ALASKA LEGISLATURE COMMITTEE FILES 1983 - 1984 8672
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II A New Technology - Continued

with a faster response time and the capability of delivering water which provides wetting higher on the walls to help counter the perimeter fire which is common in residential fire scenarios. Grinnell Fire Protection Systems Company, Inc., in cooperating with these agencies, developed prototype sprinkler heads for these test programs.

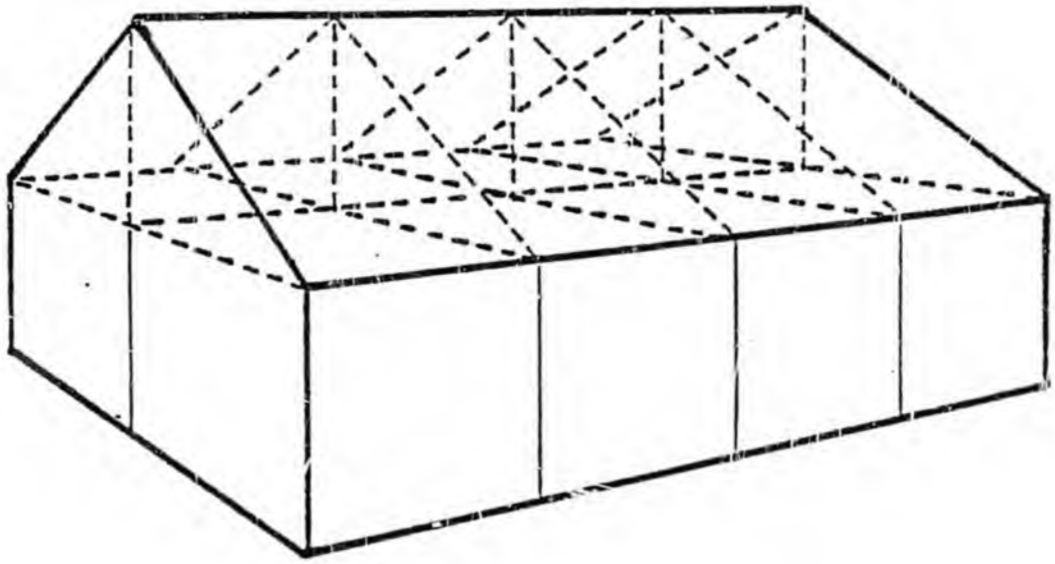
The National Fire Protection Association established a subcommittee of N.F.P.A. 13, which developed a new residential standard for one and two family dwellings and mobile homes. In November of 1980, at the N.F.P.A. meeting in San Diego, N.F.P.A. 13D, Standard for the Installation of Sprinkler Systems in One and Two Family Dwellings and Mobile Homes, was adopted. This new standard, which was based on the results of the fire test program, called for only listed new residential sprinklers for installation in accordance with the criteria established by the N.F.P.A. 13D Committee. Underwriters Laboratories (U.L.) established a new manufacturing standard U.L. 1626, which set some very stringent requirements for sensitivity and water distribution for manufacturers seeking a listing for newly designed residential hardware. In May of 1981, Grinnell Fire Protection Systems Company, Inc. became the world's first manufacturer to successfully pass all U.L. testing procedures and obtained a listing for the world's first listed residential fire sprinkler.

An old idea, utilizing a new technology whose time had come, was now a reality.

III Rationale

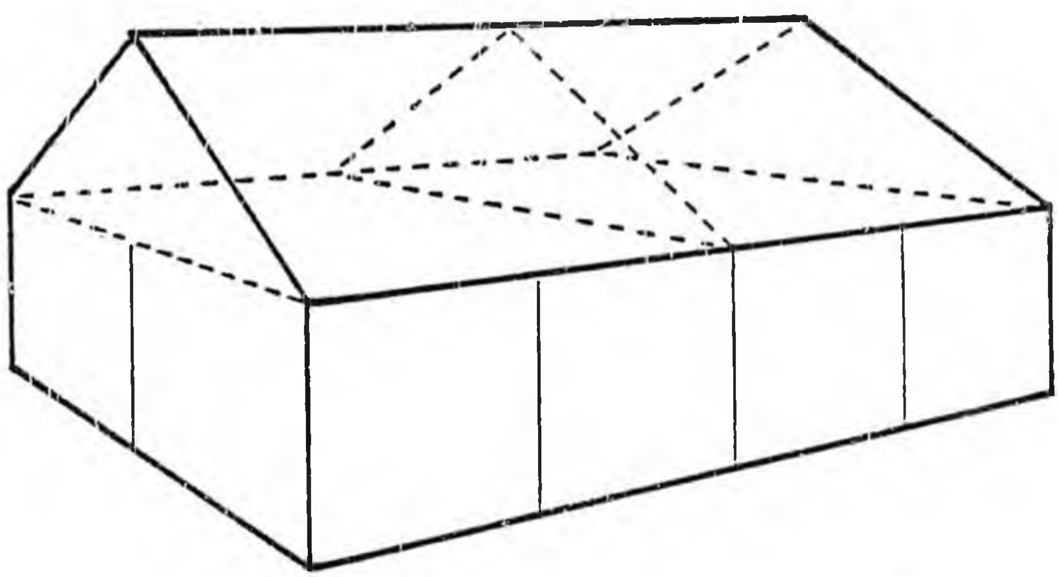
N.F.P.A. #13D-Sprinkler Systems-One and Two Family Dwellings and Mobile Homes (1980) is "intended to provide a method for those individuals wishing to install a sprinkler system for additional life safety and property protection. It is not the purpose of this standard to require the installation of an automatic sprinkler system."

Simply stated, "where" fire protection systems are required is generally covered in building and fire codes, or local ordinances. N.F.P.A. standards, on the other hand, outline the design criteria for "how" the system should be installed in order to protect a particular hazard. A subtle, but important difference. Since the present scope of application of N.F.P.A. #13D (1980) deals with the design installation of automatic sprinkler systems for one and two family dwellings and mobile homes, any system design for occupancies which fall outside the scope of this standard should only be permitted with written authorization from the "authority having jurisdiction." Based on the research conducted in developing this new residential sprinkler technology, as well as fire tests and demonstrations coordinated by the U.S. Fire Administration and Factory



FIRESTOP EACH UNIT IN ATTIC

NON SPRINKLED



FIRESTOP AT 3,000 SF IN ATTIC

SPRINKLED

III Rationale - Continued

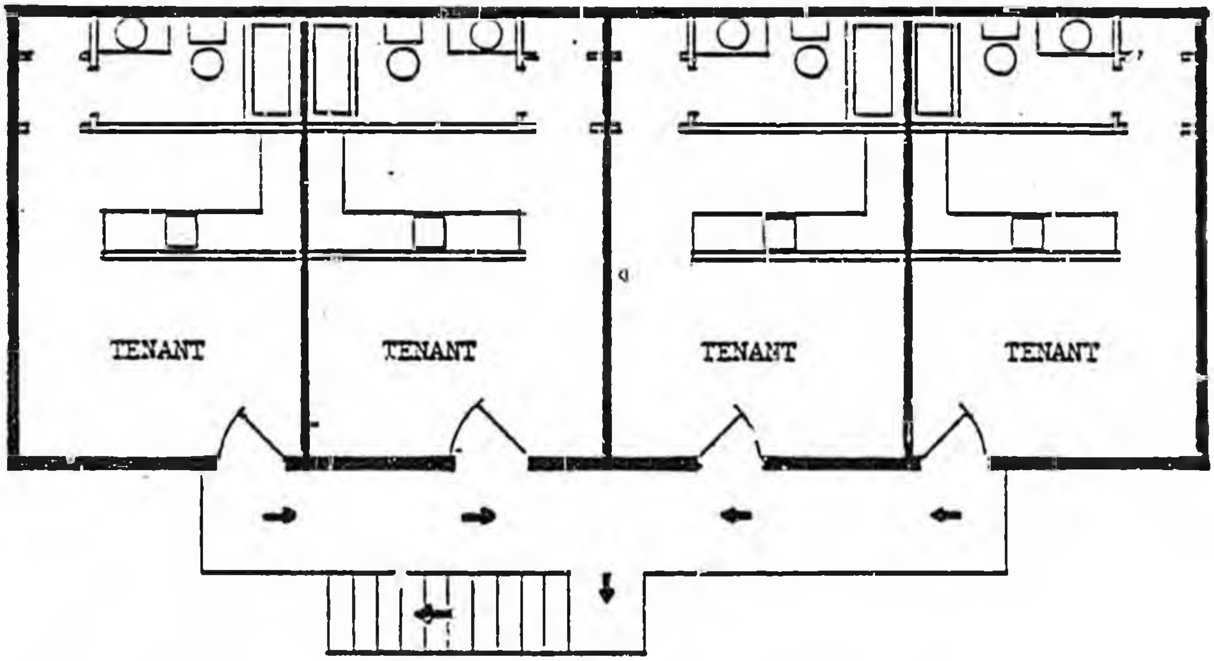
Mutual Research Corporation, a number of "authorities having jurisdiction" are in the process of considering residential fire sprinkler ordinances. The concept of "access trade-offs", as well as "construction trade-offs" is gaining in popularity. As an example, such ordinances may include, but not be limited to, requiring the installation of residential fire protection systems in accordance with N.F.P.A. #13D (1980) in low rise, high density type construction as a means of mitigating one or more of the following fire protection deficiencies.

Access Trade-offs

Without Residential Fire Protection	With Residential Fire Protection
Units must be within 5 minute response of nearest fire station	Waived
Units must not be located more than 150 feet from closest vehicular access way.	Waived
Standard street widths required	Reductions permitted
Street grade of 15% or greater not permitted	Waived
Must adhere to hydrant spacing requirements	Greater hydrant spacing permitted
Fire flow requirements must be met	50% reduction in required fire flow
Hazardous areas - 75 units for single means of ingress or egress	Number may increase
Nonhazardous areas - 150 units for single means of ingress or egress	Number may increase
Access for ladder trucks - 50' from rear of parking stalls to face of unit	Extended to 75' or 100'
When any portion of a buiding is in excess of 150' from a water supply, it may be required that on-site fire hydrants and mains capable of supplying the required fire flow be installed.	Waived

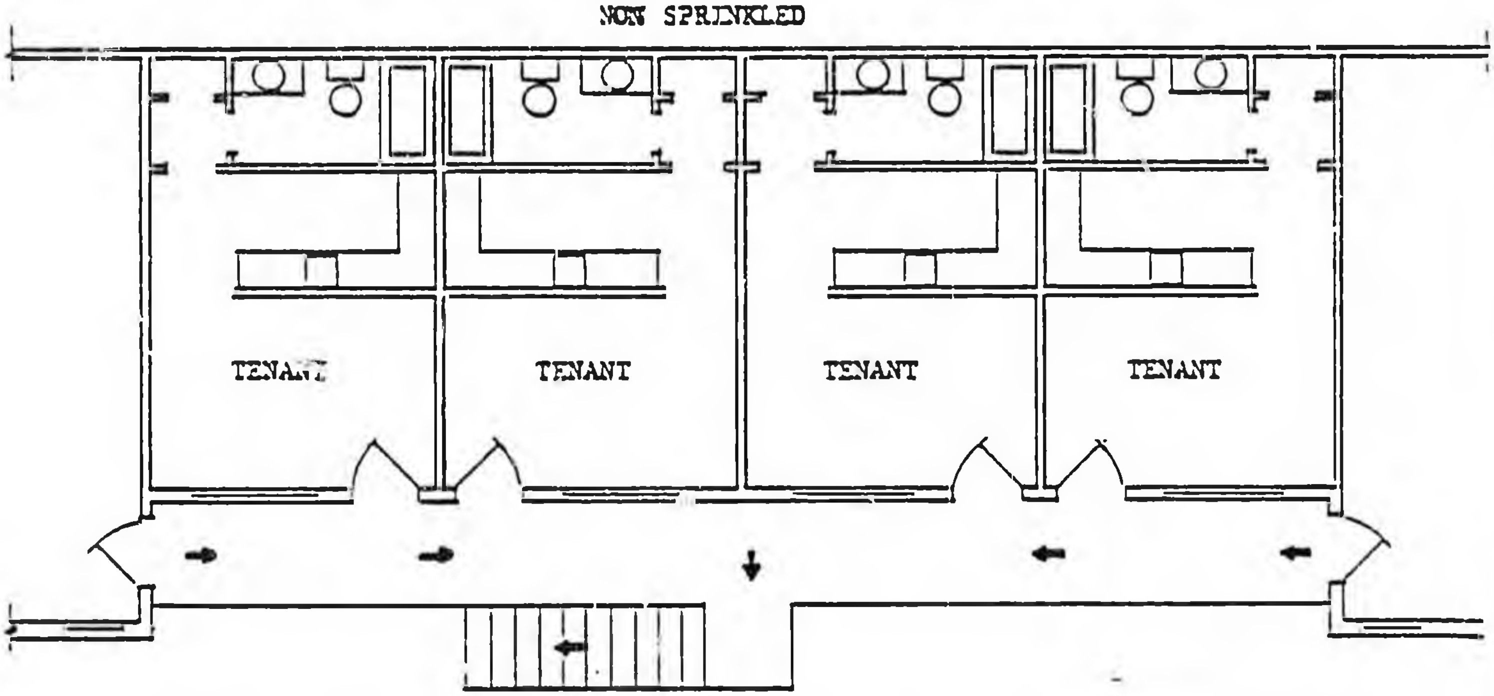
CONSTRUCTION TRADE-OFFS

Without Residential Fire Protection	With Residential Fire Protection	Savings/ Advantage*
Tenant separation walls must be made of 5/8" Type X Fire Rated Gypsum Wallboard.	Half-inch standard Gypsum Wallboard may be substituted.	$23.00 per 1,000 sq. ft.
5/8" Type X Rated Gypsum Wallboard and 3/4" plywood must be used in one-hour floor/ceiling assemblies.	Half-inch standard Gypsum Wallboard and 5/8" plywood may be substituted in floor/ceiling assemblies.	$55.00 per 1,000 sq. ft.
Fire stops are required in the attic at every unit.	Fire stops in attic required every 3,000 square feet.	$123.00 each fire stop.
Maximum tenant travel to a fire exit must not exceed 20 feet.	Exits may exceed the maximum required travel from a tenant with one exit may be exceeded by 15 feet for a maximum travel of 35 feet.	Design Freedom
Tenants may not travel by other tenants' doors unless those doors are 3/4-hour fire rated doors in 20 minute frames with 3 UL listed spring hinge closers.	Standard doors and frames with no closers may be used.	$111.70 each door.
Interior finish must be Class "A".	Interior finish may be Class "C" or better.	Design Freedom
One-hour rating on walls and doors of hazardous areas.	No one-hour rating of doors or walls of hazardous areas.	$23.00 per 1,000 sq. ft. (walls). $111.70 each door.
Hazardous area must be one-hour rated walls with 3/4-hour rated doors with 3 UL spring hinge closers. (Hazardous areas are: common storage, common mech. rooms, etc.)	Standard 1/2 inch sheetrock and standard doors with no closers may be used.	$23.00 per 1,000 sq. ft. on walls. $55.00 per 1,000 sq. ft. on ceilings. $111.70 each door.



One hour party walls are required between tenants. 3/4 hour U.L. entrance doors are required with 20 min. U.L. frames and 3 U. L. spring hinge closers. No windows within 15' of other tenants travel. One hour exterior wall facing exit. Max. travel distance for one exit is 20'.

NON SPRINKLED



Standard 1/2" sheet rock partitions may be used between tenants standard entrance doors, frames and no closers. Unlimited number of windows any place. Standard exterior wall facing exit. Maximum travel distance for one exit is 35'.

SPRINKLED

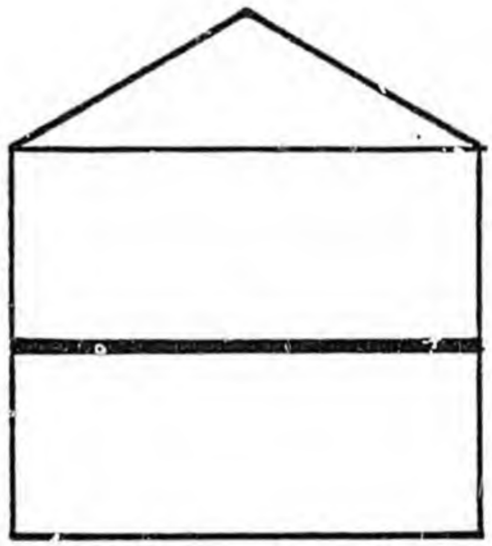
Every 6,000 square feet a four-hour masonry fire separation is required.	The fire rated separation would not be required until 10,000 square feet and after 8,000 square feet a two-hour separation would be permitted.	$8,345 each 4-hour wall. Note: Cost of 2-hour sheet-rock wall-$750.
Buildings must be placed on property to not exceed 50' from paved parking area for aerial rescue operations.	Buildings allowed up to 125' from street or parking area. This allows freedom in design as well as being able to place building in more esthetic surrounding.	Allows maximum use of site and landscaping.
There can be no windows within 15 feet of other tenants travel.	Windows may be placed anywhere desired.	Design Freedom

*Builder/Developer, Cobb County, Georgia.

IV Housing Trends

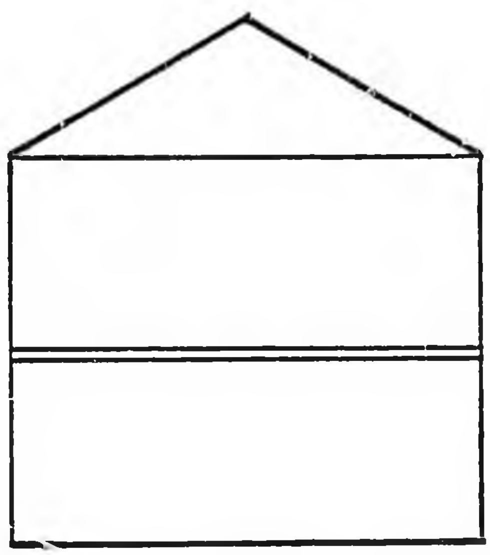
America is facing a severe housing crisis. If the demographic demands of the fertile 50s are not met, this country will face, during the decade of the 80s, a housing shortage unparalleled in the annals of the residential construction industry. Because of rising construction costs, coupled with high interest rates, affordable housing is beyond the economic reach of the majority of our population. Many builders believe that the days of the "sprawling single family dwelling" are coming to an end. In an effort to make greater utilization of skyrocketing land costs, many builders/developers are turning to "high density" construction in the form of low-rise condominiums, townhouses, triplexes, four-plexes, and garden apartments. It is hoped this type of residential construction will make housing more affordable and provide a salvation for a severely depressed housing industry. Unfortunately, the burdens this type of construction is placing on local fire departments is becoming very real indeed.

It is well known that tax reform legislation sweeping the country has caused substantitive cutbacks in many municipal budgets. These fiscal constraints are dramatically affecting fire department funding in many cities and towns. Manpower reductions and the lack of ample funding for additional fire stations, new equipment and training programs is seriously hampering the fire fighting effectiveness in many municipalities. High density type construction does not help. Financially



One hour floor-ceiling is required using 3/4" plywood decking and 5/8" type X sheetrock on ceiling.

NON SPRINKLED



5/8" plywood decking and 1/2" standard sheetrock on ceilings.

SPRINKLED

IV Housing Trends - Continued

beleaguered fire departments simply do not have the necessary resources needed to protect these properties. As the result, many municipalities are turning to private fire protection in the form of residential fire sprinklers to supplement already strained public protection.

V Financial Motivations for Residential Fire Sprinkler Systems

In addition to access and construction trade-offs which are gaining popularity among the fire services, a number of financial inducements are being enacted which will provide financial motivation for individuals to install residential fire sprinkler systems.

Insurance Savings

Following the test program in Los Angeles, an Ad-hoc Committee composed of the insurance industry conducted a series of fire tests to consider the impact of residential sprinklers on fire losses in dwelling properties. Although it was acknowleged that the greatest benefit of residential sprinklers will be in saving lives and preventing injuries from fire, the major focus of this test program was on the single factor of determining impact on property loss reduction.

Based on the results of this test program, it was the observation of the Ad-hoc Committee that residential fire sprinkler systems definitely had the ability to reduce claim payment expenses. The committee further recognized that an earlier I.S.O. discount (1977) is less than what seems to be indicated as a result of these tests.

Since 1977, the Insurance Services Office has had filings in many states providing a 5% discount on a total homeowner policy premium covering a dwelling with an approved and properly maintained sprinkler system that covers all areas of the insured structure. Their filings, also, allowed a 2% discount for a similar system that omits specified areas, such as closets, attics and bathrooms.

After considering the report from the Ad-hoc Insurance Committee, and the U.S. Fire Administration's sprinkler comparison test program, the Homeowner's Committee of I.S.O. has made a recommendation that could result in a tripling of the discount for residential sprinkler systems installed in accordance with N.F.P.A. 13D (1980). Discounts up to 15% would be applied to the entire homeowner policy premium for single family residences protected in accordance with N.F.P.A. 13D (1980). Since a homeowner premium is multi-peril in nature, it is estimated that the fire protection portion of the premium usually accounts for 40% of the entire policy. A 15% discount applied to the total homeowner premium translates into a fire insurance discount of almost 37%.

Water Damage

It has been suggested that the installation of a residential fire sprinkler system in a home would cause an insurance company to penalize a homeowner because of the threat of water damage due to sprinkler leakage. Insurance statistics from commercial underwriting departments of several large insurance companies demonstrate that sprinkler leakage is one of the most profitable lines of coverage that insurance carriers underwrite. The payment of claims for the inadvertent discharge of sprinklers is minimal considering the number of exposure units (large numbers of sprinkler installations in commercial/industrial properties) carriers underwrite. As a result of this excellent experience, the ISO recommendation of a 15% reduction on a total homeowner premium when a residence is protected with a system installed in accordance with N.F.P.A. 13D (1980), does not include a penalty for sprinkler leakage.

Since I.S.O. provides rate making advice for its subscribing membership, the implementation of these recommendations will depend on individual carriers. I.S.O. has proceeded with state filings with a number of Superintendents of Insurance and several adoptions of this credit have already taken place. (See Table I enclosed)

Real Estate Tax Reductions

On January 1, 1981, the State of Alaska enacted into law a significant piece of legislation which will impact dramatically the installation of sprinkler systems throughout the state.

The law provides that 2% of the assessed value of any structure would be exempt from taxation if the structure is protected with a fire protection system. The word "structure" is significant in the law as it, also, applies to homes.

In effect, if a home was assessed for $100,000, for purposes of taxation, the assessed value would be computed at $98,000, provided it had a fire protection system.

This law has received widespread attention, particularly among the fire services and a number of jurisdictions are studying its implications for potential adoption in other states. (Copy of law is included)

TABLE #1

I.S.O.

STATE ADOPTIONS

ALASKA
ARIZONA
CALIFORNIA
KENTUCKY
MARYLAND
MONTANA
NEVADA
NEW MEXICO
NORTH DAKOTA
OREGON
UTAH
VIRGINIA

Codes

DURAFLEX polybutylene pipes have been approved by every major national and regional plumbing code in the United States and Canada. In addition, over 65 percent of the major metropolitan areas in the United States have approved the use of DURAFLEX polybutylene plumbing pipe.

Under a contract to the United States Fire Administration, Factory Mutual has issued a specification for the use of plastic pipe in fire sprinkler systems for one and two family residences and mobile homes. DURAFLEX polybutylene pipe and fittings have been submitted for testing to this standard and are expected to be approved in the first quarter of 1983. In addition, tests are also under way at Underwriters Laboratories for sprinkler applications in both residential and light and ordinary hazard occupancies.

SPECIFICATIONS, STANDARDS, APPROVALS, ACCEPTANCES, AND LISTINGS FOR POLYBUTYLENE PLUMBING

I. SPECIFICATIONS

ASTM D2581 - Polybutylene Material Specification
ASTM D2662 - Polybutylene Pipe Specification (IPS sizes) water service
ASTM D2666 - Polybutylene Tubing Specification (CTS sizes) water service
ASTM D3000 - Polybutylene Pipe Specification
ASTM D3309-82 - Polybutylene plastic for hot and cold water distribution systems
ANSI 119.1
ANSI 119.2 - Mobile Home and Rec. Vehicle Specifications
AWWA C902-78 - Polybutylene Water Service Sewer Tubing (American Water Works Association)
CSA B137.7 - Polybutylene Cold Water Service (Canadian Standards Association)
CSA B137.8 - Polybutylene Hot and Cold Water Distribution Tubing

II. CODES AND LISTINGS

BOCA (Code) - Building Officials Congress of America (accepts PB per ASTM D3309)
FHA (Listing) - Farmers Home Administration (cold water only)
FHA-HUD (Listing) - Federal Housing Administration (Bulletin 68) UM78 4/25/78 - (hot and cold water approval) UM 76.
ICBO (Code) - International Congress of Building Officials (plumbing approval)
IAPMO (Code) - International Association of Plumbing and Mechanical Officials (Uniform Plumbing Code)
MHA (Listing) - Manufactured Housing Association
NSF (Listing) - National Sanitation Foundation - (Standard #14)
NSPC (Code) - National Standard Plumbing Code (NAPHCC)(Code Table 3.1.3)(plumbing approval) National Association of Plumbing-Heating-Cooling Contractors
PPI (Listing) - Plastic Pipe Institute
RVI (Listing) - Recreational Vehicle Institute
SBCC (Code) - Southern Building Code Congress (accepts PB per ASTM D3309)
UL (Listing) - Underwriters Laboratory
MHMA (Listing) - Mobile Home Manufacturers Association
NFPA - National Fire Protection Association #501.C (mobile home)(plumbing approval)
South Florida Building Code

LEGISLATION AND MODEL RESOLUTION

MODEL RESOLUTION... ________ FIRE CHIEFS' ASSOCIATION

WHEREAS... expanding and developing communities in our ________. States with underdeveloped public services are particularly vulnerable to catastrophic fire losses and...

WHEREAS... the maximum utilization of private fire protection systems minimizes fire losses and minimizes costs of operating fire department and water utilities and...

WHEREAS... legislation creating incentives for the installation of private fire protection systems will encourage an area wide shift towards maximum utilization of more efficient, less costly fire fighting technology, thereby stabilizing the cost of water utilities and fire departments; along with savings to life and property; the conservation of water and reduced cost of local government services with the widespread installation of private fire protection systems.

RESOLVED... that the ________ Fire Chiefs' Association in conference in ________ on ________ of 198__ actively promote legislative incentives to move towards the utilization of the best and most economical fire safety technology private fire protection by

... Actively promoting legislation that will assure tax credits by exempting the value of private fire protection systems from the true cash value of a building and

... Eliminating water stand-by charges that a utility may charge for the connection of a private fire protection system and

... Providing low interest loans that will cause financing to be available so that automatic fire sprinklers can be installed in both new and existing buildings.

RESOLVED... On ________ by the ________ in conference at ____________ on ________ 198__.

Signed ______________________________

Original Sponsors: Malone and Duncan — Offered: 5/9/80

IN THE HOUSE — BY THE RULES COMMITTEE

SENATE CS FOR CS FOR HOUSE BILL NO. 648

IN THE LEGISLATURE OF THE STATE OF ALASKA

ELEVENTH LEGISLATURE - SECOND SESSION

A BILL

For an Act entitled: "An Act relating to fire prevention."

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF ALASKA:

*SECTION 1. AS 18.70 is amended by adding a new section to read:

Sec. 18.70.081. APPROVAL OF FIRE PROTECTION SYSTEMS. Before October 30 of each year the Department of Public Safety shall prepare and make available a list of approved fire protection systems to the Department of Community and Regional Affairs, the Department of Commerce and Economic Development, and the public.

*SECTION 2. AS 29.53.020(a) is amended by adding a new paragraph to read:

(7) real property to the extent and subject to the conditions provided in (j) of this section.

*SECTION 3. AS 29.53.020 is amended by adding a new subsection to read:

(j) Two percent of the assessed value of a structure is exempt from taxation if the structure contains a fire protection system approved under AS 18.70.081, in operating condition, and incorporated as a fixture or part of the structure. The exemption granted by this subsection is limited to

(1) an amount equal to two percent of the value of the structure based on the assessment for 1981, if the fire protection system is a fixture of the structure on January 1, 1981; or

(2) an amount equal to two percent of the value of the structure based on the assessment as of January 1 of the year immediately following the installation of the fire protection system if the fire protection system becomes a fixture of the structure after January 1, 1981.

*SECTION 4. AS 42.05.331 is amended by adding a new subsection to read:

(d) A utility shall provide for a reduced fee or surcharge for standby water for fire protection systems approved under AS 18.70.081 which use hydraulic sprinklers.

*SECTION 5. AS 44.33.170 is amended by adding a new subsection to read:

(b) Tourist attraction development matching money may also be obtained for the purpose of purchasing and installing a fire protection system approved under AS 18.70.081 for a building used or to be used for the purposes described in (a) of this section.

*SECTION 6. AS 45.95.020(a) is amended to read:

(a) The commissioner shall, under regulations and policies adopted by him, make small business loans to acquire, finance or refinance or equip businesses, including farming equipment, fire protection systems approved under AS 18.70.081, mining and fishing, not exceeding $500,000. The loans shall be secured by acceptable collateral and may not exceed 75 percent of the appraised value of the collateral offered as security. The rate of interest may not exceed nine and one-half percent a year on the unpaid balance.

*SECTION 7. AS 45.95.020 is amended by adding a new subsection to read:

(a) The commissioner may not disqualify an applicant for, or prejudice an applicant's priviledge to receive, a loan to purchase and install a fire protection system solely because of a loan already made to the applicant under this chapter.

Installation Requirements

No piping system will perform properly if it is not installed correctly. Because the materials are different, there are significant differences between the installation of metal pipe and that of DURAFLEX polybutylene pipe. These differences do not result in costly designs or complicated, expensive installations. Quite the contrary, they will greatly simplify the design of the system and significantly reduce the installed costs. Included in this section are information on making and testing fusion joints, pipe function loss as a function of flow rates, pipe support spacing, protection against external abrasion, allowances for thermal expansion, need for boxing or other separation and protection from ultraviolet exposure.

Shell has more detailed design information on these subjects than is included here. This information can be made available as needed for specific installations.

Heat Fusion Techniques

A. Prepare Heating Tool

1. Bolt proper size socket heater faces onto heating tool.

2. Connect tool to 120v AC power source.

3. Allow heating tool to reach 500°F min. - 525°F max.

a. If the temperature is other than above adjust temperature by inserting a screwdriver in the hole near the thermometer and turn thermoswitch adjusting screw clockwise to lower the temperature and counterclockwise to increase the temperature.

B. Prepare Pipe End

1. Cut pipe end square with a tubing cutter.

2. Chamfer the outside corner of the pipe end for pipe 1-1/4" IPS and larger with proper chamfering tool.

3. Clean pipe end. (Pipe must be free of dirt or grease.)

4. Place depth gauge on pipe end.

5. Clamp cold ring around pipe with one side contacting the depth gauge. (Cold ring rounds the pipe end and limits the depth that the heater face and socket fitting slide over pipe end.)

6. With 1/2" and 3/4" pipe use insert stiffner to insure pipe roundness.

C. Prepare Fitting

1. Clean fitting. (Socket must be free of dirt or grease.)

D. Heat Pipe End and Fitting

1. Place pipe end and fitting adjacent to heater elements.

2. Push pipe end, heater and fitting together with an even pressure.

3. With heater in contact with the fitting and cold ring, begin measuring the heating time. Optimum heating times are as follows:

Pipe Size	Heating Time	Pipe Size	Heating Time
1/2"	5 - 7 sec.	1-1/2"	12 - 15 sec.
3/4"	5 - 7 sec.	2"	12 - 15 sec.
1"	10 - 12 sec.	3"	15 - 20 sec.
1-1/4"	12 - 15 sec.	4"	15 - 20 sec.

Good joints will still be made when heating times vary from 75% to 150% of these times.

4. When heating time is complete, remove fitting and pipe from heater with a quick snap action.

E. Join Pipe and Fitting

1. Quickly line up pipe with fitting. Push together until fitting is against cold ring.

2. Hold joint together for cooling time as follows:

Pipe Size	Cooling Time	Pipe Size	Cooling Time
1/2"	30 sec.	1-1/2"	90 sec.
3/4"	30 sec.	2"	90 sec.
1"	45 sec.	3"	90 sec.
1-1/4"	60 sec.	4"	90 sec.

3. When cooling time is complete remove cold ring.

4. Do not stress the fusion joint until it is cool to the touch, usually five minutes.

F. Inspect Joint

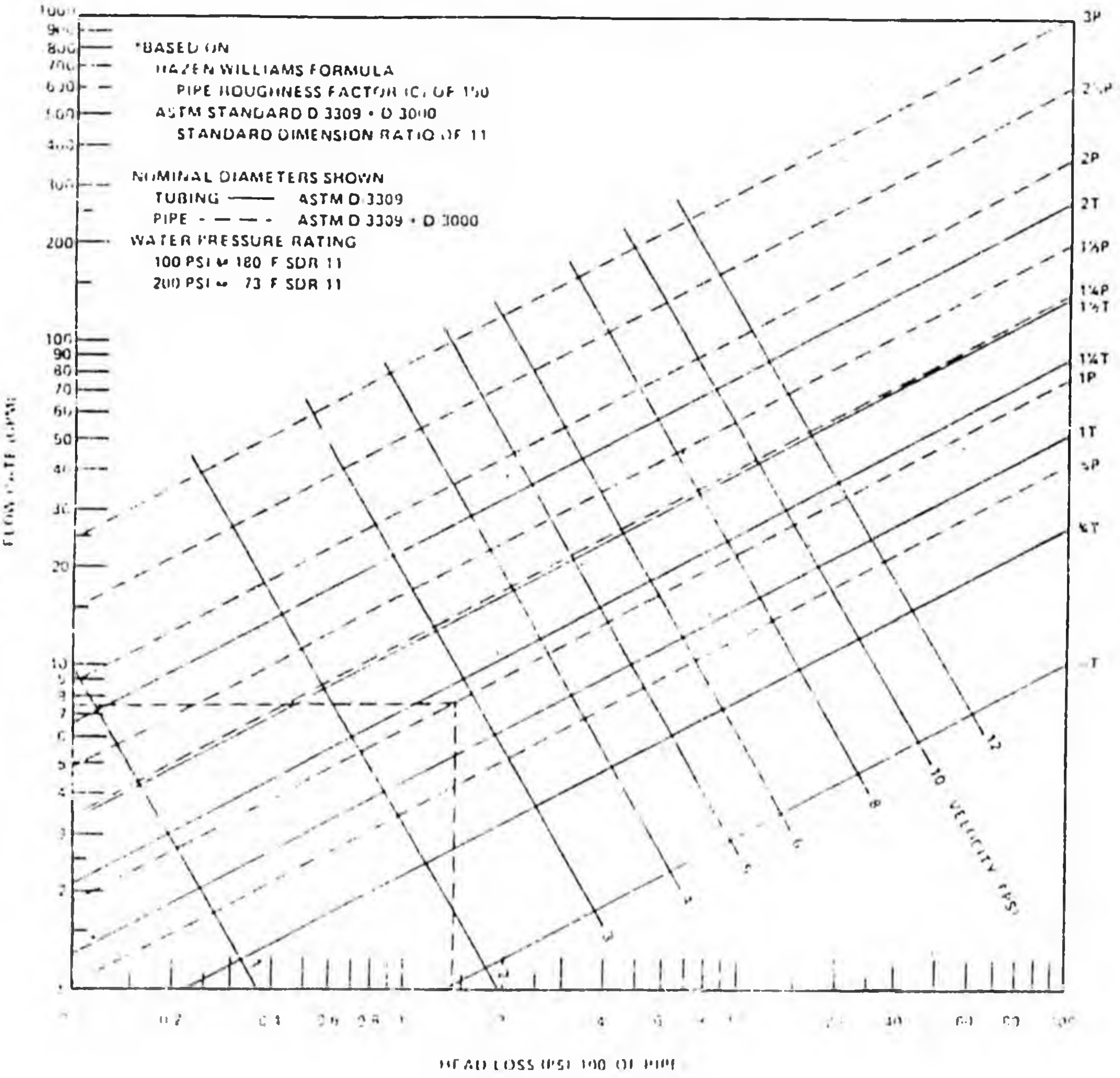
1. Make certain that joint is intact and formed properly.

G. Clean Heater Faces

1. Wipe off molten plastic from heater elements before another fusion connection is made.

PIPE FLOW CAPACITY

Friction Loss Vs. Flow Rate
Polybutylene Plumbing Pipe Tubing*



Support Spacing

The effects of gravity will cause all horizontal pipes to deflect from a perfectly straight alignment. The amount of deflection will depend upon the stiffness of the material and the pipe support spacing. The following table gives the long term deflection that unpressurized water-filled polybutylene pipes will experience. Due to Poisson's effect, pressurization will reduce the amount of deflection. It should be borne in mind that the listed deflections cause a negligible stress on the pipe itself.

HORIZONTAL PIPE SUPPORT SPACING
NO AXIAL CONSTRAINT
CONTINUOUS BEAM DESIGN

NOMINAL PIPE SIZE	LONG TERM ALLOWABLE DEFLECTION (IN.)		
CTS	0.50	1.00	1.50
1/2	20	24	27
3/4	34	40	44
1	38	45	50
1-1/4	42	50	56
1-1/2	46	55	61
2	51	61	68
IPS			
3/4	37	44	49
1	42	50	56
1-1/4	47	56	62
1-1/2	50	60	67
2	56	67	75
2-1/2	61	73	81
3	68	81	90
4	75	89	99

Abrasion Protection

To minimize external abrasion, NFPA approved hanger straps that are smooth and free of sharp edges should be used. To guard against the possibility of sharp edges or burrs, plastic sleeves are recommended for the load bearing surfaces of the hangers. Wall penetrations should be protected by plastic sleeves. Where piping may run through a number of structural members on a horizontal run, it should be sleeved at the beginning and end of the run and at significant changes of direction.

Allowances for Thermal Expansion

Polybutylene pipes will expand 0.85 inches for every 100 feet of run length for every 10°F change in temperature. In residential installations where large temperature swings can occur, the flexibility of polybutylene pipe and the frequent changes of direction, will absorb the forces of thermal expansion through the flexing of the line. The total force exerted on any fixed point will be small.

Light hazard occupancies have longer runs of larger pipe but also have much smaller temperature changes. As a result, the forces will be small and can also be dissipated by flexing of the line between supports. For the rare case where they might be needed, design data is available on the size of the forces and expansion loop design.

Boxing of the Pipe

In the bulk of the fire tests run to date with polybutylene pipe, the pipe was separated from the fire by wallboard as thin as 1/8" plywood. However, tests have also been run with exposed pipe and fast response sprinkler heads. All of these tests were successful, extinguishing the fire with no damage to the pipe. However, until more complete testing is done at Underwriters Laboratories, pipe should be installed with some separation from the room.

Exposure to Sunlight

Nonblack polybutylene pipes have sufficient ultraviolet stability for normal installation practices, i.e., up to three months, but should be stored inside. Black polybutylene pipes can be used in sunlight and have over a decade of such service in industrial applications.

FIRE SPRINKLERS

Fire Sprinkler Installation

The detailed design of a fire sprinkler system is very similar to a plumbing installation design. The water flow rates required to satisfy a sprinkler system, particularly in a residential installation, may be higher than for the building plumbing, but the methods of analysis are substantially the same. The hydraulic design does require a layout of the sprinkler locations and details of the specific auxiliary fire equipment to be installed. Sprinkler layout is dictated by equipment manufacturers' recommendations and National Fire Protection Association (NFPA) standards; NFPA 13-D for residential and NFPA 13 for industrial/commercial applications.

System Selection

Sprinkler systems are installed "wet" or "dry". A wet system is one with water in all lines up to the sprinkler head. This system is normally less complicated and less expensive than a dry system. The dry system requires an electrical connection from the sprinkler head to a solenoid valve. When the sprinkler opens, the current is applied to the valve, opening it, and allowing water to the sprinkler head. More complex, this system is normally used where danger of freezing exists.

Most systems are simple wet systems and experience little change in temperature as the lines run in relatively constant temperature areas. For this reason, expansion/contraction should not normally be a problem, even though the coefficient of thermal expansion of polybutylene is considerably larger than for metal piping. Where required, designs for expansion/contraction can be provided by consulting Section II-P.

The system designs get more complex and may require consultation with manufacturers of equipment or fire safety design engineers as the size of the system increases. Simpler systems, as used in small commercial and residential jobs, can be designed with knowledge of a few basic principles. The following paragraphs outline the procedure for residential design (NFPA 13-D) but the engineering principles of design remain the same for many projects which would fall under the jurisdiction of NFPA 13.

Hydraulic Design

First it is important to recognize the flow requirements of residential fire sprinkler systems. The system must provide a discharge of not less than 18 gpm to any single operating sprinkler, and 26 gpm if two sprinklers are operating (13 gpm to each head). The code states the number of design sprinklers in a wet residential system shall include all the sprinklers in a room up to a maximum of two. In the case where two sprinkler heads are actuated in the same room, their spray patterns reinforce each other making it possible to get by with a lower flow from each individual sprinkler head. For a two family dwelling, the piping entering the building must be sized to handle a 31 gpm flow. The requirement for an extra 5 gpm is based on the assumption that the family in the other half of the dwelling may be using some of their appliances, e.g., dishwasher, shower, etc., when the fire sprinklers in the other half of the dwelling are actuated.

NFPA standard 13-D has set forth the following requirements for sprinkler head location. The section numbers shown below are directly from the 13-D standard and are included for cross-referencing purposes:

4-1.4 Sprinkler Coverage.

4-1.4.1 Residential sprinklers shall be spaced so that the maximum area protected by a single sprinkler does not exceed 144 sq ft (13.4 m^2).

4-1.4.2 The maximum distance between sprinklers shall not exceed 12 ft (3.7 m) on or between pipe lines and the maximum distance to a wall or partition shall not exceed 6 ft (1.8 m). The minimum distance between sprinklers within a compartment shall be 8 ft (2.4 m).

4-6 Location of Sprinklers. Sprinklers shall be installed in all areas.

Exception No. 1: Sprinklers may be omitted from bathrooms not exceeding 55 sq ft (5.1 m^2) with non-combustible plumbing fixtures.

Exception No. 2: Sprinklers may be omitted from small closets where the least dimension does not exceed 3 ft (0.9 m) and the area does not exceed 24 sq ft (2.2 m^2) and the walls and ceiling are surfaced with non-combustible materials.

Exception No. 3: Sprinklers may be omitted from open attached porches.

Exception No. 4: Sprinklers may be omitted from carports, garages, and similar structures.

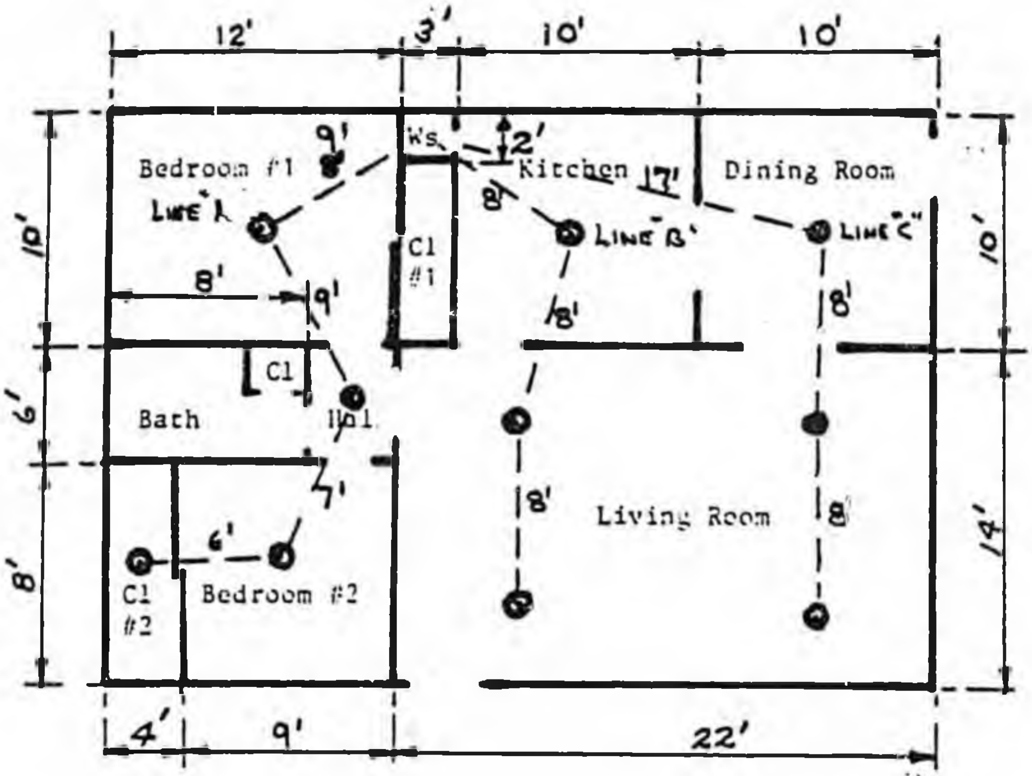
Exception No. 5: Sprinklers may be omitted from attics which are not used or intended for living purposes or storage.

Exception No. 6 Sprinklers may be omitted from entrance foyers which are not the only means of egress.

To illustrate the various steps required to arrive at the preferred design, the house represented in the drawing following will be used as an example. The sprinkler heads have already been positioned in accordance with NFPA 13-D and a proposed piping layout is shown.

FIRE SPRINKLER DESIGN
SPRINKLER HEAD AND PIPING LAYOUT
TYPICAL SMALL RESIDENCE

PRELIMINARY



Legend

Cl - closet with sheetrock walls
Ws - water supply
Bath - porcelain fixtures and ceramic tile walls

The piping layout can generally be made in a number of ways, and economics enters into the selection of the best design. All piping layouts are compromises and in larger more complex designs, several different layouts may need to be developed and evaluated to know which one is most cost-effective. You should remember that costs are effected by both line size and length. If longer lines are used, fewer are required, but the loss of available head pressure in each line due to friction will be greater. This may in turn require a larger size line to accommodate the flow requirements thus illustrating the need to carefully design the piping layout.

To determine the pressure requirement on any piping layout, the following steps should be followed.

1. Calculate sprinkler pressure requirement.

   A. Get the "K" factor for the sprinkler head to be used (this is published by each manufacturer for each sprinkler head he produces).

B. Calculate the sprinkler pressure requirements (psi) from the formula:

$$P = \left(\frac{Q}{K}\right)^2$$

CALCULATION OF PIPE HEAD LOSS
FIRE SPRINKLER LINE

	REQUIRED FLOW (GPM)	LINE LENGTH (FT)	LINE HEAD LOSS (PSI) 1-1/2" T	1" P	1" T	3/4" T
LINE A (30' long)						
Sprinkler Head	18	-	19.3	19.3	19.3	19.3
Line Between last Two Heads	18	6	0.1	0.4	0.8	3.0
Remainder of Horizontal Line	18	25	0.6	1.8	3.5	12.3
Line Floor to Ceiling	18	10	0.2	0.7	1.4	4.9
Elevation Difference (10')	-	-	4.3	4.3	4.3	4.3
Equivalent Fitting Length	18	21 (equiv.)	0.5	1.5	2.9	10.3
Tees (3)						
Elbows (4)						
Valves and Controls	18		4.0	4.0	4.0	4.0
Total Bldg. Head Loss			29.0	32.0	36.2	58.1
LINE C (33' long)						
Sprinkler Head	13		10.1	10.1	10.1	10.1
Line Between Last Two Heads	13	8	0.1	0.3	0.6	2.2
Remainder of Horizontal Line	26	25	1.2	3.5	7.0	24.3
Line Floor to Ceiling	26	10	0.5	1.4	2.8	9.7
Elevation Difference (10')	26		4.3	4.3	4.3	4.3
Equivalent Fitting Length	26	18 (equiv.)	0.8	2.5	5.0	17.5
Tees (2)						
Elbows (4)						
Valves and Controls	26		8.0	8.0	8.0	8.0
Total Bldg. Head Loss			25.0	30.1	37.8	76.1

LINE B (30' long)

Analysis not required - slightly shorter than Line C, therefore, total head loss would be less and sizing would be the same as determined for Line C.

Similarly, the service line head loss can also be calculated for different size piping.

CALCULATION OF PIPE HEAD LOSS
WATER SERVICE LINE
(160 psi)

	REQUIRED FLOW (GPM)	LINE LENGTH (FT)	LINE HEAD LOSS (PSI) 2" T	1-1/2" T	1" P
Meter	26		[illegible]	1.2	3.8
Line - Main to Meter	26	20	[illegible]	0.8	2.8
Line - Meter to House	26	60	[illegible]	2.3	8.4
Elevation Difference (5')			2.2	2.2	2.2
Total Service Head Loss			[illegible]	6.5	17.2

where P is the required pressure (psi) and Q is the required water flow (gpm).

As an example, a sprinkler head with a K factor of 4.1 would require the following pressure at the actual head for:

One head operating $P = \left(\frac{18}{4.1}\right)^2 = 19.3$ psi

Two heads operating $P = \left(\frac{13}{4.1}\right)^2 = 10.1$ psi

2. Obtain manufacturer's data on head loss through valves, meters, and controls at various flow rates.

3. Obtain the equivalent length of pipe data for fittings to be used and estimate the numbers of each fitting in each line.

4. Calculate the water flow head loss (psi) for each line in the piping layout.

5. Repeat the same procedure for the building service lines including all of the meters, valves, fittings, etc., and add this to the building head loss to obtain the total head loss.

The table below shows the head loss for each individual building line assuming they are made from 1-1/2" tubing, 1-1/4" pipe, 1" pipe and 1" tubing.

To arrive at the most economical design, the minimum main pressure must be obtained from the water department. Since it is essential that the fire sprinkler system operate properly, this minimum pressure must be used.

For the purposes of this example, let us assume that the municipality has a minimum pressure of 50 psi available. The sum of the building and service line head losses must then total less than the 50 psi. The most economical design would then involve a 1-1/2" tubing service line and one inch tubing distribution lines inside the building. If, however, only 40 psi were available, the most economical design would use a 1-1/2" tubing service line and 1" pipe distribution lines. If only 35 psi were available, a 2" tubing service line would be required along with 1-1/2" tubing for line A and 1" piping for lines B & C. It is questionable whether using two different line sizes is practical in this design, however, and the savings would probably not offset the added costs of material supply and handling. On larger sized jobs this would be done. As you can see, the overall economics will be heavily dependent on the minimum pressure available at the main and optimum economics will be obtained by using large sizes for the lower cost service lines.

It can be seen from the calculations for a 3/4" tubing line that the head losses are relatively large. This size tubing will only work for short lines or as a reduced sized section of a longer line. Its relative economics should be considered, however, when designing a system as it can be used with metal insert fittings which are a fast economical joining system for 3/4" tubing lines. Currently lines sized 1" and above must use fused joints.

It should also be pointed out that the design method outlined produced the minimum acceptable pipe sizing for proper functioning of the sprinkler heads. Larger size lines with correspondingly lower pressure drop would provide additional sprinkler water volumes and so would provide a greater safety factor.

Thermal Expansion/Contraction

As shown in Section II-P, the flexibility of DURAFLEX polybutylene prevents it from generating much force, even when it is continuously restrained. Because it requires even less force to bend the pipe, its response to increases in temperature will be to bend, forming its own expansion loop. In residential fire sprinklers where pipe diameters of 1 to 1-1/2 inches are typically used, the force generated will be less than 20 pounds. Even in light hazard (hospitals, motels, hotels, etc.) situations where pipe diameters up to 2 inches can be used, the forces are still less than 200 pounds. These can be easily handled by normal pipe clamps.

The most important consideration in designing for expansion/contraction in fire sprinkler systems is to prevent the sprinkler head from canting (moving off vertical or horizontal wall mount head) as this will change its flow pattern. A certain amount of lateral movement is normal and is typically allowed for by drilling the hole for the sprinkler oversize by upwards to 1/4 inches (the escutheon plate will conceal this). If large temperature changes are anticipated, i.e., pipe installed on top of insulation in an attic, the polybutylene pipes should be anchored as close to a fitting as possible. A guide should then be installed within two feet of the other side of the fitting.

Equipment Selection

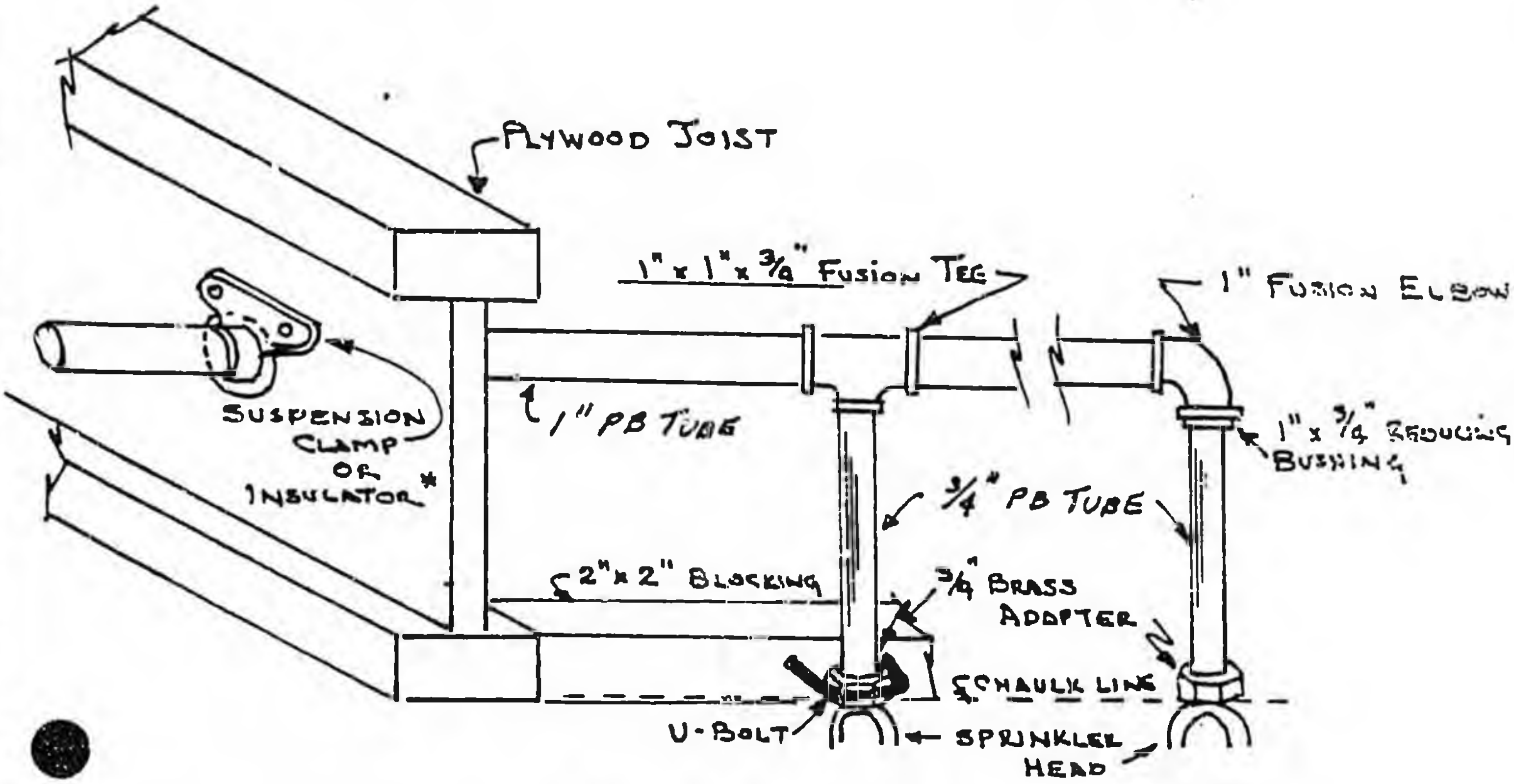
When the sprinkler system is connected to the potable water supply, a back flow preventor is normally used to prevent contamination of the drinking water. A further safety factor is that polybutylene pipe has been certified by the National Safety Foundation (NSF) as being safe for potable water and is approved for plumbing hot/cold water distribution systems by all major codes.

The equipment necessary for a complete sprinkler installation will be determined by the design requirements of the system. Components are available from a number of manufacturers who can assist in an economical, satisfactory performance. For a typical residential installation the following equipment could be used:

Residential Sprinkler Heads (Fast Response)
Check Valve (1" Rubber Faced)
Drain Valve (1/2" Ball)
Test Valve (1/2" Ball)
Main Control Valve (1" Ball)
Flow Alarm Switch (1" Flow Sensing Switch with Time Delay)
Alarm Bell (6" Diameter)
Anti-Water Hammer Device (Not Required With Polybutylene)

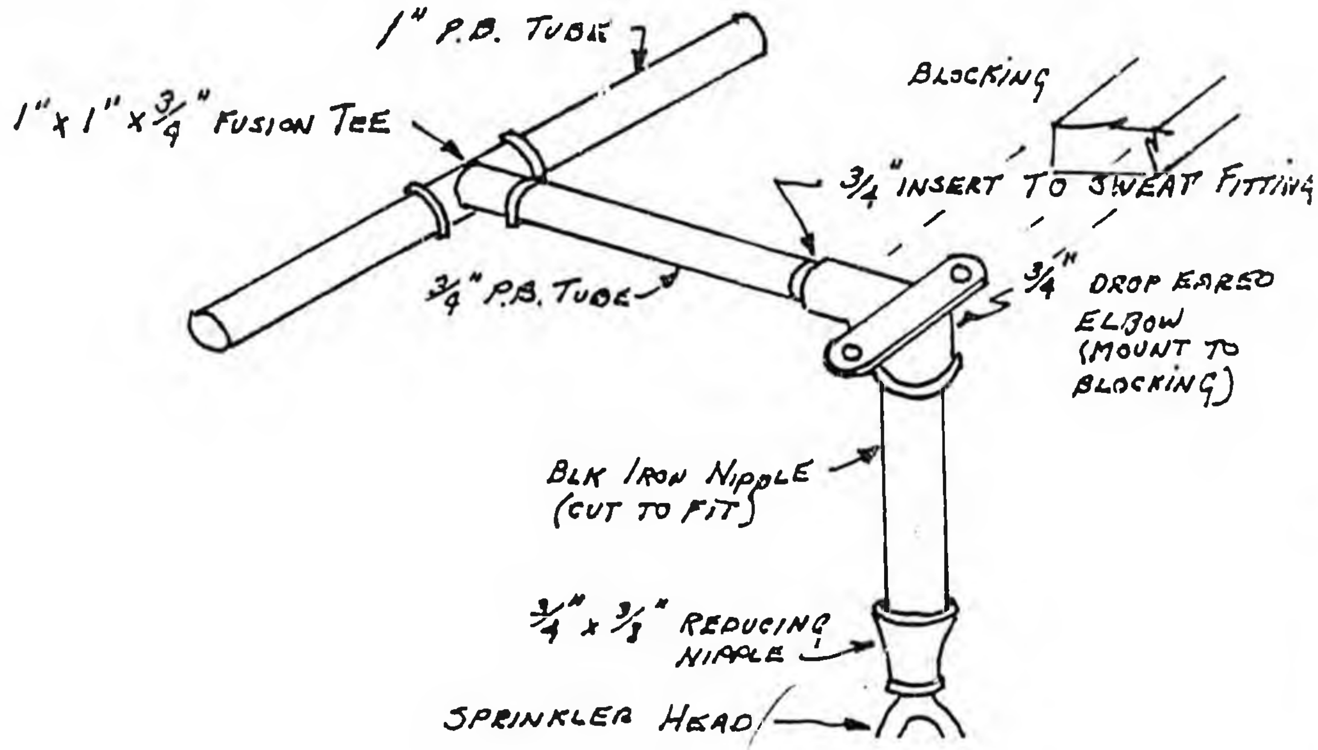
FIRE SPRINKLER SYSTEM

PROPOSED INSTALLATION DETAILS



* SEE ITEM 2 - PROPOSED INSTALLATION DETAILS WRITEUP

ALTERNATE PROPOSAL



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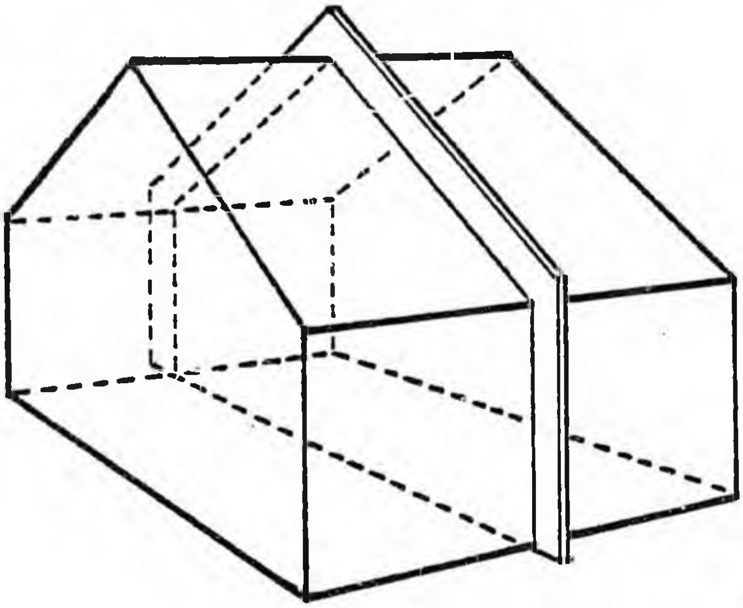
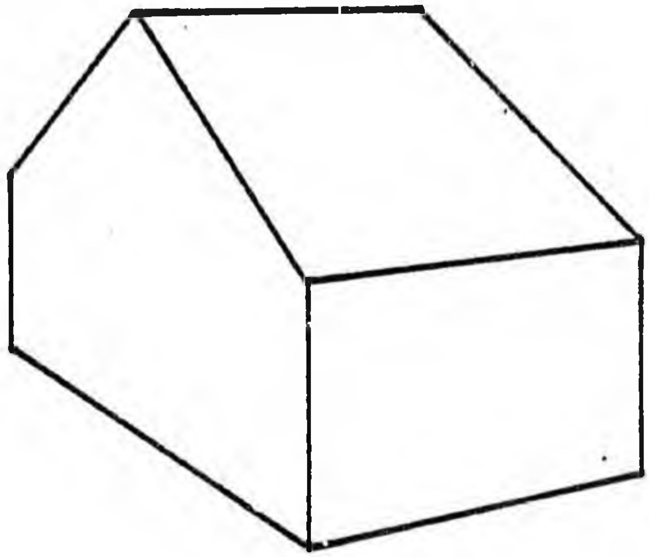
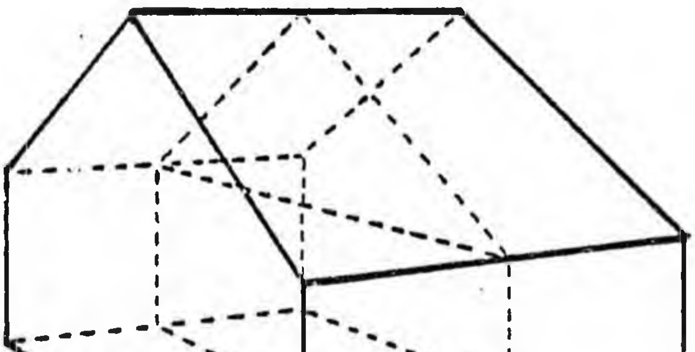


6000 SF = a four hour masonry firewall is required.

Up to 8000 SF no firewall is required

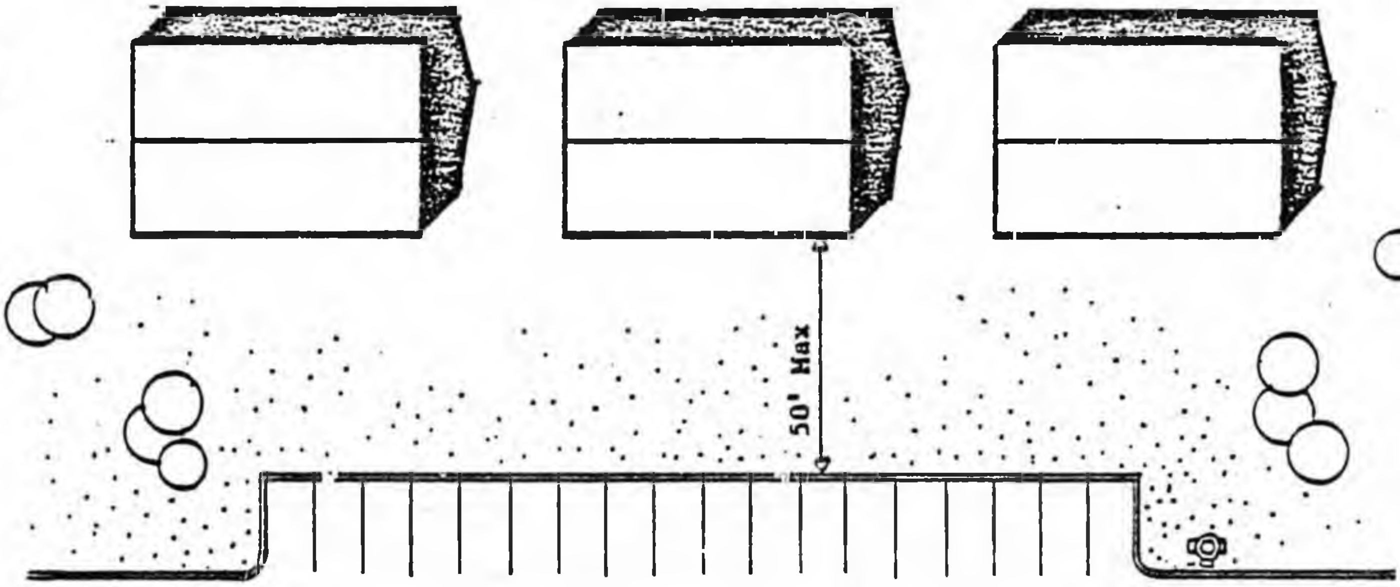
SPRINKLED





8000 SF to 10,000 SF
A two hour gypsum board firewall is required

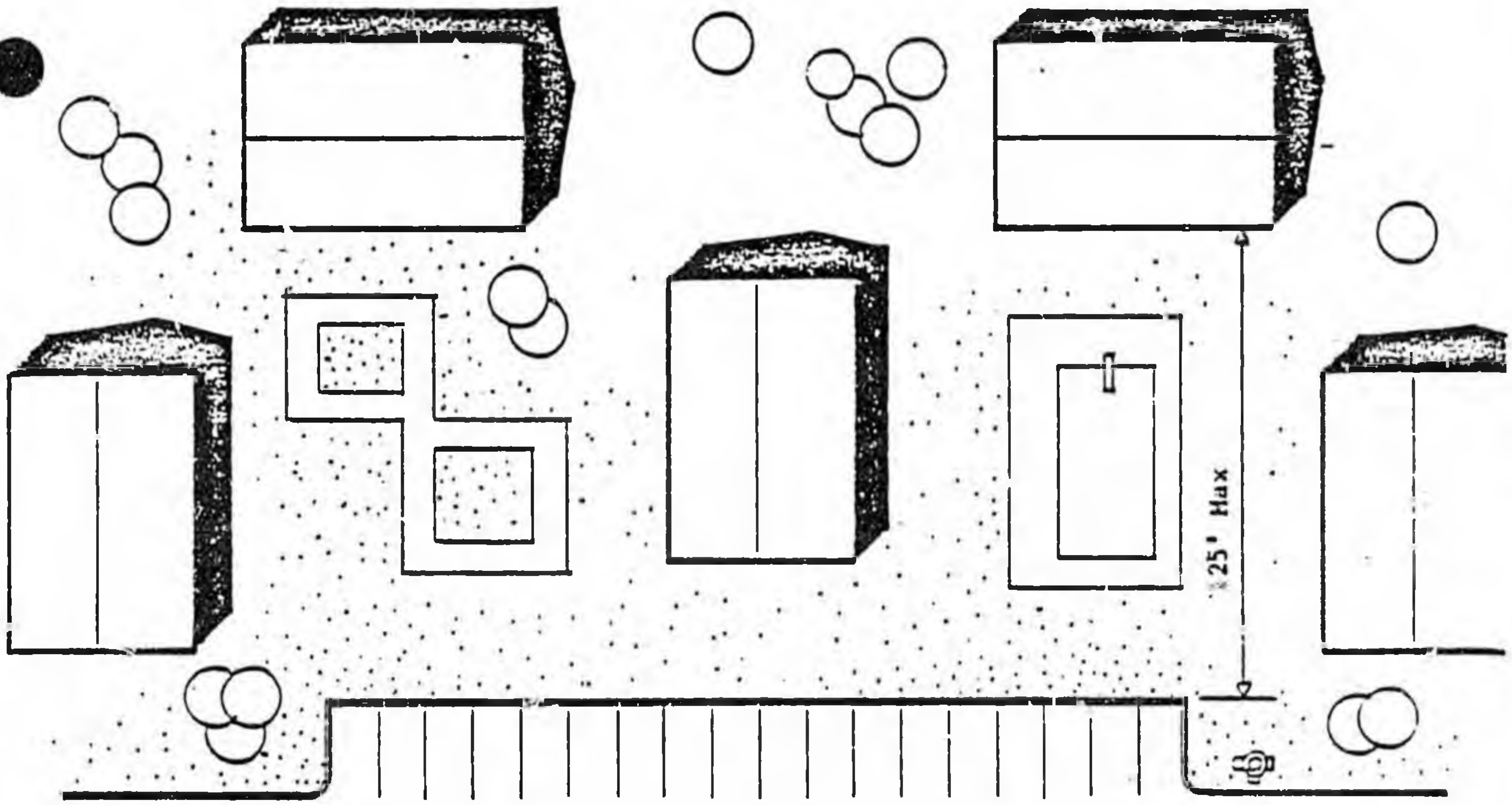
SPRINKLED



50' Max. from back of parking to front of bldg.

Fire Hydrant
Spacing at 300'

NON SPRINKLED



125' from back of parking to front of bldg.

Fire Hydrant
Spacing at 300'

SPRINKLED

Cobb County leads the way in fire sprinklers for homes

☐ ADDING SPRINKLERS 3J

By H. Jane Lehman
Staff Writer

Ten years from now, you may wake up from a deep sleep to find yourself, your bed and the rest of your room dripping wet.

But don't curse the leaky plumbing. Instead, call the fire department and then say thanks to your fire sprinklers for saving your home from a roaring inferno.

Although a sprinkling system in every home is most likely years away, Cobb County is busy ushering in the future now. The county government has taken the lead locally and nationally in pioneering the safety concept.

"I would say that in the next six to eight years that 75 percent of new residences of all types in Cobb County will have sprinklers," said David Hilton, Cobb County fire chief.

With the help of private industry donations of $10,000, the Cobb County Fire Department has been computer-testing the effectiveness and reliability of sprinkler heads.

As part of a pilot program, apartment and condominium developers are winning variances to build residences with sprinkler systems in Cobb County that would otherwise not meet the fire code. So far, 754 apartment or condominium units with sprinklers have been constructed or approved, said Lt. Jerry Grier, Cobb County fire inspector.

Within the next few months, Hilton expects an amended fire code including the sprinkler provisions to be adopted. And he is encouraging homeowners to look into retrofitting existing homes with the help of the fire marshal's office.

The most obvious feature of the lifesaving system is the sprinkler head protruding a couple of inches from the ceiling. This hardware is installed in each living area — the living room, dining room, kitchen, den and bedrooms.

The sprinkler heads are connected to the house water supply via a flexible piping made from a newly developed plastic called polybutylene that is used in place of copper and steel piping. An alarm bell and control valve complete the system.

Each sprinkler triggers independently whenever the room temperature reaches 135 degrees, Hilton said. Then the sprinkler head sprays forth 18 gallons of water a minute. The systems turn off automatically once the fire is extinguished.

The dousing qualities of sprinkler systems are hailed as saving both lives and property, feats that still elude other preventive measures like smoke alarms. Cobb Coun-

SEE Sprinklers 3J ➡

WATERFORD PLACE: Sprinkler in Cobb home.

Sprinklers

FROM 1B

ty's tests showed that one sprinkler head was able to control 99 out of 100 fires, Hilton said.

And if the fire breaks out in your neighbor's apartment, the buzzing from his smoke detector probably won't be loud enough to alert you to evacuate the premises.

Sprinklers, unlike smoke detectors, can counteract the lethal effects of poisonous fumes, Hilton explained. Smoke contains carbon monoxide and cyanide, both of which are toxic.

"The water spray aids in washing the air and diluting some of those products," he said.

Cobb County's test results show that fires contained by sprinklers emit less than 300 parts of carbon monoxide per million parts of clean air. Hilton said a human can easily breath 1,500 parts per million and not suffer ill effects.

During 1981, four people died in fires in Cobb County, Hilton said. Additionally, fires caused an estimated $3.978 million worth of damage to residential structures, he said.

A sprinkler system can prevent a small blaze from escalating into a large-scale fire. A Cobb County demonstration conducted last week in a specially built test house showed the dramatic difference sprinklers can make.

The fire department set a wicker basket full of newspapers on fire, which consequently set a nearby chair ablaze.

Hill said one insurance claims adjuster present for the test estimated that almost $7,000 worth of damage could have been wrought. But the sprinkler kept losses to $1,067.

Sprinkler systems are nothing new. Commercial structures have incorporated them as safety features for years. During the past decade, frequent discussion has been directed at residential application of the devices, but Cobb County, which began its effort in in September 1981, is credited with launching the research into a cost effective sprinkler system.

Other local counties and communities across the nation are watching Cobb closely and are expected to follow suit. In fact, the DeKalb County Commission is expected to decide Tuesday whether to adopt proposed amendments to its fire protection code.

The new code would mandate sprinklers in any structures over 10,000 square feet or at least three stories tall, which could include apartments and condominiums. It would also require retrofitting of existing buildings by 1997.

DeKalb County's contemplated mandatory use of sprinklers is typical of the controversy surrounding the safety system. Many builders oppose mandatory sprinklers — a ruling adopted in San Clemente, Calif. — suggesting that the public is unwilling to pay the additional costs for the protection.

In fact, for years builders have been free to erect homes with sprinklers, but the systems and construction had to conform to criteria established by the National Fire Protection Association, an independent standard-setting organization. For the most part, that approach was rejected as too expensive.

Hilton estimates that it would cost from $1,800 to $2,500 to install the National Fire Protection Association system in a 2,000-square-foot single family house while it was under construction. In contrast, he claims that his fire department's research has come up with a more economical approach costing $426 per two- or three-bedroom apartment or condominium unit. The savings is accomplished mainly through trade-offs in the fire code.

Many fire codes, including Cobb County's, dictate the placement of doors and windows that border an individual's escape route from a burning multi-family unit. The purpose is to eliminate openings through which a fire could easily burst and block the path to safety. However, Cobb County is willing to allow greater design flexibility if the units include sprinklers.

Fire codes also mandate fire-resistant doors and walls between adjoining units. These features not only are expensive, but labor intensive to install. With sprinklers, developers can cut out those otherwise unavoidable expenses.

Thomas C. Graham, developer of Waterford Place, the first Cobb County condominiums to include the system, estimated it cost an extra $400 a unit to install the hardware.

However, the trade-offs work only with multi-family housing, because there is nothing to swap off with single family housing, Hilton conceded. His hope is that Congress will step in with tax breaks for sprinkler installation and that insurance companies will reduce their normal homeowner insurance premiums. ■

Sprinklers can be installed in existing homes

By H. Jane Lehman
Staff Writer

Although much local interest in residential sprinkler systems has been directed at new construction, it is possible to retrofit existing homes.

However, until Congress decides to enact tax credits or insurance companies begin giving generous premium discounts, there is little financial incentive for homeowners to invest in the system. Developers, on the other hand, are finding ways to offset the costs.

Motivation, therefore, will come from concern for the safety of your family and preservation of your possessions in the unfortunate event of a fire.

Cobb County Fire Chief David Hilton strongly encourages the addition of sprinkler systems to existing homes.

"Retrofit is possible and feasible," he said emphatically.

In fact, he has volunteered the services of his fire marshall's department, (call 428-6348), to give advice to county residents.

Most homeowners will want to pass the job onto a sprinkler contractor or plumber. Unlike smoke detectors, which are relatively simple to install, a fire sprinkler system is a much more complicated.

Basically, installation entails laying the piping along the attic floor, drilling holes through the ceilings to accomodate the sprinkler heads and installing a control valve and alarm.

But, there are several clinchers. The system has to be hooked into the water supply where the service line comes into the basement or garage. Usually, a plumber is required to do the tap.

The services of a hydraulic engineer also are advisable. He needs to compute the water supply and the water pressure necessary to operate a sprinkler system. This will determine the size of piping to be used.

Your local water authority can be called upon to conduct pressure and flow tests, although there may be a fee for the service.

"I would not advocate doing-it-yourself," said Buck Buchanan, vice president of sales for Central Sprinkler Corp. His company does not sell the necessary parts to retail customers.

"The real mystique is the hydraulic calculations," he explained. "No matter how much is being used by you or your neighbor, you have to have enough water to flow through to extinguish a fire.

"The last thing I want to see on the 11 o'clock news or read in the newspapers is about a body being carried out of a sprinkler-fitted home where the system didn't work" because it was installed by an amateur, he said.

Buchanan predicts that a number of companies with the technical expertise soon will move into the retrofitting business, once public awareness of sprinkler systems grows.

Selasco Corp. is one Atlanta company already planning to get into retrofitting, according to Tom Multer, vice president of sales and engineering. The sprinkler contractor, which heretofore had sold sprinkler equipment for commericial buildings only, would charge from $125 to $175 per sprinkler head. Most homes require between five to 10 heads, he said.

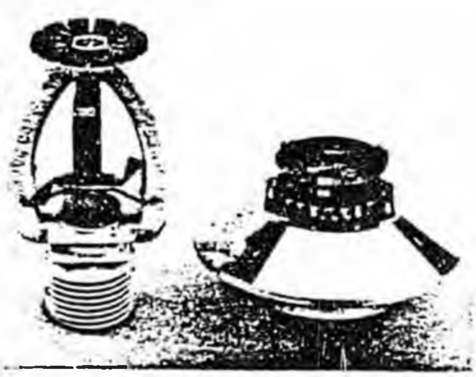
If you did have the know-how to attack the plumbing and the hydraulic calculations, Ha Sanders, a hydraulic engineer, estimated i would cost less than 50 cents a square foot to install a system yourself in a one-story house. In contrast, hiring a contract sprinkler would run closer to $1 a square foot, he said.

Multer's firm also sells the sprinkler system components individually. The list price is $10 per head. Polybutylene one-inch pipe goes for approximately 50 cents a foot. It costs the same as steel pipe, Multer said, but because the plastic pipe is more flexible, it takes substantially less time to install.

Together, a control valve and alarm would cost around $300, Multer said.

An alternative to installing the piping in the attic space would be to hide it under molding where the wall meets the ceiling, Hilton suggested. Then side wall sprinklers could be used.

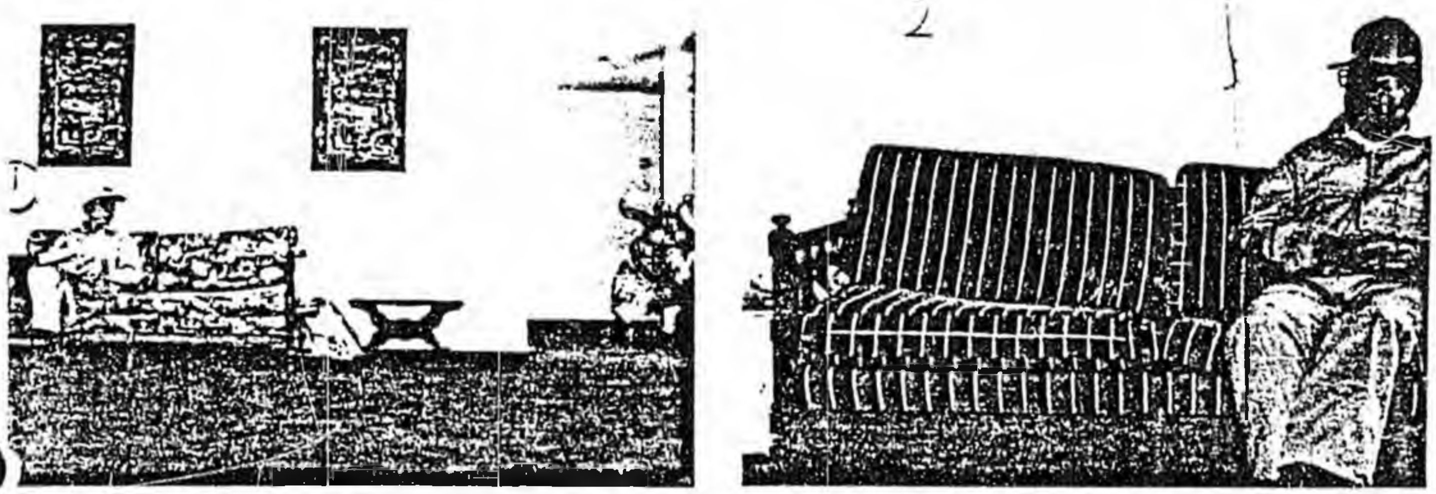
Selasco sells molding especially designed for that purpose with channels ranging from 2 inches square to 4-inches square, Multer said. It's priced at about $4 a foot. ■



Preliminary Data

Rural/Metro Fire Sprinkler Tests

Scottsdale, Az. April 19-21, 1982



Ron Butler (Right) and Lou Witzeman await sprinkler action, sitting on sofas

Tests Demonstrate Fire Sprinklers In New $70,000 Subdivisio' H~mes

The Rural/Metro fire sprinkler tests were held in Scottsdale, Arizona (a community provided with fire protection by Rural/Metro Cor. April 19 through 21, 1982. A total of nine tests were conducted in the living rooms, kitchens and bedrooms of two $70,000 subdivision homes i prinkler systems had been retrofitted. A planned 10th test was aborted.

The tests were largely funded by the Federal Emergency Management Agency. Other co-sponsors included the Phoenix Fire Department and Arizona State Department of Emergency Services. Womack-Mastercraft, Inc., provided the two homes, which were repaired after the tests and are being put on the market with sprinkler systems installed. More than 250 person representing much of the country and many interested organizations attended the tests, witnessing the actual burning periods on closed circuit television sets installed in a tent across the street and viewing the burn rooms before and after each test.

Objectives

Objects of the test series included:

Objective 1: To combine the results of many years of study and experimentation into one summary, concl sive test of the residential sprinkler concept in the ultimate real environment of subdivision homes built for resale.

Objective 2: To test state-of-the-art sprinkler technology as currently approved. To this end one hom (generally designated as the "West House" or "Home A" in data on these tests was equipped with approved Grinnell heads on an iron pipe system to specifications of N.F.P.A. Standard 13D.

Objective 3: To study installed costs and test in actual use a proposed polybutylene piping system of Shell Oil C mpany on a fast-acting head manufactured by Central Sprinkler Company but not yet approved. The new head and polybutylene pipe in effect provide test of advancing technology. This system was installed in the "East House" or "Home B". Since it did not represent an at-that-time approved system, a duplicate iron pipe system was also installed in the attic of this home so it could be fitted with approved heads after the te t and turned back to the builder for sale as a fully approved system.

Objective 4: To affirm faith and provide a conclusive test by placi g two persons in the b ing homes. To this end Ron Butler, president, and Lou Witzeman, board chairman of Rural/Metro Corp., were seated on sofas ignited for the first ests. Both Butler and Witzeman have been active students of the residential sprinkler concept for many years and the City of Scottsdale, at rging of Rural/Metro, passed one of the nation's landmark early commercial sprinkler ordinances approximately seven years ago.

See Tests, Page 2

Sprinkler Test Chronology

(continued from Page 1)

Test Chronology
Monday, April 19

Four tests were held the first day of the series. The first two were living room fires in each house [illegible] on couches on which Witzeman and Butler were seated. The first test, in the West House, involved the couch with Witzeman on it; the second [illegible] couch with Butler on it. Sprinkler activation in the first test was 2 55 (two minutes 55 seconds) and 1 17 in the second house.

> **Note: preliminary test data, compiled by Factory Mutuals Laboratories, is reproduced elsewhere in this report in comprehensive chart form. Likewise, damage estimates of the fires set in the tests and of presumed dollar losses had the homes not been sprinklered are also plotted, with data provided by Sentry Insurance Company.**

Second and third tests Monday were grease fires on stoves in the kitchens of the two houses. In each test a pan of grease was heated to [illegible] degrees, at which time the clock was started for the test. The first (West House) test flamed at 3 15, the second at 4 12. In the first house sprinklers operated 30 seconds after open flame was recorded, in the second house at 38 seconds.

Damage resulting from these two tests was the highest of the series, exceeding even the final Christmas tree fires. It was estimated at $3600 for the West House and $2400 for the East House. Loss without the sprinkler system protection was estimated to be $12 500 in the West House and $6 500 in the East House.

Tuesday Tests

[illegible]

[illegible]

Wednesday Tests

[illegible]

[illegible]

[illegible]

Sprinklers Save 85% of Fire Loss in Tests

Property savings of 85 per cent due to fire sprinklers were recorded in the Rural/Metro fire sprinkler tests by observers of Sentry Insurance Company who monitored each test to determine estimated losses after test fires, and also losses which their experience indicated would have occurred had the properties not been sprinklered.

Fire losses in the sprinklered fires were estimated at $17,200. Estimated losses without the sprinklers were set at $116,000 for a saving of $98 800 or 85 17 per cent.

The estimates were based on eight of the 10 scheduled tests. Tests 7 and 8 were not summarized because one of them, Test 7, was aborted due to malfunction of the coffee maker it was planned to use for ignition.

Estimates of losses without sprinkler equipment were based on normal fire department responses in terms of time, manpower and equipment. Estimates of damage with sprinkler operation were based on review of actual conditions after each test.

Even without the Christmas tree fire tests, which produced the highest estimates of loss without sprinkler systems, there was still a 75 59 per cent saving in the comparison of sprinklered and unsprinklered property fire losses. Interestingly, although the Christmas tree tests produced the highest estimates of loss without sprinkler systems they did not produce the highest estimates of loss with sprinklers installed — the highest loss occurred in the kitchen grease fires.

Estimated Damage
(Calculated on Basis of Damage with Sprinkler System and Without Sprinkler System)
Rural/Metro Fire Sprinkler Tests, April 19, 20, 21, 1982

Test Number	1	2	3	4	5	6	9	10	Totals
A Carpets — repair, replace, clean	$ 800	$ 150	$ 150	$ 150	$ 400	$ 350	$ 1,100	$ 650	$ 3750
B Floors uncarpeted — as in A above			200	150	75		50		475
C Walls, ceilings — paint, clean, seal	300	350	550	700	425	500	950	800	4575
D Drywall repair			500		150	150	300		1100
E Deodorization	100	100		150	150	150	150	150	950
F Electrical repairs			300	150					450
G Kitchen light panels			100						100
H Kitchen cabinets, hoods			1500	500					2000
I Furnishings, drapes — clean, repair, replace	300	400	300	400	700	500	150	150	2900
J Clothing — cleaning					250	150	150		550
K Fireplace — cleaning							150		150
L Unidentified				300					300
Totals	$ 1500	$ 1000	$ 3600	$ 2400	$ 2150	$ 1800	$ 3000	$ 1750	$ 17200
Mid-range damage estimate without sprinklers	$ 3500	$ 3500	$12500	$ 6500	$12500	$12500	$32500	$32500	$ 116000
Low range damage estimate without sprinklers	3000	3000	10000	5500	10000	10000	25000	25000	91500
High range damage estimate without sprinklers	4000	4000	15000	7500	15000	15000	40000	40000	140500
Indicated saving by fire sprinkler systems	$ 2000	$ 2500	$ 8900	$ 4100	$10350	$10700	$29500	$30750	$ 98800

Preliminary Data — Rural/Metro Fire Sprinkler Tests

Test Number	1	2	3	4	5	6	7	9	10
Test Description	Living Rm W House Couch	Living Rm E House Couch	Kitchen W House Grease	Kitchen E House Grease	Bedroom W House Bed	Bedroom E House Bed	Kitchen W House Coffee Pot	Living Rm W House Xmas Tree	Living Rm E House Xmas Tree
	Min Sec	Min Sec	Min Sec	Min Sec	Min Sec	Min Sec	Min Sec	Min Sec	Min Sec
Ignition	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00
Vapor	10	18	40	1 20	20	24	2 00	07	04
Open Flame	33	31	3 15	4 12	1 10	52	3 15	07	04
Smoke Detector Actuated	1 18	2 07	4 34	5 20			8 57		1 07
Sprinkler Actuation	2 55	1 17	3 45	4 50	1 58	1 04	6 47	15	10
Control by Sprinklers	4 15		3 55	5 12	3 07	4 00	7 07		45
Sprinkler Shutdown	4 40	4 15	8 50	7 15	4 48	4 25	7 50	2 15	2 04
Ceiling Temperature (F)	161	130	189	455	256	160	169	560	285
Temperature at 5 ft (F)	88	82	82	109	124	81	85	88	78
Temperature at 3 ft (F)	81	80	82	88	82	84	81	81	74
Carbon Monoxide — PPM	162	239	<100	0	693	618	164	400	300
No. Heads Actuated	1	1	1	1	2	1	1	6	2

Data on this chart was prepared on site at time of test. Items not filled in are those that were unavailable at time of printing. All data from Factory Mutuals observations.

How to light a Christmas tree...

. . . carefully

Audience Views Tests

Factory Mutuals "Command Post"

Shaw Summarizes Sprinkler Progress, Praises R/M Tests

Mr. Lou Witzeman
Chairman of the Board
Rural/Metro Fire Department
2857 North Miller Road
Scottsdale, Arizona 85257

Dear Lou:

The "Scottsdale-Phoenix" quick reaction residential sprinkler fire test program conducted by Chief Bob Edwards during the week of April 19, 1982, was the climax of a five year research and development program to provide a low cost, life safety, residential fire protection system. The history of the research and development program included the evaluation testing by Factory Mutual Research Corporation, under the direction of Dr. Kung, where a requirement for a quick reaction sprinkler with a special distribution pattern was established.

The requirements were satisfied by the Grinnell Fire Protection Company with the development of a quick reaction sprinkler with a sensor five to fifteen times faster than the current commercial and industrial sprinklers. Earl Page, President of Grinnell, committed the necessary resources to help solve the residential fire problem.

The development of the quick reaction sprinkler was followed by an extensive test program which was supported by Robert Grant, President of the National Fire Protection Association (NFPA). Technical support was provided by Factory Mutual. The tests were conducted by the Los Angeles Fire Department under Chief John Gerard with Don Manning as site manager, and the Charlotte Fire Department under Chief Jack Lee. Art Cote of NFPA was the program manager.

The test program was followed by the development of a product acceptance standard by Underwriters Laboratories, and the adoption of a new 1980 NFPA 13D, one- and two-family and mobile home sprinkler standard.

In May 1981 the Grinnell model [illegible] became the first sprinkler listed under the new standard.

The "Scottsdale-Phoenix" sprinkler test program using Central and Grinnell sprinklers under the sponsorship of Rural/Metro Fire Department, Inc., the Arizona Department of Emergency Services and the Phoenix Fire Department, demonstrated the life safety characteristics of the quick reaction sprinkler system the only way it should be demonstrated — with people in the room of fire origin throughout the entire fire test — from ignition to extinguishment.

Lou, your participation as the first occupant of a room of fire origin during a test of the NFPA 13D system is not only a major contribution to the promotion of the residential sprinkler program but also an expression of confidence to all who have participated in the development of the system.

I believe as you do that the answer to reducing the number of lives lost in residential fires is in-place protection with automatic suppression systems and smoke detectors. I am confident that with leaders in fire protection such as you, that the quick reaction sprinkler will soon be used in residences, hospitals, nursing homes, hotels and motels, and boarding homes, with the result that fire deaths will be reduced significantly.

In closing I want to commend Chief Bob Edwards for a well-managed and very informative demonstration. It was a pleasure to participate.

Sincerely,

Harry Shaw

Harry Shaw
Assistant Administrator
Office of Fire Protection
Engineering and Technology
U.S. Fire Administration

Bob Edwards

Ron Butler

Butler, Edwards Planned Testing

More than 10 months of planning and detailed implementation were required for the Rural/Metro fire sprinkler tests. The tests were carried out under the direct supervision of Bob Edwards, R/M Scottsdale Administrative Chief, in consultation with Ron Butler, President of the firm.

Major tasks of the project were twofold: to coordinate the vast number of individuals and agencies involved and to plan the detailed logistical support involved in finally staging the tests over a three-day period without delaying any aspect of the tight schedule for those days.

Both Edwards and Butler were assisted by a large number of R/M staffers to whom individual aspects of the testing — crowd management, in-place fire fighting backup, furniture placement, documentary photography, backup of Factory Mutual staffers and other functions — were assigned. Butler and Edwards praised this group of individuals highly for the smooth and coordinated test operation.

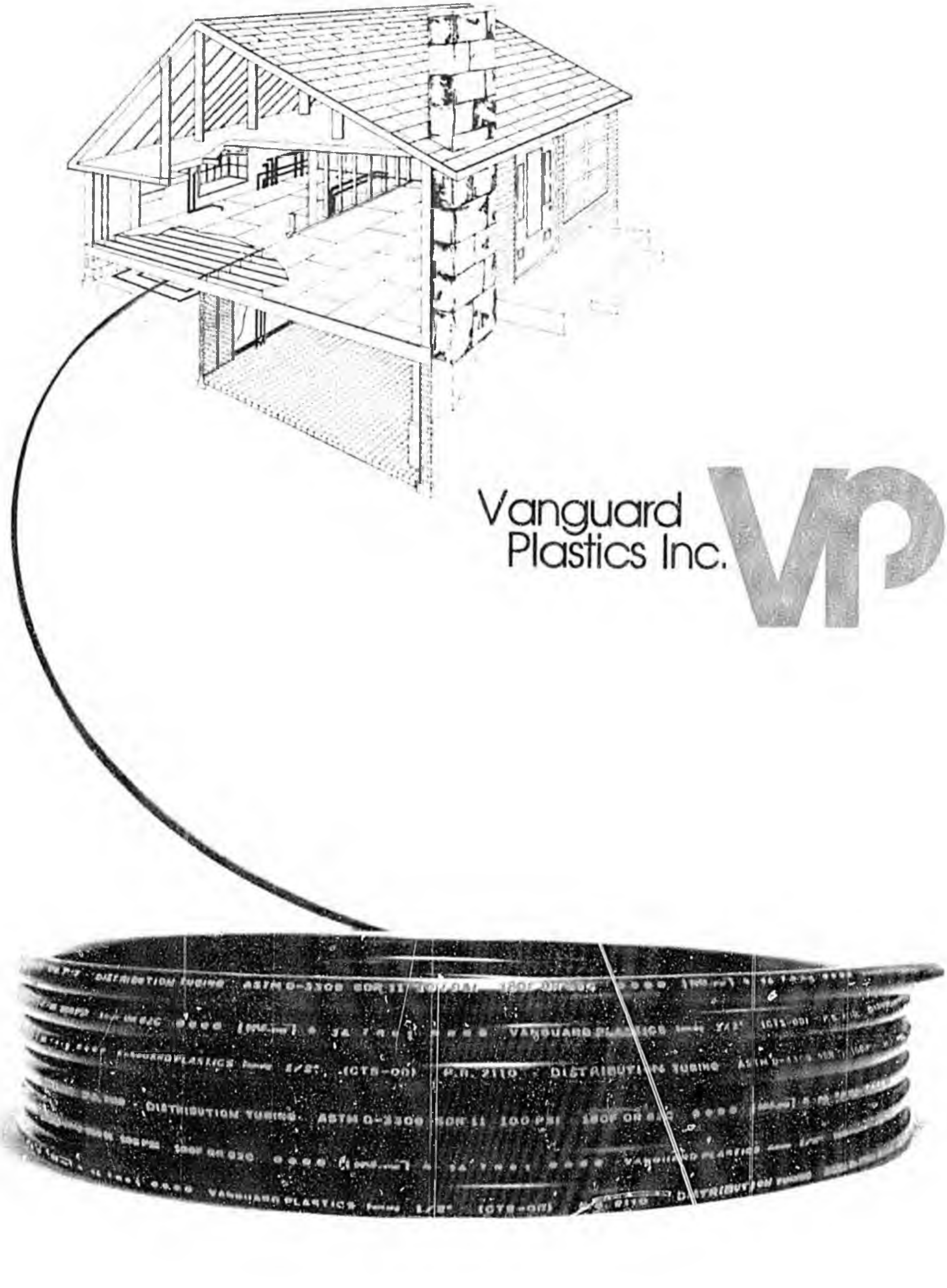
It didn't look as smooth during all of the two weeks prior to the actual test date. As is inevitable in such massive planning, blips occurred: the computer shipped in for documentation refused to do its thing for almost five days; the night before the test a large tent under which spectators were to watch the interior views over three CATV sets (and very necessary in Arizona's heat) failed to turn up and a replacement was hastily recruited from the Arizona National Guard; placement of three water meters of three different sizes for the tests was held up until the last minute because no one at the water company could understand what kind of an idiot wanted three meters on his house; a pipe fitter's strike interrupted installation of the sprinkler system in one house, and plastic pipe fittings shipped by air freight to meet a crunching deadline took three days to arrive (they evidently went where the airlines send the suitcases). Other than these and a number of other little problems, however, it all went very smoothly.

After a hectic last weekend of preparation during which all hands turned out for a stitch-it-all-together session, all was in place and ready to go by the time the tests started at 10 a.m. Monday.

Many Agencies Helped With Tests

Planning and implementation of the Rural/Metro fire sprinkler tests was a massive job. Among those particularly deserving of thanks for their participation in planning and testing itself were:

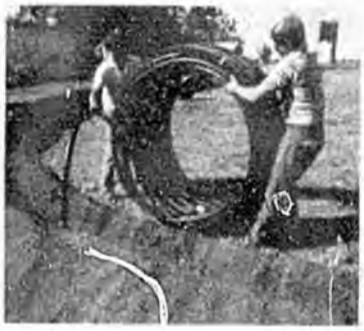
National Fire Protection Association; The City of Scottsdale; Phoenix Fire Department; United States Fire Administration; Division of Emergency Services, State Fire Marshal's Office; Womack-Mastercraft Homes, Division of Lennar Corp., Grantham Fire Protection Company, Grinnell Fire Protection Company, Central Sprinkler of Pennsylvania, Factory Mutual Testing Laboratory, Shell Oil Company, Vanguard Plastics, Ode Electric Company, The City of Phoenix, Digital Corporation, Marriott Corporation.



Vanguard
Plastics Inc.

Vanguard GEO-PIPE

Vanguard Polybutylene *Geo-Pipe* is made of sturdy, durable and flexible polybutylene thermoplastic and is the premium quality pipe for geothermal heat pumps.



GEO-PIPE

"125" psi
Polybutylene Pipe
for Earth Coupled
Heat Pumps

ASTM D-2662

CHARACTERISTICS

--High Heat Transfer

Geo-Pipe has low wall thickness for maximum heat transfer so important to efficient geothermal heat pump operation.

--Strength

The high design stress of polybutylene allows *Geo-Pipe* to operate continuously at 125 psi pressures, and withstand surges more than twice as great.

--Wide Temperature Range

Geo-Pipe will operate continuously at 140° F., and take temperature surges as high as 200° F. Yet, *Geo-Pipe* will withstand below-freezing temperatures without effect.

--Corrosion and Chemical Resistance

Geo-Pipe's corrosion resistance will withstand the most corrosive soils. Stress crack resistance is the highest of all polyolefins. Anti-freeze solutions such as ethylene-glycol and propylene-glycol have no effect on *Geo-Pipe.*

Electrolysis cannot occur.

--Flexibility

Geo-Pipe has three times the flexibility of polyolefins with the same pressure rating. This means fast and easy installation.

--Long Term Integrity

Test and actual performance in similar application show that *Geo-Pipe* will retain all the above minimum properties beyond 11.4 years. Theoretical useful lifetime should run beyond 50 years.

--Long Coil Length

Geo-Pipe comes in coil length of 300' for 2" pipe, and 500' for 1½" pipe. Therefore, fewer connections are necessary.

--Straight Lengths

For in-house connection, 20' straight lengths are available for easy handling and neat appearance.

--Connections

Only nylon, 300 series stainless steel, or brass IPS insert fittings are to be used with *Geo-Pipe.* Only all 300 series stainless steel clamps are to be used to connect fittings.

Vanguard Plastics Inc.
The Polybutylene People

Vanguard GEO-PIPE

GEO-PIPE

"125" psi
Polybutylene Pipe
for Earth Coupled
Heat Pumps

ASTM D-2662

Vanguard
Plastics Inc.

The Polybutylene People

GENERAL SPECIFICATIONS:

All polybutylene pipe described in this bulletin shall conform to all applicable requirements in the latest revision of ASTM D-2662 specifications for polybutylene (PB) plastic pipe that is inside diameter-controlled, unless otherwise specified.

MATERIAL:

Polybutylene extrusion compound from which the herein described pipe is extruded shall conform to all applicable requirements in the latest revision of ASTM D-2581 standard for polybutylene PB 2110 Type II, Grade 1 plastic material.

CLASSIFICATION AND DIMENSIONS:

1. Rating--The PB pipe shall be rated for use with water at 73.4° F at a hydrostatic design stress of 1000 psi and a maximum working pressure as listed in table below

2. Dimension--The Standard Dimension Ratio (SDR) for all PB pipe described herein shall be 11.5 for iron pipe size (IPS-ID) for in-house use, and 15 for earth couple pipe.

NSF

AWWA

EARTH COUPLED PIPE IPS-ID, ASTM D-2662

Nom. Pipe Size (in.)	Ave. I.D.	Min. Wall	Approx. Wt. per 100 ft.	Std. Coil Length*	Working Pressure @ 73.4° F.	Bend Radius
1	1.049 +.010 -.020	0.091 +.020	13.9	100'**	160 psi	12.5"
1½	1.610 +.015 -.020	0.140 +.020	33.5	200'**	160 psi	19"
1½*	1.610 +.015 -.020	0.107 +.20	24	200'/500'	125 psi*	19"
2*	2.067 +.015 -.020	0.138 +.022	40	300'	125 psi*	24"

*SRD-15 for use with earth couplings only **Also, available in 20' st. length

TEST SPECIFICATIONS:

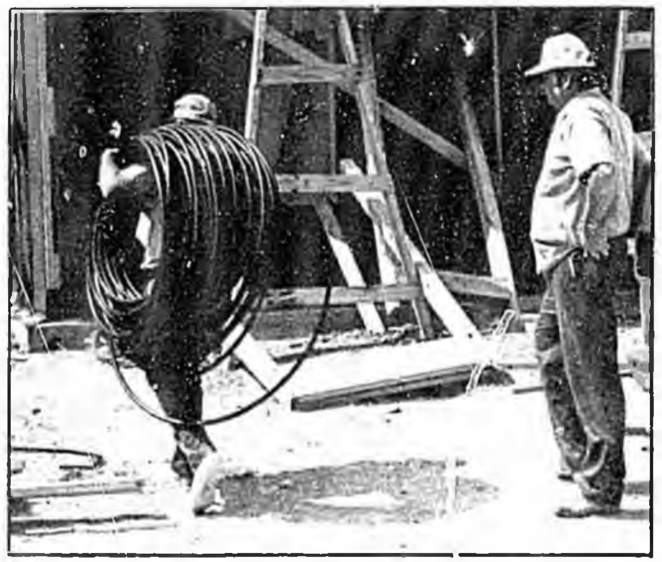
MINIMUM BURST PRESSURE
In accordance with ASTM D-1599, the minimum burst pressure shall be 350 psi at 73.4° F.

SUSTAINED PRESSURE
ASTM D-2662 Standard Specification requires that PB pipe satisfy minimum 1000 hour sustained pressures of 300 psi at 73.4° F and 290 psi at 100° F without failing, bursting or weeping, as defined in method D-1598

ENVIRONMENTAL STRESS CRACKING RESISTANCE
PB Pipe shall not be susceptible to environmental stress cracking, per ASTM specification D-1693.

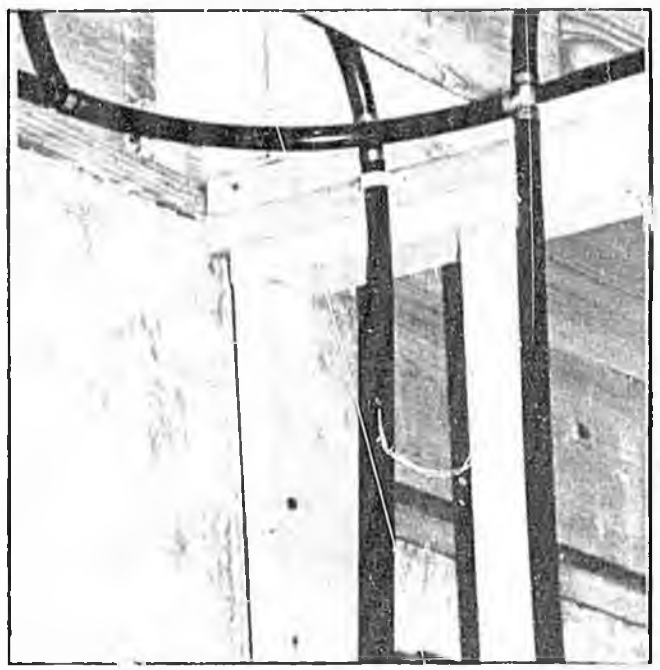
WORKMANSHIP
PB Pipe shall be homogeneous and lack visible defects such as cracks, holes or foreign inclusions which would affect its service use. It shall be uniform in color, opacity, density and other physical properties.

MARKING: The PB pipe described herein shall be PERMANENTLY INDENT MARKED to indicate the manufacturer, the nominal size, SDR, PB 2110, date, code, ASTM D-2662, rating psi @ 73.4° F, and the NSF-pw seal indicating potable water approval.



Vanguard polybutylene tubing forms the basis for a practical, economical and versatile plumbing system that makes it possible to reduce plumbing installation time by as much as 50% without an increase in material costs. Flexible polybutylene tubing is approved for hot water plumbing service, yet costs only about half as much as copper. Compared to rigid CPVC, the material cost is about the same, but you save on installation time and fittings.

Goes Almost Anywhere



Vanguard polybutylene tubing is lightweight and easily flexed around corners and over obstructions so it can be installed almost anywhere.

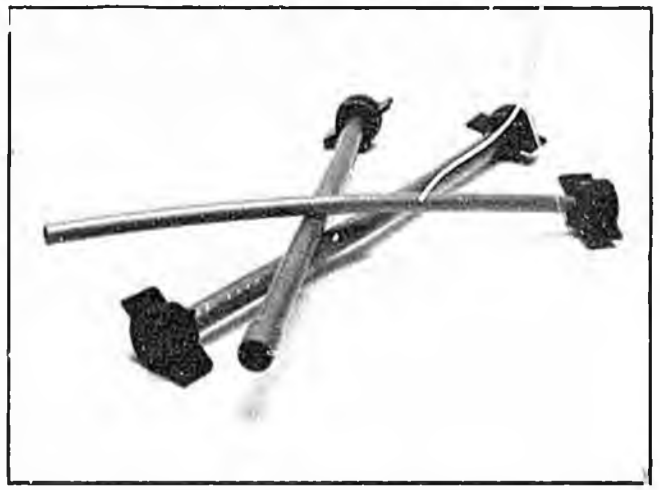
Reliable Performance

Vanguard polybutylene tubing is unaffected by temperature extremes. Freeze it. Thaw it. It won't split or crack. Vanguard polybutylene tubing will also withstand water pressures well in excess of 100 psi, and dampens water hammer rather than propagating it.

Quiet and Easy to Live With

With Vanguard polybutylene tubing there is almost no sound of rushing water. Polybutylene will not scale or corrode, and it also acts as an insulator

No-Strain Basin and Closet Supplies



Turn a tough, tight-quarters job into a simple, no-strain connection with Vanguard polybutylene risers. Several riser styles available in any length. Plastic handtight center set nut, or plastic hex ball-cock nut are available with riser for fixture connection. Riser may be connected at stub-out or stop valve by several means: compression, flare, insert, or half inch male thread.

Approved

NSF — NSPC — CSA — BOCA — AWWA — Southern Building Code Congress International

Vanguard polybutylene tubing and manufacturer's recommended fittings have been tested and accredited for use in the distribution of potable water. Risers have been approved by IAPMO.

General Specifications

All polybutylene tubing described in this bulletin shall conform to all applicable requirements in the latest revision of the ASTM D-3309 specification for polybutylene (PB) plastic tubing, unless otherwise specified.

Material

Polybutylene extrusion compound from which the herein described tubing is extruded shall conform to all applicable requirements in the latest revision of ASTM D-2581 standard for polybutylene, PB 2110 Type II, Grade 1 plastic material.

Classification and Dimensions

1. Rating—The PB tubing shall be rated for use with potable water at 180°F at a hydrostatic design stress of 500 psi and a maximum working pressure of 100 psi (160 psi at 73.4°F).
2. Dimension—The Standard Dimension Ratio (SDR) for all PB tubing described herein shall be 11 for copper tube size (CTS-OD) only.

Hot and Cold Water Tubing CTS-OD, SDR-11, ASTM D-3309

Nom. Tubing Size (in.)	Ave. O.D.	Ave. I.D.	Min. Wall	Working Pressure @ 73.4°F	Working Pressure @ 180°F	Design Stress @ 73.4°F	Design Stress @ 180°F
¼	.375 ±.003	.250	.062 +.010	160 psi	100 psi	1000 psi	500 psi
⅜	.500 ±.003	.375	.062 +.010	160 psi	100 psi	1000 psi	500 psi
½	.625 ±.004	.500	.062 +.010	160 psi	100 psi	1000 psi	500 psi
¾	.875 ±.004	.715	.080 +.010	160 psi	100 psi	1000 psi	500 psi
1"	1.125 ±.005	.921	.102 +.010	160 psi	100 psi	1000 psi	500 psi

Test Specifications

Minimum Burst Pressure

In accordance with ASTM-1599, the minimum burst pressure shall be 440 psi at 73.4°F and 320 psi at 180°F.

Sustained Pressure

Polybutylene tubing properly assembled with manufacturer's recommended fittings, will maintain sustained pressures of 220 psi for a minimum of 1000 hours at a temperature of 120°F when tested in accordance with ASTM method D-1598.

Thermocycling

Polybutylene tubing properly assembled with manufacturer's recommended fittings, will not separate or leak when thermocycled 1000 times between the temperatures of 60°F and 180°F when tested in accordance with procedure outlined in ASTM Standard D-3309.

Workmanship

Polybutylene tubing shall be homogeneous and lack visible defects such as cracks, holes or foreign inclusions which would affect its service use. It shall be uniform in color, opacity, density and other physical properties.

Marking

The polybutylene tubing described herein shall be PERMANENTLY INDENT MARKED to indicate the manufacturer, the nominal size, SDR-11, PB 2110, date, code, ASTM D-3309, 100 psi @ 180°F, and the NSF-pw seal indicating potable water approval.

General

Vanguard polybutylene is a high quality, economical thermoplastic piping material approved for potable hot and cold water distribution. It comes in coils or straight lengths, stores easily inside or out, is lightweight, rugged and durable for safe handling, and, because of its flexibility, is easy to install.

Storage and Handling

Vanguard polybutylene tubing is furnished in coils of 100 to 1000 feet, and 20 foot straight lengths in bundles containing 500 to 1000 feet. Tubing colored black can be stored outside without damage from weather. Colors other than black should be protected from sunlight if stored more than 6 weeks outside. Avoid dragging tubing over rough terrain or contact with sharp objects that may cut or puncture the tubing.

Installation

Vanguard polybutylene tubing is fast and easy to install when used with recommended fittings.

Before installation, tubing should be inspected for cuts, punctures or excessive abrasion that may have resulted from shipping or handling damage. Damaged spots may be cut out and recoupled to form continuous lengths.

Tubing should be blown out before final connections are made to eliminate any dirt, sand or sawdust that may have entered the tubing during installation.

Plastic expands and contracts more than metal when subjected to temperature changes. Therefore, allowances must be made when installing polybutylene tubing. An extra 4 inches per 100 feet of tubing per 45°F expected temperature change will compensate for thermal contractions (.085 inches per 10°F per 100 feet). Hangers used for support of tubing should be snug, but not so rigidly anchored as to prevent expansion and contraction.

Since polybutylene is flexible it is recommended that smooth metal or plastic hanger straps be used for support every 3 feet. Hanger straps should be free of sharp edges. Staples are not to be used.

Water service entering the system should not have pressures exceeding 100 psi. Although polybutylene will withstand pressure surges well in excess of its rated capacity, water hammer arrestors should be used in conformance with local codes.

Polybutylene tubing should not be curved with a radius of less than ten times the O.D. (eg., ½" OD tubing should not be curved with a radius of less than 5").

Pressure testing should be conducted before enclosing the wall. A test pressure of 150% of the system design pressure is normally used. Check all connections. Testing may be done immediately upon completion of the final connection.

Cutting

Tubing cutters especially designed for cutting Vanguard polybutylene to length are recommended. They are inexpensive and will produce a square, clean cut.

Fittings

Vanguard polybutylene tubing can be joined by recommended crimp ring, flare, compression and heat fusion fittings systems. The systems may require the use of special hand tools readily available.

Vanguard
Plastics Inc.
831 North Vanguard Street
McPherson, Kansas 67460
316 241 6369

THE POLYBUTYLENE PEOPLE

HOT AND COLD WATER
PLUMBING PIPE

The Toughest Pipe at the Lowest Cost.

Pipe made with Duraflex* polybutylene resin from Shell Chemical Company is the toughest *and* the most economical plumbing you can buy.

When you match Duraflex pipe against copper, galvanized, CPVC or any other plumbing material used for hot and cold water service you'll see there's no comparison. You won't find a better pipe for homes, townhouses and apartment buildings at any price.

Duraflex pipe is tough — tougher than any other plumbing pipe. It resists corrosion, rust, scale and freezing. It can be used for water systems with pressures up to 200 psi at 73°F (cold water pipe) and up to 100 psi at 180°F (hot water pipe).

And Duraflex pipe is less expensive than other types of plumbing pipe. Material costs will be less than half as much as the cost of copper. In addition, its price is more stable than the cost of copper, allowing contractors to bid jobs more accurately. Duraflex pipe is less expensive than CPVC and also saves on installation time.

*Duraflex™ is a trademark of Shell Chemical Company for its polybutylene resins. Shell Chemical does not manufacture pipe.

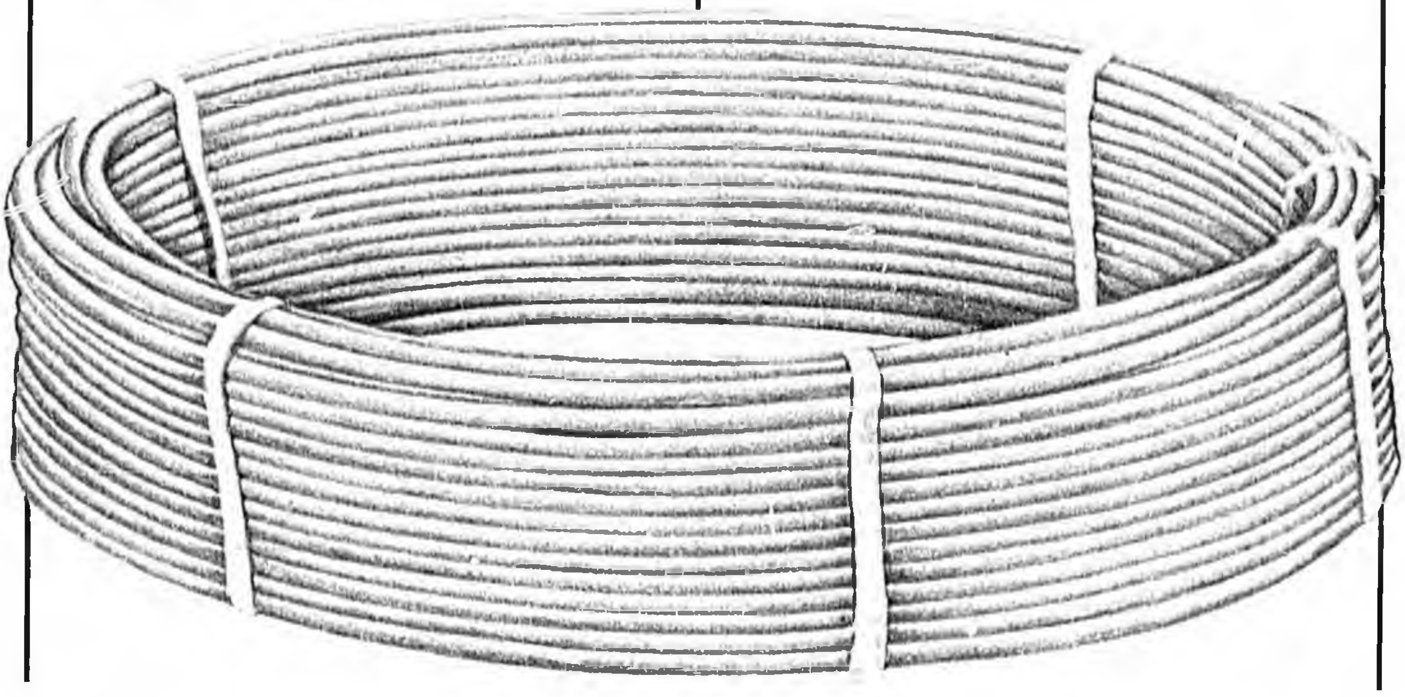
Flexibility Simplifies Installation.

Duraflex pipe is lightweight and flexible, which means it's easy to install.

Because it weighs about one-ninth as much as copper, Duraflex pipe can be handled by one person. It bends easily, so elbows aren't needed every time you turn a corner. You can pull it through wall studs in tight spaces, simplifying retrofit jobs.

You also can curve it to meet fixtures, reducing the number of costly and time-consuming fittings required.

Duraflex pipe offers other savings. You have less waste with Duraflex pipe compared to other plumbing because it comes in coils up to 1,000 feet in length. You can cut the amount you need and save the rest. It also is available in



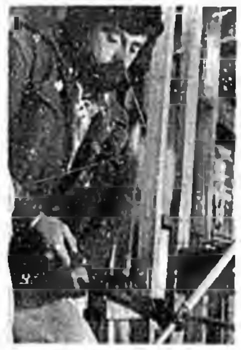
straight lengths for areas where plumbing will be exposed after construction is completed.

A Choice of Fitting Methods.

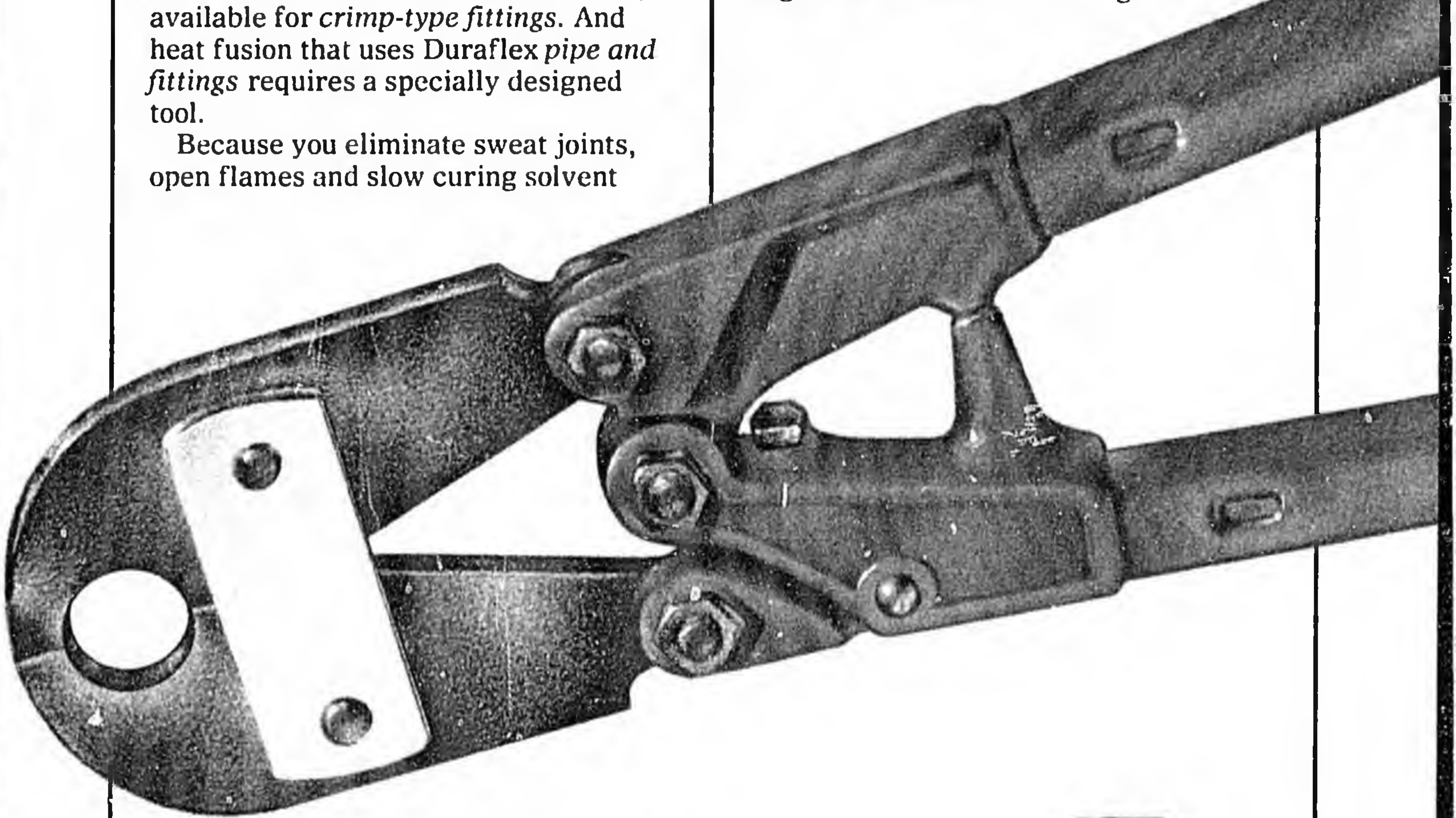
Duraflex pipe can be joined using one of four common methods. (Shell does not endorse or recommend any joining method. They are listed merely for completeness of information.)

A tubing cutter and a wrench are required if you use *compression fittings*. A flaring tool is needed for *cold flare fittings*. Low-cost tools are readily available for *crimp-type fittings*. And heat fusion that uses Duraflex *pipe and fittings* requires a specially designed tool.

Because you eliminate sweat joints, open flames and slow curing solvent cement, you improve the safety of your operation. You don't have to wait for joints to cure before making pressure checks. Water can be turned on when the last pipe connection is completed.



Adapters are available for connecting Duraflex pipe to existing copper, CPVC or galvanized systems, making it the logical choice for remodeling work.



Freeze Resistance Protects Homes.

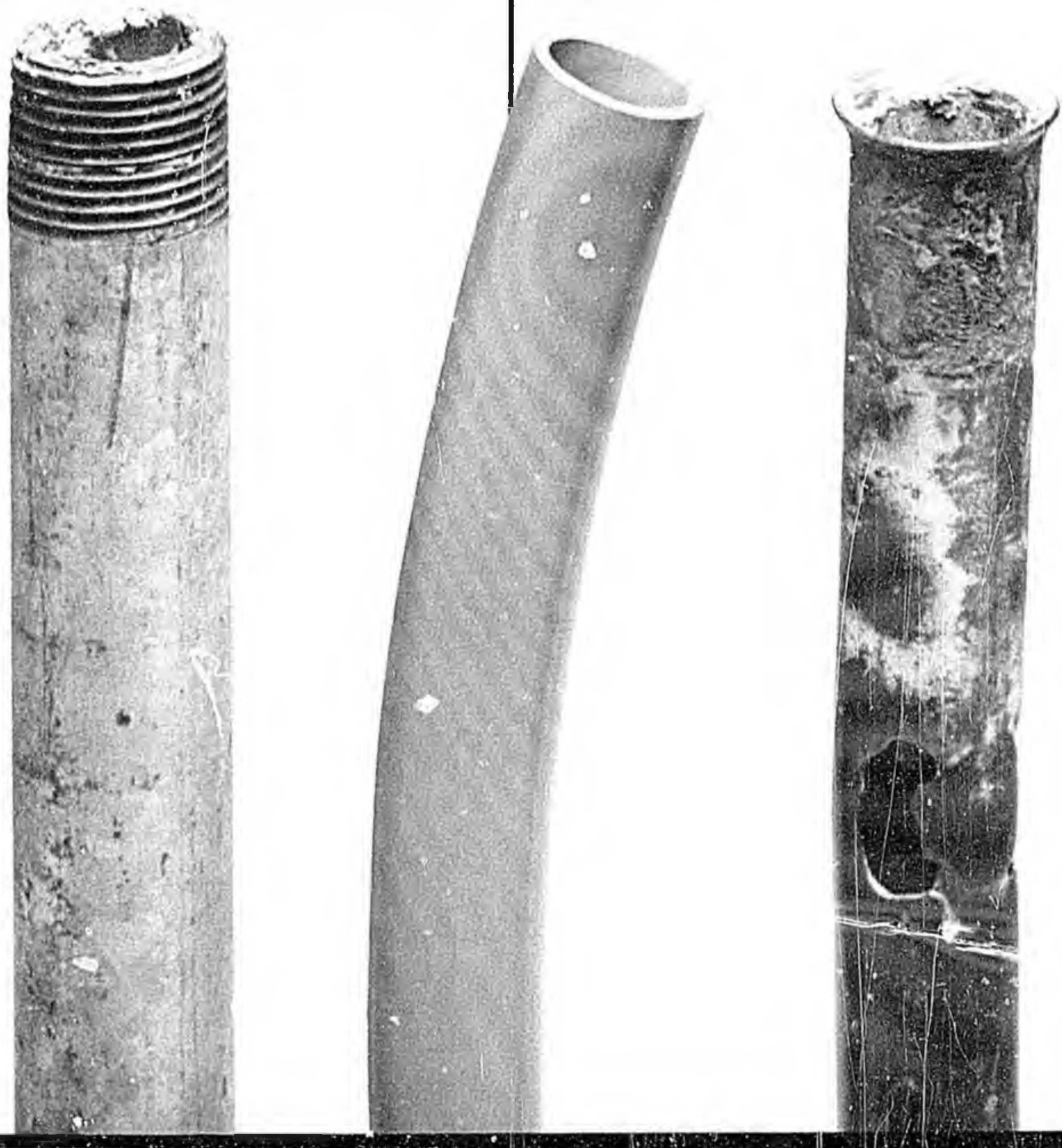
Homes, townhouses and apartments with Duraflex plumbing pipe have an extra degree of protection against damage that might occur when pipes burst during freezing weather.

When water freezes, it expands, causing ordinary copper plumbing to crack and eventually burst. But Duraflex pipe expands to accommodate frozen water and then regains its original shape after the water thaws with no loss of strength. Duraflex pipe won't split or crack under subfreezing conditions. However, when short lengths of polybutylene pipe are connected to rigid fittings or pipe, the pipe may not be able to expand sufficiently to protect the whole system. In such cases, protect against freezing.

Corrosion, Rust and Scale Resistant.

Pipe made with Duraflex polybutylene resin offers added protection because it won't corrode, rust or rot. Duraflex resin is inert, so it resists the corrosive elements in water that can eventually eat holes in metallic pipe.

Duraflex pipe also is totally unaffected by soil conditions or electrolysis. And it resists scale buildup from hard water that can block other plumbing systems.



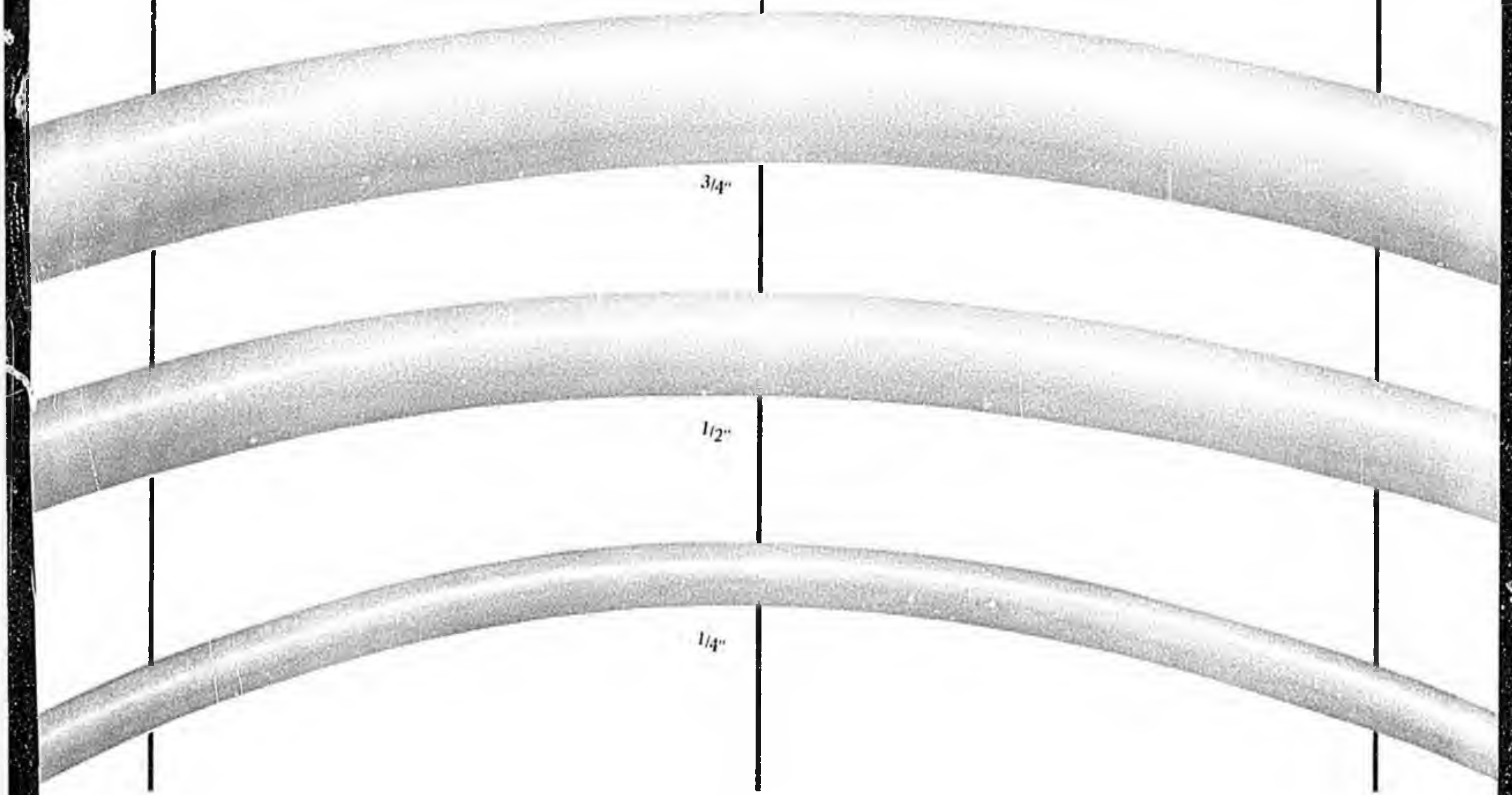
DURAFLEX PIPE ☆ SEAL OF APPROVAL ☆

The Seal of Approval.

Plumbing pipe for hot water service made with Duraflex polybutylene resin meets the following codes, standards and regulations:

- National Sanitation Foundation (NSF)
- Plastics Pipe Institute (PPI)
- National Standard Plumbing Code (NSPC)
- Southern Building Code Congress (SBCC)
- Building Officials Code Administration (BOCA)
- International Congress of Building Officials (ICBO)
- Federal Housing Administration (FHA) UM-68
- HUD Mobile Home Construction and Safety Standard
- Canadian Standards Association (CSA)
- Manufactured Housing Institute (MHI)
- American Society of Testing and Materials (ASTM)
- American National Standards Institute (ANSI) A119,2/NFPA 501.C
- International Association of Plumbing and Mechanical Officials
- Numerous State and Local Codes

Duraflex pipe for both hot and cold water service is available from manufacturers in sizes ranging from ¼ inch to 3 inches in diameter.



TECHNICAL DATA

Applications

Since it was first commercially produced in 1967, Duraflex pipe has been used for a large variety of hot and cold water applications, including:

Plumbing and Heating

- Domestic Hot Water Supply
- Hydronic Heating
- Slab Radiant Heating
- Solar Heating and Cooling
- Commercial Hot Water
- Fire Sprinkler Piping

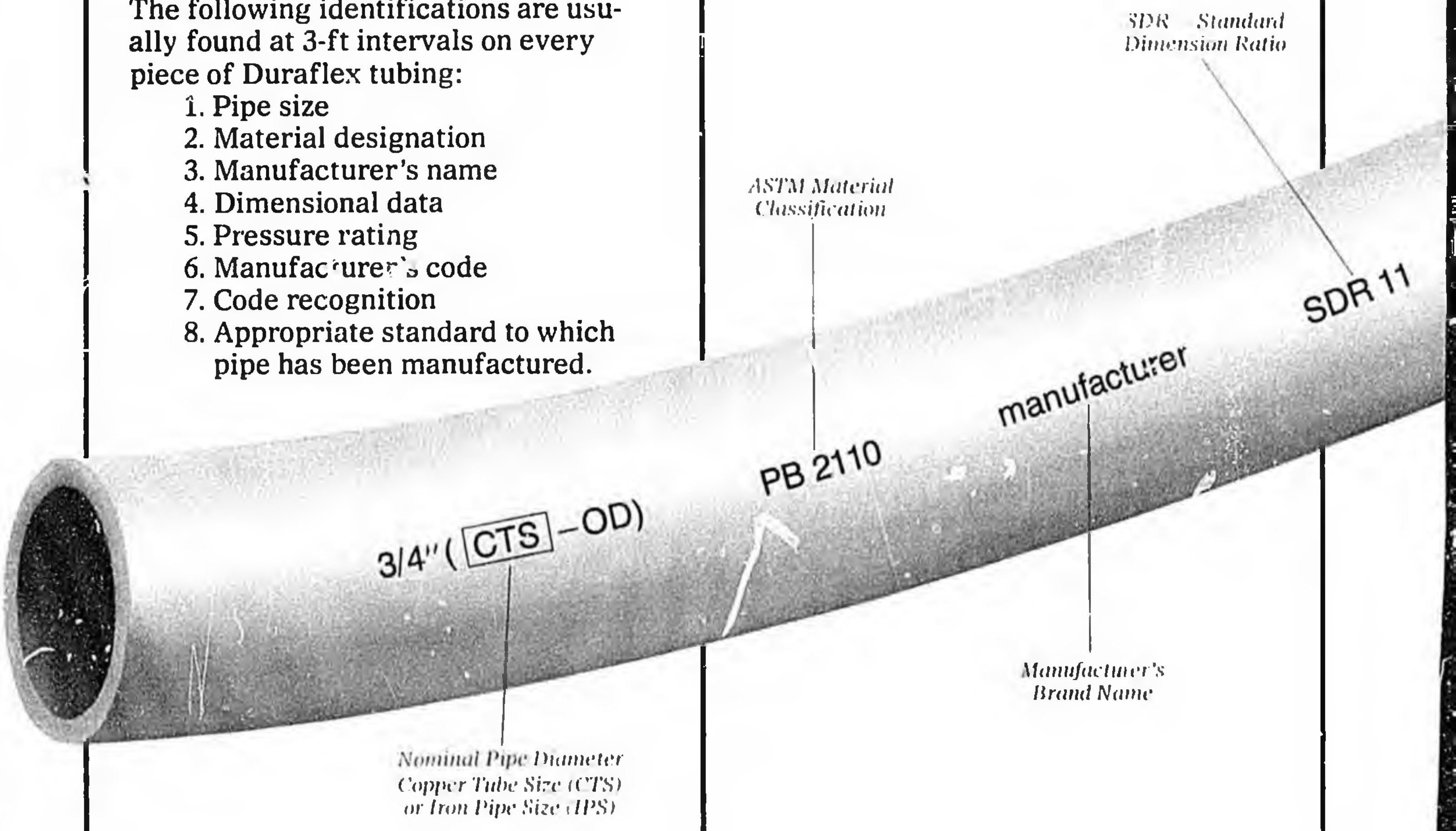
Water Supply

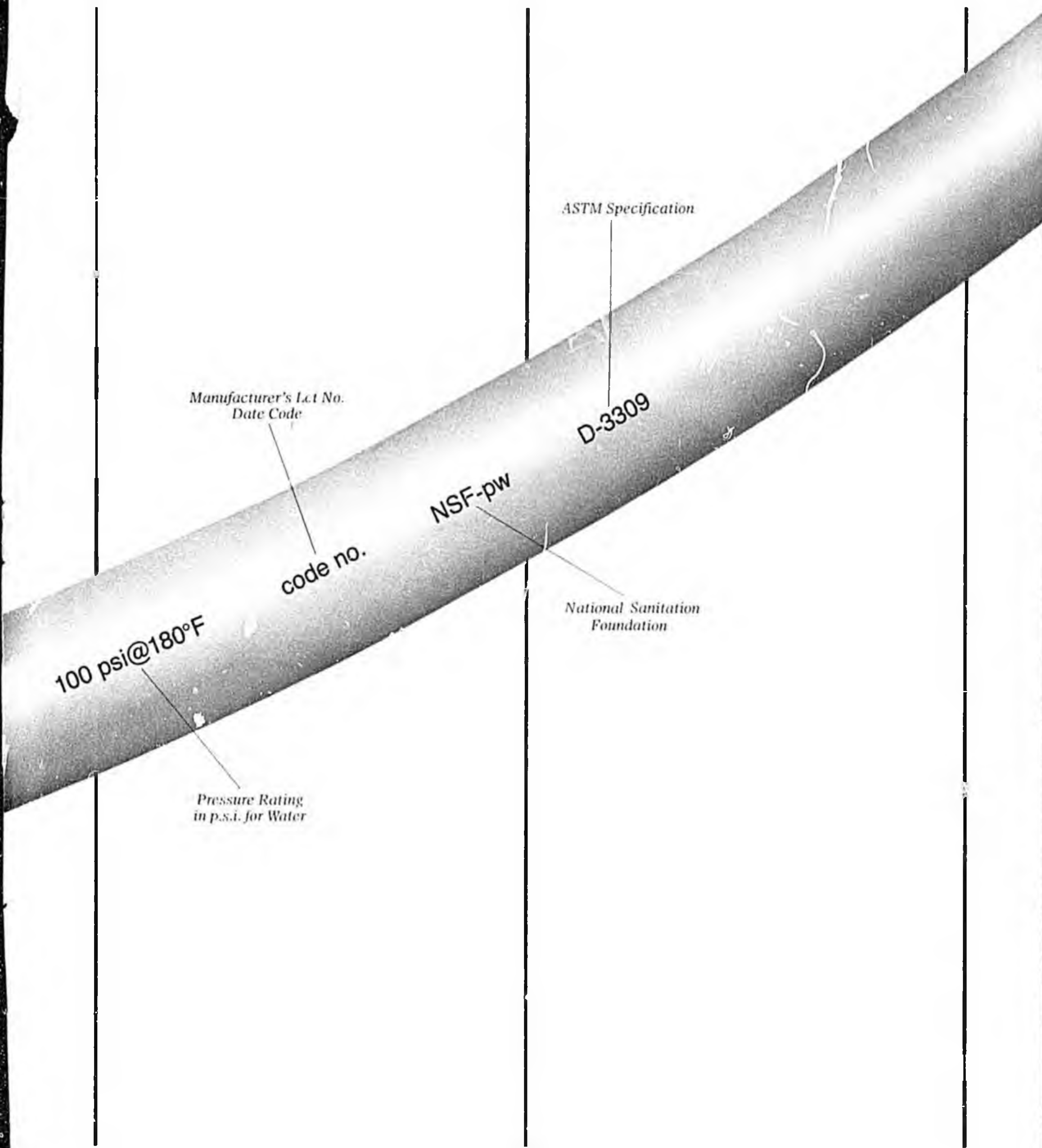
- Municipal Water Service Systems
- Yard Piping
- Deep Well Submersible Pumps
- Drip Irrigation
- Ditch Irrigation
- Rural Water Supply
- Ground Water Heat Pumps

Pipe Identification

The following identifications are usually found at 3-ft intervals on every piece of Duraflex tubing:

1. Pipe size
2. Material designation
3. Manufacturer's name
4. Dimensional data
5. Pressure rating
6. Manufacturer's code
7. Code recognition
8. Appropriate standard to which pipe has been manufactured.




ASTM Specification
Manufacturer's Lot No.
Date Code
D-3309
NSF-pw
code no.
100 psi@180°F
National Sanitation
Foundation
Pressure Rating
in p.s.i. for Water

Pipe Storage

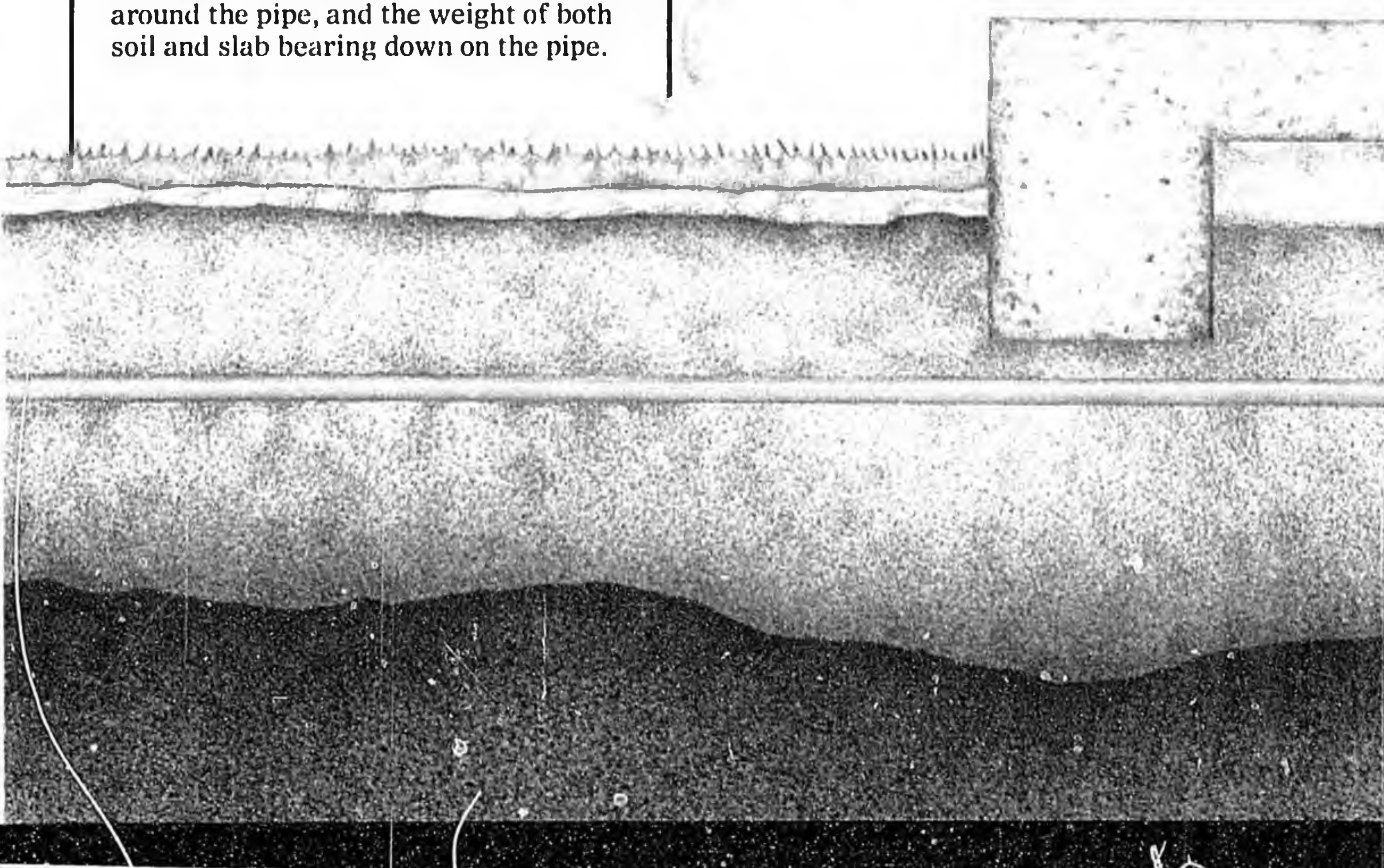
Thermoplastic materials such as Duraflex polybutylene resin are susceptible to ultraviolet attack as a result of continued outdoor exposure. The amount of ultraviolet damage will depend on the material, formulation, exposure time, geographic latitude, climate conditions, etc. Black grades of Duraflex polybutylene resin (4101 and 4121) are formulated for continuous exposure and can be stored outside. The other grades (4103, blue; 4127, gray; 4128, beige; and 4129, brown) are not formulated for continuous outdoor exposure and should be stored under cover. Outdoor exposure of these grades should be limited to reasonable construction and installation periods.

Buried Pipe

Running Duraflex pipe under a slab does not significantly affect its properties.

Duraflex pipe buried under a slab is compressed by earth and slab loadings. The amount of compression depends on the temperature of the water in the pipe, the compaction of soil around the pipe, and the weight of both soil and slab bearing down on the pipe.

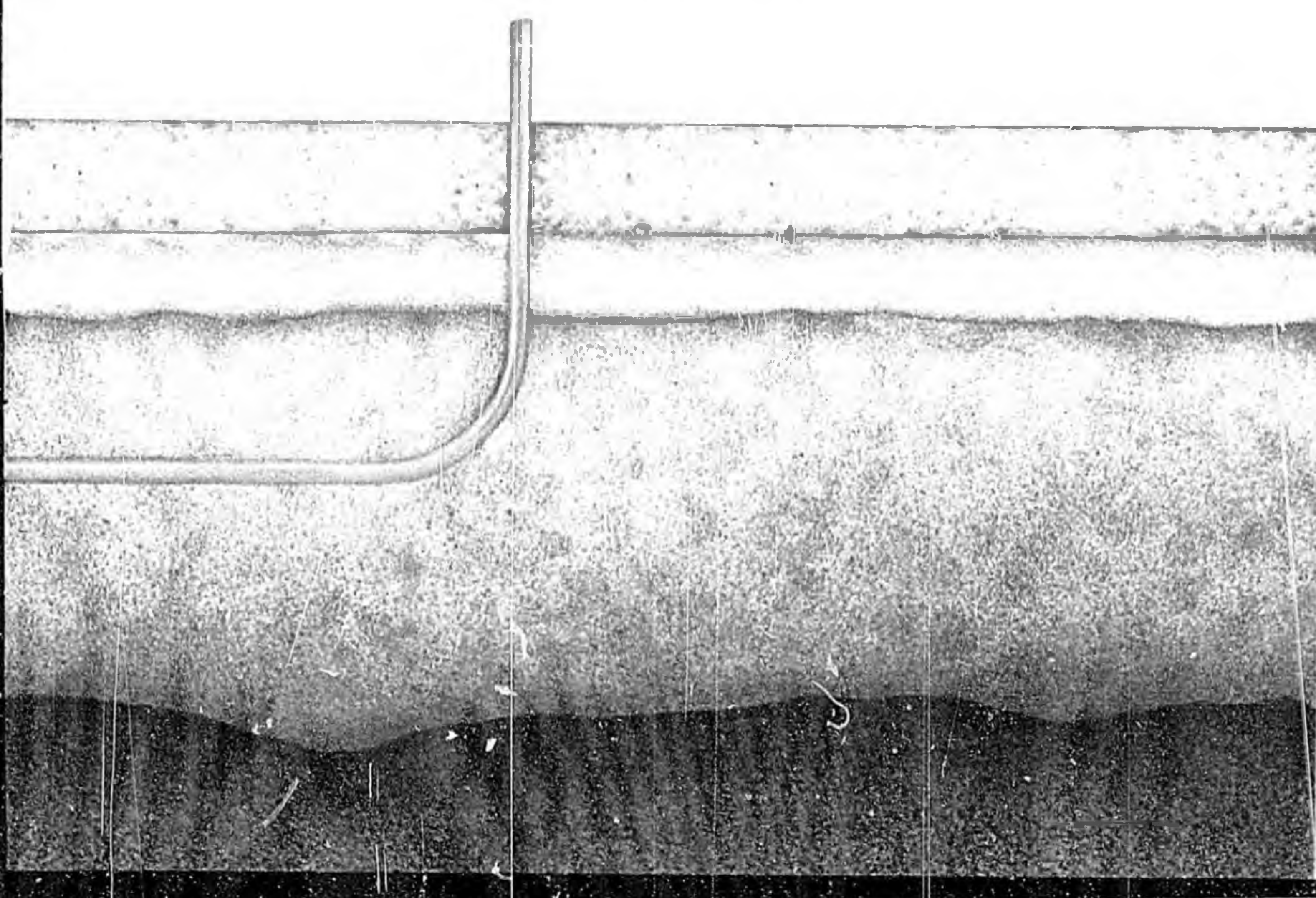
Under typical conditions (pipe buried 3 feet under a 4-in.-thick slab with 90-percent soil compaction around the pipe), the pipe is compressed by 1 percent at room temperature and 2 percent at 180°F. Both of these values are well within the design limit of 5-percent deflection. Because of its chemical resistance, Duraflex is totally inert to any chemical interaction with concrete and thus can be used safely within and through a slab. In addition, because it is immune to electrolysis it also can be placed in contact with supporting steel mesh. As a matter of good installation practice, fittings should never be used in or under a slab.



Freeze-Thaw Resistance

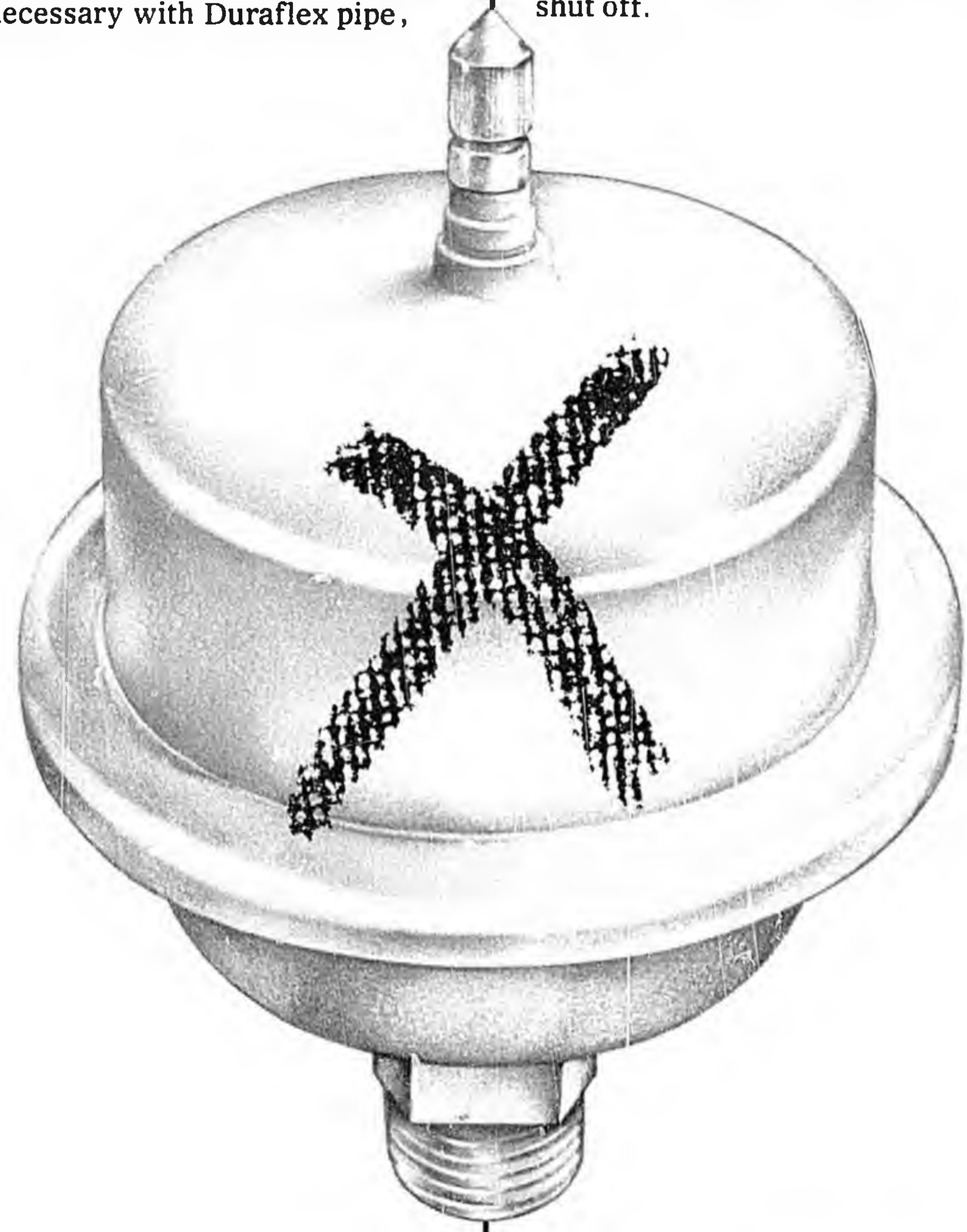
Properly extruded Duraflex pipe has sufficient elasticity and ductility to withstand the expansion of frozen water. To demonstrate this, three samples of ¾-in. CTS Duraflex pipe were frozen overnight and thawed daily for a six-day period. After six days, all of the samples were still intact and quick-burst tests showed no apparent loss of strength.

Control Not Subject to Freeze-Thaw Cycle	Frozen Under 50 PSI Internal Pressure	Frozen Under 100 PSI Internal Pressure
Burst Pressure (psi)	**Burst Pressure (psi)**	**Burst Pressure (psi)**
490	485	490
495	480	485
505	490	495
497 *Average*	485 *Average*	490 *Average*



Water Hammer

Because Duraflex pipe is more flexible than either CPVC or copper, it is less affected by water hammer caused by rapid shut off. Water hammer arrestors are unnecessary with Duraflex pipe, although some local code authorities may still require their installation. The chart below shows the calculated pressure surge (psi) for Duraflex, CPVC, copper and galvanized pipe in a rapid shut off.



	Pressure Surge (psi)		
Velocity (fps)	2	4	8
Duraflex pipe	14	30	59
CPVC	45	90	180
Copper	106	212	422
Galvanized Iron	110	225	464

Pipe Support

Being flexible, Duraflex pipe must be supported. For ½ and ¾ inch plumbing pipe, support intervals of 32 inches can be used. Longer support intervals can be used with larger pipe. If the pipe is passing through studs, the pipe should be sleeved (plastic sleeves are available for this purpose).

Bending Radius

A minimum bending radius (ratio of the bend radius to the diameter of the pipe) of 10 is recommended.

Hot Water Heater Considerations

Duraflex tubing is easily capable of withstanding the malfunction of a water heater. It is made in accordance with ASTM D3309 and is designed to operate continuously at 180°F, 100 psi. This is within the expectations of any normal household plumbing system.

In the event of a hot water heater malfunction, Duraflex pipe may be exposed to a higher temperature and pressure for a short period. (Temperature/pressure relief valves normally are designed to release at 210°F and 150 psi.) Tests conducted under the auspices of the National Sanitation Foundation have shown that at 210°F, Duraflex plumbing tubing has average burst values of over 275 psi and can sustain a pressure of 150 psi continuously for over 20 months without failure.

As a general precaution Duraflex pipe should not be installed within 18 inches of a burner or direct source of heat.

Fire Potential

The smoke hazard from Duraflex plumbing is minimal, and the incremental contribution to a residential fire from Duraflex plumbing is *infinitesimal.*

The average three-bedroom house would require an estimated 15 pounds of Duraflex pipe for its total plumbing service. This same house would also contain *several thousand pounds* of other combustible products such as rugs, furniture, bedding, draperies, etc. In addition, the same house would contain *tens of thousands of pounds* of combustible construction materials such as wooden beams and flooring, shingles, weather stripping, etc.

Duraflex resin is a saturated organic polymer composed of carbon and hydrogen; therefore, it burns slowly and cleanly in a manner similar to a candle. Its combustion products are similar to those derived from burning other organic materials such as paper, cotton and wood and less onerous than those obtained from burning wool, leather, or other complex materials.

Furthermore, Duraflex resin *will not* produce an acrid, toxic smoke. Comparative bioassay tests under simulated fire conditions have shown that combustion products of Duraflex polybutylene pipe are less toxic than those of Douglas fir.

Disclaimer

The information contained in this guide is based on data obtained by Shell research and is considered accurate. However, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THESE DATA OR THE RESULTS TO BE OBTAINED FROM THE USE THEREOF. This information is furnished upon the condition that the person receiving it shall make his own tests to determine the suitability thereof for his particular purpose.

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P. M.

MAR 31 1983

V CEQA SUMMARY

This chapter covers various information not presented earlier but required by the California Environmental Quality Act (CEQA) for Environmental Impact Reports. As this document is a preliminary environmental review, this section has not been fully developed. When the draft and final versions of the EIR are proposed, it is likely to expand and some of the findings will undoubtedly change or at least be stated more confidently.

A. Significant Unavoidable Environmental Impacts

For this preliminary environmental review of a very subtle and complex proposal, SRI chose to describe our current overall conclusions about the proposed plumbing code changes and our reasons for them, without making definitive findings of significance except where they were clearcut.

First, we discovered nothing to suggest that the issues discussed earlier as the prime ones are insignificant or that other issues are dominant. The only new issue of potential significance that surfaced was the permeation of buried plastic pipe by contaminants in soil and the resulting possible public health impacts. Although the possibility that such effects could occur from permeation of water supply lines from the meter to the house is plausible, any potential problem would also occur--probably in much greater proportion--from the public water distribution system. This problem should be re-examined when better understood and if found significant should influence state policies with respect to plastic use in both public and residential systems. With adequate education of building inspectors on the permeation issue, improper installation of plastic water service in contaminated soils should be rare.

As to public health impacts from chemicals leaching from water pipe into potable water, we find that significant impacts are possible but unproven, both for plastic pipes--especially the chlorinated varieties--and for metal ones, specifically copper systems. If the upper ranges of possible concentrations of leachates are regularly reached, the cumulative risks to public health may be high enough to be of concern by typical standards of acceptable risk, for example, a lifetime cancer risk of one in a million. The chemicals of concern are lead from the solder in copper pipes, possibly leading to neurologic disorders, and carbon tetrachloride, perchloroethylene, and trichloroethylene from plastic (especially PVC and CPVC) pipes, possibly resulting in cancer.

Two major considerations limit the significance of the findings. First, the status of information about long-term levels of leachates is exceedingly flimsy. Reasonable further testing could resolve at least part of the uncertainty (see Section VI). Second, the risk assessment procedure is moderately conservative. If risks still appear to be of concern after concentrations are better known, more attention would need to be devoted to assuring that the assessment procedure took into account detailed properties of the chemical. Finally, thorough initial flushing would effectively mitigate the effects of the rapidly leaching materials, especially the solvents used with plastic pipe. Overall, current information does not establish an environmental preference between copper and plastic pipe, with neither clearly likely to cause a great number of deaths or serious illnesses.

For worker safety and health, a similar situation exists. Both lead from solder fumes in installing copper pipe and solvents from installing ABS, PVC, and CPVC pipe could be hazardous if plumbers have high exposures by inhalation; dermal absorption could also be significant in the case of solvents. The diseases of concern for solder fumes are related to the lead exposure and are neurologic. The solvents may also cause nerve damage, and they may be involved in liver damage or reproductive problems as well. However, they are not implicated in cancer unless benzene is more common than thought. Unless the NIOSH report about to be released resolves the range of exposures satisfactorily, further testing would be useful before completing the EIR. Safety issues generally favor plastic over metal, which appears to lead to more burns (hot solder and especially flux) and strains and contusions (from heavier metal pipes). PB (like PE, although its uses are not proposed for change) poses little if any worker safety and health concern. Use of gloves, other protective equipment, ventilation, and simple care will significantly reduce any potential hazards from either plastic or metal pipe, but these practices have not achieved widespread acceptance among plumbers.

Fire safety is a very real concern with plastic DWV pipe; ABS is combustible, and PVC and CPVC will at least soften and slump in lines. If these plastics are installed as direct substitutes for metal, as they already are in non-fire-rated residences, they will degrade the fire resistance of structures. The gaskets in no-hub cast iron will also fail in fires and cause the pipe to fall, leaving fire passages. But the proposed code changes apply to fire-rated, fire-resistive construction that could retain its fire rating if appropriate installation procedures are developed and enforced. In such conditions, no degradation of fire resistance would occur. This issue thus turns on enforcement, not science. The potable water pipes, kept cooler by the water inside and of much lower mass, are not a significant fire safety issue.

As with fire safety, smoke toxicity is an issue in which plastic can only be less environmentally acceptable than metal. However, whether the difference is significant is less certain. Both ABS, which seems likely to contribute the majority of pipe mass in California, and the polyolefins PB and PE produce combustion products that are not highly toxic; few if any additional fatalities or serious injuries would be likely from their combustion. PVC and CPVC both produce significant quantities of hydrogen chloride vapor in fire environments, and this corrosive material could, under certain circumstances, make a difference in the probability of human survival in lines. The frequency of such occurrences is clouded by lack of a generally accepted test for smoke toxicity. This problem is currently being addressed both by the State of California Department of Industrial Relations and by the State of New York. We believe DHCD should pay close attention to results from those studies, but does not need to delay a decision solely on those grounds.

No other significant adverse impacts are likely to result from the expanded use of plastic plumbing pipe if relatively simple mitigation measures are taken. Plastic drain pipes may be slightly noisier than cast iron pipe. See the following section (V-B) for further elaboration.

Overall, the SRI study team sees little evidence that expanded use of plastic plumbing pipe would cause significantly greater environmental problems than the materials it would replace. Unfortunately, lack of evidence is not the same as lack of hazard. We believe it is especially important to gather more information on leaching of chemicals from both plastic and metal pipe systems into potable water and on the exposures of plumbers to material from plastic (ABS, PVC, CPVC) and metal (copper) plumbing systems.

Table V-1 summarizes our present assessment of our relative environmental concern about pipe systems. There we show our relative degrees of concern for different materials for each of the major areas of impacts. A high rating does not necessarily mean an impact that is significant in the sense of CEQA, but does mean that the material rated seems to us more likely to be environmentally harmful then other materials on that dimension. For example, the chlorinated plastics clearly are of highest concern for smoke toxicity, but may not pose any significantly higher impacts in the proposed new DWV uses (fire-resistive construction).

Table V-1

RELATIVE DEGREE OF CONCERN REGARDING
POTENTIAL ENVIRONMENTAL IMPACTS*

	Potable Water				Drain, Waste, and Vent			
	Plastic		Metal		Plastic		Metal	
Impact Area	PB/PE	PVC/CPVC	Copper	Galv. Steel	ABS	PVC/CPVC	Copper/ Gal.Steel	Ca Ir
Public Health	3	4	3	3	0	0	0	[illegible]
Worker Safety	1	2	4	2	2	2	3^+	[illegible]
Worker Health	0	3	4	2	4	4	3^+	[illegible]
Fire Safety	3	2	0	0	5	4	0	[illegible]
Smoke Toxicity	1	3	0	0	3	5	0	[illegible]
Other Impacts	0	0	0	0	1	1	0	[illegible]

*Key: 0 - No concern
1 - Considerably less concern than average
2 - Less concern than average
3 - About average concern
4 - More concern than average
5 - Considerably more concern than average

Note: High relative concern does not necessarily imply high absolute concern; significance of ratings depends on mitigation measures taken.

+More for copper, less for galvanized.

B. Insignificant Effects

The following environmental effects of expanded uses for plastic plumbing pipe may occur but are probably insignificant by any reasonable interpretation of CEQA:

- Plastic pipe systems may fail slightly more frequently than metal systems until a body of experience with installation errors has accumulated.

- Plastic pipe will consume slightly more petroleum than metal pipe, but slightly less energy overall.

- Plastic pipe will contribute a slightly different load of pollutants to public waste water treatment systems, but the direction of impact, let alone its magnitude, is uncertain.

- Plastic DWV pipe will be slightly noisier than metal systems if installed so as to contact wall surfaces; this may be more significant than otherwise in the multifamily, fire-rated construction that is affected in the DWV code changes.

- Plastic DWV pipe could be damaged by pipe cleaning equipment, but because of its resistance to corrosion, the frequency of such cleaning should be low.

- Plastic pipe will slightly decrease the life-cycle cost of plumbing and therefore of housing, but not enough to change demand patterns or growth.

- Small shifts in employment from metal pipe manufacturing to plastic pipe manufacturing will occur.

- A small reduction in the work of plumbers will occur, mostly as a result of repair and renovation work by do-it-yourselfers.

C. Effects of Alternative Actions

In addition to the proposed project, e.g., the proposed change to the 1982 Uniform Plumbing Code (UPC) allowing certain new uses of plastic plumbing pipe as described in the Project Description, this environmental review has examined the potential effects of alternatives to the proposed project on the quality of the natural and human environment. The eventual EIR will consider alternatives as well as the project itself to provide a baseline for evaluating the significance of the impacts and to provide possible alternative courses of action should the proposed project create significant adverse impacts that cannot be successfully mitigated. With this goal in mind, the alternatives we have selected for analysis are no changes to the state code, partial approval of plastic pipe use, and complete rejection of all plastic pipe (that is, reversal of earlier provisions allowing certain uses of plastic pipe).

Under the no-action alternative, there would be no changes in the state code regarding the use of plastic plumbing pipe. All currently approved uses for plastic pipe would continue to be permitted and no new uses of plastic pipe would be allowed. None of the impacts attributable to the use of plastic pipe in expanded applications would be observed; any public health and worker safety and health effects of currently allowed plastic and metal piping systems would persist.

The partial approval alternative would amend the state code to permit certain new uses of plastic pipe, but not all of the new uses proposed under the project. Counting cold and hot water supply in a given application as one new use, the proposed project would change the code to permit 11 new uses of plastic pipe (i.e., 1 new use for ABS pipe, 3 for PB pipe, 1 for PVC pipe, and 6 for CPVC pipe). Considering all the possible combinations of these uses, over 2,000 partial approval alternatives are possible.

Our analyses of the environmental consequences of the proposed project have guided our selection of the subset of the partial approval alternatives to be considered in the EIR. That is, we define the partial approval alternative(s) to permit those new uses of plastic plumbing pipe that are least likely to have significant adverse effects on the quality of the natural and human environment. At present, the only partial alternative that seems reasonably certain to meet this requirement is to allow PB for hot and cold water supply both outside buildings and inside buildings that are not fire-rated or within the fire-resistive construction of fire-rated buildings. No other new uses of plastic pipe would be allowed. Parenthetically, there seems little reason to prohibit PB in exposed locations of fire-rated buildings as long as the penetrations of fire-resistant construction are designed to maintain the rating of that construction. The state of information on the impacts of this alternative is generally the same as on those of the metal water pipe currently allowed for these two uses. Although PB will certainly burn and metal will not, the additional risk of fire spread appears minimal, as does that of smoke toxicity. Leachates from PB have not been shown to be risk-free, but neither have those from copper or galvanized steel. Of the two plastic alternatives, PB is somewhat less likely to be a public health hazard than CPVC, although the relative ratings of PB, CPVC, copper, and galvanized steel will not be clear without further testing (see Section VI). PB is clearly a preferred material, from the worker safety and health viewpoint, compared both with metal systems and with plastics that require cementing.

Under the option of disallowing currently allowed uses of plastic pipe, any impacts of these materials would disappear and those of metal systems reappear. The possibility of permeation of water supply piping by organic contaminants would decrease to the extent that PVC and PE supply lines would be replaced by metal with impermeable joints (but even metal pipe joints can be permeable). Leachates from PVC and PB would be replaced by those from copper, with no clear impact, positive or negative, on public health. The metal pipes would be somewhat more likely to corrode in soil than plastic (galvanized steel is not recommended for buried supply lines). Only small changes in worker safety and health would result from the changes in water supply piping.

Any major impacts of disallowing current uses of plastic pipe would be associated with the widespread use of ABS (and less widespread use of PVC) in DWV applications. Fire load and fire spread would be reduced in nonfire-rated construction. It is probable that few fatalities or little property damage would be avoided by this action, but both are possible benefits. Smoke toxins would also decrease somewhat, especially if PVC were replaced. The decrease in plumbers' exposures to solvent cements would be offset by increased work-related injuries from working with cast iron and, to some extent, with soldered joints in copper DWV. Whether the net effect on worker safety and health would be positive or negative is difficult to predict, given the current lack of information on plumbers' exposures.

Finally, the alternative that would disallow current uses of plastic would transfer some profits and jobs from the plastics to the metal pipe industries. Since large quantities of DWV are involved, these impacts would probably be greater than those for the prime project alternative of allowing expanded uses of plastic pipe. Houses could become more expensive, depending on the prices of cast iron and copper, but probably not enough to significantly affect the demand for housing.

In summary, the alternative of approving only the expanded uses of PB appears to pose fewer environmental risks than does the full proposed project given the state of current information. Because metal systems also pose some unique risks and may be comparable to plastic systems in other risk areas, we are not prepared to say that the no-project alternative or the alternative that would disallow current uses of plastic are environmentally preferable to the partial approval alternative, or even to the full proposed project.

D. Cumulative and Long-Term Implications

Increased use of plastic plumbing pipe can contribute to cumulative environmental impacts in two ways.

First, the sum of the environmental impacts of plastic pipe could be significant even when no one individual impact is deemed significant. In the case of plastic pipe, the most plausible example is for the various leachates that could each contribute to public health impacts. For example, no one leachate might reach the level of 10^{-6} lifetime risk for cancer, but the cumulative risk of all leachates acting together might exceed that level. Given the current uncertainties about the public health impacts, especially those concerning the long-term levels of leachates in drinking water, we are unable to determine whether the cumulative impact is significant. A similar situation is found with worker health impacts, where the risk of one solvent might be insignificant, but that of two or more could be significant. For fire safety, the cumulative impact of all the proposed new uses for plastic pipe are likely to be dominated by the new DWV uses; the contribution of PW pipe is likely to be negligible. The same is true of smoke toxicity, except that the combined affect of HCl, CO, and other toxicants could be significant even when the effects of any one alone were not.

A second issue of cumulative impact is the question of whether the expanded use of plastic water pipe would add to the impacts of other similar actions and in total create a significant effect even though the use of plastic water pipe is not itself significant. We can consider two levels of cumulative impacts:

- Cumulative impact of expanded and existing use of plastic plumbing pipe.
- Contribution of plastic plumbing pipe to total use of plastic products.

As has been made clear earlier, the expanded uses of plastic pipe are in many ways rather small in comparison to existing approved use of plastic pipe. Most new California houses are already being plumbed with ABS DWV if they are not fire-rated; the addition of 10% (by weight) more plastic pipe as PB or (less likely) CPVC water pipe will be of little consequence for fire safety, especially as water piping is less sensitive. The increase for plastic pipe in fire-rated construction, of course, is total since no plastic is being used now; however, if ways of maintaining the rating are developed as required by code, little fire safety impact would be expected. Similarly, the cementing of plastic potable water pipe is probably much less of a problem for workers than the cementing of already approved ABS DWV. Thus, the greatest issue of cumulative impact involves public health impacts, in which plastic in residences can add to plastic in public utility distribution systems. We have no way of estimating the relative contribution of each to the total hazard, as the source of contaminants found in the water supply (control) during leaching tests is not known. We doubt that the combined effects of distribution and residential piping would be significant if neither one alone were, but we cannot rule out that possibility. Similarly, permeation of plastic distribution pipes by toxic substances is more likely than it is for residential piping systems, but the significance of either, in terms of an overall risk assessment, will not be clear for a long time.

With regard to plastics in total, the expanded uses of plastic pipe will be a relatively small contribution in most respects. Plastics are by now endemic in our society. Most of the contaminants of PVC and CPVC that could be public health hazards will be ingested in much greater quantities from other PVC products such as food containers or, in the case of some of the chlorinated methanes, simply from waste products reaching the raw water supply. Those from PB and PE are similar to those from PE food contact materials. If plasticizers do contaminate plastic pipe, they will still do so at much lower levels than they do in any number of plasticized products to which people are regularly exposed, such as flexible vinyl upholstery (where they would yield inhalation rather than ingestion exposures). But equally clearly, plastic pipe does contribute to the total load of plastic-related hazards in California--for example, to the total of all combustible plastics in residences. The hazards from the total use of plastics are undoubtedly appreciable, even though nearly impossible to estimate. Whether or not they are greater or less than the hazards of the materials they replace is perhaps even more difficult to state. About all that can be said is that plastic pipe is not an unusually prominent or special case among plastics in general.

CEQA also requires an assessment of whether long-term environmental costs will be incurred as a result of short-term economic or other benefits. Certainly, any public health impacts of plastic pipe that do occur will probably be delayed for decades, as will some of the worker health or smoke toxicity impacts. However, for the purpose of determining the environmental consequences of the expanded uses of plastic pipe, those should be counted as current impacts, and not discounted in comparison with current benefits. We believe that, when it is viewed from this perspective, this CEQA issue is irrelevant to the decision at hand.

E. Significant Irreversible Changes

CEQA also requires an assessment of environmental changes or consumption of resources that would be permanent and irreversible. For example, the mining of a mountain is an essentially irreversible impact, whereas most air pollutants and their impacts would disappear once the source of pollution is removed.

In the case of the expanded use of plastic plumbing pipe, there would be a small permanent commitment of petroleum resources (but not other energy sources) to the manufacture of the pipe constituents. Total energy resources would be conserved to a slight degree. If any deaths occurred as a result of diseases caused by leachates or occupational exposures, or from fire or smoke toxicity, they would also be irreversible. If plastic pipe were later disapproved, the occurrence of new fatalities would gradually disappear. Some of the leachates from plastic pipe are mutagens and some mutations can be heritable. Thus, it is possible that a heritable--and more likely than not adverse--mutation could persist in the population as a result of drinking from plastic water pipes. Neither the specifics of the leachates in water from plastic pipe nor the overall state of the art of genetic risk assessment allows an evaluation of this possibility at present. If the impacts of plastic pipe eventually were judged unacceptable, it is possible that the metal pipe industry would have declined by that time to the point at which it would prove difficult to revive, but that possibility is also extremely speculative. Overall, we believe that the reversibility of the impacts is not as important an issue to resolve as the magnitude and significance of current impacts.

F. Growth-Inducing Impacts

California's population is projected to increase from the 1980 total of 23.8 million people to 25.9 million by 1985 and to 27.9 million by 1990 (California Department of Finance, 1981). The proposed code change is not likely to significantly affect this forecast population growth for the following reasons. First, the reduction in the cost of housing construction that would result from use of the newly permitted plastics in place of currently approved plumbing materials is so small that it would have virtually no effect on the sales price or rent of dwelling units in the state. Therefore, there will be no change in the demand for housing and consequently no additional in-migration of residents who would be attracted by a drop in the price of housing. Second, the plumbing material substitutions that are likely to result from the proposed code change would not significantly affect employment opportunities in the state and so would not affect the in-migration and out-migration forecasts. Nor would either housing prices or employment opportunities significantly affect shifts in population from one part of California to another.

TR-2-82-17

TOXIC METALS IN DRINKING WATER

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May 1982

PREFACE

Historically, there has been a keen awareness that certain metals play a central role in human disease processes. However, recently the issue of metal-induced adverse health effects has moved into an area of both greater prominence and urgency.

Many of these toxic metals reach humans via the water they drink and arise from leaching of the pipes through which it is transported. Thus, it was felt a review of this topic would be both timely and needed.

We believe this review will serve to focus needed attention on the issue of how toxic metals reach humans via the water they drink and thereafter induce or participate in the induction of a variety of diseases.

We are grateful for the review and comments of this paper by Dr. S. D. Lee of the U.S. Environmental Protection Agency and by Dr. A. Furst of the University of San Francisco.

It has long been recognized that metals play a central role in the cause or aggravation of a variety of diseases **(Ref. 3)**. This situation has posed some perplexing paradoxes. Many metals are essential to good health and a deficiency state is to be avoided. However, under certain circumstances, an overabundance of certain metals causes disease. As more and more information has accumulated that positively relates metals to human diseases, intense interest has been focused on the sources of these metals in the environment and on how they reach man.

It is now known that human intake of metals occurs from exposure to a variety of sources: food, air, soil and drugs. Another very important and readily available source is drinking water. This fact has been recognized by the EPA who has promulgated drinking water standards for several metals known to be harmful (Table #1).

Drinking water and the source of the metals it contains are the subject of this report.

Metals enter drinking water from a variety of sources, some natural and some man-made. Natural sources include simple dissolving of minerals from the earth through which the water percolates or over which it flows. Some metals arise from fallout of windblown dust. Man-made sources include industrial waste discharge into water along with emissions from automobiles or power plants. Another very important means by which metals enter water is by leaching from the surface and joints of pipes used for potable water distribution. It is well documented **(Ref. 5,6,7)** that metals leach into water from a variety of metal pipes (lead, copper or galvanized).

For the purpose of this discussion we will focus on several toxic metals which are found in drinking water and which leach from the pipes through which the water is transported. We will examine factors that contribute to this leaching and diseases the metals cause.

The potential problem is by no means small, since most dwelling units in the United States are supplied with water through metal pipes. These materials have long been and remain the standard of the plumbing industry. Indeed, most plumbing codes, including that of the State of California, still permit the use of lead pipe in addition to copper joined with lead or tin solder and galvanized (zinc coated) steel pipe.

LEAD

The first example of a harmful metal which reaches man via drinking water is lead. It is estimated that 10-15% of daily human lead intake is via drinking water **(Ref. 12).**

Therefore the U.S. EPA under the Safe Drinking Water Act, has established a Maximum Contaminant Level for lead of 0.05 mg/liter or 50ppb (parts per billion)(see Table #1).

This is a worthwhile effort and merits continued concern. However, based on a large number of surveys it has been established that a high percentage of the water-borne lead we drink comes from the metal pipes through which the water is commonly transported to and within the residence.

For example, in a recent study by the Carroll County Health Department in Maryland, lead in tap water within homes was measured. Lead concentrations were shown to exceed the Maximum Contaminant Level 24% of the time (see Table #2, **reference therein).** Measurements of the water entering the plumbing system showed little or no lead. In each home studied the drinking water was carried through copper tubing joined with lead solder. This evidence clearly implicates the in-house copper plumbing as the source. Other studies confirm this finding **(Ref. 4,5,6,7).** No matter what restrictions are placed on the quality of water supplied by a public utility, human beings will still be at risk if they live in homes with metal plumbing.

Evidence suggests this problem of lead solubility is linked to both the pH (acidity or alkalinity) of the water as well as the level of other minerals it contains (see for example the Seattle EPA Study). Acidic water, which is low in minerals, causes more lead to leach out of pipe and joints. This is not surprising inasmuch as it has been long known that waters that are so constituted are by nature highly corrosive and over a period of time will destroy a metal plumbing system. Unfortunately, such waters are widely distributed throughout the U.S.

What, then, can be said of the consequences of this dissolved lead and human disease? In a phrase, too much and none of it good. The list of diseases and symptoms which have been associated with ingestion of lead is long and we will not document each individual reported study here **(see Bibliography for a list of references).**

Suffice it to state that lead adversely affects almost every aspect of human physiology. It is neurotoxic **(Ref. 7,8,12)**, i.e., it causes both pathologic and distinct and degenerative changes in the nervous system. The pathologic changes range from headaches through memory loss and delirium to death. Subtle changes including mental retardation and other behavioral changes, are is particularly noted in minority group children **(Ref. 8,12)** living in the inner city commonly classified as ghettos.

Lead is hemotoxic causing a shortened life span of red blood cells, alteration of hemoglobin, and interference with normal blood oxygen transport **(Ref. 12)**. Additionally, lead has been implicated as a cause of adverse reproductive effects. Miscarriages, premature membrane rupture and preterm infants have all been tied to lead intoxication **(Ref. 12)**.

Recent data from animal studies suggest that lead contributes to or causes excess renal tumors establishing that it has carcinogenic or mutagenic properties **(Ref. 13)**. The U.S. EPA Carcinogen Assessment Group (CAG) has recommended that the Maximum Contaminant Level in drinking water be reduced from 50 to 25ppb because of its suspect carcinogen status. If the carcinogenity of lead is further substantiated then truly this adds another dimension to public health concern.

Clearly, lead is a "bad actor" and its presence in potable water can be traced in part to the combination of metal plumbing systems (copper or lead) and common water characteristics.

CADMIUM

Conditions which favor lead leaching from pipes and joints also favor leaching of cadmium and copper. For cadmium, the EPA (Table #1) has recommended a drinking water standard of 0.01 mg/liter (10ppb). In man, drinking water is the source of 10% of daily cadmium intake and once again metal plumbing is implicated. As we shall discuss, cadmium leaching is commonly associated with both galvanized and copper pipe **(Ref. 5,9)**. Cadmium is a common impurity in the zinc used to galvanize steel pipe.

Like lead, cadmium adversely affects a broad spectrum of human physiological processes. Symptoms of cadmium intoxication range from acute poisoning to more long-term damage to the liver and kidneys **(Ref. 14)**.

Attention to the role of cadmium in human disease traces its origins to Japan wherein a peculiar disease known as Itai-itai was first described over a decade ago by Tsuchiya **(Ref. 11).** This disease has one outstanding characteristic: proteinuria (protein in the urine). This symptom is now known to be secondary to destruction of kidney tubules essential to their proper function. Also, cadmium has been linked to hypertension and increased cardiovascular disease **(Ref. 2,3,9).**

To make matters worse, it can now be shown that the adverse health effects from cadmium are additive with those from lead. This further compounds the problem since the same water quality factors promote leaching of both metals from metallic plumbing systems **(Ref. 15).**

Most disturbing is the recent finding that cadmium also produces adverse effects on the reproductive system **(Ref. 14).** This metal has been shown to be spermatotoxic (kills sperm) and fetotoxic (toxic to the growing fetus) **(Ref. 14,16).** As a result, cadmium intoxication has now been directly linked to increased mortality of the newborn **(Ref. 16).**

Limited data also suggests a role for cadmium in carcinogenesis, however this role is not yet firmly established nor clearly defined.

Thus, even acting alone, cadmium can be considered to be a very serious environmental toxin. This fact coupled to the finding that its actions are often additive to an equally serious toxin such as lead should serve to further heighten public health concern.

Because the presence of both lead and cadmium in drinking water is increased by corrosive water, the public health problems they pose are significant on both a national and global scale. In the U.S., aggressive water is most commonly found on the East Coast and in the vast area west of the Sierras. Fortunately, less aggressive water is generally found in the Intermountain areas where rainfall is sparse and wells are deep. However, a quick review of the population distribution in the U.S. reveals that high population density and corrosive water are, more often than not, synonymous.

COPPER

In contrast to cadmium and lead, copper presents a more complex picture. Copper is essential to life and for years the primary focus of concern has been on alleviation of a deficiency state rather than on its toxicity per se. Recently, however, this emphasis has begun to shift. Currently, the U.S. EPA Drinking Water Standard for Copper is 1mg/liter or 1000ppb. However, this is based on the levels required to avoid a bad taste or smell (organoleptic) rather than on a recognized health effect. Despite this current status, increasing evidence is accumulating which implicates excess copper in the cause or aggravation of disease.

Regarding toxicity, for example, early reports have now been confirmed which link copper to hemolysis (red cell damage) and mental disturbances (schizophrenia) **(Ref. 17,18).** Interestingly, copper related diseases seem to have a predilection for the young (infants), chronically ill or genetically predisposed humans **(Ref. 18,19).**

There have been reports of infant illness (poisoning, prostration, edema, lung damage) and death which have occurred as a result of copper accumulation in drinking water. In one case the level implicated was 0.8mg/liter or 800ppb, which is less than the current Drinking Water Standard **(Ref. 20).** In addition, kidney disease patients on dialysis, who have been inadvertently intoxicated by copper-laden water, have experienced red cell damage and varying degrees of mental disorientation including psychosis **(Ref. 20).**

In other subjects, nausea, diarrhea and jaundice have been observed secondary to copper intoxication, **(Ref. 20).** In a pattern of consistency, excess copper has been linked to hemolysis (red cell rupture) in a group of patients suffering from a disease which is characterized by a genetic deficiency of a red cell enzyme called Glucose-6-phosphate dehydrogenase **(Ref. 19).** This enzyme is essential to proper energy metabolism and cell life and its deficiency predisposes the cell to early death and damage.

Thus, copper intoxication, like lead and cadmium intoxication clearly can lead to illness and death.

Finally, and most important for our purposes, evidence suggests that the increased use of copper pipe in the last 20 years is implicated in the growing problem of zinc deficiency which we are now observing **(Ref. 7,21)**. It has been suggested that the excess copper we receive from the attack of aggressive water on copper pipes retards the uptake of zinc from the food we eat. This retardation causes a metabolic imbalance that seriously affects a variety of cellular and organ processes. The particular effects of zinc deficiency are dwarfism, circulatory abnormalities, and a loss of the sense of taste **(Ref. 22)**.

Recently, a survey of copper and cadmium in water has been made from a variety of sources and transported through several types of pipe. These data which are derived from a report by H.A. Schroeder, are summarized in Table 3. As can be seen, transporting water through copper or galvanzied pipe can cause a significant rise in the level of either cadmium or copper or both. The potential health effects of such leaching, as noted above, can be extremely serious.

OTHER METALS

The story by no means ends with lead, cadmium and copper, for indeed other metals play a role in disease. Certain chemical forms of nickel play a role in carcinogenesis **(Ref. 23)**, while chromium is both toxic and a suspect carcinogen **(Ref. 24)**. Even iron, which like copper is essential, has been shown, in excess, to interact with copper to contribute to psychotic disturbances such as schizophrenia **(Ref. 25)**. Recently, excess iron has also been linked to a greater incidence of heart disease in both men and postmenopausal women **(Ref. 10)**.

Given these facts it is not surprising that public concern over these long ignored hazards of metals has recently heightened. Indeed, public health bodies, such as the American Medical Association and the U.S. EPA, have recently expressed concern over the leaching of toxic metals into potable water from various metal pipes **(Ref. 3,13,20)**. Nevertheless, metal piping continues to be the "standard" in most plumbing codes.

This is due to the fact that the scientific findings, however frightening, must be balanced against one immutable reality: humans must drink water to survive. Yet another reality is that only a select few individuals can obtain this water from crystal clear springs high in a pristine forest. Most humans must, at some point, turn on the tap to obtain water for drinking, as well as for cooking and bathing. Consequently, a means of transporting water to man is needed. Given these circumstances a clear question emerges. Is poisoning by heavy metals leaching into drinking water from the metal pipes that transport it, a necessary consequence of urbanization with which humans must live or is it a problem society can solve?

SUMMARY

It is our belief that the problem need not be tolerated and, in fact, that the solution has been at hand for several years. The facts we have marshalled in this brief paper from a host of sources, lead clearly to the following conclusions:

1. Metals in drinking water are proven culprits in disease and death.

2. The diseases they cause run the gamut from nausea and birth defects through psychosis to cancer.

3. Metal piping systems, including those made of copper and galvanized steel, are a primary cause of human exposure to these toxic agents.

4. The problem posed by metal pipes will not disappear easily for they result from the natural properties of water and metals themselves.

5. If metal pipe is used, water contamination by toxic metals leached from the pipe is virtually certain. As always, hypothetical risks must be weighed against those which are certain, quantifiable and preventable. Preference must always be given to the elimination of known risks such as those posed by metal pipe since this is the only sound public health posture.

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TABLE 1

NATIONAL PRIMARY DRINKING WATER REGULATIONS
(Metal Contaminants)

Contaminant	Maximum Contaminant Level (mg/l)*
Arsenic	0.05
Barium	1.0
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.0
Selenium	0.01
Silver	0.05

*1mg/ℓ (milligram per liter) is the equivalent concentration of one part per million, or about one teaspoon in 1300 gallons of water.