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REVIEW OF "CHRYSOTILE ASBESTOS FIBERS IN DRINKING WATER FROM ASBESTOS-CEMENT PIPE"

By

T. A. Scripps[1], J. P. Leineweber[2], H. L. Olson[3] and

J. F. Welch[4]

1 Statistician, Research Department, Manville Corporation, Denver, Colorado

2 Technical Director, Health, Safety and Environment Department, Manville Corporation, Denver, Colorado

3 Manager, Environmental and Engineering Development, Pipe Division, Johns-Manville Corporation, Denver, Colorado

4 Vice President, A/C Pipe Producers Association, Arlington, Virginia

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I. INTRODUCTION

The paper, "Chrysotile Asbestos Fibers in Drinking Water from Asbestos-Cement Pipe" by Kanarek et al [1] is a supplementary analysis of data taken from a larger two part study [2,3,4,5,6] that examined the presence of asbestos fibers in drinking water and disease incidence in the San Francisco (California) Bay Area. In the paper, the authors question "the validity of aggressiveness indexes for prediction of fiber release from asbestos-cement pipes." Their arguments are based on a purported "demonstration of substantial increases in asbestos fiber counts in nonaggressive drinking water" flowing through asbestos-cement (A/C) pipe within selected distribution systems.

This review will comment on the Aggressiveness Index (AI) as a measure of asbestos release from asbestos-cement pipe, the assumptions and inferences made by the investigators, experimental design, sampling and data analysis techniques, and possible explanations for the study's observations.

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II. ASSUMPTIONS ABOUT THE AGGRESSIVENESS INDEX

The underlying assumption of the paper is, in the authors' words, " ... that there is a positive correlation between fiber release from the walls of A/C pipe and the 'aggressiveness' or corrosiveness of water." It is further assumed that this correlation is quantitative, consistent and predictive. These assumptions are incorrect.

Prior to development of the Aggressiveness Index (AI), manufacturers recommended that the use of A/C pipe in water with a Langlier Index of -2.0 (AI=12.0) or less would be inconsistent with maintaining the 50-100 year design lifetime of water systems. In the early 1970's, engineering consultants requested that American Water Works Association (AWWA) and American Society for Testing and Materials (ASTM) specifications for A/C pipe further define conditions of product use in so-called aggressive and non-aggressive waters. It should be emphasized that the manufacturers' recommendations and AWWA/ASTM guidelines[7,8] were developed solely for the purpose of ensuring long-term, structural integrity of A/C pressure pipe. The AI was not conceived to be a predictor of asbestos fiber release. As the U.S. Environmental Protection Agency (EPA) Drinking Water Research Division has stated on this matter:

> The use of the AI as a predictor of the condition of the interior surface of the pipe in contact with the drinking water and its tendency to retain or release asbestos fibers has come about in spite of the fact that the original intention of the index was to outline water conditions that might cause structural failure of the pipe. The difference in application is very significant.[9] (emphasis in original)

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There is a substantial body of scientific evidence supporting the view that there is neither a quantifiable nor a predictive relationship between any corrosion index and levels of asbestos released from A/C pipe into drinking water.

In 1980, an EPA researcher testified:

> Further work has shown that the aggressive index is not the perfect indicator of whether a water will corrode an asbestos-cement pipe and release fibers.
>
> The calculation of the aggressiveness index alone is not always sufficient to predict actual behavior of A/C pipe.[10]

And in 1981, EPA again underlined the imprecision of the AI, almost flatly rejecting the AI-fiber release hypothesis:

> Substantial field and pilot plant data, combined with comprehensive evaluation of many of the important chemical complexation and precipitation reactions occurring in drinking water, give compelling evidence that the AI has immense shortcomings with regard to use as a predictor of fiber release and interior surficial pipe condition that enjoin against its use under most circumstances.[11]

The Agency's most recent published work on the Aggressiveness Index states:

> There are several major avenues by which the AI is open to criticism as an indicator of corrosivity and fiber release, the manner in which has most frequently been used.[12]

The EPA paper goes on to detail the deficiencies of the AI in reliably predicting fiber release, concluding:

> The Aggressiveness Index as traditionally conceived is not theoretically sound from a chemical standpoint to predict fiber release and degradation of the interior pipe surface in systems that are undersaturated with respect to calcite. Fortunately, it has generally proved to predict falsely pipe deterioration more often than to predict falsely pipe stability in field situations.
>
> * * * *
>
> Observations of A/C pipe sections from many localities conclusively demonstrate that natural inhibitory factors, such as those mentioned, are commonly the pipe protection mechanism, not calcite saturation.[12]

The AI is a technical guideline governing the selection of the proper type of A/C pipe for waters of differing aggressiveness. It is based on empirical observations and physical testing of specimens from A/C pipe systems. Based on published analyses[13], it can be concluded that the AI is comfortably conservative in assuring long-term structural integrity of the product.

In summary then, the basic assumption of the Kanarek et al paper i.e. that there is a valid correlation between the AI and fiber release, simply is incorrect. The AI was never meant to correlate with fiber release from A/C pipe and in fact, extensive studies by the U.S. Environmental Protection Agency demonstrate this rather conclusively.

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III. EXPERIMENTAL DESIGN AND DATA COLLECTION

The original study design and collection of data, which are the bases for this paper, gave little or no consideration to selecting a sample population (representative distribution systems) in such a way that a valid generalization to a larger population (all distribution systems in the San Francisco area, for example) could be made.

The data suggests no purposeful sampling technique to determine whether the A/C distribution systems were contributing asbestos to water conveyed through them. The authors explain this away by stating the collection of "before" and "after" A/C pipe samples " ... was only one of several factors involved in this overall assessment of asbestos in drinking water supplies." The facts are that the study of fiber release from A/C pipe was a matter of tertiary importance to the authors. By its own admission, the original study had limited relevance to A/C pipe:

> Samples were taken before and after lengths of asbestos-cement pipe (See Table 18). Although, in some cases there were apparently substantial increases as a result of the water passing through the pipe, the data appear inconsistent. This study did not include the amount of asbestos-cement pipe in the various distribution systems as a variable in the analysis because of its questionable significance and the difficulty of determining its location, age, and dimensions.[14] (emphasis added).

An EPA funded report on the asbestos sampling plan for the San Francisco Bay area study states:

> The contribution (if any) of asbestos-cement pipe to the level of asbestos found in drinking water has yet to be determined. The Cooper study was not specifically designed to measure the

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risk that might be attributed to the use of asbestos-cement pipe.[15]

The harshest criticism of the study's design and data collection/analysis comes from the Environmental Protection Agency, which funded the original project:

> The only suggestion of asbestos cement pipe being attacked by water with an aggressiveness index greater than 12 was in conjunction with an epidemiological study done in the Bay Area of California. The data on the pipe were not gathered specifically for the purpose of studying pipe corrosion but were pulled from the overall study data set. Some information about the systems such as previous tapping procedures and whether the pipe had been deteriorated from some other cause were not available. None of the pipe had been dug up for inspection, unfortunately. I did not feel after reviewing the data that I could consider this a complete picture of what is happening in these systems. A more complete study is necessary before I can conclude pipe corrosion occurs with water of an aggressiveness index of greater than 12.[16] (emphasis added)

With these facts in mind, any statistics generated from this sampling data base and any conclusions drawn from those statistics, must be considered of dubious value.

A closer examination of the samples themselves reveals equally serious compromises in sound science. The authors purport to have thirty-nine pairs of "before" and "after" water samples corresponding to "before" and "after" flowing through A/C pipe. There are not thirty-nine paired samples. Firstly, consider a day on which a single "before" sample is taken from a water treatment plant discharge and four "after" samples are taken from residential taps after flowing through varying lengths of A/C pipe. This sampling plan is not generating four independent "before/after" pairs. The four "before" samples are artificial — they are not independent of each other, they are the same observation because only one

sample was actually taken. In the paper, nineteen of the thirty-nine pairs of samples were selected in this manner. Table 1 (page 8) lists the original data, indicating which pairs are from identical "before" samples. No attempt is made by the authors to account for this dependence. This is particularly ironic in light of the authors' statement that various taps were sampled "to determine the continuity of values throughout the distribution area." So, although the paper acknowledges the need for a supplementary analysis to account for this dependency, it was never undertaken.

Second, consider a given section of A/C pipe sampled on different days. Each repeated sample contributes information regarding the change in fiber counts within that section. Only to the extent that the given section of pipe is better characterized does each repeated sample contribute information with respect to characterizing the distribution system as a whole. These repeated samples logically should not be allowed to have as much influence in an analysis of the total system as a pair of measurements on different sections of pipe within the system. In the paper, fifteen of the thirty-nine samples are from sections of pipe with repeated measures. Again, no attempt was made by the authors to account for these two different sources of variation in fiber counts.

It should be mentioned that these "within-section" repeated measurements are desirable. They supply information concerning the variability of fiber counts over time. This information can be used to establish limits on the uncertainty associated with the expected number of counts for a given sample. Unfortunately, as seen above, the authors do not use the data to this end.

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TABLE 1

PAIRED BEFORE AND AFTER RESULTS
CHRYSOTILE FIBERS PER LITER FROM COOPER ET AL[2]

Pair Number	System	Before A/C Pipe	After A/C Pipe
1	A	$< 1.0 \times 10^4$ (A)	$< 2.0 \times 10^4$ R1 (C)
2	A	6.0×10^4	$< 2.0 \times 10^4$ R1
3	A	$< 2.5 \times 10^4$	$< 1.0 \times 10^5$ R1
4	A	$< 2.0 \times 10^4$	$< 2.0 \times 10^4$ R2
5	A	2.0×10^5	1.5×10^5 R2
6	A	1.0×10^5	3.0×10^5 R2
7	A	$< 1.0 \times 10^4$	$< 2.0 \times 10^4$ R3
8	A	$< 2.0 \times 10^4$	1.4×10^5 R3
9	A	1.0×10^5	2.0×10^6 R3
10	A	$< 2.0 \times 10^4$	$< 2.0 \times 10^4$
11	A	4.0×10^5	1.0×10^5
12*	A	5.0×10^4	5.0×10^4 (B)
13*	A	5.0×10^4	3.5×10^5
14*	A	5.0×10^4	5.0×10^5
15*	B	$< 5.0 \times 10^3$	$< 7.0 \times 10^3$
16*	B	$< 5.0 \times 10^3$	$< 2.5 \times 10^4$
17	B	1.6×10^5	5.4×10^5 R4
18*	B	$< 2.5 \times 10^4$	1.5×10^5 R4
19*	B	$< 2.5 \times 10^4$	1.9×10^6 R5
20*	B	$< 2.5 \times 10^4$	5.4×10^4
21*	B	$< 2.5 \times 10^4$	$< 2.5 \times 10^4$
22	B	1.8×10^5	3.8×10^4 R5

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Pair Number	System	Before A/C Pipe	After A/C Pipe
23*	B	7.6×10^5	2.0×10^5
24*	B	7.6×10^5	4.0×10^5
25	B	2.6×10^5	2.0×10^5
26	B	2.5×10^4	2.0×10^5
27*	C	5.0×10^4	6.2×10^6
28*	C	5.0×10^4	3.4×10^7
29*	C	5.0×10^4	2.5×10^6
30*	C	5.0×10^4	$< 1.0 \times 10^6$
31	-	2.5×10^4	2.0×10^5
32	-	$< 2.5 \times 10^4$	3.0×10^5
33*	C	2.0×10^5	8.0×10^6
34*	C	2.0×10^5	8.4×10^6
35*	C	$< 2.5 \times 10^4$	2.0×10^7
36*	C	$< 2.5 \times 10^4$	1.5×10^6
37	C	$< 2.5 \times 10^4$	5.4×10^4
38	-	4.0×10^4	4.0×10^4
39	-	$< 2.5 \times 10^4$	1.6×10^6

< The fiber count is below the lowest detectable limit listed.

* One 'before' sample for multiple 'after' samples.

RX Replication of same section of pipe.

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IV. STATISTICAL ANALYSIS

Although the shortcomings of experimental design and data collection are sufficient to invalidate this research, there also exists erroneous data analysis. Assume for discussion purposes that there are indeed thirty-nine pairs of "before/after" samples with the results as reported: nineteen increases, eleven ties, nine decreases. The authors claim a two-sided significance level of 0.039 from a sign test corrected for continuity. This is not obtained by the standard formula [17]:

$$\chi^2 = \frac{(|a - b| - 1)^2}{n}$$

$$= \frac{(|24.5 - 14.5| - 1)^2}{39}$$

$$= 2.08$$

where each tie is treated as one-half an increase and one-half a decrease. The significance level of the above chi-square value is 0.150 — not considered to be a significant result.

So, not only does the study fail to employ sound scientific principles in data collection, it incorrectly calculated the significance associated with the most important test statistic.

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V. CONFOUNDING FACTORS

The paper concludes that in comparison to the "before" water in one system (System C) " ... an increase of 115 times the number of fibers" was observed after passage through sections of A/C pipe. The authors go on to hypothesize a number of possible explanations for these apparent increases, including:

- breakup of naturally-occurring fiber after flow through A/C pipe
- size of pipe
- water flow rate
- alternate wetting and drying of (pipe) surfaces
- quality of joint materials used
- corrosive cleaners in use to flush sections of pipe
- tapping of pipe
- the possibility that hydrants or "dead ends" could have acted as "reservoirs" for fibers, producing artificially elevated fiber counts.

The paper then dismisses out of hand, without any supporting justification or substantiating data, the possibility that <u>any</u> of the above factors accounted for the apparent asbestos releases in System C. There is no explanation as to whether these factors might explain smaller apparent increases in Systems A and B.

Conspicuous by its absence in the list of potentially confounding factors is perhaps the most important — variations in levels of naturally-occurring asbestos in the source waters. Many of the source waters in the study have fiber concentrations in excess of one million fibers per liter (mfl) and some over 20 mfl. Other

investigators have pointed out the ubiquitous nature of asbestos in Bay Area drinking waters:

> As can be seen from the charts (representative asbestos values in Bay Area water systems), none of the major water districts servicing the San Francisco Bay Area are free of asbestos fibers. Individual asbestos measurements range from 10^4 fibers per liter to 1.8×10^8 fibers per liter of finished water.[18]

To demonstrate the possibility (if not probability) of significant asbestos variations in source waters, consider the sources for System C. The Hetch Hetchy Aqueduct delivers water directly to the system's customers. The Hetch Hetchy system (0.13 mfl - 0.24 mfl) is fed by the Calaveras Reservoir (110 mfl) and the San Antonio Reservoir (0.46 mfl).

Portions of System C are also supplied by three treatment plants (0.03-2.1 mfl) and local runoff and wellfields whose asbestos content was not measured. The well and runoff water receives no further treatment which would reduce its asbestos content. Given the natural asbestos content of the different source waters, the variability in asbestos content in the treated waters and the distinct possibility that intermittent "slugs" of untreated high asbestos content water may have been delivered directly to System C by any number of sources, any asbestos levels observed in that system clearly are subject to wide variation regardless of the pipe material. The inability to control for such an important confounding factor clearly renders meaningless any conclusions regarding the role of A/C pipe in contributing asbestos to the drinking water.

Further, the limited number of water samples also raises serious questions about

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the paper's observations. An EPA funded report on asbestos sampling in the San Francisco Bay Area comments on the problems of such limited sampling, as well as the previously mentioned likelihood of asbestos level variability:

> The individual asbestos fiber concentrations listed in previous sections of this report (Kanarek et al samples) are the values for a single grab sample of tap water taken from a census tract. Water sampling sites were chosen on the basis of 1) being representative of a specific water distribution system and 2) convenience of sampling. In order to more fully characterize the asbestos content of these water systems, it may be necessary to sample a small proportion of a very large flow of water. This would minimize the problems of utilizing grab samples and reduce the number of water samples to be analyzed. This would also take into account the intermittent and non-uniform occurrence of asbestos in water from various sources.[19] (emphasis added).

Finally, in the 1950's and 1960's substantial amounts of asbestos caulking rope were used with lead caulked valves and fittings. This rope is in contact with the water and could convelvably contribute asbestos to water in the distribution system.

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VII. AGREEMENT WITH OTHER DATA

Interpretation of data should have coherence i.e. the results of a study are suspect if they conflict with findings from other studies. In this regard, the paper is in serious want of corroboration. Nothing in the extensive body of literature produced on the subject of potential fiber release from A/C pipe makes findings comparable to those made in this paper.

The results of an independent study conducted by one of the Bay Area's largest water utilities actually contradict the paper's findings and hypothesis.

TABLE 2

SYSTEM X
COMPARISON OF ASBESTOS LEVELS IN WATER BEFORE AND AFTER CONVEYANCE THROUGH A/C PIPE

Sample	pH	Alkalinity (mg/L. $CaCO_3$)	Calcium Hardness (mg/L $CaCO_3$)	AI	Chrysotile Asbestos (f/L.)
1-Treated Water	9.38	20	8.6	12.21	BDL
Tap Water[1]	9.38	19	8.6	12.20	BDL
2-Treated Water	8.09	103	35.9	12.14	BDL
Tap Water[2]	8.08	103	38.7	12.16	BDL

[1] Conveyed through approximately 1700 linear feet A/C pipe.
[2] Conveyed through approximately 2000 linear feet A/C pipe.

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The paper discusses the "unusual" water chemistry of System C and theorizes that the high pH may be unduly and falsely weighting the AI towards nonaggressiveness. The authors also note the low calcium content of the water suggesting this may account for the apparent asbestos increases.

A comparison of System X (Sample 1) with the mean water quality values for System C follows:

TABLE 3

COMPARISON OF WATER QUALITY - SYSTEM C AND SYSTEM X (SAMPLE 1)

Sample	pH	Alkalinity (mg/L. $CaCO_3$)	Calcium Hardness (mg/L. $CaCO_3$)	AI Before	AI After
System C	9.2	53.2	23.05	11.93	12.54
System X (Sample 1)	9.38	20	8.8	12.21	12.20

Table 3 shows that both the alkalinity and the calcium hardness of Sample 1 are considerably lower than that of System C — a worst case scenario, if you will. Yet, Sample 1 demonstrates no asbestos pick up and no increase in AI as the water traverses the A/C pipe system. Although this is a limited comparison, these observations cast serious doubts over the hypothesis that the low calcium content of the water in System C explains the purported asbestos increases.

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VII. CONCLUSIONS

The paper suffers from numerous weaknesses and errors. Its underlying assumption is fallacious — there is not, nor was there ever intended to be a positive correlation between the Aggressiveness Index (AI) and fiber release from A/C pipe. The original study's design, by its own admission, is of limited relevance to A/C pipe. The sampling procedure was extremely limited and did not generate independent "before/after" pairs. The most important test statistic is incorrectly calculated. Important confounding variables are overlooked or ignored — others are dismissed out of hand without explanation. Finally, the results have not been replicated or corroborated by other studies and are inconsistent with more contemporary knowledge on the subject.

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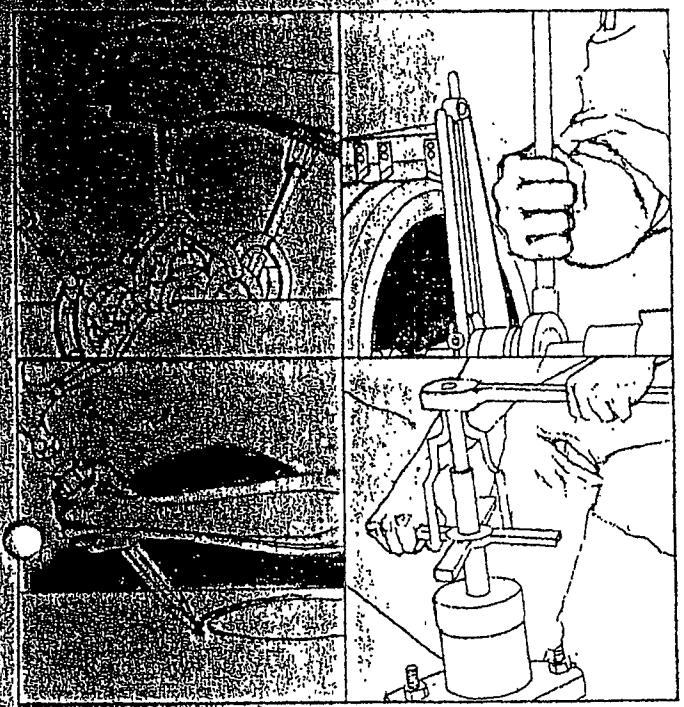
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Recommended Work Practices for A/C Pipe

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Introduction

The Occupational Safety and Health Act in the United States and similar laws in Canada and other countries were enacted to ensure so far as possible, every worker a safe and healthy work place. This legislation is far-reaching. It covers millions of employees and nearly every employer, including those involved in utility duct and pipeline construction.

In keeping with the spirit and intent of these laws, the asbestos-cement pipe industry is cooperating with labor by disseminating information regarding the potential hazards of exposure to airborne asbestos and the means of reducing such potential hazards through good work practices.

Good work practices is what this booklet is about. The recommendations that appear on the following pages are the result of field testing and were developed through study.* They are intended as general guides to achieve safe and clean job site conditions when working with asbestos-cement (A/C) pipe products. Since field conditions will vary, adherence to these work practices will not necessarily guarantee compliance with national, state or local regulations. Questions relating to compliance should be directed to appropriate regulatory agencies.

The A/C Pipe Producers Association believes this booklet will be helpful to engineers, superintendents, contractors, foremen and laying crews in understanding and explaining established procedures for the safe handling of A/C pipe products.

*See "Asbestos Exposures During the Cutting and Machining of Asbestos-Cement Pipe," report prepared by Equitable Environmental Health Inc., March, 1977 and "News from TAC," reporting on a survey by the Occupational Hygiene

Asbestos and Health

As you are aware, airborne asbestos fiber has been identified as a possible health hazard. 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.

Generally, asbestos-cement (A/C) pipe products contain less than 20% asbestos. The asbestos fibers are not free, but encapsulated or "locked-in" the cement binder like reinforcing rods in concrete. The distinction between "free" and "bound" asbestos is extremely important. First of all, it determines the probability of fiber release, which in turn, directly relates to the probability of risk. More importantly, it explains clearly and simply why A/C pipe is a non-harmful use of asbestos.

Experience has shown that minimizing exposure to airborne asbestos dust is the only effective method of preventing asbestos-related diseases. Recommended work practices are the best assurance of providing exposure safeguards for yourself and your employees.

Summary of OSHA Asbestos Standard

The Occupational Safety and Health Act was signed into law on December 29, 1970, and became effective on April 28, 1971. On December 7, 1971, the Secretary of Labor issued a temporary standard for exposure to asbestos dust. As required by the Act, a permanent standard for asbestos exposure was promulgated six months later.

Under the current standard, it is the employer's responsibility to assure that exposure of employees to airborne concentrations of asbestos fibers does not exceed the following "permissible exposure levels":

a. Eight hour time weighted average: Two fibers, longer than 5 micrometers, per cubic centimeter.
b. Ceiling concentrations: Ten fibers, longer than 5 micrometers, per cubic centimeter.

In October, 1975, OSHA proposed a revision to the current standard which would reduce the eight hour time weighted average exposure to 0.5 fibers per cubic centimeter of air and ceiling concentrations to 5.0 fibers per cubic centimeter. In their notice, OSHA stated that a separate "construction industry standard" would be issued to cover workers who handle asbestos-containing products. This work practice booklet will be revised as necessary to reflect any changes the construction industry standard may necessitate.

The work practices recommended in this booklet are based on data for "peak dust concentrations" representing short time periods of maximum exposure. Field cutting and machining operations involving A/C pipe are normally infrequent and of short duration. Using these recommended work practices, it is improbable that field personnel would be exposed in a typical working day to levels exceeding the eight hour time weighted average.

Products and Operations

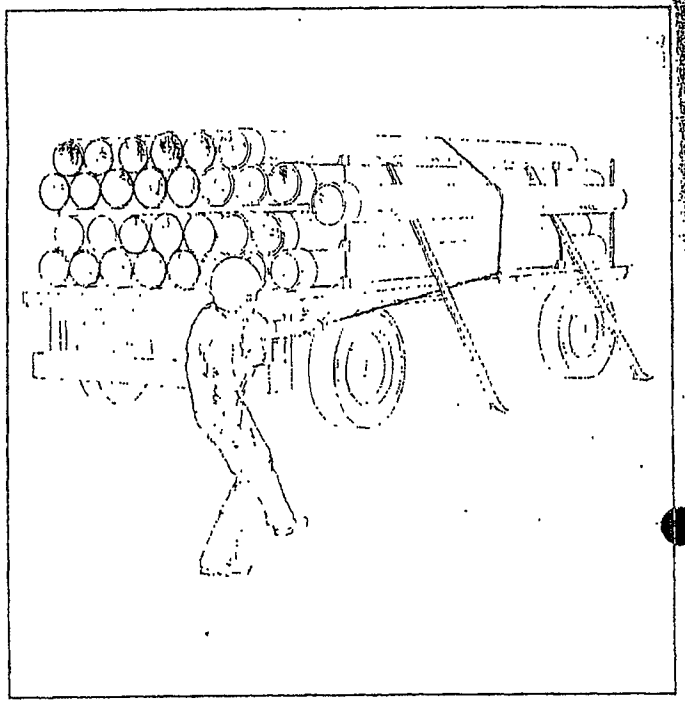
Types of A/C Pipe Products covered by these work practices include:

"Class" Pressure Pipe
"Transmission" Pressure Pipe
Pressure Sewer Pipe
Gravity Sewer Pipe
Building Sewer Pipe
Storm Drain Pipe
Perforated Underdrain Pipe
Electrical Conduit
Telephone Duct
Air Duct

Operations to which these work practices apply include:

Shipping, Receiving and Handling
Cutting
Machining
Hole Cutting
Tapping
Coupling Removal
Housekeeping and Waste Disposal

Shipping, Receiving, Handling and Assembly*

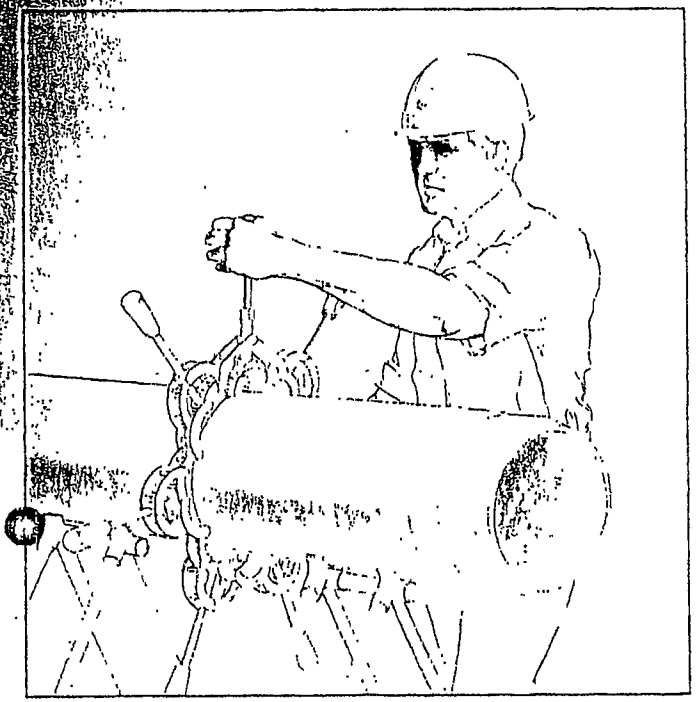


A/C pipe is shipped clean from the factory and carefully loaded using methods acceptable to the carrier. Loading, unloading, stringing out and assembling A/C pipe are essentially dust-free operations. Even in enclosed spaces, airborne asbestos fiber levels from pipe handling operations are far below existing and proposed occupational standards.

All hand and mechanical unloading operations should be carried out in accordance with the manufacturer's installation manuals.

A/C Pipe Products: All
Size Range: All

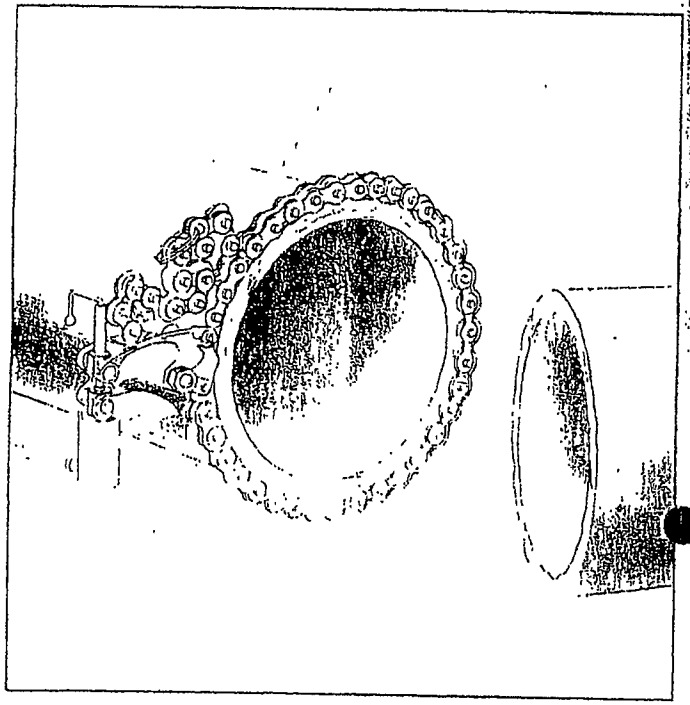
Cutting Carbide Blade Equipment



Blade cutters consist of a frame adjustable to the circumference of the pipe and a number of outboard, self-tracking rollers that align one or more carbide-tipped cutting blades. Blade cutters are typically hand-operated. Due to the relatively low mechanical input and clean cutting action, significant amounts of airborne asbestos dust are not produced.

A/C Pipe Products: All
Size Range: 3" through 24"

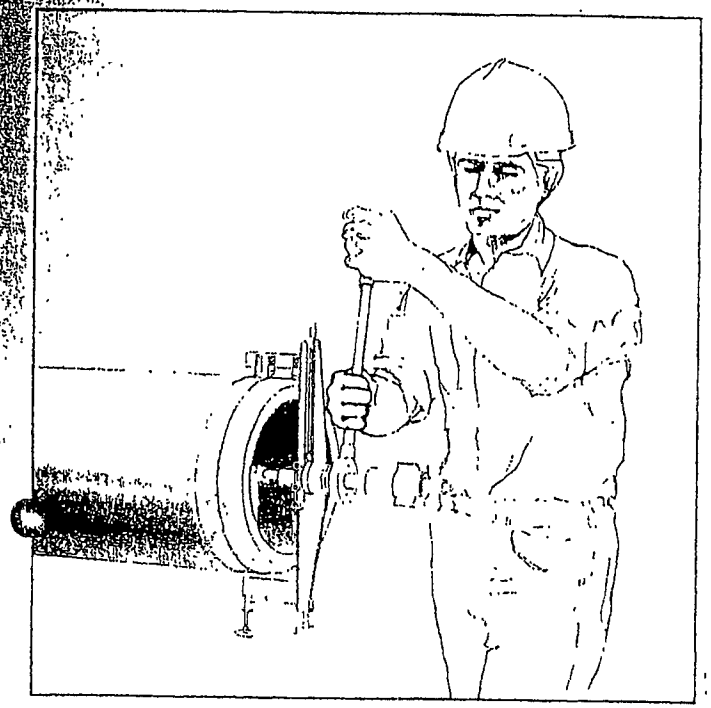
Cutting
Snap Cutting Equipment



Snap cutters or "squeeze and pop" equipment operates by means of cutting wheels mounted in a chain wrapped around the pipe barrel. Hydraulic pressure, applied by means of a remote electric or manually-operated pump, simultaneously squeezes the cutting wheels into the pipe wall until the cut is made.

A/C Pipe Products: All
Size Range: Pressure Pipe—3" through 24"
Pressure, Gravity and Building Sewer; Storm Drain; Air, Electrical and Telephone Duct—3" through 36"

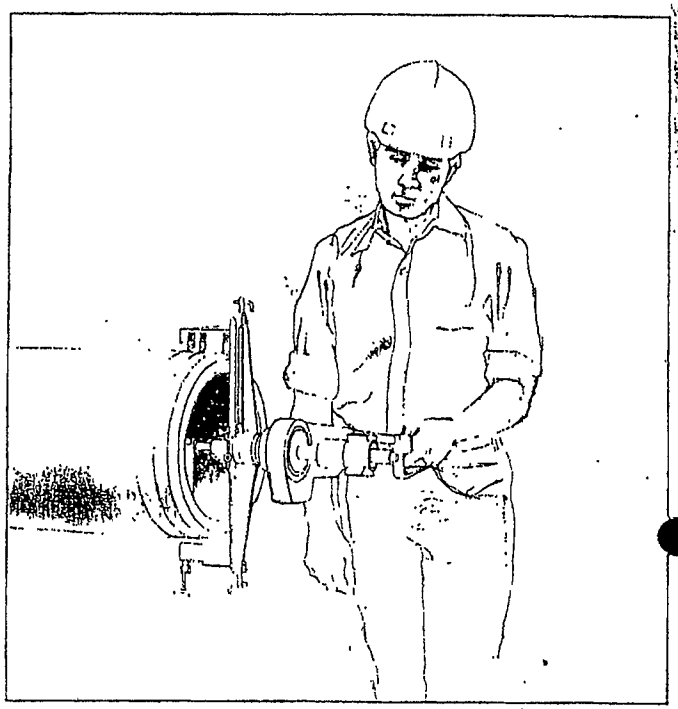
Machining
Field Lathe–Manual



Manual field lathes are designed to end-trim and re-machine rough pipe barrels to factory-machined end profiles. The lathe consists of an adjustable, self-aligning arbor inserted into the pipe bore (which acts as a mandrel upon which the turning handle operates), a screw-fed turning frame, carbide machining blades and manual (hand or ratchet) turning handles.

A/C Pipe Products: All
Size Range: All

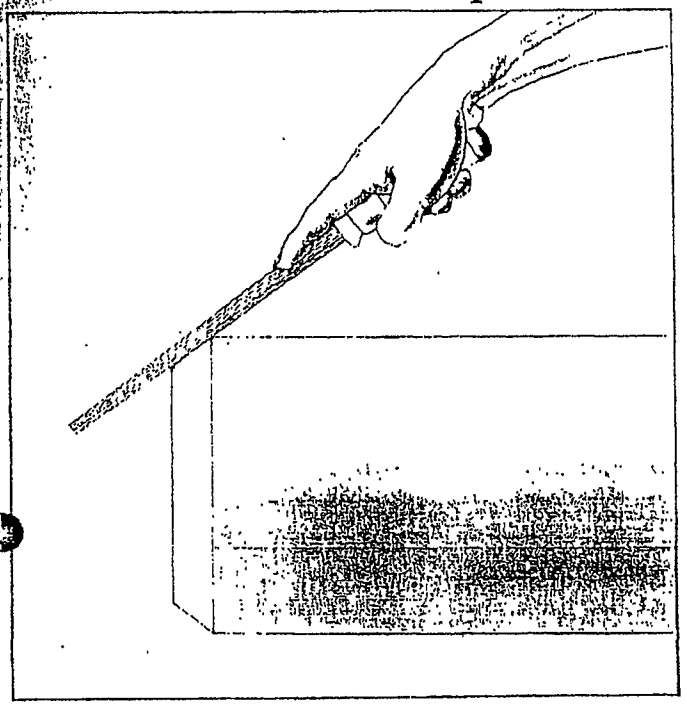
Machining
Field Lathe–Power



Power field lathes, like manual lathes, are designed to end trim and re-machine rough pipe barrels to factory-machined end profiles. The lathe consists of an adjustable, self-aligning arbor inserted into the pipe bore (which acts as a mandrel upon which the turning handle operates), a screw-fed turning frame, carbide machining blades and electric or pneumatic power drive.

A/C Pipe Products: All
Size Range: All

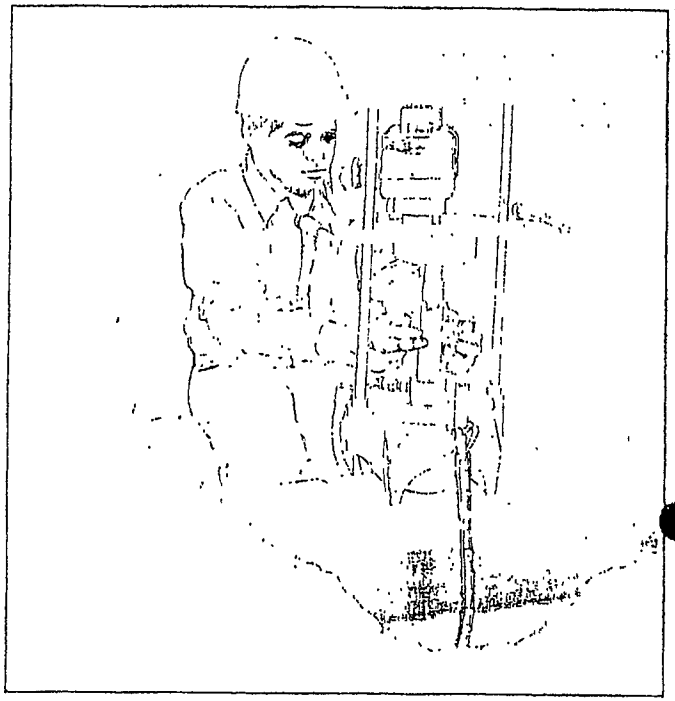
Machining
Rasp–Manual*



Short lengths of A/C pipe (MEE's & MOA's) can be cut for pipe closures, repairs and to locate fittings exactly. Field cut ends may be rebeveled with a coarse wood rasp to form a taper approximating the same profile as the factory-beveled end.

A/C Pipe Products: All
Size Range: All

Hole Cutting
Shell Cutters



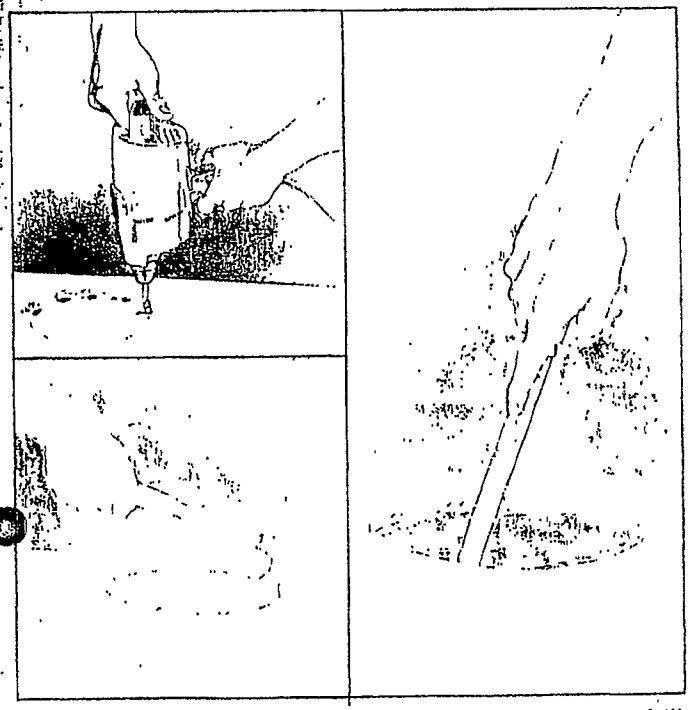
For field connections into A/C pipe, clean, even entry cuts may be accomplished by means of shell cutting equipment. Shell cutters consist of a hole cutter housing mounted on the pipe, a carbide or diamond-tipped hole cutter and a manual ratchet, pneumatic, electric or gasoline drive to power the cutting head.

When cutting holes in A/C pipe products, all dust and cuttings should be removed from the pipe or duct interior after the cutting operation. Removal may be accomplished by flushing with water, wet mopping or vacuuming prior to placing in service. DO NOT BLOW OUT WITH COMPRESSED AIR OR DRY SWEEP.

A/C Pipe Products: Pressure, Gravity and Building Sewer; Air Duct

Size Range: All

Hole Cutting
Drill and Rasp*



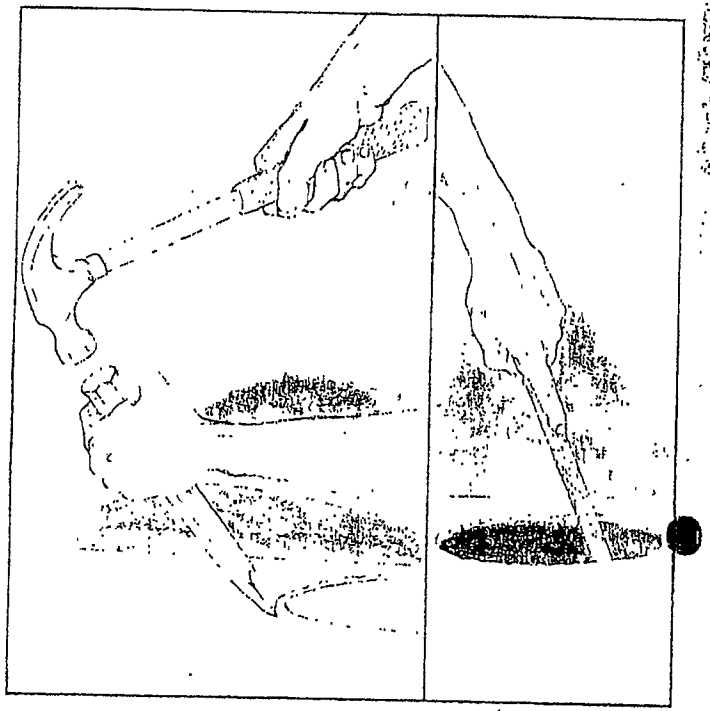
Field connections may be made with a heavy duty electric drill and rasp. Using a carbide-tipped drill, a series of closely-spaced holes are first drilled around the hole outline. The disc is knocked free with a hammer and the edges of the hole are dressed with a coarse wood rasp.

When cutting holes in A/C pipe products, all dust and cuttings should be removed from the pipe or duct interior after the cutting operation. Removal may be accomplished by flushing with water, wet mopping or vacuuming prior to placing in service. DO NOT BLOW OUT WITH COMPRESSED AIR OR DRY SWEEP.

A/C Pipe Products: Pressure, Gravity and Building Sewer; Air Duct

Size Range: All

Hole Cutting
Chisel and Rasp



Holes may be cut into A/C pipe with a hammer and chisel. The edge of a plumber's wood chisel is used to cut completely around the hole outline, about a ¼" from the prescribed line. The operation is repeated and the cut deepened until through. The edges of the hole are then dressed with a coarse wood rasp.

When cutting holes in A/C pipe products, all dust and cuttings should be removed from the pipe or duct interior after the cutting operation. Removal may be accomplished by flushing with water, wet mopping or vacuuming prior to placing in service. DO NOT BLOW OUT WITH COMPRESSED AIR OR DRY SWEEP.

A/C Pipe Products: Pressure, Gravity and Building Sewer; Air Duct

Size Range: All

Tapping
Non-Pressure*



Non-pressure or "dry" tapping for service connections may be performed in or above the trench. The equipment is affixed to the pipe by means of a chain yoke. Separate drills and taps or a combination tool drills and taps the pipe wall. Corporation stops or other connections may then be affixed to the pipe.

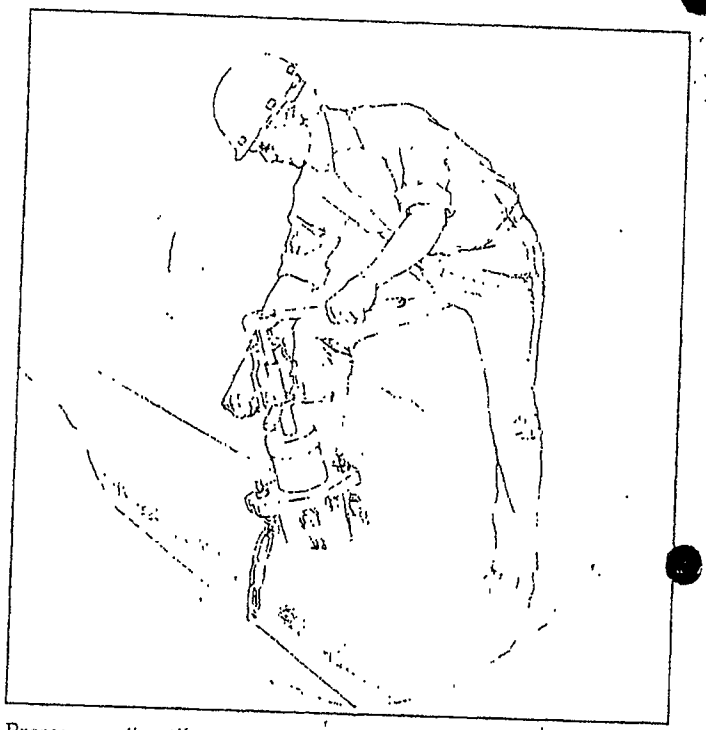
To minimize (a) the fouling of valves, regulators, meters, etc. with chips and (b) unnecessary addition of asbestos to drinking water, all dust and cuttings should be removed from the pipe interior by flushing with water, wet mopping or vacuuming prior to placing in service. DO NOT BLOW OUT WITH COMPRESSED AIR OR DRY SWEEP.

A/C Pipe Products: Pressure Pipe

Size Range: All

*exposure data not currently available. Recommendation based on exposure data

Tapping Pressure*



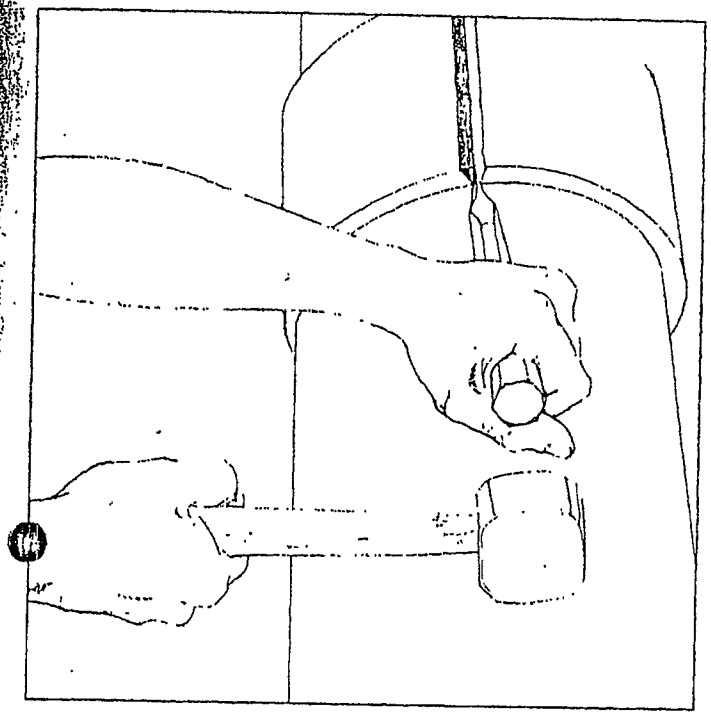
Pressure or "wet" tapping for service connections is performed in the trench while the pipe is under pressure. The equipment (manual or power driven) is affixed to the pipe by means of a chain yoke. A combination boring and inserting bar drills and taps the pipe wall and inserts a corporation stop or pipe plug. The pressure chamber, which protects against water leakage, also catches the asbestos-cement chips, so this is essentially a dust-free operation.

To minimize (a) the fouling of valves, regulators, meters, etc. with chips and (b) unnecessary addition of asbestos to drinking water, provisions should be made for downstream flushing or use of tapping equipment with positive purge or "blow-off" features.

A/C Pipe Products: Pressure Pipe
Size Range: All

* Exposure data not currently available. Recommendation based on exposure data

Coupling Removal Hammer and Chisel*



Replacement of damaged pipe necessitates excavation, exposure and removal. Coupling removal may be accomplished by gradually splitting the coupling lengthwise, using a chisel and ball-peen hammer. After the top of the coupling has been split, a crowbar or similar tool is used as a lever to split the bottom of the coupling.

A/C Pipe Products: All pipe with A/C couplings
Size Range: All

* Exposure data not currently available. Recommendation based on exposure data

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