

## Information and Guidance Note

## UNPLASTICISED PVC PIPES AND FITTINGS

## 1. INTRODUCTION

Polyvinyl Chloride (PVC) is one of the most versatile of the thermoplastics materials known. It can be produced as a rigid, horn-like material, such as is used in pipes and known as unplasticised PVC (uPVC or PVC-U), or made flexible and rubber-like by the addition of plasticisers for such applications as garden hosepipes and leather cloth. It is in its unplasticised form that the material has been found to have the appropriate combination of properties for use as a pipe for both pressure and gravity uses.

PVC was first used in the manufacture of pipe in Germany in the middle 1930s as a substitute for steel. However, its technical capability as a pipe material for the Water Industry in the United Kingdom did not start to develop until the late 1950s. The first British Standard for uPVC pipes was published in 1962 as BS 3505, covering pressure applications for water mains and services, and this was followed almost immediately by BS 3506 covering uPVC pipes for industrial purposes.

## 2. APPLICATIONS

## 2.1 Water

BS 3505 covers sizes from  $\frac{3}{8}$  to 24 inch nominal diameter range, although the major use for mains comes within the 3 to 12 inch range. uPVC has also been used to a limited extent for service pipes (including internal cold water plumbing) in the range  $\frac{3}{8}$  to 2 inch diameter. uPVC pipes are not suitable for use in domestic hot water systems. Reference should be made to the manufacturer for the operation of uPVC pipes at temperatures over 20°C up to a maximum of 60°C. They are used in pumping mains but guidance on this aspect is under review. Further guidance is given in WRc's "Selection of pipeline materials for mains renewal and replacement applications".

**NOTE.** A British Standard is in the course of preparation covering thermoplastics pipes and fittings for hot and cold water use in buildings.

## 2.2 Underground drainage pipes

This definition normally applies to domestic drainage pipes up to 160mm (6"), for use in the construction of both foul and surface water drains, and uPVC is generally suitable for this purpose. uPVC is also one of the materials used for the manufacture of slotted light duty subsoil drainage pipes for agricultural use. French drains may be made by slotting pipes made to specifications BS 3505, BS 3506, BS 4660, BS 4962 or BS 5481.

## 2.3 Sewers

uPVC pipes are used for gravity sewers in sizes from 160mm (6") to 630mm (25") diameter (mainly to BS 5481). uPVC pipes to BS 3505 and BS 3506 are used for pressure rising mains, although care must be exercised in design to avoid the generation of excessive surge pressures in the pipeline. Reference to the British Standard Code of Practice CP 312: Parts 1 and 2 will be found to be useful in these circumstances, which also applies to pumped water mains.

## 3. REQUIRED PROPERTIES

uPVC pipes and fittings have the following range of properties which makes them appropriate for use in conveying water and effluents:

## 3.1 Water Mains

- Have adequate structural strength to withstand internal water pressure alone or combined internal pressure and external loads when adequately supported by backfill and bedding;
- Are highly resistant to corrosion;
- Do not support bacteriological and biological growth;
- Do not impart taste or odour;
- Are resistant to permeation by oil and gas; however, uPVC is not recommended for use in ground known to be contaminated;
- Have smooth internal walls to minimise hydraulic resistance;
- Are easy to joint.

## 3.2 Sewer rising mains

As points (a), (b), (f) and (g) above, together with:

- Are chemically resistant to the range of materials likely to be discharged into a drain or sewer.

**NOTE.** Certain organic solvents will soften uPVC and these may be checked in Part 1 of CP 312.

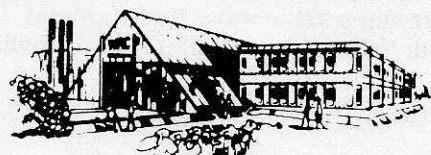
## 3.3 Gravity sewers and drains

As points (b), (f), (g) and (h) above, together with:

- Have adequate structural strength to withstand external loadings with appropriate support from the bedding and backfill.

## 4. DIMENSIONS

The diameters of uPVC pressure pipes were based on the well established steel pipe outside diameters, otherwise known as the British Standard Pipethread (BSP) diameters. These were published internationally as ISO Recommendation R330: 1963, (since



reissued as International Standard ISO 161/2) and, nationally, as Table 1 of BS 3867. BS 3867 although withdrawn in 1983, has been proposed for reissue sometime during 1987.

A further series of standard outside diameters, based on a system of preferred numbers, was also established almost 30 years ago, as ISO Recommendation R161, "Thermoplastics pipe for the transport of fluids — nominal outside diameters and nominal pressures — Part I (metric series)", and has since been revised and published as International Standard ISO 161/1. These "metric" dimensions have been published in BS 5556.

The outside diameters of uPVC pipes for pressure use conforming to BS 3505 and BS 3506 are in accordance with ISO 161/2, and are manufactured in a series of wall thicknesses to provide a number of different pressure ratings (see clause 5). It should be pointed out that the previous issue of this Information and Guidance Note made reference to the possible adoption of "metric" diameters from BS 5556 for uPVC pressure pipes. However, owing to the major cost implications for the producers of these products, this proposal has been abandoned for the time being.

uPVC gravity drains and sewers manufactured to the requirements of BS 4660 and BS 5481 respectively, are based on the metric series of outside diameters covered by BS 5556 and ISO 161/1.

## 5. BRITISH STANDARD CLASSIFICATION/ WATER INDUSTRY SPECIFICATION

### 5.1 Water mains

**Pipes conforming to BS 3505** — Although the 1968 version of this standard was confirmed in 1982, it has since undergone a major review and amendments have been put forward in order to bring the performance of uPVC pipe in line with the findings of research projects carried out over the last few years; it is expected to be published by the end of 1986.

Meanwhile, Information and Guidance Note No. 4-31-04, which was issued whilst BS 3505 was still under revision, includes the more stringent and searching requirements which are to be included in the revision. Special arrangements were made with the BSI Quality Assurance Service to extend the existing Kitemark scheme to include the requirements of IGN No. 4-31-04. This will allow the new scheme to operate immediately the revised BS 3505 is published when it will become the lead specification again. However, during 1987, users can expect to receive quality assured pipe conforming to the (identical) requirements of IGN No. 4-31-04 and marked as indicated therein.

Although BS 3506 is almost identical to BS 3505: 1968 in respect of general technical performance, BS 3506 is not appropriate for use in conveying potable water, as it does not contain a requirement for effect on water quality.

uPVC pipes for water mains and services have previously been produced in a mid to dark grey colour for all sizes. However, pipes of size 2 and below should now be coloured blue when used for carrying potable water below ground, in accordance with National Joint Utilities Group Publication No. 4.

Pipes conform to a common series of outside diameters for each size over the range of classes, thus an increase in pressure rating (and the consequent increase in wall thickness) is accompanied by a reduction in the bore of the pipe for any particular nominal size. uPVC pipes are required to be indelibly marked according to class with the colour code shown below, and must include the identification of the manufacturer as a clear text or logo, the BS number, and the size and class, at intervals along the pipe not exceeding 1 metre.

9 bar	—	Class C	Blue
12 bar	—	Class D	Green
15 bar	—	Class E	Brown

Not all sizes are available in each class.

**NOTE.** Class B pipes are no longer available.

**Joints and fittings complying with BS 4346** — This specification is written in three parts, and covers the means of providing complementary joints and fittings for use with uPVC pressure pipe made to the requirements of BS 3505 and BS3506.

- (i) BS 4346: Part 1 covers the requirements for uPVC injection moulded fittings with plain sockets for solvent welding (sometimes referred to as solvent cementing).
- (ii) BS 4346: Part 2 covers mechanical joints and fittings, and includes sockets which are thermoformed at the end of the pipe into what are more commonly called "push-fit" sockets. All these fittings are required to meet the "effect on water" clause, which thus makes them suitable for use with pipes made to either BS 3505 or BS 3506.
- (iii) BS 4346: Part 3 covers the requirements for solvent cements used for jointing uPVC pressure and non-pressure pipes and fittings. This material is normally supplied in hermetically sealed tins, and has a shelf life of at least 12 months.

Although there are no specific limitations of use in the above listed standards, WRc considers that the use of solvent weld jointing techniques should be restricted to pre-assembly in the clean dry environment of a factory.

It is a common practice for producers of injection moulded uPVC fittings to make them in only a single pressure class, which normally covers the highest class rating (15 bar), although as sizes become larger this is not always technically possible. In these circumstances it is strongly recommended that special attention be given when purchasing fittings greater than nominal size 4 (100mm), that the stated rating of the fitting is suitable for the pipe with which it is going to be used.

Fittings made to the requirements of BS 4346: Part 1 are to be marked (normally by means of an embossed mark in the mould) to show the manufacturer's name or identification, and the size and class of BS 3505 to which the pressure rating of the fitting corresponds.

A range of metallic fittings is produced by some manufacturers for use with uPVC pipes in the water mains sizes, and these are often available with a plastics coating of PVC, nylon or epoxy resin. These fittings will be found necessary at points in the water

main which are subject to high stresses, such as valve hydrants. All coatings should be listed by the UK Water Fittings Byelaws Scheme.

## 5.2 Sewers

**Components conforming to BS 4660** — This specification covers uPVC pipes and fittings in sizes 110mm and 160mm, and which are suitable for domestic sewerage and surface water discharging under gravity. This standard does not apply to installations conveying prolonged discharges at temperatures approaching that of boiling water, such as may be found in laundries or industrial kitchens, nor the conveying of liquids under pressure. Pipes and fittings are golden brown in colour, and are clearly marked to show the identification of the manufacturer, the BS number and the nominal size.

A number of manufacturers now produce a variety of inspection chambers, chamber bases and access systems for use with components complying with BS 4660, and until the availability of a British Standard to cover these items, many of them have been assessed by the British Board of Agreement for suitability of fitness for purpose, resulting in the issue of appropriate certificates.

**Components conforming to BS 5481** — This specification covers uPVC pipes and fittings in sizes from 200mm up to 630mm, and are suitable for the conveyance of surface water, domestic sewage and other effluent which is permitted to be discharged into public sewers. Pipes conforming to this standard may be used to convey untreated trade waste or discharges not exceeding 50°C. Reference should be made to CP312: Part 1 and the manufacturer concerning the suitability of the material for the intended purpose.

**NOTE.** Pipes and fittings conforming to BS 4660 and BS 5481 are not suitable for use as rising mains. Pipes conforming to BS 3505 or BS 3506 may be taken into account where pressure conditions apply (see below).

**Pipes conforming to BS 3506** — uPVC pipes to this specification are available in sizes up to 24" diameter (600mm) and may be considered for use as sewage pumping mains. The performance is very much in line with that of BS 3505:1968 but until BS 3506 is revised to incorporate the new requirements of IGN No. 4-31-04/revised BS 3505, pipes to BS 3506 may not be of equivalent quality. Pipes made in accordance with BS 3506 are classified to suit various working pressures, and are marked in colour as follows:

Non-pressure	— Class 0	White
6 bar	— Class B	Red
9 bar	— Class C	Blue
12 bar	— Class D	Green
15 bar	— Class E	Brown
For use with pipes sizes 1/4" to 2" inclusive	— Class 6	} Brown
Pressure ratings vary with size	— Class 7	

Specific recommendations concerning the use of uPVC pipes as rising mains are currently under review, and would be expected to be incorporated into CP 312: Part 2 which is planned to become part of BS 5955. Pending the completion of this review, it is recommended that caution should be exercised when considering the use of uPVC in circumstances where surge may occur, and that alternative materials should be selected in cases of doubt.

Class 0 pipes are not intended for use buried below ground and 6 bar/Class B pipes should not be used if negative pressures are liable to be generated.

## 5.3 General

**Water mains and sewers** — Elastomeric sealing rings used for jointing shall comply with BS 2494, which has recently been revised, and contains the Water Industry's requirements for "effect on water" for rings used in contact with potable water (designated "Type W"). Rings for use in drainage applications are designated "Type D". Useful additional information on this subject is also given in **IGN No. 4-40-01**.

It is considered essential to purchase all pipes and fittings referred to in this Information and Guidance Note from manufacturers who operate a quality system in accordance with the appropriate parts of BS 5750, and carry out the necessary schedule of testing to ensure compliance with the various specifications. Lists of such manufacturers are available from accredited certification bodies, for example the Quality Assurance Service of BSI, PO Box 375, Milton Keynes MK14 6LL.

## 6. BRITISH STANDARD TESTS

Some of the more important tests incorporated into the various standards are as follows:

BS 3505 — Dimensional control of wall thickness (revised/ and outside diameter.

IGN No. — Effect on water quality.

4-31-04) — Fracture toughness test.

— Short and long term hydrostatic tests.

The data obtained in these tests are used in the preparation of regression graphs for predicting the long term performance of the pipe.

— Falling weight impact strength.

— Heat reversion test.

BS 3506 — Generally as above but without requirements for effect on water quality, fracture toughness test or extended hydrostatic test requirements.

BS 4346 — Dimensional checks.

— Effect on water.

— Short and long term hydrostatic tests.

— Stress relief test.

— Negative pressure test.

- BS 4660 — Dimensional checks.  
— Heat reversion test (pipes).  
— Stress relief test (fittings).  
— Elevated temperature cycling test.  
— Falling weight impact test.

- BS 4962 — Dimensional checks.  
— Long term stiffness under load.  
— Flexibility test.  
— Impact test.

- BS 5481 — As BS 4660 but with a hydrostatic pressure test at 60°C instead of the "Elevated temperature cycling test".

The above list is not intended to be exhaustive, and includes quality control, performance and type tests.

## 7. JOINTING METHODS

**uPVC pressure pipes** — The recommended method of jointing uPVC pipe utilises some form of elastomeric sealing ring or gasket, and this may be fitted into a socket integral with the pipe or as a separate fitting. The requirements for "push-fit" joints for use with uPVC pipes are covered by BS 4346: Part 2.

The "push-fit" type of joint is used widely for water mains, because it is simple to carry out, and jointing is both rapid and reliable. Larger pipes cannot be joined using hand pressure and the procedure recommended by the manufacturer should be used. The most recent developments in ring design for uPVC pressure pipes, sometimes referred to as "locked-in" rings, which are intended to overcome some of the problems of ring displacement experienced in some earlier designs of joint.

In the case of conventional "push-fit" joints, limited ground movement is accommodated, but the pipes require the provision of properly designed thrust blocks at changes in direction and at tee-junctions in order to resist the force imposed by the internal hydrostatic pressure. As well as integral joints for the connection of successive lengths of pipe, socketed fittings and adaptors utilising the same joint rings are also available. Loose collars or slip couplers are used for providing connections, particularly where a new pipe or fitting is incorporated into an existing water main. Such collars may be made from either uPVC or metal. Joints with elastomeric sealing rings require the application of a lubricant, which in the case of potable water mains should be of a type which will not cause, or be likely to cause, the water to become contaminated.

The requirements for solvent weld fittings and solvent cements are covered by BS 4346: Parts 1 and 3 respectively, although this technique is not generally recommended for normal use as it is only suitable when the jointing can be carried out under carefully controlled conditions. Solvent weld jointed pipes have been laid using the mole plough technique, but in these circumstances the advice and assistance of the manufacturer has been sought.

Generally solvent weld joints are restricted to sizes of 8" diameter and below. Dry conditions and properly supervised training are necessary to ensure a

satisfactory joint. Fully detailed instructions covering this method of jointing are incorporated into British Standard Code of Practice CP 312: Part 2.

Solvent cements may incorporate materials which are both inflammable and harmful if inhaled, and therefore the safety instructions on the container should be closely observed. These include reference to working in a well ventilated space, and avoiding contact with naked flames. Being based on volatile materials, the solvent cement will start to lose solvent immediately the container is opened, and therefore care must be taken to replace the lid whenever practicable. If because of solvent loss, the cement becomes too thick, it should be discarded.

Flange adaptors made from both uPVC and metal are often used with uPVC pipes and specials for connecting to flanged valves and tees. A variety of stub-flange assemblies are also available for this same purpose, and may incorporate either "push-fit" or solvent weld joints. Adaptors are also available to bring the outside diameter of the pipeline up to those of other materials, which can be of benefit when making connections to pipelines of dissimilar materials.

**Drains and sewers** — Push-fit joints utilising elastomeric sealing rings are the most common form of making connections for these non-pressure pipelines, and may utilise either integral sockets formed on the one end of the pipe, or double couplers with plain-ended pipe. Although some of the rings used in these applications are of the loose type, some manufacturers have developed locked-in rings particularly for the larger sizes. Solvent welding techniques are used only occasionally as a means of jointing for these systems, and are mainly restricted to components used in the construction of inspection pits and access chambers.

## 8. CONNECTIONS

**Water mains** — Self-tapping methods and machines may be used for making service connections on to uPVC pipes, but sharp, special cutters, designed specifically for use with uPVC pipe, should be used. If they are of the re-usable type sharpness must be maintained. Gunmetal saddles are preferred, but uPVC injection moulded saddles are available for solvent weld jointing or mechanical sealing.

Care should always be taken when using mechanical saddles, as overtightening may cause deformation and subsequent overstressing of thin walled pipes.

The outlet of the saddle connection is often provided with a mechanical joint designed especially for direct connection of the service pipe, which is now most commonly blue medium density polyethylene pipe specified in BS 6572.

**Drains and sewers** — Both solvent weld and mechanical saddles are used for making branch connections on to uPVC gravity sewers, alternatively such connections can be made by cutting a section out of the existing pipe and inserting a plain-ended branch fitting or junction jointed by means of loose double socket slip couplers, i.e. without central register. Purpose-made fittings and adaptors are also available for connecting uPVC drains and sewers

into manholes, inspection chambers and access points, as well as to pipes made from other materials.

## 9. STORAGE

CP 312: Part 2 gives guidance on storage. Generally, uPVC pipes should be stacked on flat surfaces, free from anything which might deform or otherwise damage them. They should not be placed inside each other as the bores may become scratched and, if storage is expected to be prolonged, they should be kept in shade to minimise any effects of weathering.

## 10. HANDLING AND LAYING

uPVC pipes are relatively light and easy to handle, consequently there is a tendency for them to be handled less carefully than their traditional counterparts. This should be discouraged, and reasonable care should be taken in storage, handling and laying to prevent damage to the pipes. They should not be dropped from lorries. uPVC is notch sensitive, and deep scores or scratches in pipes may cause subsequent failure, particularly with those used for pressure applications. It is suggested, as interim advice, that pipes containing external scratches deeper than 10% of the wall thickness (with an upper limit of 2mm) should be rejected.

uPVC pipes are classified as flexible from the standpoint of deformation under superimposed loads, and therefore attention should be paid to providing a proper bed and good consolidation of the sidefill to support the pipe wall.

Although uPVC pressure pipes up to 6" diameter have some flexibility it is recommended that they should not be bent to accommodate changes in direction. Some push-fit joints may accommodate an angular deflection of up to 1° after insertion, but overstressing can initiate premature failure. Sizes 8" and above should normally be regarded as rigid, and all directional changes accommodated by preformed bends available from the manufacturers. In some circumstances gradual changes in direction may be accommodated in these larger diameter pipes, but in these cases the advice of the manufacturer should be sought.

uPVC pipe should not be laid in ground contaminated with, or which may be subject to contamination by, surface active organic compounds (e.g. detergents) which may increase the risk of brittle failure, or by other organic contaminants (e.g. petrol, oil, solvents) which might permeate, soften or cause degradation of the pipe material.

Detailed recommendations for the handling and laying of uPVC pipes are covered in the WRc "Guidelines to the Water Industry for the structural design of underground non-pressure uPVC pipes", as well as CP 312: Parts 1 and 2.

The non-pressure pipe guidelines are intended to be complementary to BS 5955: Part 6 and should be used in conjunction with that standard.

## 11. FUTURE DEVELOPMENTS

During the last 6 years or so a great deal of research work has been carried out to explain why many earlier failures had occurred on uPVC pipes which complied with all the test requirements of BS 3505:1968. It has been concluded that the properties

measured in that specification failed to recognise the importance of the toughness of the material, which was not measured fully by falling weight impact tests. Recommendations made as a result of that test work have already been incorporated in IGN No. 4-31-04, and will shortly appear in the revision of BS 3505. It is expected that the amended text will further support the improvement in performance of uPVC pipe resulting from the recommendations in CP 312: Part 2 concerning surge pressures introduced in 1977 as amendment AMD 2337.

Further research work is being carried out by WRc Engineering in conjunction with a number of pipe manufacturers, to assess more accurately the relationship between the working stresses applied to plastic pipes, including internal and external cyclic stresses, their predicted life and the factors of safety necessary to be assured of freedom from failure, in order to bring about a continuous improvement in specifications and performance.

One company has developed a pipe termed "high strength PVC", which derives its higher strength from the orientation of conventional PVC molecules, and this product is incorporated into the WRc Engineering programme of evaluation for long term performance. At present it is available in one size only, namely size 6 (150mm) for use in the construction of pipelines, but it does appear to offer higher strength and resistance to surge pressures than conventional uPVC.

The rate of technical development in the field of plastics materials makes it necessary to have regular reviews of existing British Standards referred to in this document; the majority of those mentioned are under review and are likely to be subject to major amendments during the next 12 to 18 months.

## 12. SUMMARY AND CONCLUSIONS

Unplasticised PVC pipes and fittings can be used for installation as potable water mains and services, as well as for gravity drains and sewers. They are used for pumping mains but guidance is under review. Such installations make use of elastomeric sealing ring joints. The use of solvent weld techniques is not recommended except under specially controlled conditions.

The products are specified through both British Standards and WAA SWMC Information and Guidance Note specifications.

Changes in technical performance will mean the continuing upgrading of specifications at frequent intervals.

## 13. REFERENCES

This Information and Guidance Note makes reference to the following publications:

BS 2494 Specification for elastomeric joint rings for pipework and pipelines.

- BS 3505 Unplasticised PVC pipe for cold water services.
- BS 3505 (revised) Specification for unplasticised polyvinyl chloride (PVC-U) pipes for cold potable water.
- BS 3506 (to be published) Unplasticised PVC pipe for industrial purposes.
- BS 3867 Outside diameters and pressure ratings of pipe of plastics materials (withdrawn, but to be reinstated).
- BS 4346 Joints and fittings for use with unplasticised PVC pressure pipes.  
Part 1: Injection moulded unplasticised PVC fittings for solvent welding for use with pressure pipes, including potable water supply.  
Part 2: Mechanical joints and fittings principally of unplasticised PVC.  
Part 3: Specification for solvent cement.
- BS 4660 Unplasticised PVC underground drainage pipe and fittings.
- BS 4962 Specification for plastics pipe for use as light duty sub-soil drains.
- BS 5481 Specification for unplasticised PVC pipe and fittings for gravity sewers.
- BS 5556 Specification for general requirements for dimensions and pressure ratings for pipe of thermoplastics materials (metric series).
- BS 5750 Quality systems.
- BS 5955 Code of practice for plastics pipework (thermoplastics materials).  
Part 6: Installation of unplasticised PVC pipework for gravity drains and sewers.
- CP 312 Plastics pipework (thermoplastics

materials).

Part 1: General principles and choice of materials.

Part 2: Unplasticised PVC pipework for the conveyance of liquids under pressure.

ISO 161/1 Thermoplastics pipes for the transport of fluids — nominal outside diameters and nominal pressures.

Part 1: Metric series.

ISO 161/2 Thermoplastics pipes for the transport of fluids — nominal outside diameters and nominal pressures.

Part II: Inch series.

WAA SWMC Information and Guidance Note No. 4-31-04 — Specification for unplasticised PVC pressure pipe for cold potable water.

WAA SWMC Information and Guidance Note No. 4-40-01 — Selection, properties, storage and installation requirements for elastomeric seals and sealing rings.

ER 162E Selection of pipe materials for mains renewal and replacement applications. (WRC external report)

ER 201E Guidelines to the Water Industry for the structural design of underground non-pressure uPVC pipelines. (WRC external report)

NJUG Publication No. 4

The identification of small buried mains and services.

**NOTE.** CP 312: Parts 1, 2 and 3 will eventually be published as parts of BS 5955.