



# British Precast Drainage Association

Publications from the British Precast Drainage Association (BPDA):

BPDA was formed in 2017 from the integration of the Concrete Pipeline Systems Association (CPSA) and the Box Culvert Association (BCA).

Information published by both CPSA and BCA will be rebranded and replaced as BPDA in due course. New material will be branded BPDA.

All CPSA and BCA web traffic will be redirected to the new BPDA web site at [www.precastdrainage.co.uk](http://www.precastdrainage.co.uk)



## PLASTIC PIPE CLAIMS

The design of sewers and culverts requires consideration of the interrelated fields of hydrology, hydraulics, structural behavior, durability, economics, and construction procedures. Knowledge of the performance of a pipe material in each of these fields is essential for complete evaluation and comparison to the performance of other pipe materials. Such knowledge must be based on scientific research and field experience rather than unsubstantiated claims. This publication presents various claims made by the plastic pipe industry, discusses engineering facts which indicate the claims are not justified, and evaluates critical properties of plastic pipe which affect performance, durability and service life.

### HYDRAULICS

**CLAIM:** *The superior hydraulics of plastic pipe, as reflected in a Manning's "n" value of 0.009, are attributable to the smoothness of the pipe interior, low amounts of slime buildup, and fewer joints.*

**FACT:** Laboratory test values of Manning's "n" for all smooth wall pipe materials, such as concrete, plastic, clay and asbestos-cement, are in the range of 0.009 to 0.011. These values have traditionally been in-

#### Manning's "n"

24-and 36-inch concrete pipe  
St. Anthony Falls Laboratories

	24"	36"
"Normal" joints	.0108	.0111
"Good" joints	.0106	.0108
No joints	.0105	.0107

creased to 0.012 or 0.013 for design purposes to account for actual field conditions not simulated in the lab, such as deflected flexible pipe, obstructions, bends, manholes, depositions and slime buildup.

Slime buildup is **not** a function of the pipe material, but, rather, the effluent, and flow depth and velocity. Evidence of this is the fact that plastics are promoted for and used as biological filter media for which slime adherence is a prime requisite.

The claim that fewer joints result in a lower Manning's "n" is refuted by research conducted at St. Anthony Falls Laboratories, University of Minnesota. Roughness coefficients were determined for 24-inch and 36-inch diameter concrete pipe with smooth joints and joints with interior mortar beads and compared to the theoretical "n" factors for pipe without joints. This research proved the difference is insignificant, and that merely reducing the number of joints in a pipeline will have no measureable effect on the value of "n".

### SLOPE

**CLAIM:** *Another advantage of a low Manning's "n" factor is the ability to lay plastic pipe on flatter-than-normal slopes and still maintain adequate capacity.*

**FACT:** Flatter-than-normal slopes decrease the flow velocity, encouraging greater slime growth on the pipe walls. Greater slime growth is likely to increase, rather than de-

crease, Manning's "n" factor, and result in reduced flow capacity.

The required flow capacity for a specific project is determined from either the drainage area for storm sewers and culverts, or from the population density for the area being served for sanitary sewers. Flow capacity requirements are independent of the pipe material. For any project, minimum velocities are specified by either state or local authorities. For any given slope, velocity is a function of "n" and depth of flow; therefore, pipe of different materials but with the same diameter and roughness coefficient will have the same capacity and velocity.

Minimum velocities of two to three feet per second are required to maintain self-cleansing action. Flatter-than-normal slopes will likely result in depositions, reduced capacity, and increased maintenance costs.

In sanitary sewers, low velocities result in longer detention times and increase the probability of hydrogen sulfide generation. Hydrogen sulfide gas is dangerously toxic, has an obnoxious odor, and directly attacks ferrous and other metallic compounds.

### WEIGHT

**CLAIM:** *Plastic pipe weighs only 10 to 30 percent as much as many other common pipe materials. This leads to significant savings in the cost of transportation, manpower and equipment for handling and installation.*

**FACT:** Although light weight appears to be an advantage to the contractor, the longer lengths of plastic pipe result in total weights often greater than two men can safely lift, so equipment for handling and installation is still necessary.

The same equipment used by the contractor to excavate the trench is used to handle and install pipe. No special handling equipment is normally required. Construction regulations generally limit the length of trench which can be excavated and left open at any one time. These limitations effectively require that the excavating equipment be continually present on the job site and available to handle and install pipe.

In addition, the low weight per foot places plastic pipe at a distinct disadvantage when installed where the groundwater table is above the trench bottom, and the trench temporarily dewatered. As installation proceeds, the trench behind the lead pipe gradually becomes inundated with water, sometimes before initial backfilling begins. In these instances, the buoyant force on the pipe is sufficient to move it off grade and to disturb joints. As an example, for 15-inch diameter PVC pipe when the water reaches the springline, the buoyant force is 28 pounds per foot, and when the water covers the pipe, it is 68 pounds per foot, or more than 1,300 pounds on a 20-foot length. In contrast, 15-inch diameter wall B reinforced concrete pipe will not float at all under the same conditions.

*Forces on 15-inch pipe in a wet trench*

Pipe	wt./ft.	Buoyancy per foot	
		water to spring line	water to top
PVC (DR 35)	12 lbs.	+28 lbs.	+38 lbs.
ABS Composite	26 lbs.	+27 lbs.	+80 lbs.
RCP (Wall B)	148 lbs.	-79 lbs.	-10 lbs.

## INSTALLATION

**CLAIM:** *Plastic pipe is easy to install because it is light and employs bell and spigot push-on joints. The*

*speed at which plastic pipe is placed in the trench is a major advantage over heavier materials like concrete pipe.*

**FACT:** Plastic pipe must be installed in accordance with ASTM Standard D2321 which outlines flexible pipe principles that recognize performance is primarily dependent upon proper bedding, side support, and haunching of the embedment material. Rigid pipe is designed to support the entire vertical load, therefore control of material and compaction of the sidefills are not as demanding as for plastic pipe.

Not only is the compaction level more difficult to obtain for plastic pipe, but the volume of select material is, in some cases, many times that for concrete pipe. If the select material is imported, the cost of installation for plastic pipe will increase dramatically.

OSHA and other construction safety regulations require the use of sheeting, shoring, or trench boxes in trenches that cannot be adequately sloped. Removal of the sheeting or movement of the trench box must be coordinated with placement and compaction of the select embedment material or much of the required pipe side support will be lost.

## MAINTENANCE

**CLAIM:** *Because of tight joints, and the smooth interior surface of plastic pipe, maintenance is reduced to a bare minimum.*

**FACT:** Regular maintenance, such as flushing and inspection, is recommended for all sewers, regardless of pipe material. Properly installed concrete pipe and plastic pipe both have smooth walls and tight joints.

During sewer cleaning operations, when blockages are encountered, augers and rodding equipment can scratch plastic pipe while

removing the obstruction. All plastics become increasingly susceptible to stress corrosion when scratched, but the problem is particularly acute for ABS composite pipe. This product has such thin walls that even surface damage can significantly reduce resistance to stress corrosion in the presence of aggressive substances.

## WATERTIGHTNESS

**CLAIM:** *Joints for plastic pipe can be made quickly and easily and are permanently watertight. Root intrusion problems are virtually nonexistent.*

**FACT:** The performance of a jointing system is not a function of pipe material, but of the design of the joint and the installation. Leakage and root intrusion can occur in plastic pipe when improperly joined, or with differential deflection between bell and spigot due to poor installation techniques.

Gasketed jointing systems have long been the standard for sanitary sewerage systems, yet ABS composite pipe still employs solvent welded joints. Solvent welded joints must be made with extreme care during normal conditions, and a muddy or wet trench bottom compounds the problem of making a sound joint. In addition, the solvent is highly toxic and flammable and creates a safety hazard for workers in the trench.

Some new plastic pipe products, not covered by ASTM Standards, also claim superior joints. Close examination, though, reveals that some of these products do not use traditional, proven joint designs. Gasketed joints for ribbed PVC are neither confined nor roll-on because the spigot groove cuts through the ribs, which results in an irregular compression pattern around the circumference of the joint, making it susceptible to leakage. Polyethylene pipe with thermal welded joints made

by hand in the trench is a relatively new development. Problems with preparing and welding the joints in a wet trench have created skepticism as to the integrity of the jointing system.

### INFILTRATION/ EXFILTRATION ALLOWANCES

**CLAIM:** *Infiltration/exfiltration allowances for new construction should be set at a tight 50 gallons per inch of diameter per mile per day.*

**FACT:** The United States Environmental Protection Agency recommends an infiltration allowance of 200 inch-gallons, a level which can be specified and met without any appreciable increase in construction costs.

This numbers game is analyzed in the 1979 EPA Manual of Practice, **Sewer System Evaluation, Rehabilitation And New Construction.** The manual states that 200 inch-gallons is appropriate and that tighter specifications may increase the cost of construction in excess of any wastewater treatment savings achieved. It is apparent that the inflow component can be many times the infiltration component and that overemphasis of infiltration is unjustified.

### DEFLECTION TESTING

**CLAIM:** *Deflection testing of plastic pipe is just one method of verifying proper installation. When proper installation practices are confirmed by construction inspection, soils testing or television inspection, deflection testing is redundant, and need not be conducted.*

**FACT:** Just as construction inspection is not adequate to assure that infiltration/exfiltration requirements are met, neither will it confirm that flexible plastic pipe has not deflected excessively. Deflection should be measured initially 30 days after in-

stallation, and after a full year for long-term effects.

### PVC PIPE DEFLECTION

**CLAIM:** *PVC sewer pipe installed in accordance with ASTM Standard D2321 can be expected to perform satisfactorily provided that the internal diameter is not reduced by more than 7-1/2 percent of its base diameter when measured not less than 30 days following installation.*

**FACT:** A deflection of 7.5 percent has never been accepted as a design limit, but as an outside maximum limit which accounts for deflection lag from soil and pipe creep, and consolidation due to water table fluctuations and surface loads. Long-term deflection occurring up to a year after installation can exceed 150 percent of initial deflection. Therefore, deflections measured at 30 days should be considered initial values and held to 5 percent or less.

#### ASTM F-17 survey

Maximum Deflection	Number of Replies	Percentage of Replies
3%	9	10
4%	3	4
5%	66	76
greater than 5%	9	10

} 90%

A survey conducted by ASTM Committee F-17 on Plastic Pipe in 1976 asked the question, "What is the maximum deflection allowed in your specification?" The reply was overwhelming — 90 percent of the respondents allowed no more than 5 percent deflection for plastic sewer pipe. This puts to rest the claim that 7.5 percent is commonly specified in the engineering community.

When determining a deflection limit for PVC pipe, it is essential to establish a proper and logical base, or reference, diameter from which to measure deflection. The base diameters recommended in an appendix of ASTM Standard D3034 include extreme out-of-roundness allowances which increase the allowable

deflection of pipe of average diameter by 3 percent or more. These allowances were selected from measurements of PVC pipe made by a handful of producers. The out-of-roundness was temporarily and artificially induced by bundling the pipe as if for shipment. The pipe, when subsequently unbundled, showed much less out-of-roundness. In short, PVC installed and measured for deflection in accordance with this standard would be acceptable with initial deflections in excess of 10.5 percent, and with long-term deflections approaching 16 percent! The average inside diameters in ASTM Standard D3034, rather than the base diameters, should be used as the reference diameter in deflection calculation and measurement.

### ABS PIPE DEFLECTION

**CLAIM:** *Performance of ABS composite pipe has been essentially the same in trenches built for rigid or flexible pipe standards. Deflection has been limited to about one percent average in either case.*

**FACT:** Deflection of ABS composite pipe must be limited to one percent average and 2 percent maximum if it is to perform satisfactorily for the design life of the project. These deflection limitations can be consistently obtained only by installing the pipe in the same manner as all other flexible thermoplastic pipe, according to ASTM Standard D2321.

In tests conducted by the Wisconsin Concrete Pipe Association, five samples of 12-inch diameter ABS composite pipe failed by web failure or wall rupture at an average 5.1 percent deflection when tested in a parallel plate apparatus. Failure at such low deflections establishes that ABS composite pipe is very different from PVC pipe, and that more stringent deflection limits must be applied. The one percent average, 2 percent maximum criteria will offer some assurance that the plastic

webs are still intact and that the thin inner and outer walls have not ruptured.

## CHEMICAL RESISTANCE

**CLAIM:** *Plastic pipe is almost totally immune to deterioration from groundwater or chemical effluents, as well as electrolytic and galvanic corrosion.*

**FACT:** The resistance of plastic to aggressive substances, although generally considered good, is highly dependent upon the aggressive substance and the plastic's state of stress and formulation.

Chemicals such as acids, that are normally considered aggressive may be benign or only mildly aggressive to plastics. Other commonly used substances that are considered nonaggressive may be highly aggressive to plastics.

Of more significance, though, is the concept of stress corrosion, or environmental stress cracking. An unstressed plastic pipe, in contact with most substances, will not show signs of softening or deterioration. Place that pipe under stress, such as in the buried state, and many of those same substances will cause distress in a matter of minutes, hours or days. Common household liquids such as cooking oil, salad dressing, bleach and Liquid Drano caused rapid rupture in ABS composite pipe held under only 7.5 percent deflection.

Fillers added to improve processing, ultraviolet resistance and other qualities have a profound effect upon the chemical resistance of plastics. There is no standard or program for certifying acceptable filler formulations for plastic pipe.

Tests on plastics with specific formulations have been conducted to measure relative resistance to various substances. One manufacturer lists resistance of several PVC formulations, and it is interesting to note that PVC has limited, poor, or no re-

sistance to more than 34 percent of the substances tested.

## ULTRAVIOLET DEGRADATION

**CLAIM:** *Plastic pipe, which is buried, has no long-term exposure to ultraviolet radiation. In addition, tests have proven that the properties of PVC pipe remain essentially unchanged in up to two years of outdoor exposure.*

**FACT:** The rate of degradation from ultraviolet radiation, UV, of PVC is dependent on the type and degree of exposure and the degree of UV inhibitor used in the PVC formulation. The degree of exposure is difficult to estimate and will vary from manufacturer to manufacturer depending on inventory and sales. The amount of UV inhibitor used can also vary between producers and is not standardized.

The tests performed by the PVC pipe industry actually recorded up to 35 percent reductions in impact strength over a two year period. It should be remembered, however, that these significant reductions are laboratory values from tests performed at 73 degrees Fahrenheit. As temperature falls, so does the impact resistance of PVC. The tests should be performed at temperatures normally encountered in the winter. ASTM Standard D2680 for ABS composite pipe makes absolutely no reference to impact resistance. This is hard to understand, since the thin wall makes ABS composite pipe extremely susceptible to damage during installation, and it also suffers from reduced impact strength at low temperatures.

## FIRE RESISTANCE

**CLAIM:** *PVC will not support combustion. Hydrogen chloride gas liberated under flame tends to smother the fire, making PVC self-extinguishing.*

**FACT:** Fire resistance of plastics is a well established deficiency.

PVC, subjected to fire, produces toxic hydrogen chloride, which will smother the fire under conditions of low air movement. With adequate air flow, PVC will burn and quickly lose its stiffness, which causes the pipe to sag or collapse.

In tests performed by an independent laboratory, a smooth wall and a ribbed PVC pipe, a ribbed polyethylene pipe and an ABS composite pipe were placed in an ASTM Standard E84 fire test tunnel, and observed for rate of flame spread and smoke generation. The ABS composite pipe produced dense smoke and the highest flame spread, and left little more than lightweight concrete filler after the test was completed. The smooth wall PVC and ribbed PVC pipe suffered similar fates. It is obvious that plastic pipe cannot withstand the elevated temperatures common to fires. The most striking observation of these two tests is the difference in smoke density. Smoke density factors for the ribbed PVC and smooth wall PVC pipe were 10 and 330, respectively. This is testimony to the variation in fillers and inhibitors used for PVC pipe. There was nothing left of the ribbed polyethylene pipe at the end of the test, and this product had a smoke density factor of 820, the highest of any plastic tested.

## SUMMARY

The adequacy of any pipe material must be based on sound engineering principles, including hydraulic performance, structural integrity, long-term serviceability and durability. A realistic economic evaluation should not be based on promotional claims found in the literature of new and unproven pipe products. Concrete pipe has an impressive record of performance spanning over 150 years, and can be specified with confidence.