insulation on her pipes and machinery. The next-generation, *USS Gearing* class, carried just over 24 long tons per ship despite having the identical power plant as *Fletcher* because more efficient and lighter materials became available. At the extreme, the *USS Iowa* class battleships carried nearly 465 long tons of thermal insulation. Ships intermediate in size between destroyers and battleships carried intermediate amounts of the material. [Insulation weights come from ship weight reports and insulation schedules].

Some Navy Specifications Required Asbestos, Some Did Not

In 1945, there were 13 insulation product line specifications for shipboard thermal insulation and lagging. (BSTM Chapter 39 1945). Lagging

correctly describes only the outer covering of an insulation system but the word is sometimes used to refer to the entire system. Each specification included several variations such as different grades of asbestos cloth or different service temperatures for pipe insulation. Seven of these specifications required, or at least permitted, asbestos as an ingredient and six called specifically for asbestos-free materials such as fibrous glass or cotton. Some of the seven asbestos specifications called for "materials suitable to the intended service," or words to that effect and indeed, some of the products provided under such specifications contained no asbestos. Thus, even as early as 1945, the Navy's door was open to non-asbestos products as long as they met the required performance standards.

Amosite Was The Dominant Asbestos Fiber in Navy Insulation

There are six fibrous minerals commonly called asbestos, five in the amphibole mineral family and one in the serpentine mineral family. Two of the six were used in Navy insulation. These are:

1. Amosite, a trade name for an amphibole fibrous mineral (Cummingtonite-Grunerite) came from South Africa. It was the dominant Navy insulation fiber amounting to approximately 86% of all the asbestos fiber in the insulation systems of an average ship if the schedules were followed exactly. Amosite was used in nearly pure form as a felt and as pre-molded insulation, and as a reinforcing fiber in matrix insulation materials. Amosite asbestos was favored because of its very long water-resistant and matting-resistant fibers.

2. Chrysotile, the mineral name for the only serpentine asbestiform mineral, was largely imported from Canada. Chrysotile asbestos fibers, while sometimes shorter than amosite's, are soft and flexible unlike amosite fibers and could be made into thread and cloth.

Other Materials Were Also Used

During WWII, asbestos was scarce but asbestos products still comprised most of the insulation in Navy ships. Because of asbestos shortages, insulation engineers sought ways to stretch the supplies. Cotton fiber was included in some grades of asbestos cloth so as to facilitate weaving of fabrics with the more readily available short-fiber chrysotile. Fibrous glass, a truly modern material at the time (having been first formed as an insulation material in 1938) had many uses during the war. [interestingly, workers often complained of skin irritation from fibrous glass and mineral wool products and from that standpoint, they often preferred working with asbestos.] As with cotton, it was used as an asbestos fiber extender in some grades of asbestos cloth and used alone as glass-cloth lagging and felt. Mineral wool was also used as an insulator. Fibrous glass insulation board, commonly called "Navy board" was used almost exclusively during and after the war as bulkhead, deck, and hull insulation in most US Navy ships. Similar products are still widely used. Canvas was often specified as a lagging material on lower temperature surfaces where the high temperature capabilities of asbestos or fiberglass were not needed.

Shipboard Insulation Systems Varied

Insulation used in a ship depended on technical matters such as the system and component operating temperature, the effect of the insulation on system performance, and the availability of materials. Some hot components, such as steam traps, were not insulated because to do so would interfere with their functions. These and other concerns were all ultimately expressed in the ship's insulation schedules and implemented during construction in accordance with the building yard practices of the time and the availability of the materials listed on the schedule. Substitution of schedule materials with approved alternatives, including asbestos-free alternatives, was common and was expressly authorized on many schedules. Boiler feed system piping, for example, may have required preformed 85% magnesia insulation conforming to Navy Department Specification 32P8. Because feed water is not very hot, it may have been insulated with mineral wool under Navy Department Specification 32I2 instead. Of course, the opposite could also

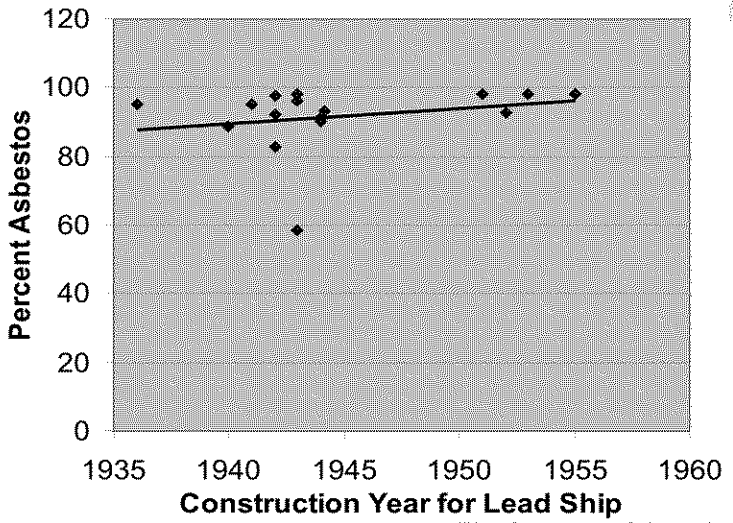
happen — a schedule requirement for fibrous glass cloth lagging to meet Specification 32C15 could have been implemented at the yard using asbestos cloth to Navy Department Specification 32C11.

Schedule Requirements Varied Among Ship Classes

The insulation materials required by the schedules varied substantially among ship classes. The differences reflected design or building yard practices, the local availability of materials, and the importance the Navy or the Maritime Commission assigned to a specific ship type. The ships that needed the greatest staying power for the war effort received the best quality materials. Ships that could fulfill their mission with only a few sailings were built with the materials at hand. Among insulation materials, asbestos products were usually viewed as best-quality. **FIGURE 1** shows the relative percentage by weight of the asbestos-containing thermal insulation materials used in 16 WWII ship classes including Liberty Ships, LSTs, *Fletcher* and *Gearing* class DDs and *Essex* class aircraft carriers (determined by summing the weight of the materials listed on insulation schedules or from ship weight reports).

Except for the lowest value in Figure 1 (1943, 59%), the weight percent of asbestos or asbestos-containing insulation varied between 80% and 99%. Note that it was never 100% because, for some insulation systems even in the most vital ships, asbestos free products worked well. The lowest value on the chart (59%) is the USS *Buckley* class of destroyer escorts. These ships were for few-mission escort duty and were therefore insulated with the most readily available and inexpensive materials — many of which were not asbestos.

Figure 1:
Percentage Asbestos By Weight In Lead Ships



Some Ships Were Asbestos-Free Even During WWII

There were many special cases. The *USS Indianapolis* (CA35), built in 1931 and lost in 1945, was originally insulated with mineral wool products. These materials were also tried in other Navy and commercial ships of the time and worked poorly. The WWII-era mineral wool products were easily crushed to dust during operation causing them to loose their insulating quality and release abrasive rock dust to the ship's air that fouled machinery (Cox memo 1933) Others reported that the chemicals in some mineral wool attacked pipes when wet (U.S. Naval Experiment Station 1935) Modern improvements have made mineral wool products entirely satisfactory in many services, but the early experiences may be a reason mineral wool products were not used more frequently during WWII.

Maritime Commission Ships Used a Wide Variety of Materials

U.S. Maritime Commission ships were merchant ships for commercial or naval logistics service. Their merchant crews varied from about 30 to several hundred depending on the ships function and they typically carried a complement of 20 to 30 Navy men, the so-called Armed Guard, to man defensive guns. But despite their wartime features, Maritime Commission ships were much less strictly specified than Navy warships. The Commission's ships were insulated from what was available — asbestos, mineral wool, hair felt or fibrous glass. In the case of the EC-2 *Liberty* class, the ships and their insulation systems were designed with a lifetime of five years but a single voyage was considered success given the rate of ship losses early in the war. *Liberty* class ships also

used sprayed-on insulation for the fire protection of magazines. No other use of sprayed insulation has been found although War Production Board records indicate that some was also used in Navy ships. (Office of Procurement and Material 1943)

Insulation Materials Changed Over Time

Insulation practices changed as engineering knowledge advanced along with the technology. For example, fresh water and cold seawater piping in nearly all early Navy ships was insulated with hair felt until about 1943 when the Navy changed to water-repellent amosite felt in order to eliminate hair felt's fire, vermin, and disease hazards. (BUSHIPS letters 1942, 1943) Hair felt continued to be used in auxiliary and merchant ships and in smaller warships throughout the war because of the shortage of amosite. Amosite felt continued in service in Navy ships as fresh-water system insulation until 1958 when foam rubber was specified to save money and weight. (BUSHIPS Note 1958) The wisdom of this choice can be questioned because it reintroduced the fire hazard of the old hair felt, introduced a new hazard of highly toxic combustion products and, as we now know, increased the asbestos hazard. But naval engineers, as with all engineers, are often faced with imperfect solutions and inadequate budgets for resolving competing requirements.

Thermal Insulation is Dry and Can Be Dusty

Regardless of the fibers involved, installation and removal of thermal insulation creates airborne dust exposing anyone in the vicinity to health consequences. For asbestos those consequences are substantial. Vibrations and temperature changes during normal operation of a ship may also release dust as can bodily contact by the ship's force. Many reports of dust measurements aboard Navy ships have been reviewed and frequent reference to loose dust on surfaces and in the air, particularly during repairs, but also during operation have been reviewed. While for the most part dust levels were controlled to within the standards of the time, there is no question that many Navy sailors and workers breathed some of this dust and in some it may cause or have caused disease.

Incentives for Production of Asbestos-Free Insulation

Throughout and following WWII there were many incentives for the Navy and for Navy equipment manufacturers to offer asbestos-free insulation alternatives. Health effects were not among those incentives until the early 1970's but up to then there were many others.

The Need for Imported Asbestos Encouraged the Search for Alternatives

Most chrysotile and all amosite asbestos fibers were imported. (Virta Undated) U.S. production of asbestos fiber never supplied more than about 20% of the nation's total asbestos demands and the best grades needed for fabrication of most insulation products came from elsewhere. All amosite was imported from the Union of South Africa. Indeed the name "amosite" is not the fiber's proper mineral name but comes from the principal source in South Africa, the Amosa Mine. [Amosite's proper mineral name is Grunerite or in some manifestations, a complex mixture of Grunerite and Cummingtonite in a fibrous habit]. During WWII, asbestos of most insulation grades and types was a "critical material" with the Government's Metals Reserve Company (MRC) handling much of the purchasing and distribution of the critical grades. The Kriegsmarine and the wolfpacks were keenly aware of this fact and acted accordingly. During 1943 and 1944, for example, all amosite asbestos used in the U.S. was purchased and imported by MRC and provided under strict quotas to producers of asbestos-containing products almost entirely for the Navy. (War Production Board 1944) The expense and limited availability of imports provided the "asbestos-free" elements of American industry to continually offer insulation products to the Navy. Over the ensuing years many were adopted. Throughout and after the war, the Buy America Act providing encouragement to domestic firms to develop insulation materials made entirely from domestic materials 9War Production Board

Asbestos Insulation Was Technically Mature

Typical asbestos-containing insulation in use

during WWII weighed from 12 to 27 pounds per cubic foot and had adequate thermal insulation capabilities. (Various WWII Navy Specs) While these products were good for the times, mineral wool and fibrous glass systems offered the promise of much lower weight and better insulation properties that would reduce each ship's total weight by many tons.

Perhaps most importantly, at the end of WWII, asbestos insulation was at its performance limit. Asbestos products dated from 1866 and had been used and perfected for nearly 80 years by the end of the war. The most common product "85% magnesia" (the 15% being mostly amosite asbestos in Navy insulation) had been in use since 1882 and had gone through many technical iterations and improvements. (Virta undated) Naval engineers had to look elsewhere if lighter, more heat-resistant insulation were to be found.

Asbestos Fiber Was Expensive

High quality long-fiber asbestos used for insulation was expensive. Such fiber cost over a thousand dollars per ton during WWII in current dollars and constituted most of the cost of many asbestos insulation products. The long-fiber amosite grades needed for most Navy insulation services were particularly expensive and in scarce supply during WWII as it had to be shipped from Africa.

Non-Asbestos Products Became More Popular With Time

Over the years, many new insulation products were developed. A Bureau of Ships report from 1955 summarizes the development of four new non-asbestos materials. (BUSHIPS ltr 1955) The material LK-61 was an "aerojel" developed by Johns Manville for *USS Nautilus* (SSN 571). The material was much lighter than the common insulation materials of the time but it dissolved in water. While it was tested in *Nautilus*, it was not ultimately approved for widespread use. Three other firms developed aluminum silicate refractory fiber materials for very high temperature service that were ultimately approved for use. (Thermoflex, 1200 John's Manville, Kaowool, Babcock and Wilcox; and Fiberfax, The Carborundum Company)

The Navy Searched for New and Better Insulation

In 1959, the Bureau of Ships began an active search for more new products that weighed less, cost less, and were better insulators than their predecessors. (BUSHIPS memo 1959) This work slowly bore fruit. By 1960, many new products were in use and half were asbestos-free materials. By 1967, the Navy continued to move towards non-asbestos products with the number of asbestos insulation products having been reduced to less than half of all. (NSTM 1967)) Up to about 1970, these changes were being made because of engineering goals, not because of health concerns.

Eliminating Asbestos Insulation

Naval Engineers Became Aware of the Health Conseqenes About 1970

About 1970, the U. S. Navy engineering community was alerted to the urgency of the asbestos health problem by a letter from British sources advising of the serious disease rate among workers in British "dockyards." The sources advised that because of the problem, the Royal Navy was eliminating the use of asbestos insulation products in their shipbuilding and repair programs, a process it had essentially completed by 1971. (Harries 1971) In about 1971, the U. S. Navy initiated its own "Asbestos Elimination Program". Almost immediately, Navy acquisition of amosite felt and the pure amosite grades of preformed pipe insulation ceased. Work then began to qualify asbestos free substitutes for the remaining materials. By 1972 six asbestos-containing products remained on the approved list (NSTM 1972) and by1974 there were none. MIL-STD 769E 1974) The Navy asbestos elimination program continued on for many years to find and approve substitutes for the myriad of other asbestos-containing products used in Navy ships such as electric cable insulation, gaskets, packing, adhesives, caulks, and others. **TABLE 1** summarizes these developments. Asbestos-containing product lines are highlighted in red for clarity.

Navy Insulation Product Development

Prohibiting Asbestos in Specifications Did Not Solve All of the Problem

By the end of 1974 the Navy was neither specifying nor purchasing asbestos or asbestos-containing thermal insulation materials either for new construction or for the repair of ships. (MIL-STD-769E 1974) But at that time there were still supplies of asbestos-bearing materials that had been acquired earlier. For some ships under construction or repair, money was found to dispose of the asbestos products purchased for them and to buy new asbestos-free products. For others, existing asbestos insulation products were consumed to exhaustion. Several materials "purges" were also conducted to rid the Navy of residual stores of asbestos materials. By the end of 1979, all asbestos insulation materials had been disposed of and ships delivered after then were free of asbestos insulation products. (NSTM 1986) There were, however, still hundreds of ships built in the earlier years that were still in service with asbestos insulation products. While Navy safety procedures were instituted in the early 1970's and improved over the years, there remained potential for asbestos-caused harm to workers and sailors aboard these ships until the insulation was replaced or the ship retired and recycled.

TABLE 1:

		1945		1960		1967		1972	
Specification	Material	Asb	Not Asb	Asb	Not Asb	Asb	Not Asb	Asb	Not Asb
32P8	Molded pipe	+							
32P11	Molded cork		+						
32I8	Molded block	+							
32F1	Thin felt	+							
32F3	Thick felt	+							
32I1	Thick batt		+						
32I2	Thick batt		+						
32I5	Molded pipe		+						
32T1	Tape	+							
32C14	Cement								
32P10	Plaster	+							
32C11	Cloth	+							
32C15	Cloth		+						
24D8	Cloth		+						
MIL-P-2781	Molded pipe			+		+			+
HH-I-551	Molded pipe & block				+		+		+
MIL-P-876	Molded cork				+				
MIL-I-2819	Molded block			+		+		+	
MIL-F-20077	Thin felt			+					
MIL-F-15091	Thick felt			+		+			
MIL-I-15475	Thick batt				+		+		+
MIL-I-2818	Thick batt				+		+		+
MIL-I-16022	Thin felt				+				
MIL-T-15349	Tape			+		+		+	
MIL-C-2861	Cement			+		+		+	
MIL-C-2908	Plaster			+		+			
MIL-P-15280	Molded sheet & tube						+		+
MIL-P-52350	Paper					+		+	
MIL-I-16411	Thick felt				+		+		+
MIL-I-22023	Thin felt						+		+
SS-C-466	Cloth			+		+		+	
MIL-C-20079	Cloth				+		+		+
MIL-C-788	Cloth				+		+		
MIL-P-15006	Paper				+				
HH-M-351	Board			+		+		+	
MIL-I-23128	Thin felt						+		+
MIL-I-24172	Molded sheet & tube						+		+
UU-B-790	Paper						+		+
SS-C-160	Plaster								+
		7	6	9	9	9	11	6	12
	Total	13		18		20		18	

National Safety and Consumption Patterns

Recent court decisions suggest that manufacturers of Navy hardware such as pumps and valves knew or should have known about the dangers of asbestos as far back as the 1940's and should have taken action to eliminate the material or at least warn their customers of the dangers. (Berkowitz v. A.C. and S., Inc. 2001)The available records concerning the regulation and consumption of asbestos do not support this expectation. safety standards as this knowledge spread and a corresponding decline in consumption as asbestos became progressively more difficult to use. As we will show, there were neither improved asbestos safety standards nor a decline in its consumption for nearly 30 years following the war.

Consumption Continued to Climb and Asbestos Limits Stayed High

The Navy was not the only consumer of asbestos and was not the only party that may have been concerned with asbestos safety issues. If the larger community of asbestos users knew of asbestos hazards, one would expect improved

Industrial Hygiene Standards Did Not Suggest Serious Danger (FISHER 1998)

In 1938, the National Bureau of Standards set an American Standard Safety Code for mineral dusts, of which asbestos was only one, of five million particles per cubic foot (5 mppcf) for continuous exposure of workers. This is equiva-

lent to about 177 particles per cubic centimeter. The threshold of visibility for airborne dust is about 10 particles per cubic centimeter so a limit of nearly eighteen times higher easily permitted visible airborne dust. In 1943, the U. S. Navy and the U. S. Maritime Commission jointly issued minimum safety and health standards for "contract shipyards', i.e., private shipyards building ships for the government. (U.S. Navy and Maritime Commission 1943) This document established minimum requirements for several safety and health matters with a major focus on industrial safety, welding safety and fumes from welding and painting. Asbestos was mentioned briefly as a material that could be handled safely with proper ventilation and respiratory protection. This document neither changed the existing mineral dust standard nor imposed a separate asbestos standard.

Post War Studies Affirmed the Wartime Standard

In 1946, a study of the health of workers building Navy ships found that asbestos insulation work was "relatively safe." (Fleisher and Drinker 1946) About that time, the American Conference of Governmental Industrial Hygienists (ACGIH), previously the National Conference of Governmental Industrial Hygienists promulgated its limit for asbestos dust and made it equal to the existing 5 mppcf mineral dust limit. The ACGIH limit was the federal standard of the time for military contracts under the Walsh-Healy Act (1936) and remained so for some 34 years until the Occupational Safety and Health Administration (OSHA) was created in 1970. (Williams-Steiger 1970) OSHA issued an asbestos standard (5 f/cc) under its own authority in December of 1971.

The Measurement Method Changed

The 5 mppcf limit was measured by a so-called "impinger" method involving collection of dust in a water bath and then counting all particles in a measured volume of water. When new asbestos dust standards were later developed, the measurement method was changed to a so-called "membrane filter" method. This involved collecting dust on a filter and counting under a microscope only those particles defined as fibers, i.e., having a length to diameter ratio of at least three, and counting only those fibers that were greater than 5 microns in length - the limit of visibility in the prescribed microscope. A sample drawn in an atmosphere containing 5 mppcf of asbestos dust would appear as roughly 30 fibers >5 microns under the new method. [The factor for conversion of mppcf to f/cc is contentious because asbestos mineral is originally a fibrous mass that is broken down into individual fibers by mechanical action. What is a non-fibrous particle in one setting such as asbestos mining can become a large number of fibers in another such as asbestos textile production. The conversion factor used in this paper (5mppcf =30 f/cc is taken from textile production] The balance of the dust in the sample (177 less 30 particles per cubic centimeter) might be asbestos "chunks" that could break down to fibers after being inhaled. Thus the new method might be non-conservative, but it is hard to tell in an industrial environment just from what visible chunks are made. In later discussions, 30 fibers per cubic centimeter (f/cc) are used as the reference basis for comparing old and new standards.

Asbestos Dust Standards Stayed High Through the 1970's

The 30f/cc limit as supplemented by ventilation and respirators was reviewed by the ACGIH in 1951, 1956, 1958, 1960, and beyond. (Fischer Maritime 1998) In 1965, a paper published by the New York Academy of Science first questioned the suitability of the old limit and suggested that something lower is needed. (Schall 1965) At about that time the work of Dr. Irving Selikoff of New York City's Mount Sinai Hospital and many others began to make clear the nature of the asbestos hazard. But even then there was conflicting evidence. In 1968, the Industrial Hygiene Foundation of America reported that asbestos disease among workers was significantly reduced in industries that effectively used ventilation and respirators under the old 30 f/cc standard. (Goodman 1968) That same year, the U.S. Department of Labor declined to regulate asbestos dust as a hazard-

ous agent in new shipbuilding labor standards. (U.S. Department of Labor, Wage and Labor Standards Administration 1968) .

ACGIH Began Tightening It's Standards in 1967

In 1967, the ACHIH began a rapid-fire reduction in the allowable dust levels. In that year, it proposed 12 f/cc; a limit that while lower still than the old 30 f/cc limit, still allowed visible dust in the workplace. In 1969, ACGIH proposed 5 f/cc and in 1978, it proposed separate limits for chrysotile, amosite, and crocidolite asbestos of 2, 0.5, and 0.2 f/cc respectively. The split limits came from a then-new understanding among some experts that amosite and crocidolite are substantially more hazardous than chrysotile. In 1991 ACGIH proposed a single standard of 0.2 f/cc for all asbestos because there was no good field method to discriminate between the three major fibers at that level. In 1997, it proposed a further reduction to 0.1 f/cc. (ACGIH 2001) While the ACGIH adopted the standards somewhat later than they were proposed and while OSHA began adopting sometimes different standards in late 1971, the trend of ACGIH actions illustrates that it was not until about 1970 that the industrial hygiene community began reacting to the new information about the health hazards of asbestos. **FIGURE 1** illustrates this progression.

In later years, the Government tried unsuccessfully to ban asbestos entirely — it still remains usable in the US. Thus from 1938 when airborne mineral dust limits were first established, the limits for asbestos dust remained very high and were not made truly restrictive until the 1990's. Yet recent court decisions are essentially holding manufacturers of equipment delivered during the "dusty" years to the standard that has been only recently established.

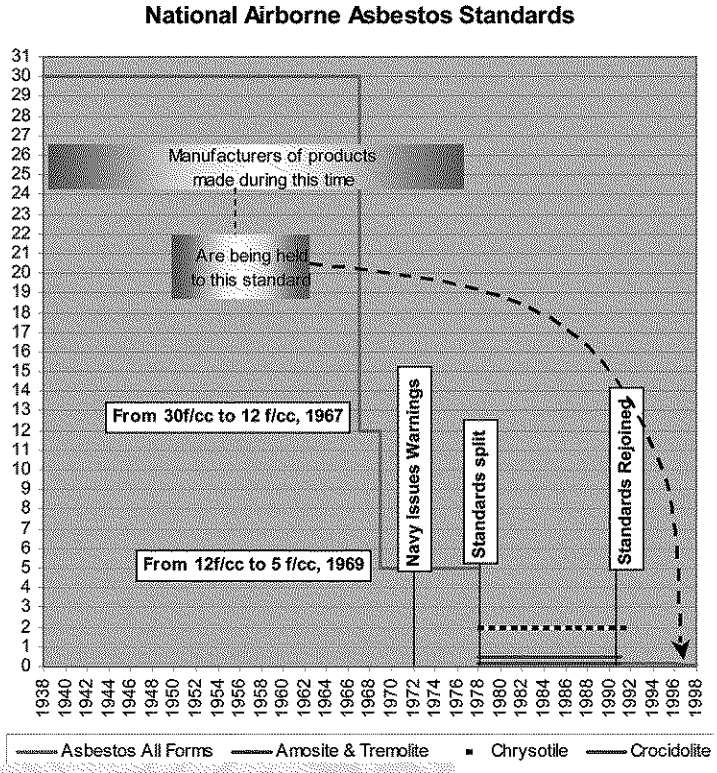


Figure 2: *National Asbestos Dust Standards Stayed High Until The 1970's*

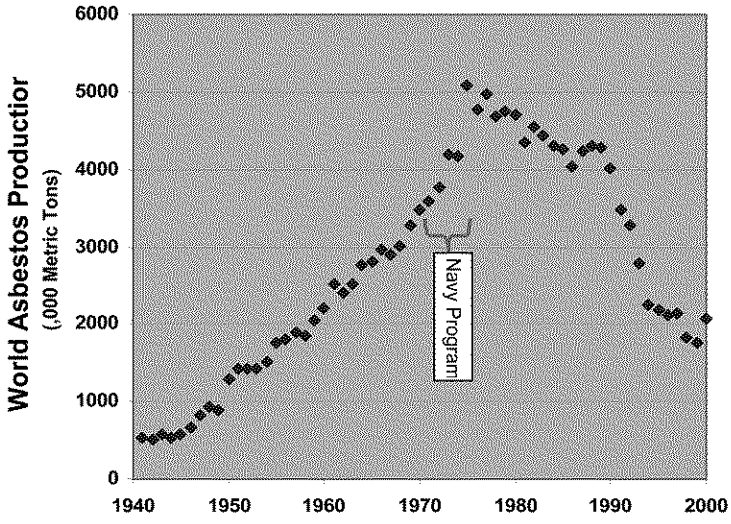


Figure 3: *World Asbestos Production 1940 to 2000*

World Asbestos Production Continued to Grow Until 1980

Throughout the 1940's and well beyond, the world production of asbestos fiber continued to increase rapidly. It is apparent from the consumption data that consumers of the fiber were not aware of concerns regarding health or safety or any other issue that might restrict the use of the mineral. (Virta) **FIGURE 2** shows the fiber production trends and also indicates the time of the Navy's final effort to eliminate the last uses of asbestos thermal insulation.

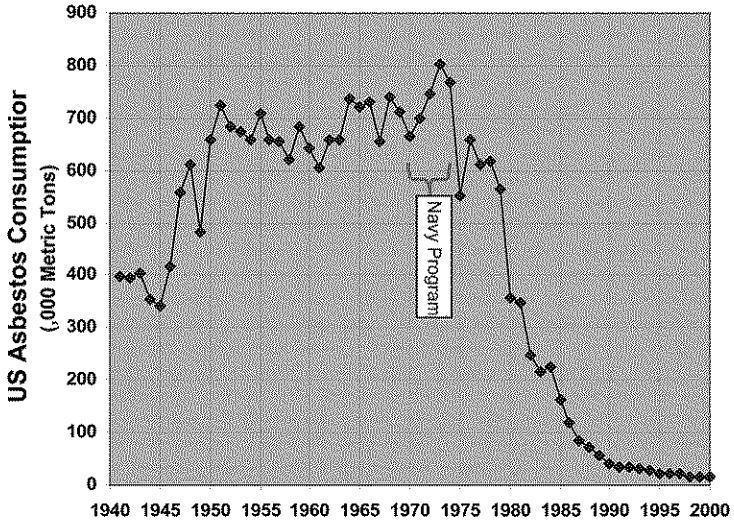


Figure 4: *U.S. Asbestos Consumption 1940 to 2000*

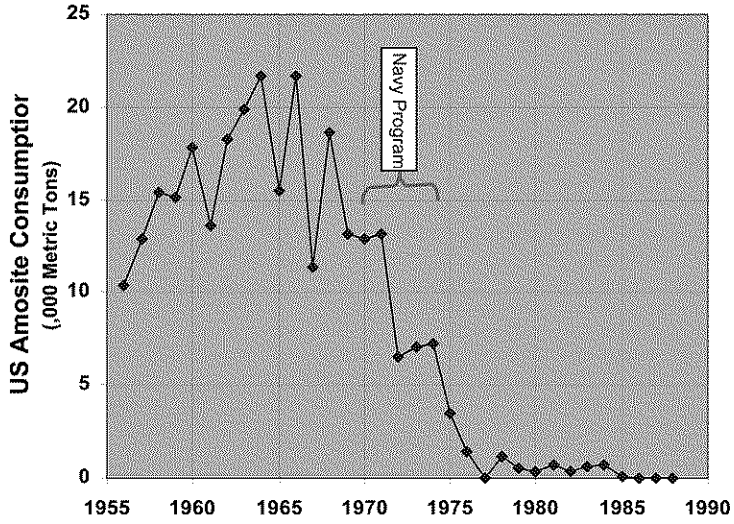


Figure 5: *US Amosite Consumption*

World consumption of asbestos fiber steadily increased to just over 5,000,000 metric tons of asbestos fiber per year in 1980, leveled off, and stayed above 4,000,000 metric tons until 1990 when it began to drop rapidly as the truly serious nature of the asbestos problem became well known.

U.S. Total Asbestos Remained High Until 1979

American demand and consumption shows a pattern comparable to world production and supply as seen in **FIGURE 3**. [This is not the same as production. Very little native asbestos fiber was produced in the United States.]

American asbestos consumption continued to increase until 1974 even during the main thrust of the Navy's asbestos elimination program. Until about 1975, asbestos consumers were apparently not aware of any growing recognition of an asbestos safety problem and the Navy's gradual move towards asbestos-free insulation products, culminating in 1974, had no apparent effect on national asbestos consumption. Indeed, consumption dropped and then rose again during the mid 1970's business downturn and stayed high until about 1979 when, despite a good business environment, it began to decline rapidly. This is perhaps due to the growing understanding among consumers of the fiber's dangers and the legal actions arising from that understanding. Even in the year 2000, however, 15,000 metric tons were consumed, despite some publicized health concerns.

Amosite Consumption Declined Earlier Than Overall Asbestos Consumption

FIGURE 4 shows the U.S. amosite consumption pattern since 1956. Data prior to 1956 are not available.

Amosite consumption was a fraction of total asbestos consumption, peaking at about 20,000 tons per year compared to about 800,000 tons per year for all asbestos as seen in Figure 3.

The Navy Was a Small Consumer

Figure 4 suggests that the Navy's asbestos elimination program may have been responsible for the sudden decline in U.S. amosite consumption. This is not confirmed by examination of the insulation quantities demanded by Navy ships. The quantity of insulation in Navy ships of the 1970's ranged from about three long tons in a tugboat, about long 39 tons in a new DDG, and about 55 long tons in a nuclear powered cruiser.(VAdm.T.J. Bigley 1979)Aircraft carriers of course, carried much more. The U.S. Navy shipbuilding rate in the 1960's and 1970's

averaged about 14 ships per year totaling about 100,000 long tons light ship weight. (Colton Co.) If we assume that the full weight of all insulation in Navy ships of the time was amosite asbestos (and by far it was not) and we assume that the average ship was equivalent to a DDG in terms of its insulation burden, about 550 long tons of amosite would be needed to insulate 14 ships per year. Further assuming that an equal amount is needed for fleet maintenance, our estimated annual Navy consumption of 1,100 long tons still leaves us well short of the 700,000 to 800,000 metric tons of total asbestos or the 10,000 to 20,000 metric tons of amosite consumed annually at the time.

Navy Actions Were Consistent with National Patterns

While the Navy was a major consumer of asbestos during WWII, thereafter as other consumption increased and Navy shipbuilding programs declined, it became one of many asbestos-using industries in the U.S. and, if anything, began to eliminate asbestos use much sooner than any other industrial sector. The national industrial hygiene community did not begin to treat asbestos as a special problem until about 1970 and even then, took about 20 years to develop truly restrictive regulations. It was conclude that:

Navy equipment manufacturers could not be expected to have known from the 1940's to the 1970's that asbestos was a unique hazard and even if a manufacturer did know, a recommendation to warn the Navy would have been inconsistent with the national consumption patterns and industrial hygiene regulations of the time.

The Hardware Manufacturer's Perspective

Manufacturers Products had to Meet Navy Department Specifications

Equipment for Navy ships was manufactured in accordance with a large number of Navy Department Specifications promulgated by various Navy offices. Beginning about 1950, these specifications were reissued as Military Specifications. There were many thousands of these specifications that detailed the design, construction and pre-delivery testing of ships, the equipment that goes in them and the materials from which they were made. Particular attention was paid to those features involving interfaces with systems or other manufacturer's equipment or affecting how the ship was operated. Even the content, organization and format of operating manuals (if any were required) was exactly defined by specification to ensure the crew could find the same type of information in the same place in each of the many manuals a ship carried. Similarly, the content, organization, and format of label plates — and even the material from which they were made — was strictly specified so the crew could easily determine a machines identity and key operating parameters. Small items such as some small valves had no label plates — the necessary information was cast into the bodies of the valves. Larger and complex items such as pumps and motors had specific label plates defined by the equipment specifications.

Conformance to Specifications Was Mandatory

The basic requirements of Navy contracting are made clear in a variety of ways. Standard "Changes" clauses, the "Extras" clause, the "Guarantee" clause and other clauses have been used for ship and material acquisitions in various forms during and following WWII. These and other standard clauses demanded strict conformance with the specifications — no more and no less — and required prior Navy approval for any changes (NAVEXOS P- 1995 1959) Additionally, Article 4 of the Special Provisions used for shipbuilding contracts states in part:

"No changes shall be made in the contract, exclusive of the plans and specifications, except on written order of the Secretary of the Navy, and no changes shall be made in the plans and specifications unless approved in writing by the Secretary of the Navy or by the Chief of the Bureau of ships, as his duly authorized representative...." See for example, the contract for construction of five Fletcher class destroyers (DD 498-502) executed in September 1940 with Federal Shipbuilding and Dry Dock Co. of Kearny, New Jersey

Occasionally, equipment specifications themselves expressly required prior approval of any deviations from requirements. For example, Navy Department Specification 45V18(INT) of 1946 states:

"Specific approval shall be obtained where departures are made from the referenced specifications." (Specification 45V18(INT) 1938)

Such a practice appears to be rare in Navy Department specifications, likely because the issues of specification conformance and prior approval of changes were so well covered in standard contract clauses. Regarding asbestos, we have found no requirements for warnings in any Navy specifications or documents of any kind prior to the early 1970's. Therefore it appears that addition of any warning about asbestos would have required prior written Navy approval.

Contractual Safety and Health Obligations Arose from National Standards

Navy contracts and specifications were not silent on the subject of personnel safety. A sample of the hundreds of specifications and manuals we have reviewed contain warnings or prohibitions on some subjects, most commonly warnings concerning dry cleaning solvents used for cleaning oily components. Most safety and health issues were addressed, however, through national policies. General Provision (GP) 17 of Navy shipbuilding contracts and the standard contract clause invoking the Walsh-Healy Public Contracts Act were the vehicles. Such clauses required shipbuilders and equipment manufacturers to comply with the relevant safety, sanitary and factory inspection regulations of the time. Until 1967 as we have previously explained, the national asbestos dust standard was 30 f/cc. GP 17 specifically stated in part:

"Compliance with [these laws] shall be prima-facie evidence of compliance with this subsection."

Thus a machinery manufacturer who may have dealt with small amounts of asbestos gaskets or packing or might have known that his product would be insulated in service was specifically relieved of any additional responsibility to his workers regarding asbestos through compliance with the then-current safety standards. Given the Government's contractual statement that all one needed to do regarding health hazards was to comply with Walsh-Healey standards in the workplace, it is not at all surprising that no manufacturer took the matter further.

Safety and Health Warnings are Common Now, but Were Not Earlier

Modern machinery comes with operating instructions replete with safety warnings and cautions for operators. Reference to the reader's automobile operator's manual makes that clear. It was not always so. Dozens of Bureau of Ships and Naval Ships Technical Manuals from the WWII years through the 1960's covering piping systems, pumps, main propulsion equipment, electrical equipment, and others have been reviewed as have several equipment technical manuals provided by the equipment manufacturers. It is rare to find any personnel safety warnings, cautions, or instructions whatsoever in these documents. Those that are present deal with major system considerations such as turning off the steam to a machine before opening it. The focus of these manuals was ship, system, and machinery safety. Personnel safety was covered in separate safety manuals such as "Safety Precautions for Shore Activities" and others. (NAVSO P-2455 1965)

The Navy Was Unlikely to Approve An Asbestos Warning

A request from an equipment manufacturer to add an asbestos warning to his equipment would have been referred to the Navy's Bureau of Medicine and Surgery (BUMED) for action. Up to the late 1960's or early 1970's, BUMED would have noted that the national asbestos dust standard was very high, that work on the equipment was unlikely to release dust approaching this level, asbestos was widely used in Navy ships and in worldwide industry and the product manufacturers had reported no problems. Therefore, it is not believed BUMED would have taken the matter forward.

Equipment Labels or Manuals Were the Wrong Place for Asbestos Warnings

Furthermore, the proper place for warnings concerning asbestos insulation (or packing or gaskets) that were thought hazardous to the crew was not on an individual machine or item of equipment or in any of the hundreds of equipment technical manuals carried by a ship but in the long-established insulation or packing and gasket manuals covering the use of these products aboard ships, e.g., BUSHIPS Manual Chapter 39 (1938) *The Navy did not see fit to include any warnings or cautions in any of such documents until 1972.*

Summary and Conclusions

The Navy's thermal insulation practices from WWII on were consistent with national asbestos consumption patterns, health and safety regulation, and the available materials of the times. The Navy developed more and more non-asbestos products in the years following WWII to meet performance goals. It did not act to eliminate asbestos insulation entirely until the early 1970's when the health hazards of asbestos fibers became apparent to it and the nation. Navy contractors were required to follow specifications exactly and the Navy told them exactly what to do about any health hazard (follow Walsh-Healy). In view of the abundant and continuing uses of asbestos throughout the country well into the 1970's and the acceptable dust levels permitted by Government standards until then, we believe that the Navy would not have approved an asbestos warning recommended by a manufacturer before then nor would ship's equipment have been the proper location for such a warning.

The legal environment for any Navy equipment manufacturer is increasingly perilous. Recent court decisions are holding manufacturers to health standards and legal standards that did not exist until decades (and sometimes a half a century) after the equipment was built. The legal environment for other toxins may follow the same path. Should equipment manufacturers begin to be affected by this trend, there can and will be uncertainty and substantial confusion in the Navy's ship production and repair programs. Perhaps the Navy will be forced to recreate the pre-World War I practice of building everything itself and rely on its agency sovereign immunity for liability protection. Or perhaps military equipment manufacturers will demand some new form of complete indemnification from the Government.

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