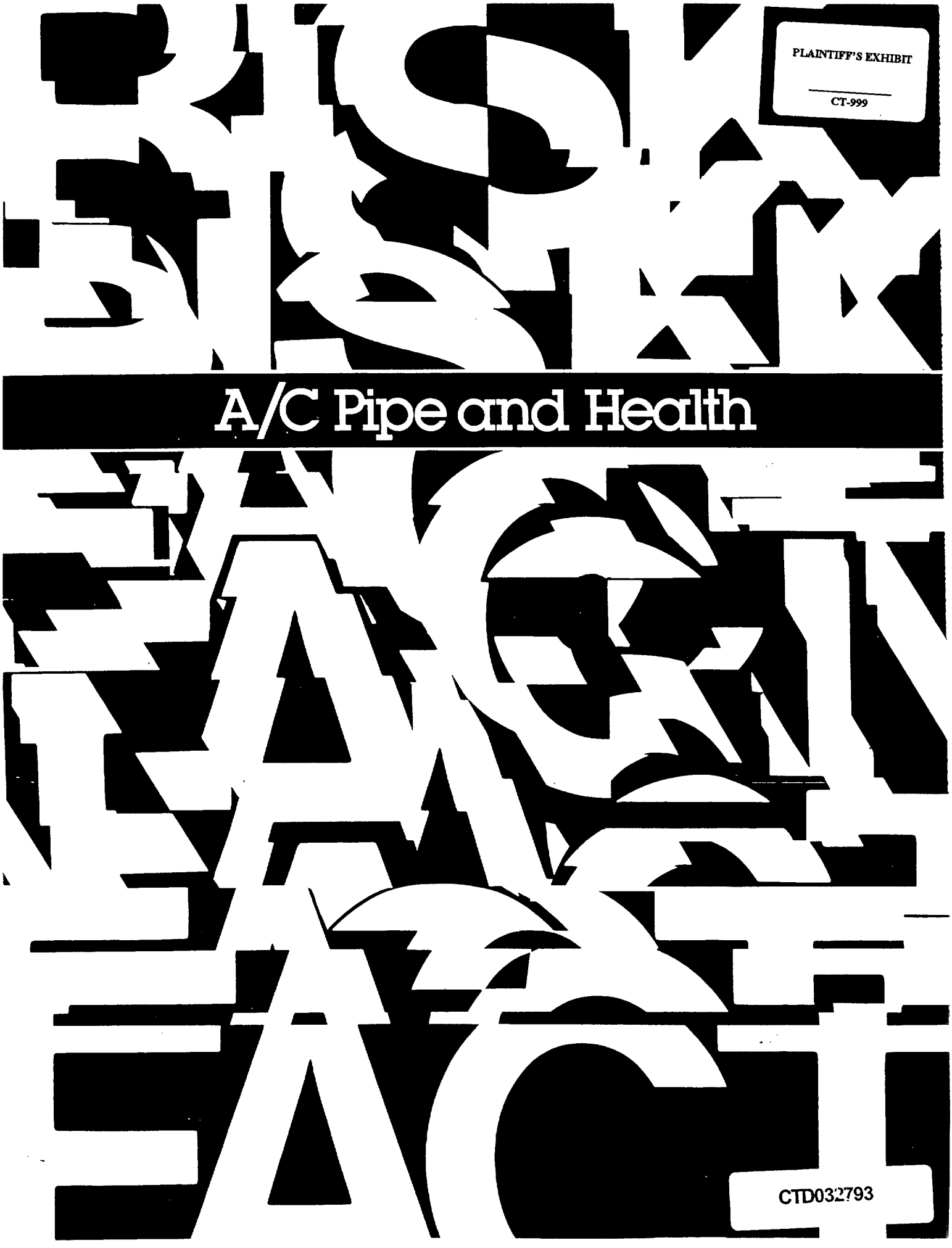

PLAINTIFF'S EXHIBIT

CT-999

A/C Pipe and Health

CTD032793

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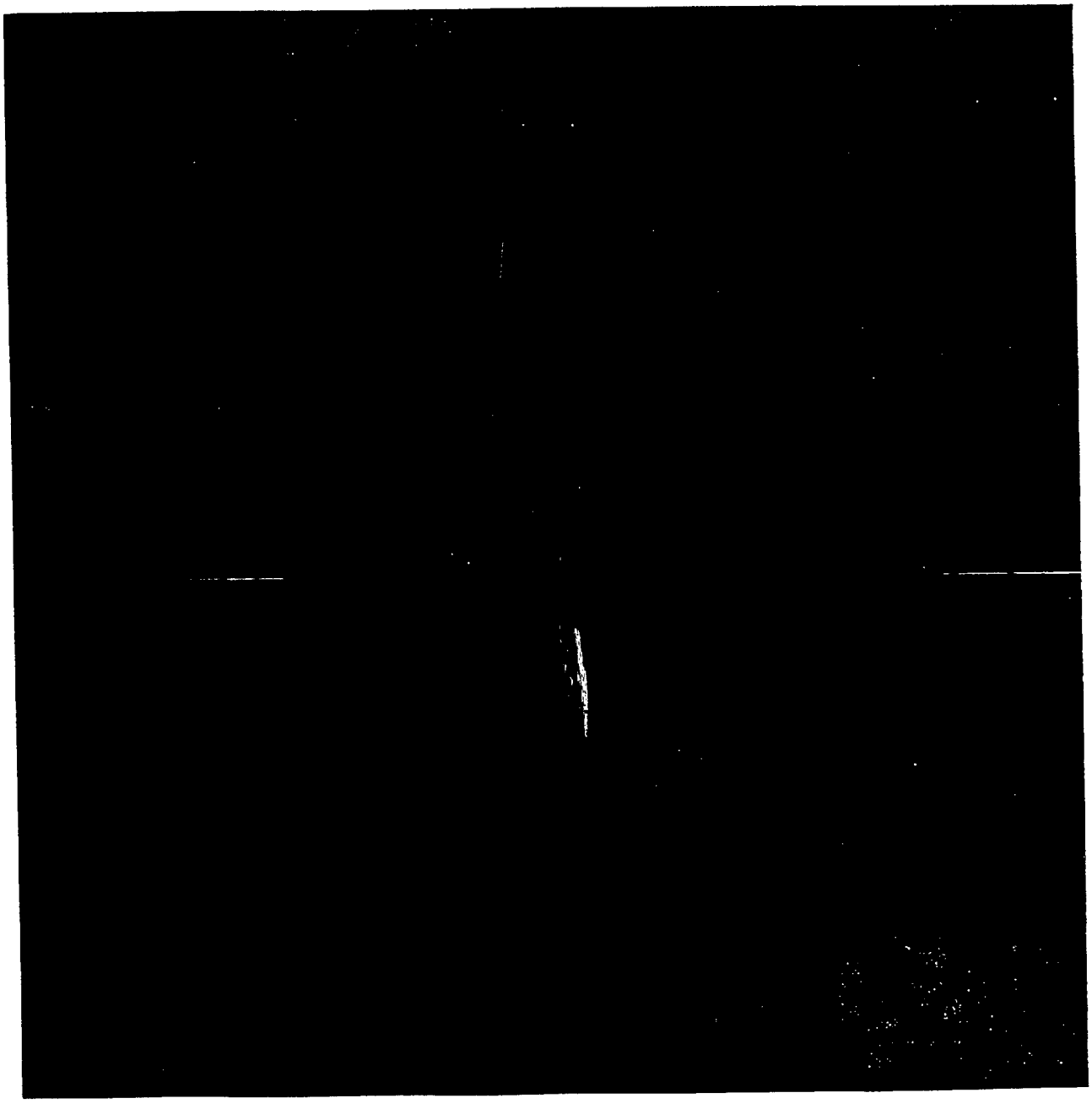

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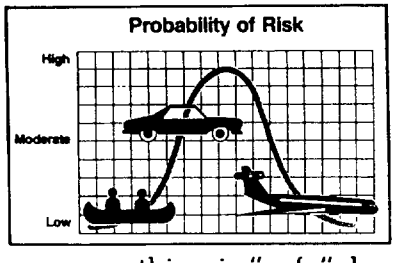
Perceptions of Risk

The world has never been . . . and never will be free from risk. It is inescapable. It is life itself . . . and since the dawn of time, man has accepted risk as a normal part of his daily activity.

The perception of risk varies . . . from situation to situation . . . from individual to individual. What one person considers safe, another may perceive as downright foolish. This simply illustrates that the perception of risk is subjective, emotional and often has little basis in fact.

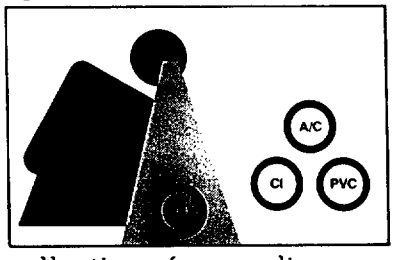
All risks *do* have one thing in common: they can be measured . . . objectively, scientifically. There is a name for this measurement . . . it is called *probability*. Just as the meteorologist predicts the probability of rain, so can odds be calculated for driving an automobile and having a severe accident or lying on the beach and getting sunburned.



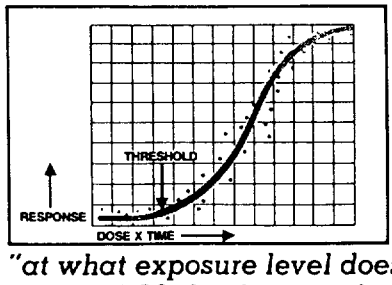
SAFE VS. ZERO RISK Something is judged "safe" if its probability of risk is acceptable. However, to say something is "safe" does not necessarily mean it is "free from risk". A seemingly "safe" 6-minute canoe ride, for example, carries the same risk of death as a 500 mph commuter flight from Washington, D.C., to New York City . . . traveling the same distance by automobile, the risk increases five-fold.[1]

Very few things to which we are exposed are "zero risks". But like the automobile, electricity and X-rays, there are non-harmful ways to use potentially harmful things . . . it's simply a matter of probabilities.

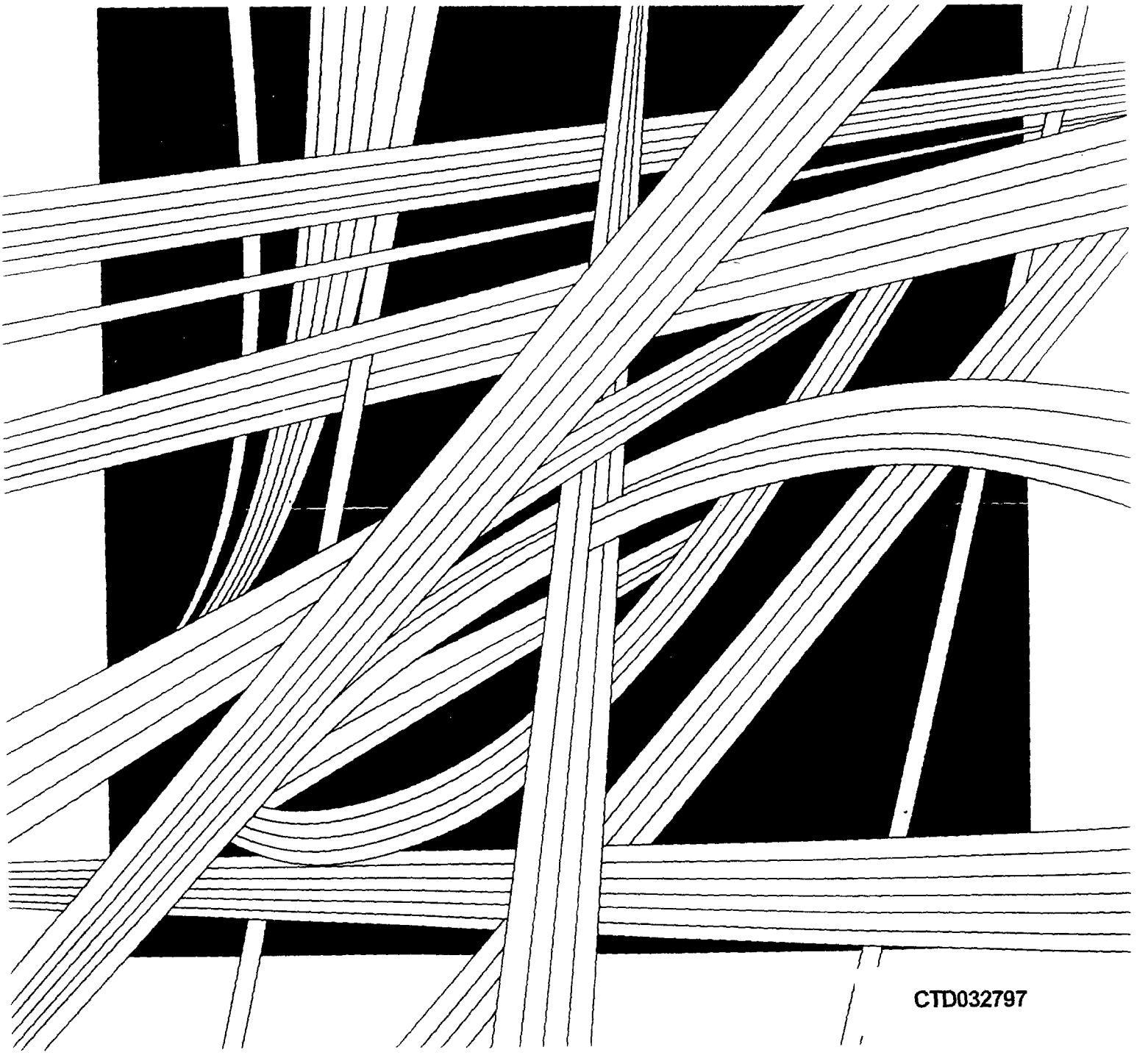
CANCER AND CARCINOGENS Just as cavemen had their risks, modern man has his. Certainly none is as well-publicized, personal and fraught with anxiety, as the risk of cancer. While the fear of cancer can and does alter our *perception* of risk, it cannot . . . does not . . . alter the *probability* of risk.



In the simplest sense, cancer is an unrestrained growth of cells. It is not a single disease, but a collection of many diseases caused by agents medical science calls *carcinogens*. Asbestos is a carcinogen . . . it is not alone. It shares this dubious distinction with a growing list of common and exotic substances. As a matter of fact, nearly 300 organic and inorganic chemicals, many of them known or potential carcinogens, have been identified in drinking water *alone*. This fact has prompted a much closer examination of water pipe materials in common use to determine if any are above suspicion, since all contain toxic materials.



DOSE RESPONSE AND THRESHOLD The critical question with asbestos, as with any toxic material, is *"at what exposure level does it represent a hazard?"* Medical research determines this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Asbestos and A/C Pipe

level by a concept known as *dose-response*. The basic principle is rather straightforward: for every given dose, there is a proportionate biological response. Let's add another wrinkle to this concept . . . and it is a common sense wrinkle . . . *there is a dose small enough which will result in no measurable response*. This dose level is called a *threshold*. Threshold effects are common. We have thresholds for hearing, pain, heat and martinis.

Everything known about the potential hazards of asbestos points to the fact that it observes the rules of dose-response. Therefore, a practical threshold or safe level of exposure to asbestos must exist. If it did not, it would be difficult to reconcile the *prevalence* of asbestos in the environment with the *absence* of related diseases in the general population.

The probability of finding asbestos in the environment is very high. Asbestos-bearing rock formations are found in over 50 countries throughout the world. Geologists tell us these formations were created 470 million years ago by the action of hot, subterranean water on rock containing iron, magnesium and silica. These waters dissolved the surrounding rock layer producing "veins" of liquid minerals. As the earth cooled, these minerals crystallized into the fibrous ore we know today as asbestos.[2]

More than 2,000 years ago, pharoahs and kings used this unique product of nature which the Greeks named *asbesta*, meaning "unquenchable". Today, you don't have to be royalty to use asbestos . . . practically everyone does. There are over 3,000 products which use asbestos, usually in combination with other materials such as cement.

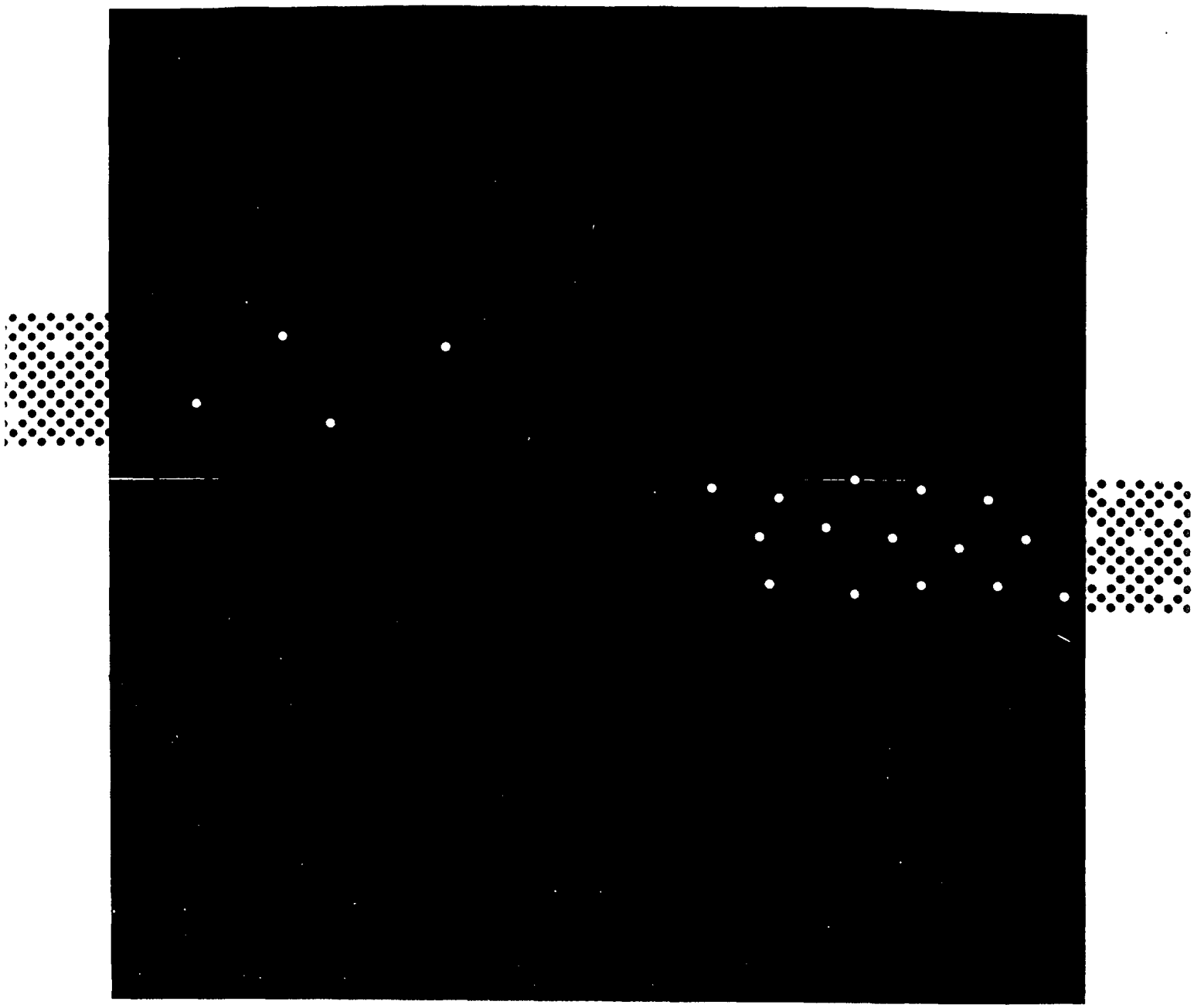
Micro-Reinforcement of Cement

Asbestos	+	+	++	++	++	++
Steel	+	+	+	++	+	+
Carbon	+	+	+	–	–	++
Glass	+	+	+	–	–	–
Organic Fibers	–	±	+	–	–	±

UNIQUE PROPERTIES

As the world's only naturally occurring mineral fiber, asbestos is truly unique. Its soft and silky fibers exhibit incredible tensile strength . . . 4 to 5 times greater than steel. Its flexibility, heat and chemical resistance are unmatched by any other natural or man-made fiber.[3] Asbestos is not only unique, it is *irreplaceable* for the micro-reinforcement of high performance products like asbestos-cement (A/C) pipe.

FREE VS. BOUND ASBESTOS Asbestos-cement pipe contains a blend of asbestos fibers: *chrysotile* for reinforcement and



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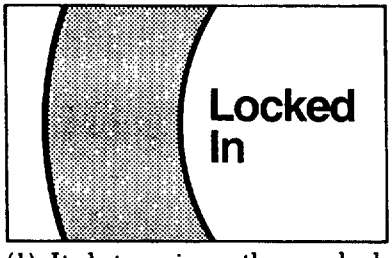
crocidolite or blue asbestos also for reinforcement as well as for facilitation of the pipe manufacturing process.

The total asbestos portion of A/C pipe is less than 20 percent. *More importantly, the asbestos fibers are not free, but encapsulated by or "locked-in" the cement binder.* Picture, if you will, the use of steel reinforcing rods in concrete.



The distinction between "free" and "bound" asbestos is *extremely* important. Why?

(1) It determines the probability of fiber release, which in turn, directly relates to the probability of risk.
(2) It explains *why* asbestos-cement pipe is a non-harmful use of asbestos.

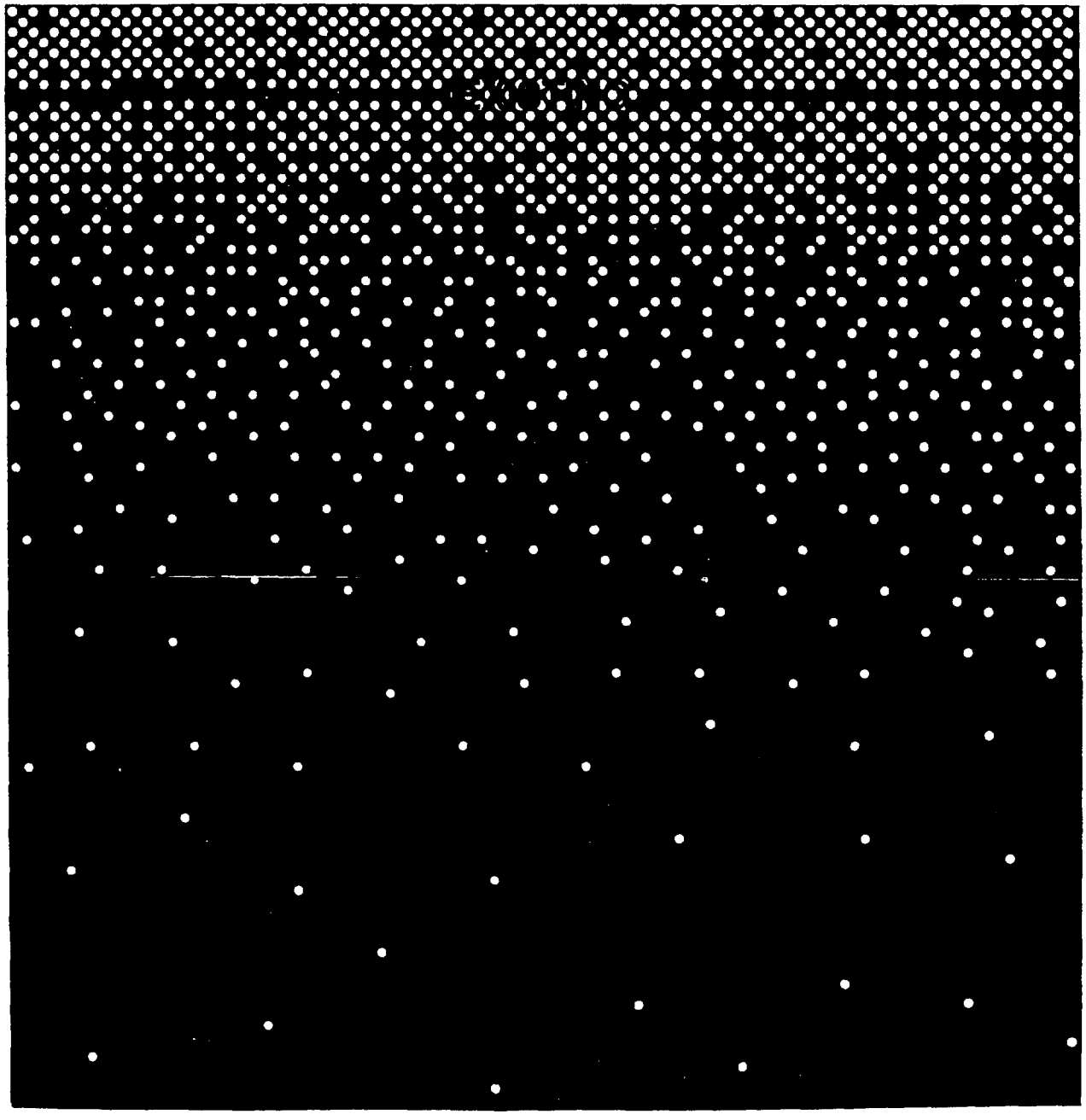
The ability of asbestos to separate into microscopically small fibers is the key to its biological availability, in other words, its ability to become airborne or waterborne and thereby inhaled or ingested. The biological effects of asbestos are believed to be a function of fiber shape and size, rather than chemical composition. Generally, the longer and thinner the fiber, the greater the potential health risk.

For regulatory purposes, an asbestos fiber has been defined as "particulate material whose length is at least three times longer than its width."[4] Fiber dimensions are measured in *micrometers* . . . that's about 39 millionths of an inch or about one-seventieth the diameter of a human hair. Asbestos fibers longer than 5 micrometers are of prime interest from a health standpoint.

SUSCEPTIBILITY Like all biological effects, asbestos health effects vary significantly from person to person. Physical activity, inherited immunities, the preexistence of other diseases, and the efficiency of the body in clearing particles, all affect individual susceptibility.

Cigarette smoking, for example, increases by over 90 times, the risk of lung cancer in workers exposed to asbestos. Non-smoking asbestos workers, on the other hand, show no more than the normally expected rate of lung cancer in the general population.[5,6]

DOSE AND ROUTES OF ENTRY While the relationship between asbestos fiber exposure and "probability of risk" is not a simple one, we do know this: *the body's response to asbestos is dependent on dose and route of entry,* that is, whether it is inhaled or ingested. Inhalation is the more



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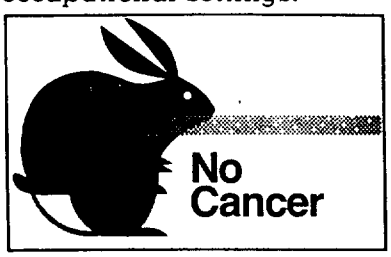
A/C Pipe and Field Operations

common means by which asbestos enters the body. Although natural cleansing mechanisms catch and clear as much as 98 percent of inhaled dust, prolonged or heavy exposure to airborne asbestos can lead to *asbestosis*, a disease which impairs breathing and in the case of smokers, high risk of *lung cancer*. To a much lesser degree, asbestos may cause *mesothelioma*, a rare cancer of the chest or abdominal cavity. Scientists believe that asbestosis and lung cancer are associated with fibers longer than 5 micrometers and mesothelioma with fibers longer than 20 micrometers.[7] *To date, all identified occurrences of these diseases attributed to asbestos, have involved exposures in or related to occupational settings.*



In contrast to inhalation, a clear "cause and effect" relationship between ingested asbestos and gastrointestinal or GI cancer has not been established. In certain heavily exposed occupational groups, a somewhat higher than normal rate of GI cancer has been reported.[8] It might therefore be concluded that ingested asbestos may be related to gastrointestinal cancer. Yet . . . everything from mice to baboons has been watered, force-fed or dined at will on asbestos . . . as much as 6 percent of their total food intake.[9,10,11,12,13,14,15] Results? *No cancers*.

These then are the risks for exposure to asbestos: "high" for heavy or prolonged inhalation exposure; solely "presumptive", with no direct evidence of risk for ingestion.

Recognizing the risks of airborne asbestos, regulatory agencies internationally have set safe levels of exposure based on the number of fibers longer than 5 micrometers. In the United States, an *occupational exposure standard* is used for workers in asbestos product manufacturing industries. A *construction industry standard*, yet to be established, will apply to workers who may handle asbestos-containing products such as A/C pipe.

OSHA Asbestos Exposure Standards

	Eight Hour Time Weighted Average	Ceiling Concentration
Occupational		
Existing	2.0 fibers/cc	10 fibers/cc
Proposed	0.5 fibers/cc	5 fibers/cc
Construction		
Existing*	2.0 fibers/cc	10 fibers/cc
Proposed**	—	—

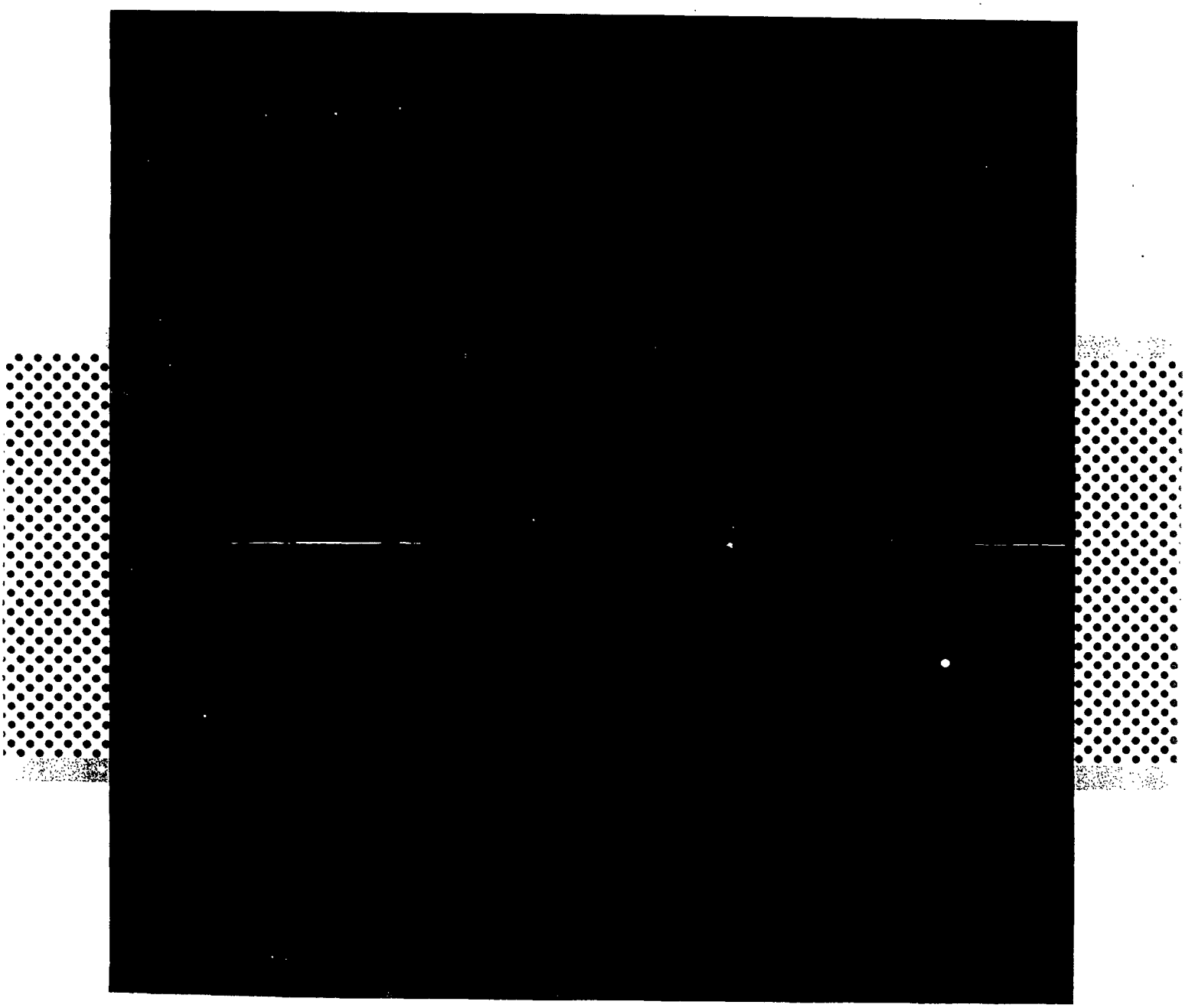
*Identical with existing Occupational Standard
**Pending.

Source: Code of Federal Regulations, 29, Part 1910.1001.

FIELD OPERATIONS Let's compare the *existing* and *proposed* occupational standards to fiber levels measured when cutting or machining A/C pipe by recommended work practices.

Loading, unloading and stringing out A/C pipe are basically dust-free operations. Even in the most confined working space, dust levels are barely measurable. A survey conducted by the Port of Tyne Authority in England measured dust levels in the hold of a ship loading A/C pipe.[16] The *highest* dust measurement was 0.01 fibers/cc . . . *one-fiftieth* of the *proposed* OSHA Occupational Standard.

The adaptability of A/C pipe and the availability of a complete line of short lengths and standard fittings greatly minimize the need for field operations.



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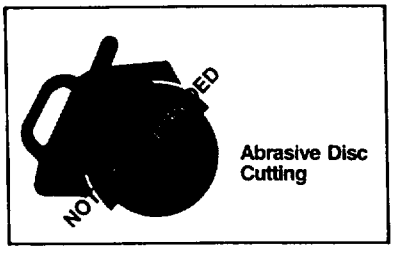
A/C Pipe and Waterborne Asbestos

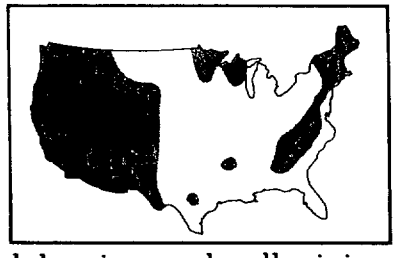
Even when cutting, machining or finishing are necessary, independent industrial hygiene studies[17] have confirmed that *when recommended work practices are followed, fiber levels are not only far below the present 2 fiber standard, but also meet the proposed ½ fiber standard* (see Appendix A).



This should come as no surprise. Remember . . . the asbestos fiber is *locked-in* the cement binder. The infrequency and short duration of field operations further reduce even these minimal exposures. *Conclusion: when recommended work practices are followed, the risk of working with A/C pipe is virtually non-existent.*

What about waterborne asbestos? Does potable water conveyed through A/C pipe pick up asbestos fiber and cause cancer?

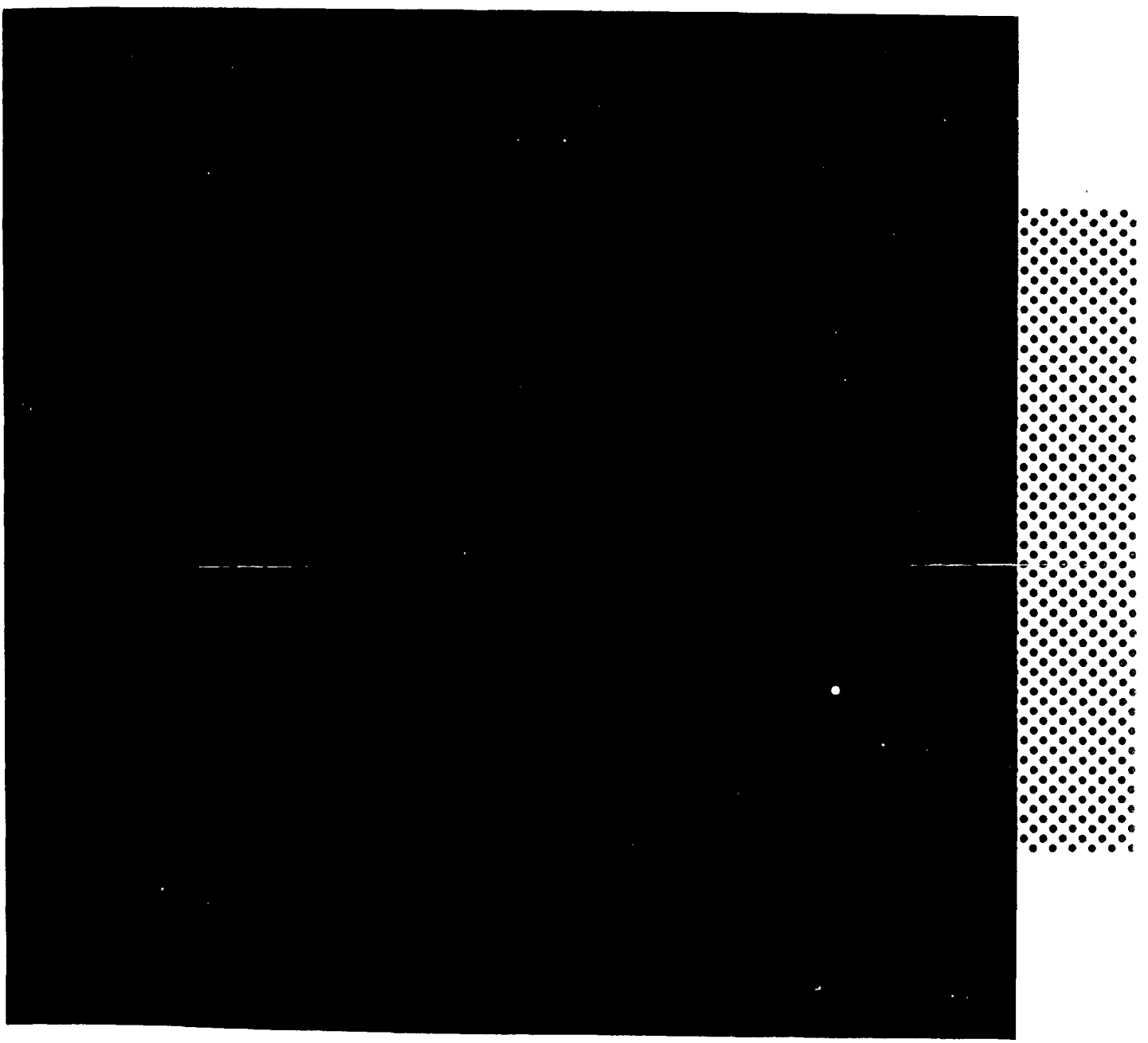
These questions about the risks of ingested asbestos are being raised because of the recognized hazards of excessive or prolonged exposure to airborne asbestos. To answer them, let's see how asbestos can enter a potable water system . . . the facts will speak for themselves.



SOURCE WATERS "The general prevalence of asbestos in soil results in its presence in most waters of lake, river and well origin, and in distribution systems whether fabricated of asbestos-cement or other materials."[18] Natural background levels have been confirmed by nation-wide surveys conducted by the United States Environmental Protection Agency.[19] Although EPA found sites with asbestos levels below present limits of detection, natural and treated waters in Montana, Oregon, Pennsylvania, California, Connecticut, Massachusetts and Georgia had levels in the range of millions of fibers per liter.

Similar studies in Canada concluded: ". . . there is asbestos in all surface waters of all habited areas of Ontario, and perhaps there always has been some asbestos there."[20]

The presence of asbestos in ice core samples dating back hundreds of years[21] confirms that natural weathering and erosion have in the past and will for generations to come, release small amounts of



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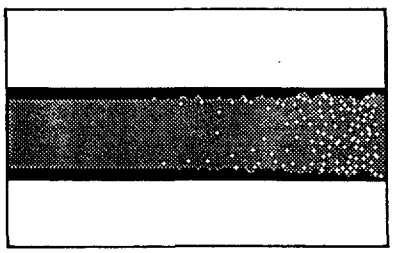
asbestos to surface watersheds and underground aquifers around the world.

SOILS Another potential source of waterborne asbestos can be asbestos-bearing soil deposited in the pipe during installation or repair. The chances of this occurring are the same whether the pipe is ductile iron, plastic or asbestos-cement. A thorough flushing of the distribution system is a simple enough precaution to eliminate any long term effects of soil contamination.

TAPPING A/C PIPE To provide house connections, water distribution mains are tapped approximately once every 140 feet. With A/C pipe, tapping can lead to a temporary increase in the asbestos fiber level of the water. *The industry recommends when tapping A/C pipe while under pressure, that equipment with a positive purge be used.* This ejects 99 percent of the asbestos-cement chips and downstream flushing takes care of the rest. Another alternative is the use of heavy-walled tapped couplings supplied directly from the factory.

AGGRESSIVE WATERS Now the critical question . . . *does A/C pipe contribute asbestos to drinking water conveyed through it?* A no-nonsense answer to this question is a simple "yes". . . and "no." *It depends on the water . . . not the pipe. As long as A/C pipe's cement binder remains intact, the release, if any, of the locked-in fiber is infinitesimal.*

A/C pipe is remarkably corrosion resistant . . . much more so than metallic piping products. There are, however, certain types of *corrosive* or *aggressive* waters that will attack even corrosion resistant asbestos-cement. The most common of these are low hardness or *soft* water and low pH or *acidic* water.



Imagine aggressive waters as being *hungry* waters . . . not only hungry for calcium and magnesium in cement, but hungry for iron, lead, copper and cadmium in metallic pipe, hungry for organic residuals in plastic pipe, polyaromatic hydrocarbons in coal tar linings, hungry for almost all materials in waterworks use today.

Aggressive waters take a staggering toll from the U.S. waterworks industry every year . . . an estimated $400 million[22] in replacement costs and perhaps as much as $600 million in protective devices and measures. But the heaviest toll of all may be its toll in human lives. In 1974, a "consistent and highly significant relationship" was confirmed between aggressive water and cardiovascular diseases such as heart attacks, still the number one killer in the United States. The study showed that the cities with the softest water had *twice* the death rate from coronary disease as cities where the water was hardest.[23] Economics *alone* argue strongly for national treatment standards for aggressive water . . . the loss of life punctuates the urgency.

AGGRESSIVE WATER GUIDELINES Though the A/C pipe industry is not the first to spotlight the need for stabilization, it has been a leader in taking positive steps to include aggressive water guidelines in its national product specifications. Any potential loss of business the industry



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could suffer as a result of these guidelines, is more than offset by the knowledge that where A/C pipe is used, both the utility and consumer are assured safe, trouble-free service. Based on a half-century of industry experience, *these guidelines do not recommend the use of A/C pipe with highly aggressive waters.*

Aggressive Water Guidelines

Type of Water	Aggressive Index	A/C Pipe Recommended
Non-Aggressive	≥12.0	Types I & II
Moderately Aggressive	10.0-11.9	Type II *
Highly Aggressive	<10.0	

*The serviceability of pipe for such applications should be established by the purchaser in conjunction with the manufacturer

Source: American Water Works Association Standards C-400-75 C-402-75
American Society for Testing & Materials Standard C-500-76

ASBESTOS IN A/C PIPE SYSTEMS

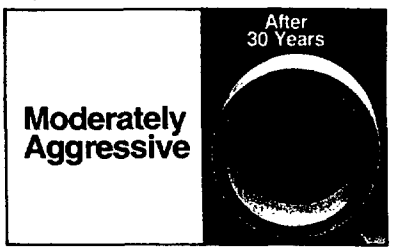
Measurements taken in the field *confirm* EPA laboratory results that for "moderately" and "non-aggressive" waters, A/C pipe does not contribute significant or in many cases, even measurable amounts of asbestos to drinking water conveyed through it.

Northeast Illinois . . . an analysis of 15 public water systems containing A/C pipe of various ages, lengths, and diameters. *Conclusion: No significant release of asbestos from A/C pipe was observed.*[24]

California . . . an analysis of water at the end of long pipe runs in a distribution system with over 1,000 miles of A/C pipe. *Conclusion: All tests for asbestos negative.*[25]

New Mexico . . . an analysis of asbestos fiber concentrations in water systems containing 548 miles of A/C pipe. *Conclusion: "No evidence of asbestos pick up from A/C pipe."*[26]

Texas, Ohio and Connecticut . . . EPA monitorings of A/C pipe systems. *Conclusion: Fiber levels either "not statistically significant" or "below detectable limits."*



Common sense alone tells us that "real world" risk must relate to "real world" exposure. For that reason, these results are important . . . they measure actual exposures to waterborne asbestos in A/C pipe systems. *Clearly, the amount of asbestos, if any, contributed to drinking water supplied through A/C pipe, is infinitesimal . . . certainly far less than is found in many natural source waters.*

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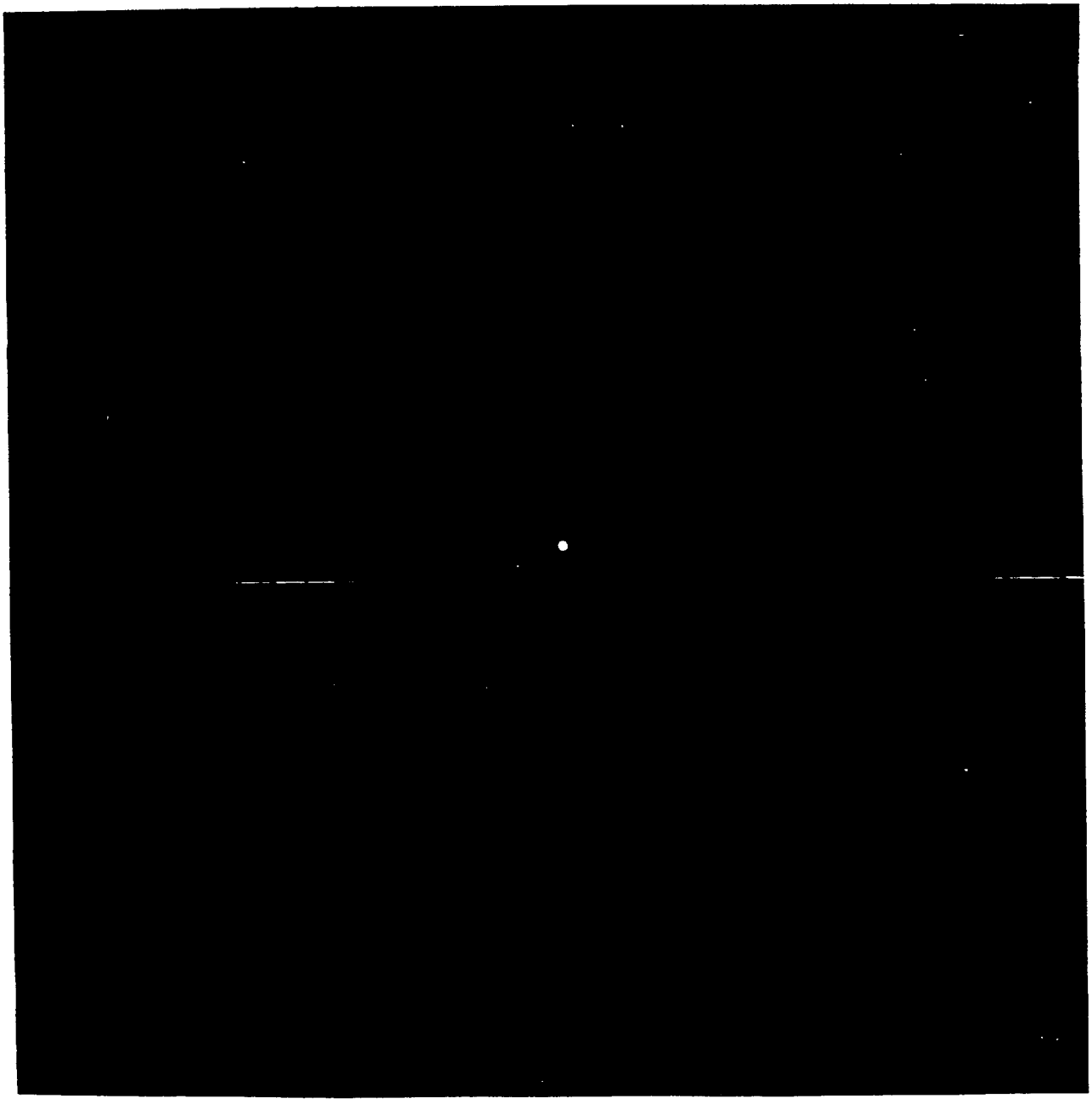

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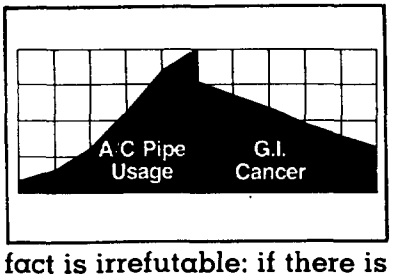
Asbestos in Water... The Risks

What about water supply systems which have measurable quantities of asbestos fiber . . . what's the risk of contracting cancer?

This time there is a straight answer to the questions . . . there is no evidence that anyone in the general public has ever contracted any disease from naturally occurring asbestos or the minute amounts of fiber released from A/C pipe. This is not a judgment of safety . . . it's a statement of fact.

A possible explanation may be the extremely small size of waterborne asbestos. You may recall that asbestos fibers less than 5 micrometers in length are not generally associated with adverse health effects. Commenting on asbestos in natural water supplies, EPA noted ". . . few samples show any evidence of fibers greater than 5 micrometers long and when these are present, they represent only a small percentage of the total fiber count."[27]



INGESTED ASBESTOS AND CANCER Whether it's the fiber size or the sub-threshold "dose", one fact is irrefutable: if there is a "cause and effect" relationship between GI cancers, ingested asbestos or the use of A/C pipe, it does not show in state, national or world cancer statistics.

Let's start with the most publicized case, Duluth, Minnesota . . . millions of asbestos-like fibers in its drinking water, and Houston, Texas, with none. A court-ordered comparison of tissues from deceased residents from both cities *failed to disclose any asbestos fibers of waterborne origin.*[28]

Duluth again . . . this time a comparison with Minneapolis-St. Paul, which has no known asbestos in its water. *No statistical difference in the incidence of gastrointestinal cancer.*[29]

Switzerland . . . the highest per capita use of A/C pipe in Western Europe. From 1951, more than 20 years after A/C pipe was introduced, to 1973, *the death rate from GI cancer dropped a significant 29 percent.*[30]

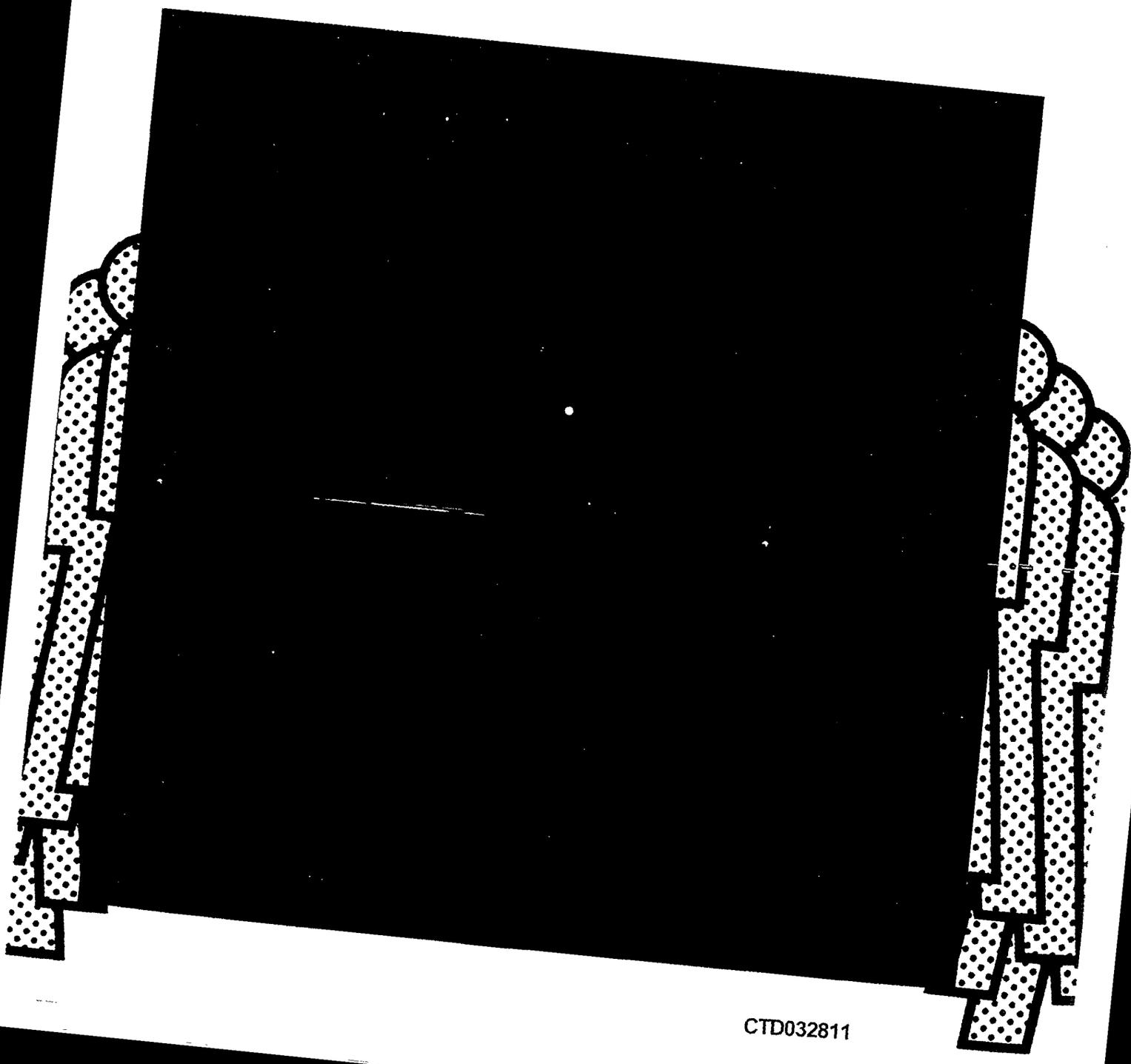
The United States . . . despite over 40 years of rapidly increasing A/C pipe usage, *gastrointestinal cancer rates for all sites for the period 1952-54 to 1972-74, declined 33 percent.*[31]

Tennessee . . . Knoxville, A/C pipe in use since 1938 and Nashville, no A/C pipe. A twenty-year comparison shows that *Nashville with metallic pipe, had a 29 percent higher death rate from GI cancer than Knoxville with A/C pipe.*[32]

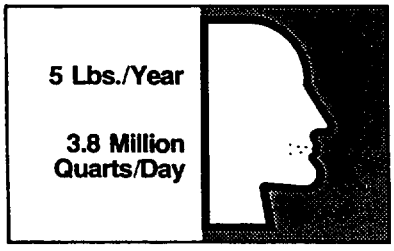
Connecticut . . . Preliminary results from an Environmental Protection Agency study show *no correlation between the incidence of GI cancer and the use of A/C water pipe.*[33]

This inability to relate a "real world" dose with a "real world" response again says in a common sense way that like the amount of asbestos contributed to drinking water by A/C pipe, the cancer risk from ingesting that asbestos must be infinitely small. An exact number? Well, we did say that all risks could be measured.

MEASURING THE RISKS Let's imagine a hypothetical human feeding experiment



based on magnified doses used in actual animal feeding studies which have failed to establish a cancer risk from ingested asbestos. Based on a diet containing 0.27 percent asbestos, this amounts to about 5 pounds of asbestos . . . roughly the amount of butter you eat in a year. Using the *highest* fiber levels found in drinking water, you would have to drink *3.8 million quarts of water per day to consume 5 pounds of asbestos in a year . . . or over 50,000 quarts per day for a lifetime.*



This is, of course, preposterous. But it does quantify and place in perspective the probability of risk from a "real world" dose of ingested asbestos from A/C pipe . . . *a dose which is not uncommonly a billion times less than asbestos levels proven to be non-carcinogenic in animal feeding studies.*

One in a billion! That figure probably doesn't register with most people. In terms of quality, it's one bad apple in 2,000,000 barrels. In terms of volume, it's a very, very dry martini . . . 1 drop of vermouth in 15,750 gallons of gin.[34] *In terms of risk . . . it's a thousand times safer than smoking 1½ cigarettes or drinking a half-bottle of your favorite wine.*[35]

NO RISK TO PUBLIC In spite of perceptions and publicity to the contrary, these incredibly low probabilities of risk tell us that A/C pipe is not . . . and never will be a risk to the public . . . a judgment that has been confirmed again and again by some of the most respected health authorities in the world.

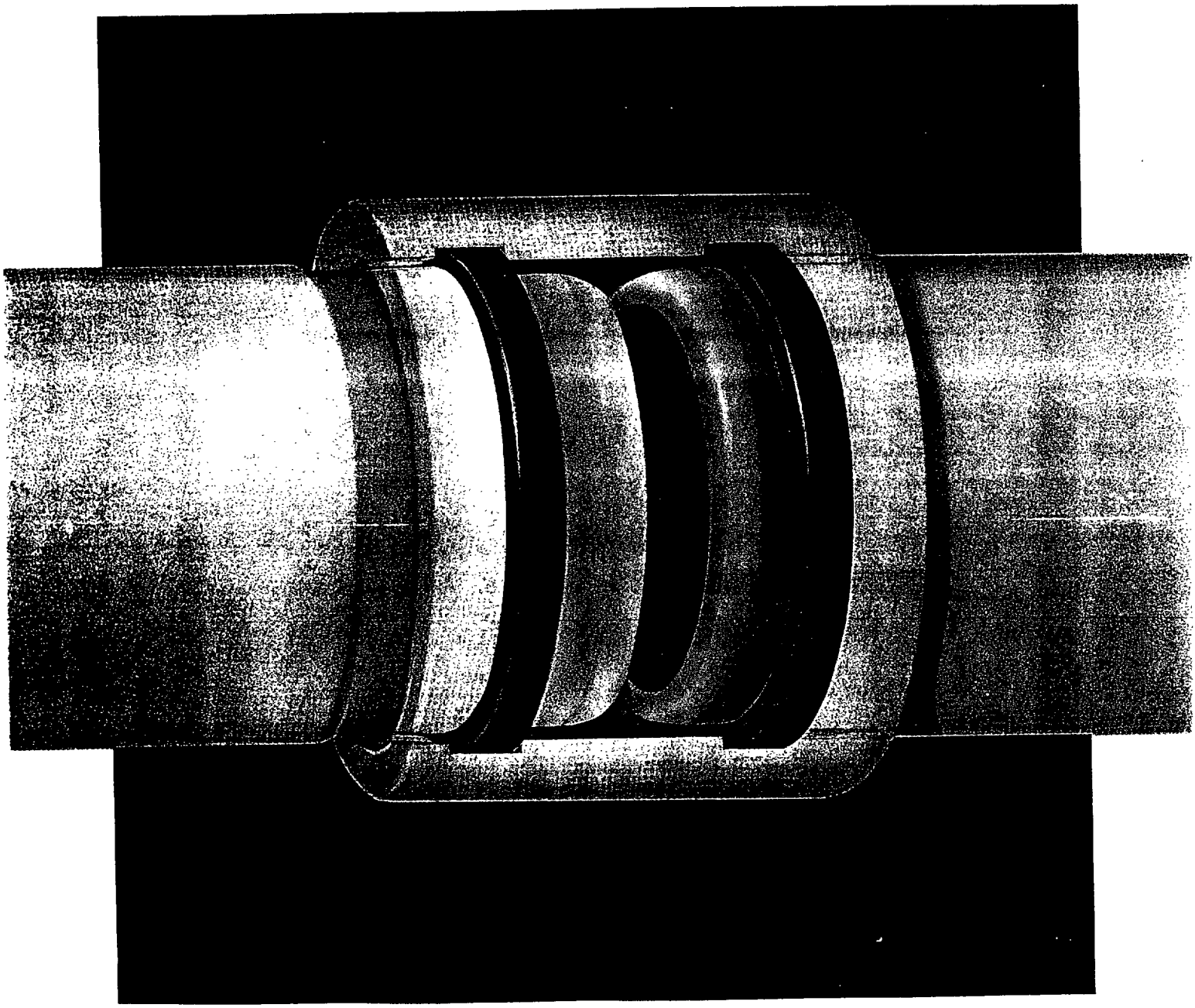
International Agency for Research on Cancer. The question: "Is there evidence of an increased risk of cancer resulting from asbestos fibers present in water, beverages, food or in the fluids used for the administration of drugs?" The answer: "Such evidence as there is does not indicate any risk."[36]

Dr. Irving J. Selikoff, Director of the Environmental Sciences Laboratory, Mount Sinai School of Medicine. There is "no evidence at all at this time that the presumably very low level exposure by ingestion which might occur by intake of water supplied through asbestos-cement pipe has resulted in a recognized health hazard."[37]

National Cancer Institute. "NCI scientists . . . have found no unusual cancer mortality patterns so far among persons residing where drinking water is contaminated by asbestos . . ."[38]

Select Study Committee of the American Water Works Association Research Foundation . . . "No firm evidence shows that the proper use of asbestos-cement pipe poses a hazard to health by reason of ingestion of asbestos fibers. Calculations comparing the probable ingestion exposure in occupational groups to that likely to occur as a result of ingestion of potable water from asbestos-cement pipe systems suggests that the probability of risk to health from the use of such systems is small—approaching zero."[39]

False accusations and "guilt by association" have created a perception of risk about A/C pipe. Scientific measurements and common sense show this distorted perception has no basis in fact.



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A Commitment to Quality

Designed for value . . . engineered for performance . . . A/C pipe is the optimum balance between high performance, long life and cost effectiveness. Quality control second to none, assures high pressure reliability with sensible factors of safety . . . consistently, inexpensively . . . *and that's a fact!*

The A/C pipe industry has a commitment . . . a commitment to quality water. This commitment encompasses much more than the simple assurance of water quality at the consumer's tap. Regardless of how bountiful or clean water reserves might be . . . whimsical as nature can be . . . and short-sighted as man has been, quality water demands conservation in use, diligence in treatment, and economical reliability in distribution. Providing distribution pipe of integrity at a cost the user can and will support is the goal of the A/C pipe industry.

Appendices

Appendix A
Ceiling Concentrations of Airborne Asbestos Fiber from A/C Pipe Field Operations

Field Operation	*Type of Pipe*	*Operation Time (Min.)*	*Exposure (Fibers/cc) Operator*	*Helper*
		Recommended Work Practices		
Manual Lathe	Pressure	12-13	0.51	0.22
Manual Lathe	Sewer	4-5	0.15	0.13
Power Lathe	Pressure	5-6	0.33	0.56
Power Lathe	Sewer	6-8	0.08	0.09
Power Hole Cutting	Pressure	1.5-2	0.44	0.23
Power Hole Cutting	Sewer	1	1.65	0.38
Cutting w/Chisel & Rasp	Pressure	10-11	1.99	0.90
Cutting w/Chisel & Rasp	Sewer	4-6	0.30	0.25
Chain-type Cutter	Pressure	2-3	0.85	0.87
Chain-type Cutter	Sewer	2-3	<0.06	<0.06
Pilot®-type Cutter	Sewer	2-3	0.09	—
		Non-Recommended Work Practices		
Abrasive Disc Cutting*	Pressure	<1	20.30	59.70
Abrasive Disc Cutting*	Sewer	<1	35.50	64.00

*Workers should be provided with respiratory protection approved by the United States Department of the Interior, Bureau of Mines, Schedule 21C or Department of Health, Education and Welfare, National Institute of Occupational Safety and Health, under the provisions of the Code of Federal Regulations, 30, Part 11.

Note: OSHA Standard for Occupational Exposure to Asbestos Dust (Ceiling Concentration): Ten (10) fibers per cubic centimeter of air.

Appendix B

U.S. Trends in Age-Adjusted Cancer Death Rates 1952-54 to 1972-74 (per 100,000 population)

Source: "1977 Facts and Figures", American Cancer Society.

Site	*Sex*	*1952-54*	*1972-74*	*Change (%)*
Colon & Rectum	Male	19.3	18.9	− 2
	Female	18.4	14.9	−19
Stomach	Male	16.4	7.4	−54
	Female	8.6	3.6	−58
			Change:	−33%

Appendix C

Nashville-Knoxville Cancer Mortality Rates (per 100,000 population)–1950 to 1969

Source: National Cancer Institute Statistics.

Site	*Sex**	*Davidson County (Nashville)*	*Loudon County (Knoxville)*
Stomach	White Males	9.8	7.8
	White Females	4.4	4.3
Large Intestine	White Males	14.1	7.5
	White Females	13.6	13.3
Rectum	White Males	4.7	3.4
	White Females	3.5	2.6
Totals		50.1	38.9
	Difference	28.7% (Higher in Nashville)	

*Complete statistics not available for non-white males and females.

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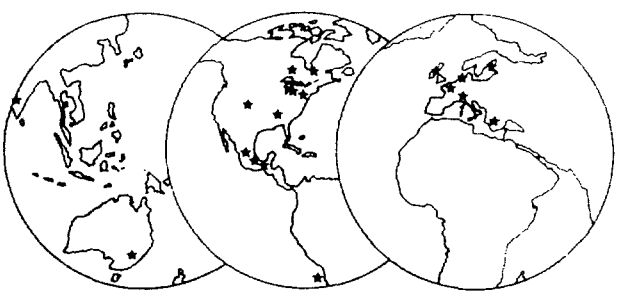

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A/C Pipe Producers Association
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