PLAINTIFF'S EXHIBIT
UC-3939



# Recommended Work Practice Procedures for Asbestos-Cement Pipe

A07439



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In order to reduce the generation of airborne concentrations of asbestos during the installation of A/C pipe, AACPP designed a field manual containing specific work practices for use with its products. AACPP distributed thousands of copies of this manual to OSHA, construction contractors, municipalities, insurance carriers, states, and others, in an effort to educate and to train their employees in the proper use of the recommended work practice procedures.

Prior to publication, AACPP contracted with Equitable Environmental Health, Inc. (EEH) to study employee exposure to airborne asbestos during field operations. The purpose of the EEH study was to determine the effectiveness of the work practices being recommended. To that end, EEH performed personal monitoring on employees in the following field operations, utilizing, where appropriate, either non-pressure (sewer) pipe and/or pressure (water) pipe:

1. Unloading
2. Laying pipe in the trench
3. Cutting operations on both pressure and sewer pipe
    a. Cutting with hack saw
    b. Cutting with snap cutting equipment
    c. Cutting with abrasive disc, wet
    d. Cutting with abrasive disc, dry
    e. Cutting with hammer, chisel and rasp

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4. Machining operations
   a. Machining with a manual field lathe
   b. Machining with a power-driven lathe
   c. Cutting and machining with Doty machine
5. Hole Cutting
   a. Hole cutting with power-operated equipment
   b. Hole cutting with drill, hammer and rasp
6. Tapping operations
   a. Dry tapping with Mueller J. tool
   b. Tapping operations with Mueller B-100 tool
7. Coupling removal
   a. Removal of coupling with hammer and chisel

The above operations and processes are representative of the types ordinarily encountered at construction sites installing A/C pipe. Certain qualifications, however, should be identified. First, for those operations monitored by EEH, several options may exist for performing a particular operation, e.g. cutting with various tools or under varying conditions. Where appropriate, these operations are also listed. Second, on any given day, any one or all of those operations listed may be conducted. This, of course, depends on the individual job and its requirements.

Pipe installation, cutting, machining, boring holes, and tapping are considered typical fabrication operations. A/C pipe, as with most other A/C products used in the construction industry, requires minimal field fabrication. For



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example, A/C pipe is supplied pre-assembled, along with a number of half and quarter lengths to minimize field cutting. When necessary, cutting to length is performed intermittently and only when the pipe terminates, as, for example, in a manhole. During the installation of smaller diameter A/C pipe, tapping is sometimes necessary, for example, when providing customer service lines from the main to the home, or when hook-up from other sources is required. The frequency of these operations is, of course, highly variable.

The total time committed to field fabrication is also quite variable. One particular survey, involving the installation of A/C pipe in seven major urban areas around the United States, reported that an average of 1.1 percent of the total job time involved the cutting, tapping, or machining of A/C pipe. Out of an average of 675 man-hours per job, these operations accounted for approximately 7.5 man-hours per job or 5.3 man-minutes per day.

In conducting their study, EEH considered the intermittent, infrequent, and short-term nature of the operations listed and decided to monitor several successive operations during each sampling period. A short-term sampling period of 15 minutes was selected unless, in the industrial hygienist's judgment, a sufficiently large sample could be obtained in a shorter time period. Additional information on the sampling and anlytical method used in the EEH study as well as a full description of the operations sampled is included in the pages below.

The following tables summarize the results EEH obtained during its validation tests.

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Table VI

Average Peak Exposures During Unloading/Laying A/C Pipe

| Operation | |
|---|---|
| 1. Unloading Pipe | 0.1 fibers/cc |
| 2. Laying Pipe | 0.1 fibers/cc |
| Background | Below detectable limit |

Table VII

Average Peak Exposures (Up to 15 Minutes) During Other Operations (fibers/cc)

| | | A/C Sewer Pipe | | A/C Pressure Pipe | |
|---|---|---|---|---|---|
| Operation | | Operator | Helper | Operator | Helper |
| 3. | Cutting Operations | | | | |
| 3a. | Hack Saw | 0.18 | <0.10 | <0.10 | 0.11 |
| 3b. | Snap Cutting | <0.10 | <0.10 | <0.10 | ND |
| 3c. | Abrasive disc, wet | 42.10 | 10.20 | 65.00 | 49.20 |
| 3d. | Abrasive disc, dry | 35.50 | 64.00 | 20.30 | 59.70 |
| 3e. | Chisel, hammer and rasp | 0.30 | 0.25 | 1.99 | 0.87 |
| 4. | Machining Operations | | | | |
| 4a. | Manual Lathe | 0.15 | 0.13 | 0.51 | 0.22 |
| 4b. | Power Lathe | <0.10 | 0.10 | 0.29 | 0.18 |
| 4c. | Cutting and Machining with Doty Machine Dry | 3.83 | 0.29 | 1.90 | 2.23 |
| | Dry, Shroud | 0.23 | 0.10 | 1.29 | 0.18 |
| | Wet Shroud | 0.20 | 0.10 | 0.21 | 0.27 |
| 4d. | Tapering Tool with Airduct Pipe | 0.18 | <0.10 | | |

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Table VII (Continued)

| Operation | | A/C Sewer Pipe Operator | A/C Sewer Pipe Helper | A/C Pressure Pipe Operator | A/C Pressure Pipe Helper |
|---|---|---|---|---|---|
| 4e. | Machining with Manual Lathe on Differing Sizes of Pipe | | | | |
| | 4-inch pipe | | | ND | <0.10 |
| | 8-inch pipe | | | <0.10 | 0.13 |
| | 16-inch pipe | | | <0.10 | <0.10 |
| 5. | Hole Cutting | | | | |
| 5a. | Powerhole Cutter | 0.44 | 0.23 | 1.65 | 0.38 |
| 5b. | Hole Cutting with Drill, Hammer & Rasp | 0.23 | 0.13 | 0.22 | <0.10 |
| 6a. | Dry Tap with Mueller J Tool | <0.10 | <0.10 | <0.10 | 0.10 |
| 6b. | Tapping Operations with Mueller B-100 | <0.10 | ND | 0.11 | 0.13 |
| 7. | Coupling Removal | | | | |
| 7a. | Removal of Coupling with Hammer & Chisel | <0.10 | ND | 0.30 | <0.10 |

It is important to recognize that the above results represent one or more consecutive operations run to a maximum sampling time of 15 minutes. Two operations clearly cannot be recommended and in fact should be prohibited: cutting and machining with Doty tool without a shroud and cutting with abrasive discs.*/ As indicated in the summary data, significant peak exposures can result from their use.

*/ The use of water on specially adapted abrasive disc cutting equipment can reduce asbestos fiber exposures below 2.0 fibers/cc (TWA), as documented by the United Kingdom Health and Safety Executive. Similar results could not be duplicated in the EEH study.

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As for the other operations, they are intermittent, short-durational operations. For the purpose of calculating 8-hour TWA's, a conservative calculation was made by assuming employees would work at a given operation 1 hour per day. Further, assuming that during the remaining 7 hours of the day they were not exposed, the following 8-hour TWA's would be expected (excluding the two operations not recommended).

Table VIII

Computed Time-Weighted Average Exposures During Operations Involving A/C Pipe (fibers/cc)

| Operation | | A/C Sewer Pipe | | A/C Pressure Pipe | |
|---|---|---|---|---|---|
| | | Operator | Helper | Operator | Helper |
| 1. | Unloading Pipe | ND | | | |
| 2. | Laying the Pipe in Trench | ND | | | |
| 3. | Cutting Operations | <0.10 | <0.10 | | |
| 3a. | Hack Saw | <0.10 | <0.10 | ND | <0.10 |
| 3b. | Snap Cutting | <0.10 | <0.10 | ND | ND |
| 3c. | Chisel, Hammer and Rasp | <0.10 | <0.10 | 0.25 | 0.11 |
| 4a. | Manual Lathe | <0.10 | <0.10 | <0.10 | <0.10 |
| 4b. | Power Lathe | <0.10 | <0.10 | <0.10 | <0.10 |
| 4c. | Cutting and Machining with Doty Tool | | | | |
| | Dry, Shroud | <0.10 | <0.10 | 0.16 | <0.10 |
| | Wet, Shroud | <0.10 | ND | <0.10 | <0.10 |



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Table VIII Continued

| Operation | A/C Sewer Pipe | | A/C Pressure Pipe | |
|---|---|---|---|---|
| | Operator | Helper | Operator | Helper |
| 4d. Tapering Tool with Airduct Pipe | 0.10 | ND | | |
| 4e. Manual Lathe | | | | |
| 4-inch pipe | | | ND | ND |
| 8-inch pipe | | | ND | < 0.10 |
| 16-inch pipe | | | ND | < 0.10 |
| 5a. Power Hole Cutter | < 0.10 | < 0.10 | 0.21 | < 0.10 |
| 6a. Dry Tap with Mueller J Tool | < 0.10 | ND | < 0.10 | < 0.10 |
| 6b. Tapping Operations with Mueller B-100 | < 0.10 | ND | < 0.10 | < 0.10 |
| 7a. Removal of Coupling with Hammer and Chisel | < 0.10 | < 0.10 | < 0.10 | < 0.10 |

In addition to the analysis performed above, Table IX below was constructed to illustrate the theoretical TWA range of exposures which might be anticipated when working with A/C pipe during pipeline installation. The theoretical TWA exposure range is calculated by assuming the duration of the operation ranged from 15 minutes to 2 hours, with the remaining time calculated at zero exposure.

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Table IX

Ranges of Eight-hour Time-weighted Average Concentrations Derived From Equitable Environmental Health, Inc. Data

| Operation | | A/C Sewer Pipe | | A/C Pressure Pipe | |
|---|---|---|---|---|---|
| | | Operator | Helper | Operator | Helper |
| 1. | Unloading Pipe | ND | | | |
| 2. | Laying the Pipe In Trench | ND | | | |
| 3. | Cutting Operations | | | | |
| 3a. | Hack Saw | *<0.10 | ND-<0.10 | ND | ND-<0.10 |
| 3b. | Snap Cutting | ND-<0.10 | ND-<0.10 | ND | ND |
| 3c. | Chisel, Hammer and Rasp | <0.10 | <0.10 | <0.10-.50 | <0.10-.22 |
| 4a. | Manual Lathe | <0.10 | <0.10 | <0.10-.12 | <0.10 |
| 4b. | Power Lathe | ND-<0.10 | ND-<0.10 | <0.10 | <0.10-.14 |
| 4c. | Cutting and Machining with Doty Tool | | | | |
| | Dry, Shroud | <0.10 | ND-<0.10 | <0.10-.32 | <0.10 |
| | Wet, Shroud | <0.10 | ND | <0.10 | <0.10 |
| 4d. | Tapering Tool with Airduct Pipe | <0.10 | | | |
| 4e. | Manual Lathe | | | | |
| | 4-inch pipe | | | ND | ND |
| | 8-inch pipe | | | ND | <0.10 |
| | 16-inch pipe | | | ND | ND-<0.10 |
| 5a. | Power Hole Cutter | <0.10-.12 | <0.10 | 0.10 | <0.10-.10 |

*/ No range is reported when both values were < 0.10 f/cc.

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Table IX Continued

| Operation | A/C Sewer Pipe | | A/C Pressure Pipe | |
|---|---|---|---|---|
| | Operator | Helper | Operator | Helper |
| 6a. Dry Tap with Mueller J Tool | ND- 0.10 | ND | ND-0.10 | ND- 0.10 |
| 6b. Tapping Operations with Mueller B-100 | ND- 0.10 | ND | ND-0.10 | 0.10 |
| 7a. Removal Coupling with Hammer and Chisel | ND- 0.10 | ND- 0.10 | 0.10 | ND- 0.10 |

As shown in Tables VI, VII, VIII, and IX, the use of certain work practices for A/C pipe will provide effective worker protection that can be feasibly and practically implemented in the construction industry.

Following the completion of the EEH study, AACPP published and distributed nearly 85,000 copies of its field manual, "Recommended Work Practices for A/C Pipe." The recommendations set forth in the manual are based on the data developed by EEH and experience gained in the field. Based on the wide-spread acceptance of the manual, the American Water Works Association (AWWA) adopted these same work practice recommendations and included them in their manual M-16 1 "Work Practices for Asbestos-Cement Pipe."

AACPP is convinced that when recommended work practices are followed, no adverse health effects will be realized during normal employment in a construction environment where A/C pipe is used. It is the position of the asbestos

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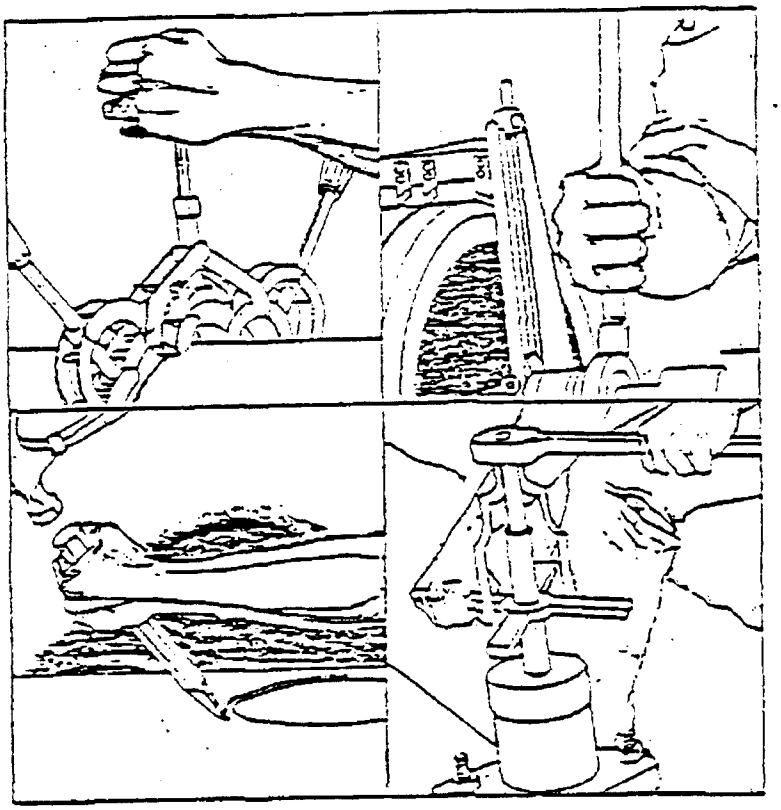
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industry that similarly safe and effective work practices can be developed to assure employee protection during the use of all asbestos-containing products in the construction industry.

The following publication sets forth recommended work practices for A/C Pipe.



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# Recommended Work Practices for A/C Pipe

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# 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:

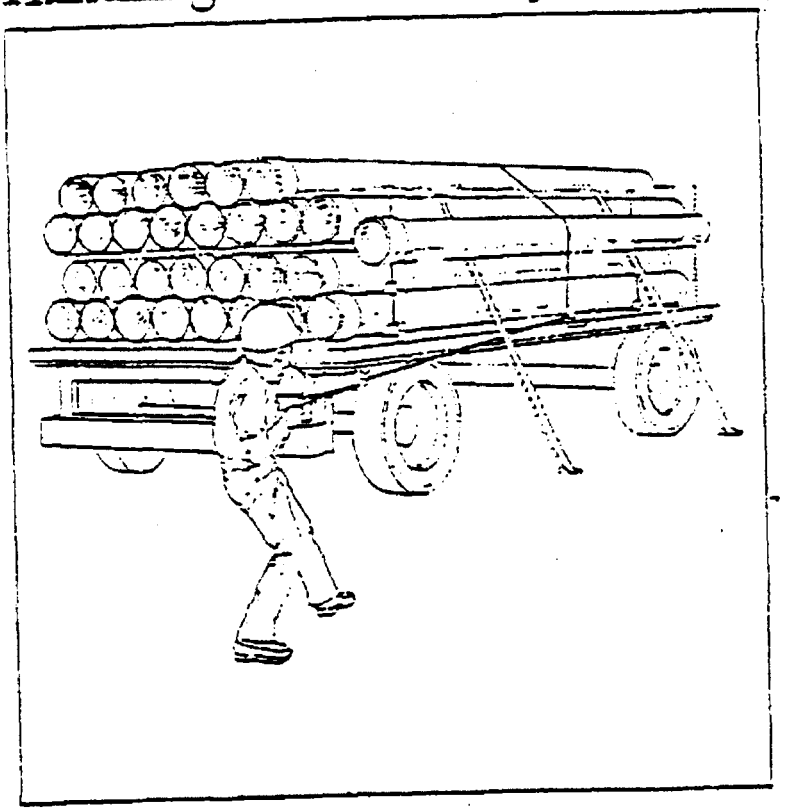
Shipping, Receiving and Handling
Cutting
Machining
Hole Cutting
Tapping
Coupling Removal
Housekeeping and Waste Disposal

A07451



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# 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

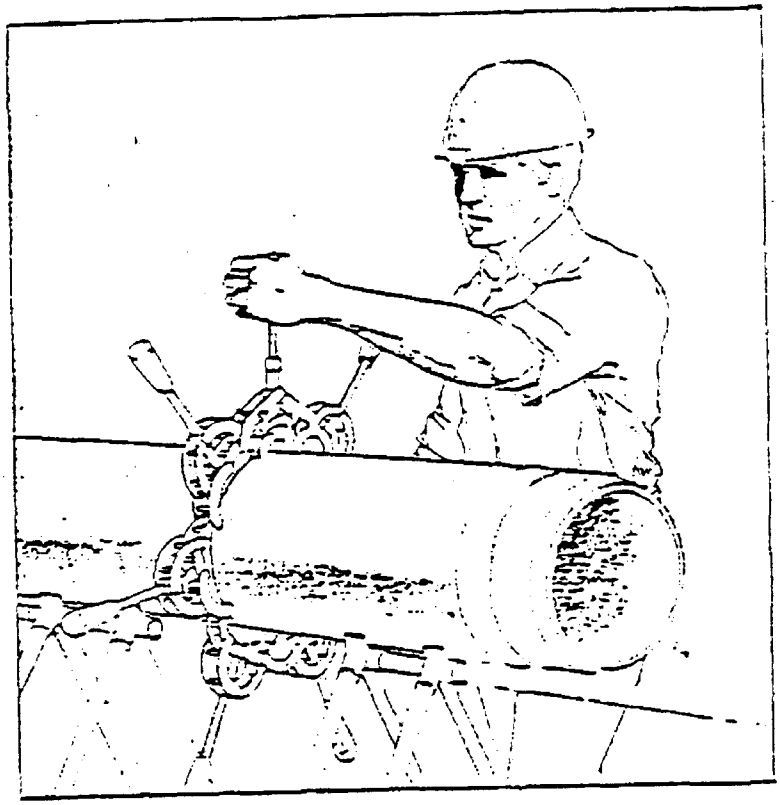
*Exposure data not currently available. Recommendation based on exposure data for operations believed to be comparable.

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- 22b - Cutting
# Carbide Blade Equipment



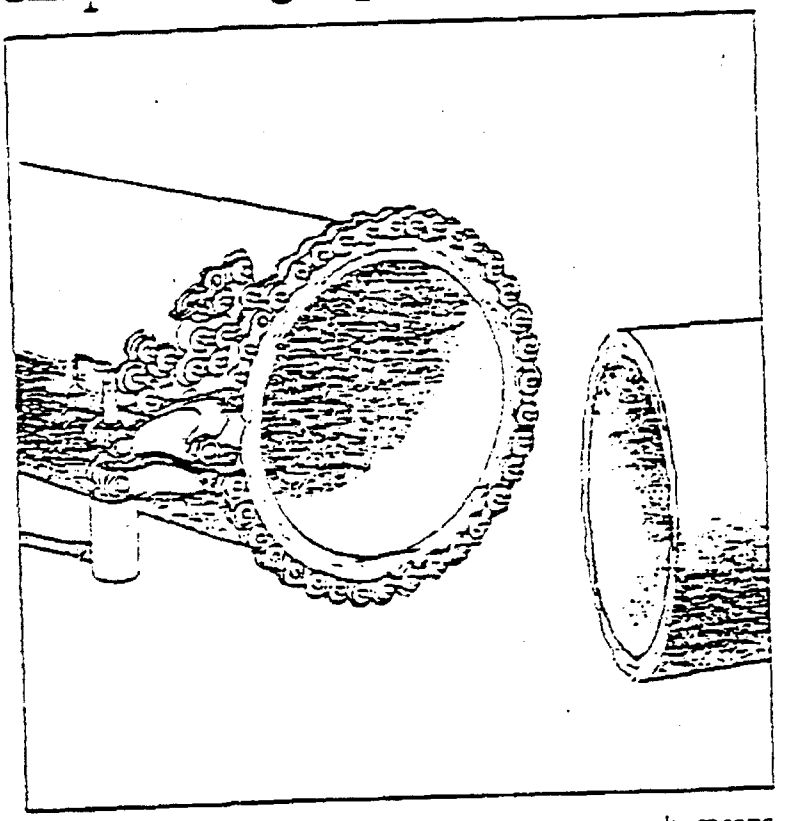
Blade cutters consist of a frame adjustable to the circumference of the pipe and a number of outboard, self-tracking rollers that align one or more carbide-tipped cutting blades. Blade cutters are typically hand-operated. Due to the relatively low mechanical input and clean cutting action, significant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

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

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# Cutting
## Snap Cutting Equipment



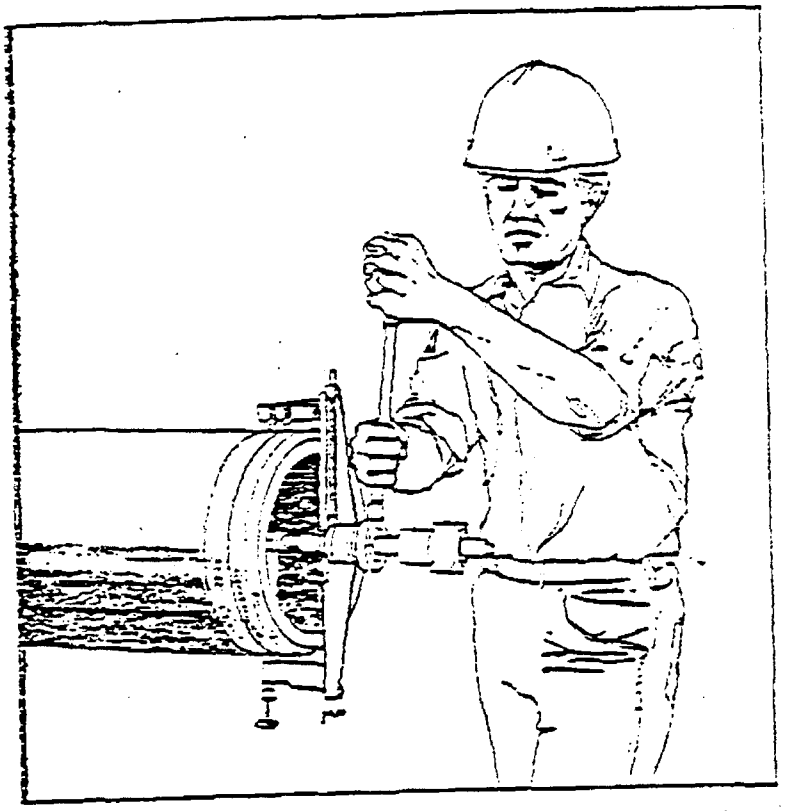
Snap cutters or "squeeze and pop" equipment operates by means of cutting wheels mounted in a chain wrapped around the pipe barrel. Hydraulic pressure, applied by means of a remote electric or manually-operated pump, simultaneously squeezes the cutting wheels into the pipe wall until the cut is made.

AC 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"

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UCC 014636

# Machining
## Field Lathe—Manual



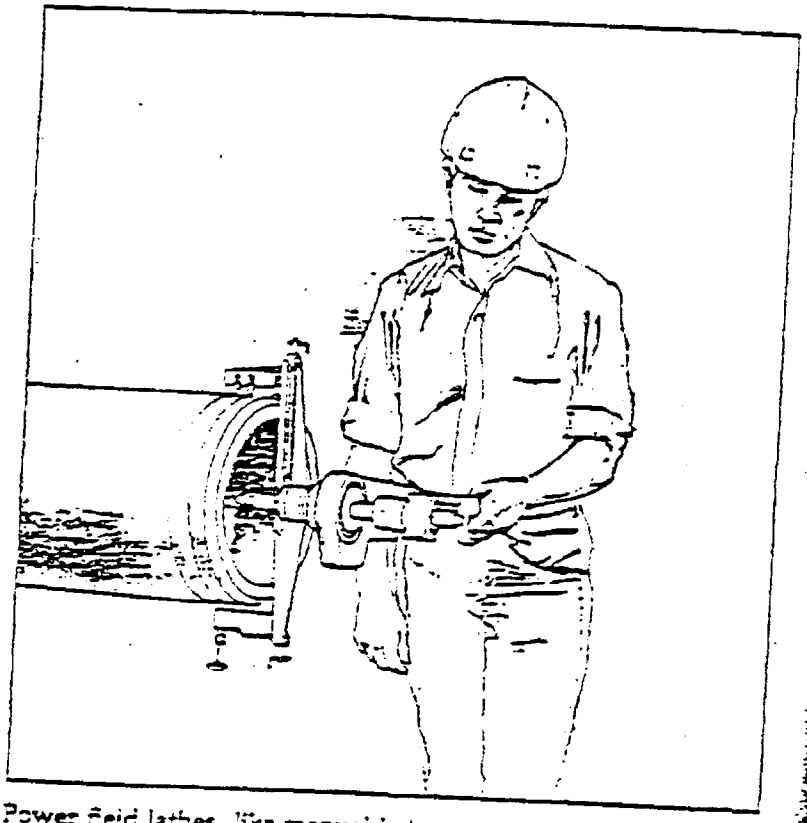
Manual field lathes are designed to end-trim and re-machine rough pipe barrels to factory-machined end profiles. The lathe consists of an adjustable, self-aligning arbor inserted into the pipe bore (which acts as a mandrel upon which the turning handle operates), a screw-fed turning frame, carbide machining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

A/C Pipe Products: All
Size Range: All

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UCC 014637

# 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.

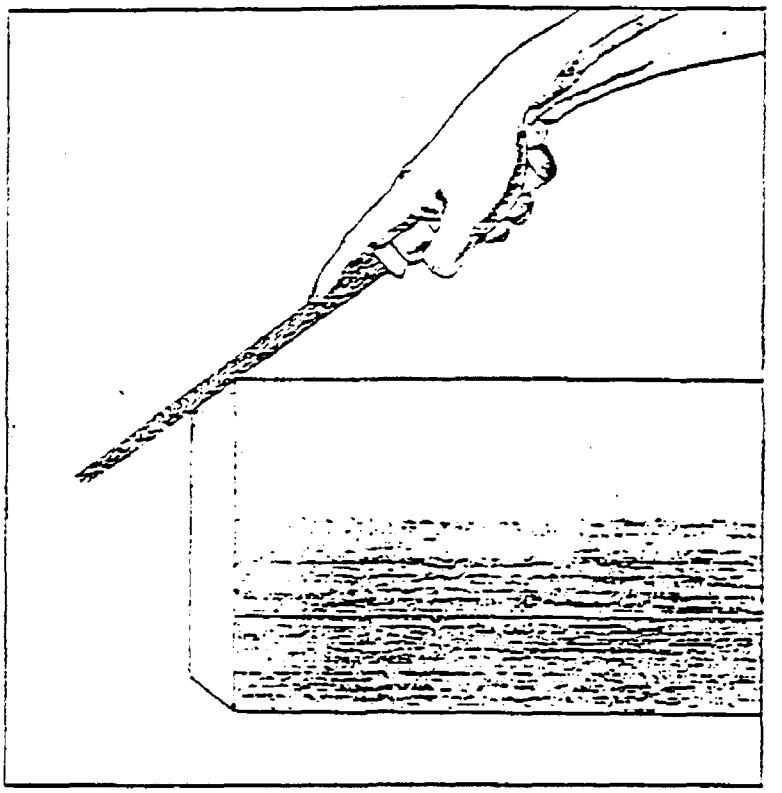
A/C Pipe Products: All
Size Range: All

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# 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

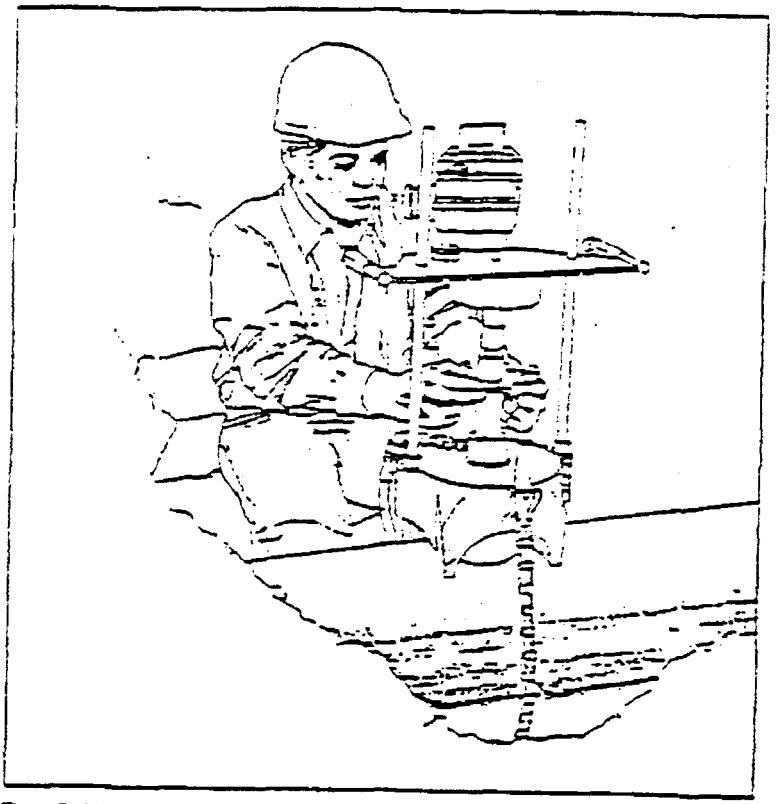
*Exposure data not currently available. Recommendation based on exposure data for operations believed to be comparable.

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# 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-dipped 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.

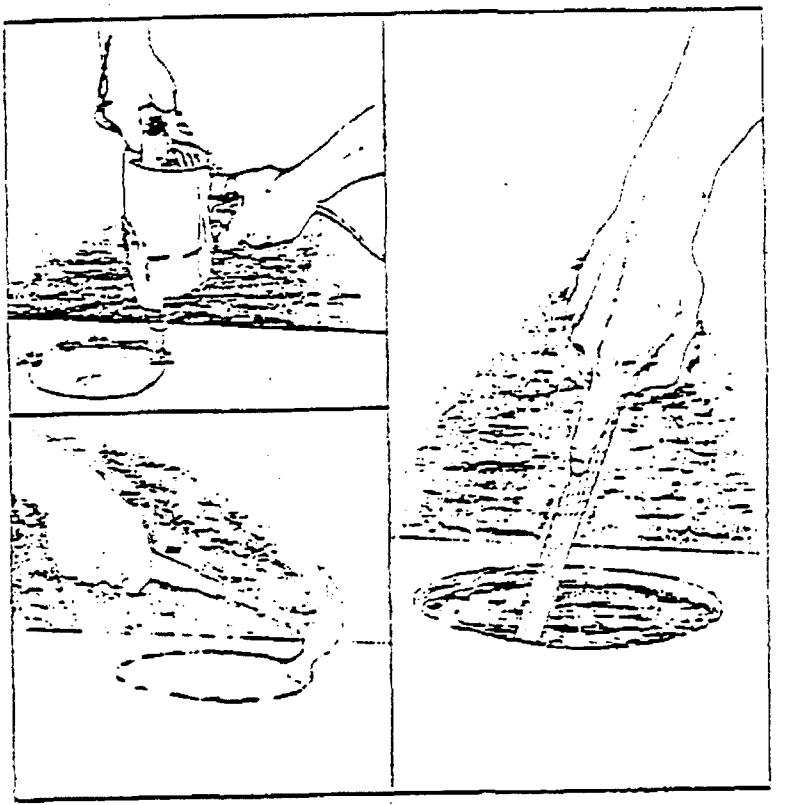
A/C Pipe Products: Pressure, Gravity and Building Sewer
Air Duct

Size Range: All

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UCC 014640

# 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

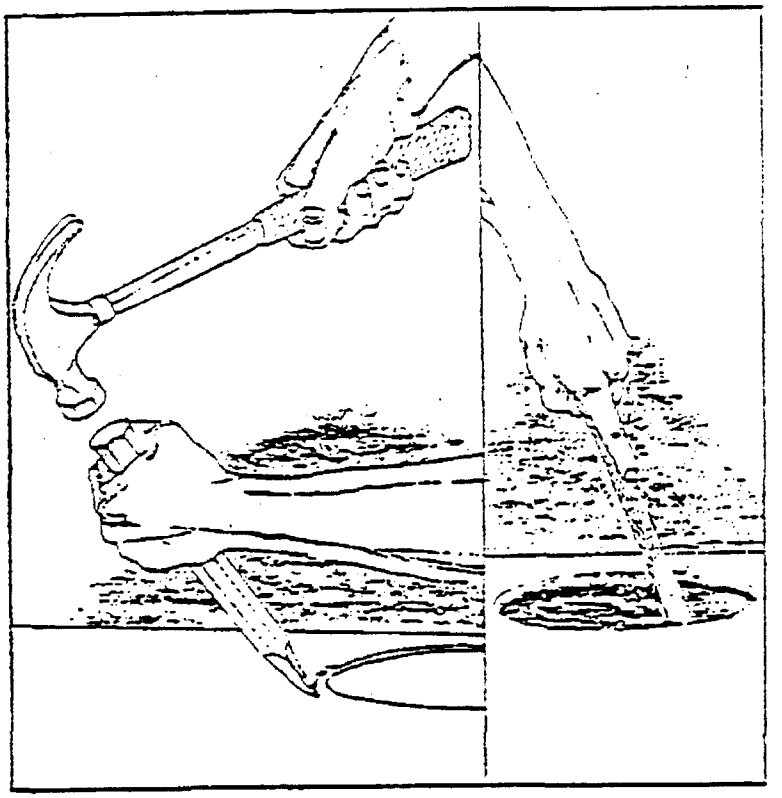
Size Range: All

*Exposure data not currently available. Recommendation based on exposure data for operations believed to be comparable.

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# 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

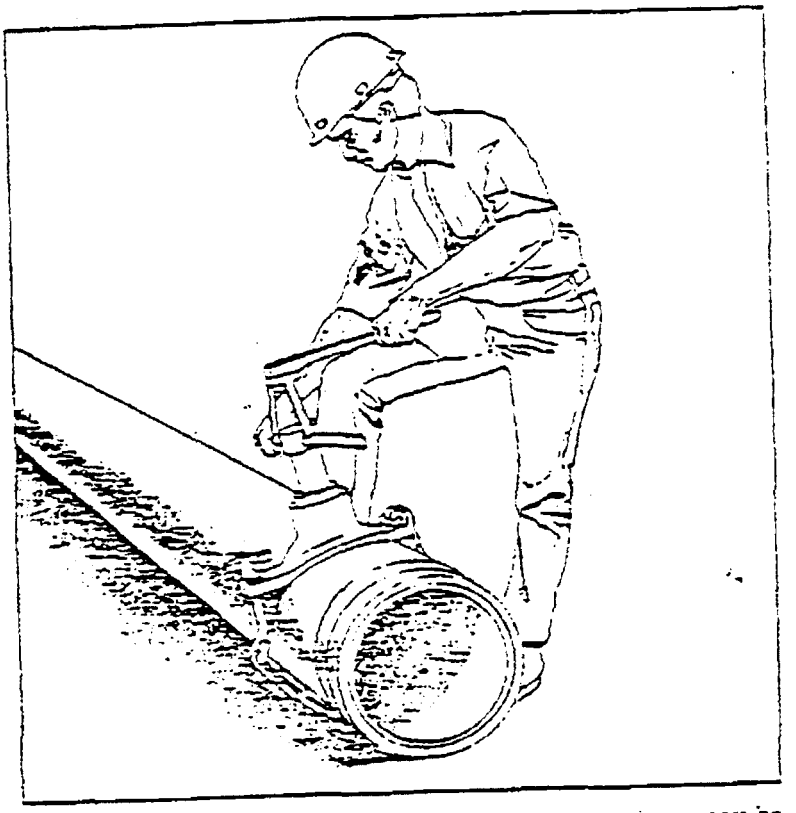
Size Range: All

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# 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

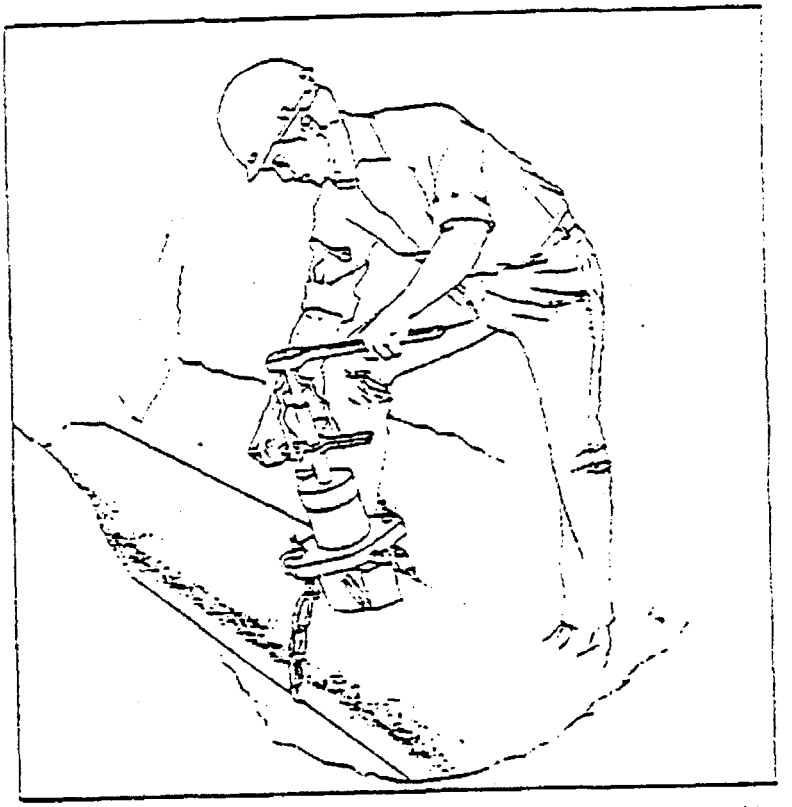
*Exposure data not currently available. Recommendation based on exposure data for operations believed to be comparable.

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# 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

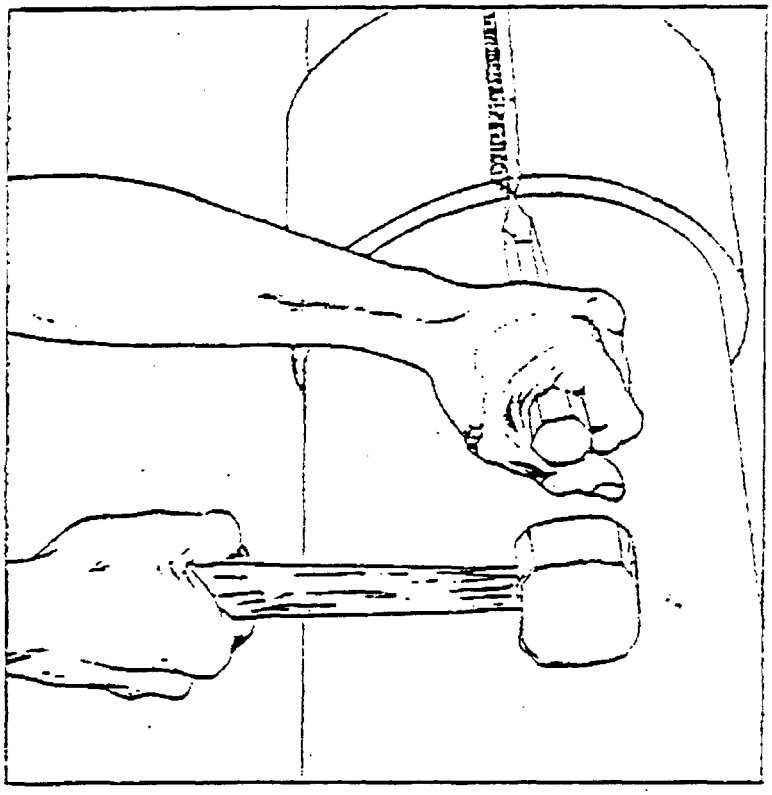
*Exposure data not currently available. Recommendation based on exposure data for operations believed to be comparable.

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# 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 for operations believed to be comparable.

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# Housekeeping and Waste Disposal

Housekeeping is an important part of any safe construction operation. It is even more essential when airborne dust created by the *lack* of good housekeeping has the potential for harm to employees or others.

EQUIPMENT: All external surfaces of equipment should be maintained free of dust accumulations that might, if dispersed, create asbestos fiber concentrations above permissible exposure limits.

WASTE DISPOSAL: Asbestos-cement chips and cuttings from the field operations described in this booklet should be disposed of in a manner that will not contribute airborne asbestos dust to the atmosphere. Where cutting and machining operations are performed at the construction site, the chips should be placed in the trench and buried with the pipeline.

Where operations are performed at a central location such as a contractor's or distributor's yard on a more or less continuing basis, the chips and cuttings may be collected and mixed wet with cement and made into non-friable forms. These forms may be used in the trench as supports for cast iron fittings and valves, as appropriate.

Otherwise, chips and cuttings should be collected in sealed bags or closed containers impermeable to asbestos dust. *Loose material should never be dry swept.* When vacuum equipment is available, it should be used. Water or other dust suppressants should be applied in those circumstances where sweeping is unavoidable. DO NOT BLOW WASTE MATERIAL WITH COMPRESSED AIR.

No visible emissions to the atmosphere may result from the collection, processing, packaging, transporting or deposition of any asbestos-containing material. Wastes should be disposed at a site operated in accordance with the requirements of applicable national, state or local laws.

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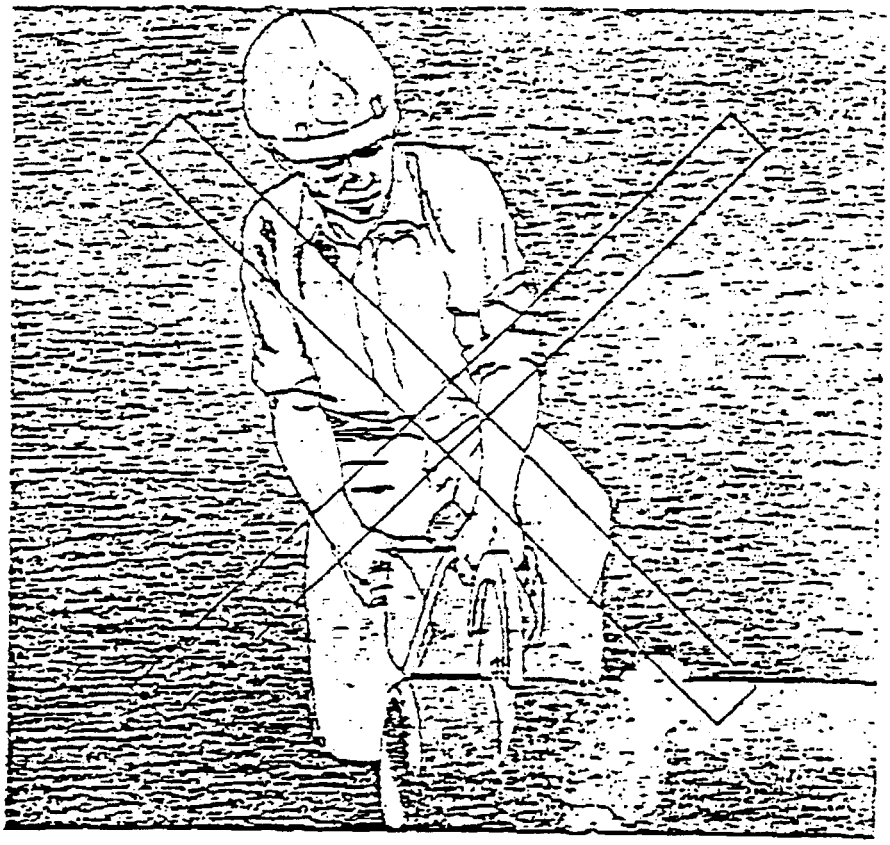
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NON-RECOMMENDED PRACTICES

# Section 2
# Non-Recommended Work Practices *

## Cutting Any A-C Pipe Using Abrasive Disc-Dry Tools.



Power-driven saws with abrasive discs (masonry blades) should not be used for dry cutting or beveling A-C pipe. Abrasive disc cutters produce concentrations of airborne dust that exceed OSHA permissible levels. *This work practice is therefore specifically not recommended.*

* This recommendation was excerpted from the work practices manual prepared by the American Water Works Association.

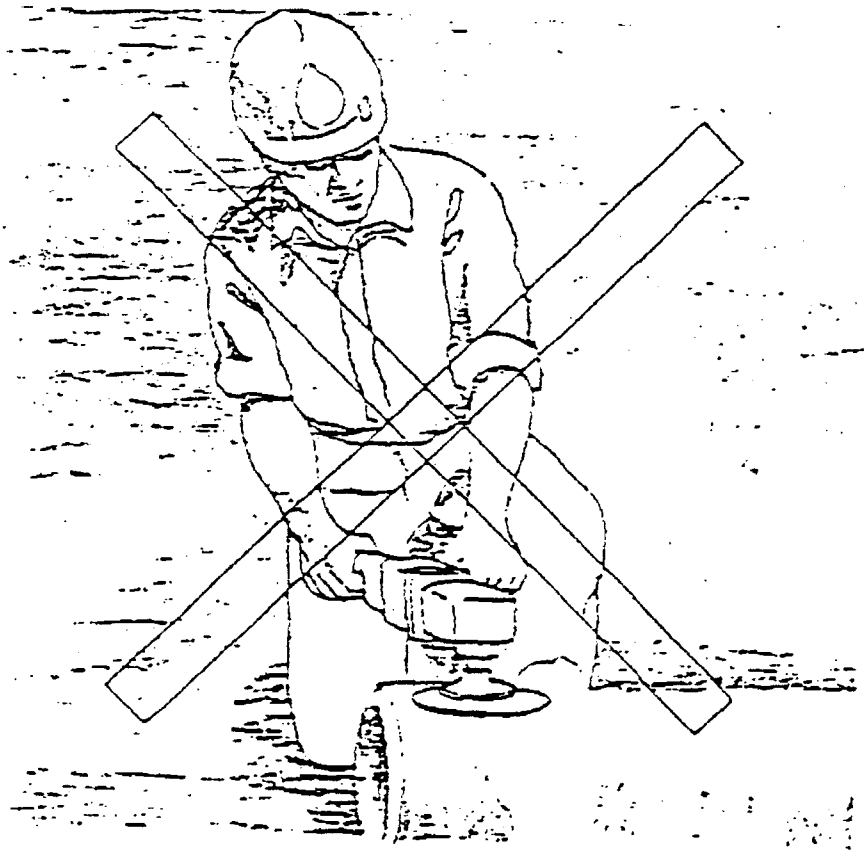
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WORK PRACTICES FOR ASBESTOS-CEMENT PIPE *

## Machining Any A-C Pipe Using Right-Angle Sanders or Other Dry High-Speed Abrasive Tools.



Power-driven abrasive-disc sanders should not be used for shaping or beveling A-C pipe. Abrasive discs produce concentrations of airborne dust that exceed OSHA permissible levels. *This work practice is therefore specifically not recommended.*

* This recommendation was excerpted from the work practices manual prepared by the American Water Works Association.

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# Sampling Methodology and Operations Sampled for Asbestos-Cement Pipe

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## METHODS

Air samples were collected on 37-millimeter diameter, 0.8 micron pore size Millipore cellulose ester membrane filters in accordance with OSHA and NIOSH recommendations. They were all "open-face" (with the cover of the filter cassette removed) samples. Personal sampling pumps were operated at flow rates ranging from 1.6 to 2 liters per minute. The pumps were calibrated by the soap bubble technique before use. Both area and personal (breathing-zone) samples were taken. In the latter, the pump was attached to the worker's belt and the filter clipped to his lapel near his face.

All samples were analyzed by a laboratory accredited by the American Industrial Hygiene Association, following OSHA and NIOSH methods. Briefly, the analytic procedure consisted of rendering the filter transparent with a high viscosity solution of membrane filter material in a mixture of diethyl oxalate and dimethyl phthalate. The asbestos fibers which lie on the surface of the filter are counted with a phase contrast microscope at 400x magnification. The count area was delineated with a Porton graticule. Only fibers exceeding 5 micrometers in length were counted. The laboratory examined 100 microscopic fields or counted 100 fibers, whichever came first. Fiber identification depended upon a particle having an aspect ratio of at least 3:1 and having approximately parallel sides.

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It should be emphasized that estimates of fiber concentrations below 2 fibers/cc are becoming increasingly less precise, and those below 0.5 fibers/cc have a fairly wide margin of error, often being based on the observation of relatively few fibers. Thus, although counts are reported as calculated to two decimal places, differences in counts in these ranges should not be overinterpreted.

## OPERATIONS SAMPLED

(1) Unloading. This operation was performed with a palletized or "unitized" load, the standard packing/shipping method for A/C pipe using a forklift. The 8 inch pipe was arranged on 4 foot pallets, 8 per bed, plus miscellaneous short lengths and couplings. Using a fork lift, it took approximately 15 minutes to unload a two-bed truck. For this operation, a single 24-minute personal sample was taken on the fork-lift operator while pressure pipe was being unloaded.

(2) Laying the pipe in trench. The operation which was studied involved trenching, laying pipe, and back-filling simultaneously. One worker remained in the trench at the forward end of the pipe. The second worker worked both topside and in the trench. He attached a lowering clamp to the pipe, lubricated the pipe end, then entered the trench to help guide it into place for coupling. Two 1 1/2

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hour samples were collected in addition to personal samplers taken from the two workers.

(3a) Cutting with hack saw. A standard hack saw with a hardened steel blade was used for this operation. The blade was changed before each run. Sampling times ranged from 12 to 15 minutes, during which time it was possible to cut about one-half way through the 8" pressure pipe. This tool was not used with sewer pipe.

(3b) Cutting with snap cutting equipment. For this portion of the study, a Wheeler Chain Cutter (Model 2990) was used. It has cutting discs mounted on a chain which is wrapped around the pipe. The action is controlled hydraulically by an operator who can stand as far as 10 to 15 feet from the pipe being cut. The set-up between cuts took about two minutes. Pumping to build up pressure required about 15 seconds. Five to 8 cuts were made during each sampling period; the average ranged from 14 to 16 minutes for sewer pipe and 13 to 16 minutes for pressure pipe.

(3c) Cutting with abrasive disc, wet. A gasoline-powered abrasive disc saw (Stihl) with a 10-inch carbide blade was used. Four 1/4 inch diameter plastic hoses were mounted on the housing of the saw, two on a side. These were connected to a manifold to which was attached a hose delivering water at a rate of 2 to 3 gallons per minute.

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A preliminary run was made with a saw that proved to be underpowered, requiring 18 minutes for two cuts. With a more powerful saw (1 1/2 hp motor) a cut would be completed in approximately 1 1/2 minutes. Two to 3 cuts were taken per sample, the sampling periods having been reduced to 3 to 6 minutes after an initial test sampling period of 17 minutes had led to overloading of the filter with dust. This test was run on pressure pipe only.

(3d) Cutting with abrasive disc, dry. A gasoline-powered abrasive disc saw (Stihl) with a 10" diameter carbide blade was used in this test. When cutting with the saw, the operator held the saw while the helper rolled the pipe along the ground toward or away from him. No machining of the ends was performed with this method of cutting. On both sewer and pressure pipe, one cut would be made in 30 to 45 seconds. Each peak sample included four cuts.

(3e) Cutting with hammer, chisel, and rasp. The pipe was cut with a hammer and chisel, and the edges then smoothed with a course file. The helper rotated the pipe as the operator worked. Two cuts of sewer pipe, each taking 4 to 6 minutes, were made during the short-term or peak sampling period. Cutting the pressure pipe lasted 11 minutes, and only one cut was made per sample.

(4a) Machining with a manual field lathe. The equipment (Pilot Ratchet Field Lathe, Model B-12R) was attached to the

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end of an 8-inch pipe supported 2 to 3 feet from the ground. The lathe had two sets of blades, one for the actual cut and the other to machine and profile the pipe end. The depth of cut could be adjusted manually with screws. A ratchet allowed the operator to turn the lathe by pumping a handle. The helper adjusted the depth of cut as the lathe rotated about the pipe and also assisted in lathe turning. For sewer pipe, one complete cycle took about 8 minutes, i.e., 2 minutes to cut and 6 to 7 minutes for set-up and machining. Each short-term peak sample represented two cycles. Cutting pressure pipe took longer, 4 minutes for cutting and 8 to 9 minutes for set-up and profiling. Each short-term sample covered a single cut.

(4b) Machining with a power-driven lathe. The electric-powered lathe (Pilot Powered Field Lathe, Model B-12P) worked on the same principle as the manual lathe. Due to the ease of operation, a helper was unnecessary. Sewer pipe took 1/2 to 1 minutes to cut and 4 1/2 to 5 1/2 minutes to profile. Two cycles were completed for each short-term ("peak") sample. Again, cutting pressure pipe took longer, 1 1/2 minutes to cut and 5 to 6 minutes to profile; two cycles were used per sample.

(4c) Cutting and machining with Doty machine. The Doty machine is custom-manufactured equipment which has two

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operating stations, one for cutting, and one for machining. It has three operating modes: dry, dry with shroud, and wet with shroud. The last two modifications were designed to reduce dust generation and dispersion. During tests of the tool in the dry mode with shroud and wet mode with shroud, a plastic bag was placed over the blade to reduce dust.

All cuts were made wet, because a diamond blade was used. A fine spray of water was directed across the blade during operations. A single cut requires one-half minute.

Machining was performed dry with no shroud, dry with shroud, and wet with shroud. Again for the wet mode, a fine spray was used. The operation took about 1 minute with most of the sampling time used for moving pipe. The Doty tool was essentially a one-man operation, a helper was needed only to move large diameter pipe.

Two to four cuts and two to four machining operations were completed per sample cycle. Because visible dust was raised by the dry mode, sampling time was reduced from approximately 51 minutes to approximately 10 minutes. Observers also noted that visible dust was released during bevelling on the dry mode with shroud tests. It was suggested that a gasket or some other seal would be helpful in preventing this.

Sampling times recorded during use of the Doty tool, wet, for pressure pipe were 10 to 11 minutes and for sewer



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pipe 9 to 15 minutes. In operations involving the Doty tool with shroud the sampling times for pressure pipe were 13 to 17 minutes, and for sewer pipe, 12 to 14 minutes. For usage of the Doty Tool, wet with shroud, 13 to 18 minute sampling times were employed for pressure pipe, 12 to 16 minutes for sewer pipe.

(4d) Use of tapering tool with A/C air duct.

Testing of the tapering tool was limited to 10-inch A/C air duct pipe, which has a wall thickness of approximately 1/4 inch. Its operating principle is similar to that of the manual field lathe. Sampling times ranged from 14 to 22 minutes which included one cut and one tapering operation.

(4e) Machining with manual lathe on differing sizes of pipe. In order to determine whether pipe size had a detectable influence on dust production, a manual lathing operation was carried out on pressure pipe with 4-inch, 8-inch, and 16-inch diameters. For the 4-inch pipe, there was one cut and one machining operation for each sample. The set-up required about 3 minutes, the cut about 3 minutes; the second set-up about 4 minutes, and machining about 8 minutes. The replicate samples ranged 13 to 21 minutes.

For 8-inch pipe, one cut and one machining operation were performed for each sample. The set-up required about 3-1/2 minutes, the cut about 2 minutes; the second set-up took about 2 minutes and machining about 10 minutes. The replicate samples ranged from 19 to 21 minutes.

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For the 16-inch pipe there was one partial cut per sample including some machining and some cutting. The set-up required 3 minutes, the cutting about 12 minutes, the second set-up about 2 minutes, and machining about 20 minutes.

(5a) Hole cutting with power-operated equipment. The tool used for this operation (Pilot Hole Cutter, Model HC-38E) is available with either an electric or gasoline engine. In this test, a gasoline powered engine was used to cut a 4 1/2" diameter hole with a small center plug. The cutter was secured to the pipe with a chain. The engine rotated the blade while the operator continuously adjusted the height of the blade. The helper aided in equipment set-up. It took about 1 minute to cut a hole in sewer pipe and 1 1/2 to 2 minutes for pressure pipe. A two minute set-up time was required between hole cutting operations. Four holes were cut for each peak sample.

(5b) Hole cutting with drill, hammer and rasp. For this operation, 5/8 inch holes were drilled on the pipe in a circular pattern about 6 inches in diameter, after which the central portion was knocked out with a hammer and the rough edges smoothed with a rasp. The operator used the exhaust air from the drill to blow off excess dust. The drilling took a long time to complete, so that only about 3/4 of the circumference was finished in one sampling period. Therefore, some samples did not include the hammer and file

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steps. Sampling times for pressure pipe ranged from 16 to 24 minutes, for sewer pipe, from 17 to 21 minutes.

(6a) Dry tapping with Mueller J tool. The Mueller J tool is used for tapping pipe for customer service connections. In field operations, the operation may be done at the trench tap, or in the trench. A manually operated tool, which cuts a hole and threads it, was used. Two one-inch holes were cut per sampling period. Sampling periods for pressure pipe were 14 to 29 minutes, for sewer pipe 15 to 18 minutes.

(6b) Tapping operations with Mueller B-100 tool. The Mueller B-100 tool is used for tapping pipes already in place and containing water. In the field, a hole is dug to expose the pipe; for the test, an uninstalled pipe was used. It has a pressure chamber to keep the water from flowing out. For the tests, this chamber was filled with water to simulate "wet" tapping conditions. There were two holes cut per sampling period. For pressure pipe, the sampling times were 14 to 19 minutes, for sewer pipe 14 to 19 minutes.

(7a) Removal of coupling with hammer and chisel. A hammer and chisel were used to make a longitudinal trough in the coupling. When this was completed, a crowbar was used to separate the coupling. For pressure pipe, this operation took about 22 minutes with one coupling being removed per sample. For sewer pipe, the same procedure

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took about 10 minutes per sample. It was soon found that by placing the chisel midline on the coupling, one or two sharp hits would split the coupling, a procedure which took only 10-30 seconds per coupling. For sewer pipe, 3 to 4 couplings were cut per sample, with the major portion of the sampling time used while the pipe was moved and secured to supports.

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