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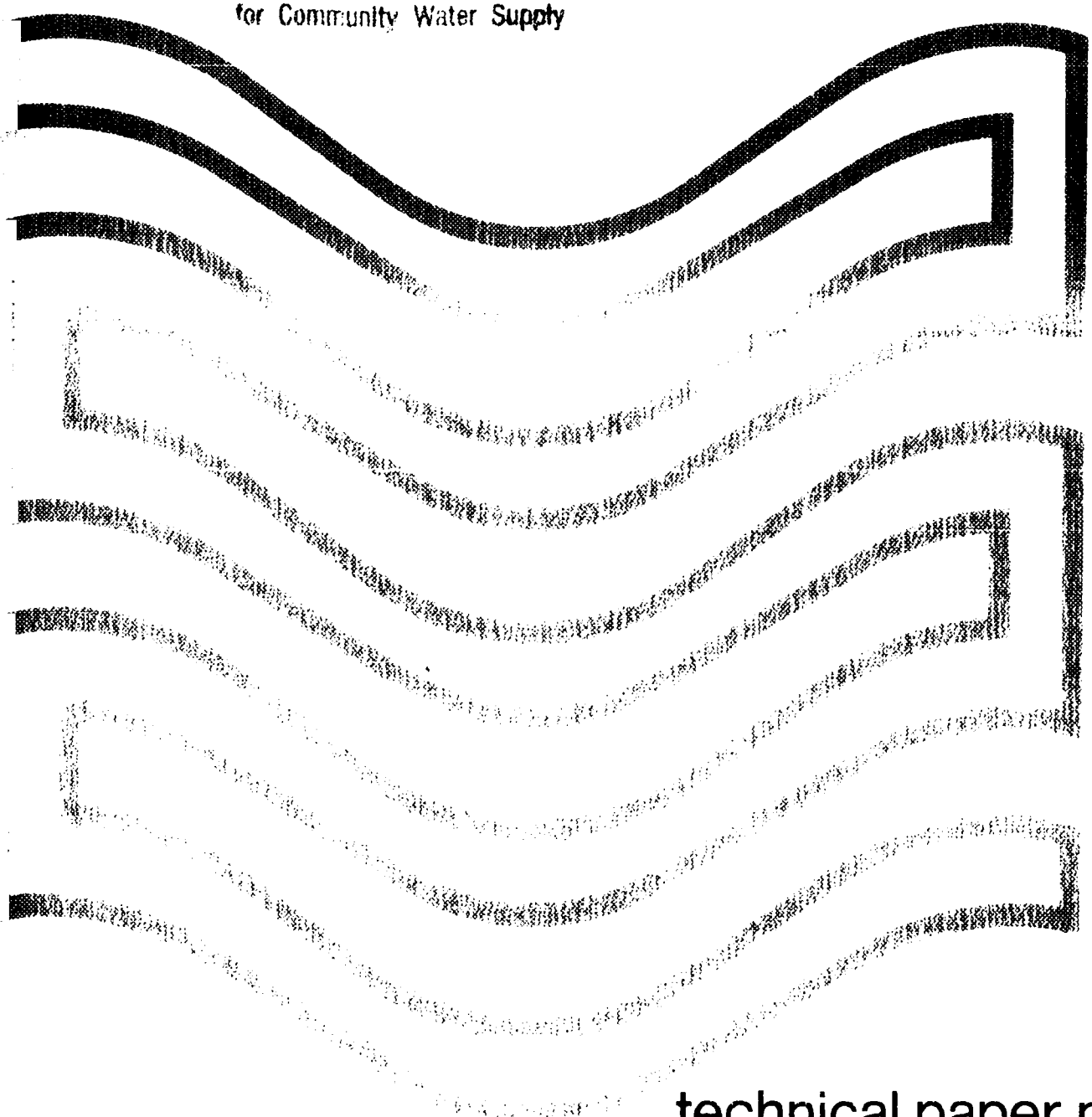
plastic pipe in drinking water distribution practice



technical paper no. 1

WHO INTERNATIONAL REFERENCE CENTRE FOR COMMUNITY WATER SUPPLY

TECHNICAL PAPER NO. 1

PLASTIC PIPE

IN DRINKING WATER DISTRIBUTION PRACTICE

(Introduction and bibliography up to 1970)

June 1971

The Hague - The Netherlands

Introduction

One of the tasks of the W.H.O. International Reference Centre for Community Water Supply is to stimulate and co-ordinate research and development in community water supply.
In the initial years of its activity in research co-ordination, among other subjects, IRC has taken up the study on water distribution systems, and within this subject the study on plastic pipe in drinking water distribution practice.

The aim of this Technical Paper is to introduce the subject and to initiate the collection of data with the following objectives:

1. To gain and collect full information on the present knowledge of production, performance, standards, specifications and test methods of plastic pressure pipes.
2. To serve and disseminate information on plastic pipe in water distribution systems.
3. To collect and produce guidelines on design, installation, operation and maintenance of drinking water distribution systems.

A bibliography of plastic pipe in drinking water distribution practice has been added to this paper, in order to serve as a guide to literature on application and development.
It is intended to cover papers published during the period 1951 - 1970.

This paper has been prepared in co-operation between IRC and the Testing and Research Institute of the Netherlands Waterundertakings KIWA Ltd.

PLASTIC PIPE IN DRINKING WATER DISTRIBUTION PRACTICE.

The major share of capital investment in water works has been in distribution networks. In many cases of community water supplies the cost of distribution pipe system is higher than 60 per cent of the total cost of water works.
Considerable research shall be devoted to reduce the cost of installation of water distribution pipe systems in order to assist governments and national agencies responsible for drinking water supply in supplying as quickly as possible the maximum number of people with safe piped water.
There are several kinds of pipe commonly used in drinking water distribution service, the most important are:

- cast iron pipe;
- steel pipe;
- asbestos-cement pipe;
- concrete pipe;
- plastic pipe.

Several types of joints are available for each kind of pipe material. The practice in the application of the different kinds of pipes and type of joints available for use in water distribution systems varies according to the actual local engineering experience, and local conditions, especially soil conditions. The choice of pipe material, the type of joints to be used for a particular water distribution system can be determined only after making a complete analysis of all factors peculiar to the site where the installation is to be made.
Basic thermoplastics used for the manufacture of plastic pipes for water transmission and distribution are:

- unplasticized polyvinyl chloride (uPVC);
- low density and high density polythylene (LD-PE and HD-PE);
- acrylonitrile-butadiene-styrene (ABS);
- cellulose-acetate-butyrate (CAB).

The two last ones have only been used in the USA.
Other plastic materials (thermoplastics but also reinforced plastics) are also used for the production of pipes, but are still too costly to be used for the conveyance of drinking water.

Plastic pressure pipes are produced in sizes ranging up to about 600 mm, pressureless and low-pressure pipes even in still larger diameters. As at present pipes of PVC and PE are only to be considered for the appliance in water distribution systems, we will confine ourselves to these two types.
To the background of this application pipes and fittings of these materials have the following advantages.

1. Excellent resistance to corrosive water and corrosive soils.
2. Bacteriological inertness.
3. Low thermal conductivity.
4. Extreme lightness.
5. Flexibility.
6. Smooth internal surface.
7. Very low water absorption.
8. Availability in longer lengths.
9. Good workability.

Because of these characteristics plastic pipes have good hydraulic (flow) properties, they are corrosion proof, they require no protective coatings, they are easy in handling, laying and installation, and have been evaluated as a suitable material for the use in dinking water distribution systems. Nevertheless to avoid difficulties it is necessary that installing of the pipe materials is carried out by people who are specialized in this work.

The drawbacks to the use of PVC- and PE- pipes are the following:

1. Temperature sensitivity, e.g. the mechanical strength diminishes with the increase of the temperature.
2. Relatively high thermal expansion.
3. Sensitivity to light (ultraviolet light) and weather (weatherability).
4. Sensitivity to notches, particularly PVC-pipes.
5. Impact strength of PVC diminishes by decrease of temperature.
6. Diffusion of odorants and other very volatile gasses through the wall of PE- pipes.
7. Sensitivity to organic solvents as ketones, ethers and chlorinated hydrocarbons.
8. Detrimental effect of the plastics to the water.

As to the above mentioned points, the following may be remarked.
Due to the diminution of mechanical strength with an increase of temperature, the admissible internal pressure has to be reduced if the

temperature increases above 25°C. By temperature above 45°C, both types of plastic pipes cannot be used for pressure pipes.
If PVC-pipes are installed at temperature near or below 0°C they are more or less brittle and therefore shall be handled carefully. By back filling, care shall be taken that the back filling does not contain sharp stones or other objects.
Connected with the sensitivity to notches, it is essential to avoid that the pipes are injured by severe scratches and scrapes during transport and installing.
If the temperature of the pipes can fluctuate considerably, it is necessary to take measurements by installing expansion joints or return bends.
The weatherability means that the properties of both types of pipes can deteriorate more or less if they are subjected to outdoor exposure.
So the resistance to the weatherability can be increased by special measurements, e.g. adding of carbon black to PE, it must be recommended not to install these pipes in the open air.
Pipes of PE shall not be installed in soils smelling of gas (e.g. due to leaky gas-pipes), morass gas (e.g. the bottom of pools with rotting leaves) or in the neighbourhood of petrol stations. Diffusion of odorants and other very volatile gasses, like morass gas, through the wall of PE - pipes causes the result that the water out of PE - pipes will taste of these gasses as it has stayed shorter or longer time in the pipes and the environment contains such gasses.
So PVC and PE by themselves are not detrimental to health, additives necessary for the manufacturing are used, e.g. stabilizers and lubricants for PVC and anti-oxydizers for PE, which may be toxic.
A plastic usually contains small quantities of subsidiary ingredients, such as:

- stabilizers to lower surface tension and to act as emulsifiers or emulsifying aids;
- plasticizers to modify the properties of the binder;
- fillers to give body and strenght to the material;
- lubricants to reduce the adherence of the plastic to the extrusion tools while the pipes are extruded;
- pigments to give colour to the plastic and to prevent deleterious effects of light penetrations;
- anti-oxydizers to protect the plastic from the oxidation;
- accelerators to aid in the vulcanization of material.

The most efficient stabilizers which use in the production of unplasticized polyvinyl chloride pipe is essential, have toxic properties. The uPVC pipes with the best stress characteristics are obtained by stabilizing with lead compounds, and the lead stabilizers are in common use in manufacture of uPVC pipes. It has been ascertained by investigations that small quantities of lead dissolve from the new leadstabilized uPVC pipes into the water. The amounts of lead leached out by the water from the wall of the pipe are very small in comparison to the total lead content of the pipe; and the majority of the lead is given off in the first two days of service.
The potential health hazard connected with the toxic stabilizers of PVC pipes has been known since the first days of the use of PVC pipes in water supply practice. However, such stabilizers are used on the terms that the quantities dissolved must be smaller than the maximum quantities permitted in the drinking water standards. This is examined by using various test methods.

As the use of plastic pipes has grown, the need for standards on plastic pipes has become apparent. Several dimensional and performance standards, test specifications and technical regulations on plastic pipes for conveyance of drinking water have been established in a number of countries. In these standards special attention is given to the effect of the additives on the quality of the water that is delivered to the consumers by these pipes.
Reports from studies and investigations indicated that:

- the raw materials PVC and PE are non-toxic;
- the additives to PVC does not effect colour, odour or taste of the water passing or stagnant in the pipes;
- some types of carbon black added to PE may effect the odour and taste of the water;
- there is no effect of PVC-and PE-pipes on chlorine-bearing water;
- there is no significant difference in bacterial counts of water from traditional materials and from PVC- and PE- pipes;
- PVC-and PE-pipes can be disinfected satisfactorily;
- the properties of PVC-and PE-pipes can be effected by some chemicals, special caution is required when PVC- pipes can come into touch i.a. with petrol, organic solvents as ketones, ethers and hydrocarbons and in case of PE-pipes when they can come into contact i.a. with hydrocarbons;

- due to the stabilizers water that has been stagnant in PVC can be toxic, as already has been told.

The last point demands special attention.
It is necessary that the production of the different manufacturers of PVC-water pipes shall be controlled regularly on the transmission of toxic substances to the water according to a for this purpose specified method.

More and more community water supplies are using plastic pipes for distribution mains, service connections, in water treatment plants and water wells. Plastic pipes and fittings are also used to a certain extent in domestic cold water plumbing installations.
In high developed countries the use of PVC- and PE-pipes have the drawback that they cannot be used for the transport of hot water. As in those countries nearly every dwelling has a hot water system, it is necessary to use metal pipe for the hot-water supply system. As for the domestic system it is preferred to have one material, the whole installations generally are carried out in copper. Furthermore the connection of PVC-pipes to stopcock, water-tap, and other sorts of apparatuses was till now rather complicated. The last time new, better methods are developed.
In particular the developing countries should be interested in plastic pipe.
It is generally known that the present status of community water supply in developing countries is more or less critical. There is acute need of improvement of drinking water supply in these countries. More than $ 9 milliard will need to be invested during the second UN Development Decade (1971-1980) to bring to people of developing countries an improved supply of drinking water.
The broad application of plastic pipes can allow to reduce dependence on metal pipes which prices tend to escalate, while the price of PVC- and PE-pipes have constantly decreased since the beginning of the application. Intensive research has been carried on in the field of plastics. Plastic materials show a great deal of promise. PE and PVC are relatively cheap, but some of the other ones among which there are with very good properties are costly because of comparatively low present production volume. Better resistance to weathering, increase of working and long-term stress levels, are requirements for continued progress in the

development of water plastic pipes.

IRC has initiated a study on plastic pipes in drinking water distribution practice with the objectives as follows:

1. To gain and collect full information on the present knowledge of production, performance, standards, specifications and test methods of plastic pressure pipes.
2. To serve and disseminate information on plastic pipe in water distribution systems.
3. To produce guidelines on design, installation, operation and maintenance of drinking water distribution systems.

IRC requests information from any institution which has gained experience, and is or was involved in problems of water plastic pipes, and would be most grateful if such information could be communicated to the

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