

The Myths of Premature Failure of Plastic Pipes in Plumbing Applications



by Ir. A. H. Ung

PLASTIC pipes, or more accurately, thermoplastic pipes, have been in use in plumbing applications since the late 1970s. Over the years, it has gained more acceptance and, invariably, its usage has increased as it has certain distinct advantages over existing material such as GI pipe which was the material of choice in the old days. One of the distinct advantages of thermoplastic is that it does not corrode over time.

So what types of thermoplastic pipes are currently being used in the plumbing sector? There are currently several thermoplastics that are being used for plumbing applications. The most common are ABS, HDPE, PVC and PPR.

Broadly speaking, thermoplastics can be sub-divided into two main categories, i.e. Amorphous and Crystalline. Examples of two common materials are ABS and HDPE, where the former is Amorphous and the latter is Crystalline. The main difference between the two is the method of joining. Amorphous material uses bonding agents such as ABS Solvent Cement, while Crystalline uses heat such as HDPE Butt/Electro Fusion.

It is no secret that there are many incidences of premature failure of thermoplastic pipes in plumbing applications in many buildings, both residential and commercial high-rise buildings, that use thermoplastic as the plumbing material. Often, the comments are that the thermoplastic pipes cannot withstand the pressure, especially so when it is used as the pumping mains. So, is this comment the gospel truth or a myth?

THE MYTHS

For lack of a better term, the comment on the premature failures shall be termed as myths. This is an attempt to list down, although the list may not be exhaustive, the most common myths, which are:

- 1) Plastic pipes are not durable
- 2) Plastic pipes cannot withstand pressure and thus cannot be used as pumping mains
- 3) Plastic pipes are not suitable for outdoor installation

Plastic pipes are not durable

One of the most common comments is that the plastic pipes installed failed prematurely and sometimes even during the Defects Liability Period. Where did these failures occur?

In landed residential properties, the most common failure occurs at the inlet pipe to the HDPE water tank. Normally, the symptom is the shearing of the elbow at the inlet area. Of course, the first reaction is that the material is brittle.

Upon closer investigation, one will invariably discover that there is flexing of the HDPE tank and the flexing forces are transferred to the inlet pipe which was not properly bracketed to prevent the shearing of the pipe. Figures 2 and 3 depict the flexing of the HDPE tank and the brackets required to prevent the shearing of the pipe. In some cases, the installer will claim that his installation has the

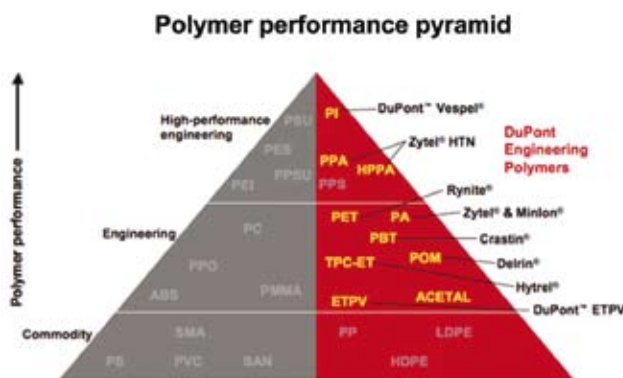


Figure 1: The DuPont polymer performance pyramid
(Source: http://www2.dupont.com/Plastics/en_US/Uses_Applications/)

Apart from the above classifications, thermoplastics are further classified into Commodity, Engineering and High Performance plastics. From the DuPont Polymer Performance Pyramid as shown in Figure 1, PVC, HDPE, PP (PPR, PPH) are Commodity Plastics, while ABS and PET are classified as Engineering Plastics. Thus, PVC, HDPE and PPR pipes are cheaper than ABS because of the difference in performances.

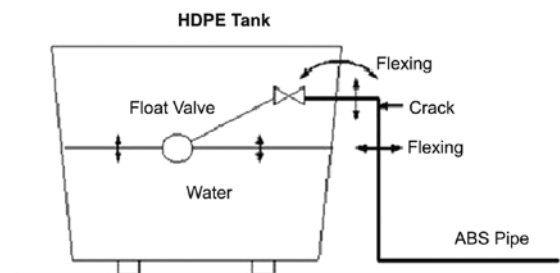


Figure 2: Common failure at inlet to HDPE tank
(Source: <http://www.azeetapipe.com>)

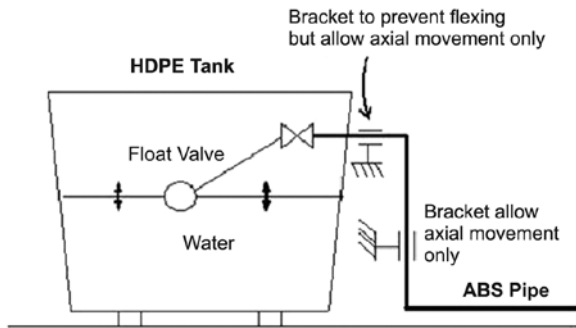


Figure 3: Recommended pipe bracket installation (Source: <http://www.azeetapipe.com>)



Figure 4: No proper bracketing (Source: <http://www.azeetapipe.com>)



Figure 5: Thin wire used as pipe bracket (Source: <http://www.azeetapipe.com>)

necessary bracketing and yet the pipe still failed. Although there is some element of truth in that statement, one should determine if the brackets were installed properly in the first place? Let us take a look at Figures 4 and 5.

Admittedly, the pipe may sometimes be brittle as a result of the non standard manufacturing process. This normally happens when unscrupulous manufacturers use adulterated material to manufacture plastic pipes. They may use recycled material and/or calcium carbonate added as filler to reduce the manufacturing costs (the addition of calcium carbonate as filler only applies to PVC products).

Consequently, the pipes will not have the same mechanical properties as the virgin or unadulterated

material. Such an unethical practice is quite rampant especially among the PVC, HDPE, PPR and ABS manufacturers. Apart from being unscrupulous, some manufacturers also lack the technical knowledge to produce good quality plastic pipes.

Plastic pipes cannot withstand pressure and thus cannot be used as pumping mains

The general belief is that plastic pipes are unable to withstand pressure, as such, they cannot be used as pumping mains. This myth is indeed the most intriguing as all applications, whether the pumping or gravity feed is pressurised. The question one should ask is, "how can the same plastic pipe, that supposedly cannot be used for pumping, withstand the static pressure of the rooftop tank or the incoming pressure from JBA?" Sometimes, the static pressure can even exceed the discharge head of a domestic pump installed in the same building.

The myth came about due to the mismatch of the pumping equipment with the design criteria. To understand the mismatch, one needs to look at the pumping system installed in the building. Firstly, the engineer will design the Total Water Requirements of the building which, invariably, will be listed as x flow rate against y head. The installer will then request from the pump supplier for a pumpset which will deliver the designed duty point. Therein lies the mismatch as, more often than not, there is no pumpset that will deliver exactly the desired duty point, although this is not the main issue. The problem may also lie in the pump's performance during the actual operation which does not match with the engineer's design.

In Figure 6, the pump will operate between points A and B according to the performance curve whereas the system requirements are between points C and D. Clearly, there is a mismatch especially when the demand is at point D and the pump is operating at point B. In this situation, the velocity will be very high, and can sometimes be as high as 5ms⁻¹ to 6ms⁻¹, and will create a transient pressure that is much higher than the rated working pressure of the plastic pipe. There are cases where the transient pressure created is as high as 30 bars. Obviously, plastic pipes with a rated working pressure below that level will fail prematurely

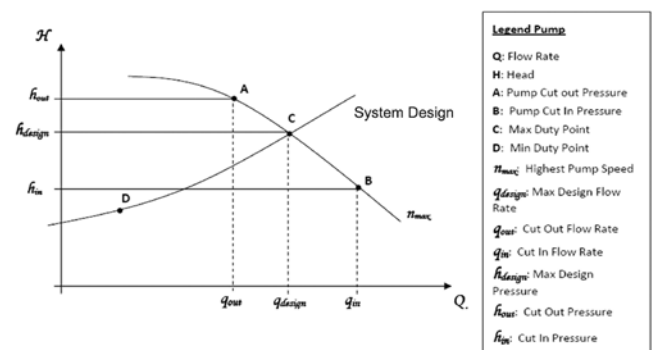


Figure 6: Single speed operation (Source: <http://www.azeetapipe.com>)

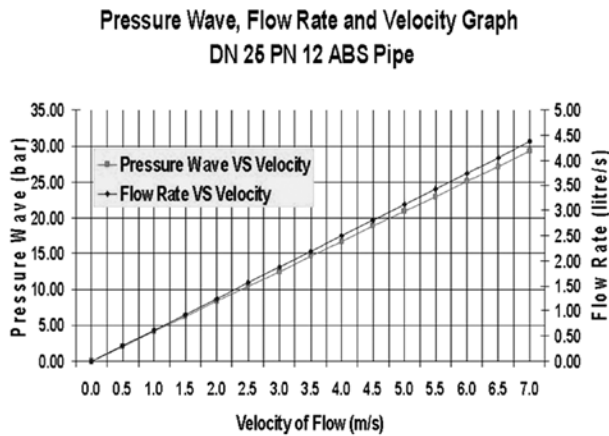


Figure 7: An example of the velocity of flow vs transient pressure or pressure wave created in an ABS pipe. (Source: <http://www.azeetapipe.com>)

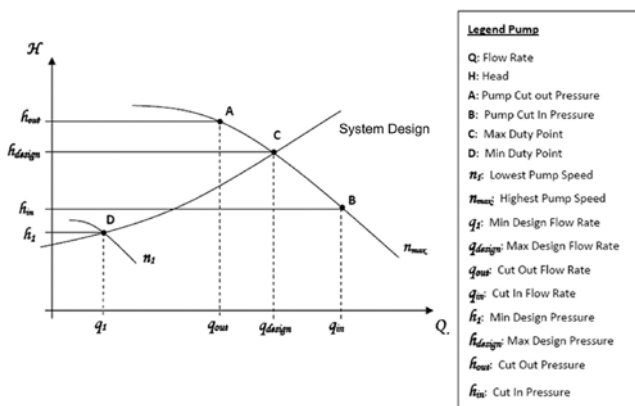


Figure 8: Variable Speed Operation (Source: <http://www.azeetapipe.com>)

(Figure 7 gives an example of the velocity of flow vs transient pressure or pressure wave created in an ABS pipe).

To make matters worse, due to the lack of understanding and knowledge on transient pressure, the installer will think that the plastic pipes are unable to withstand the pump discharge pressure and will attempt to mitigate the situation by lowering the cut in pressure. This seemingly helpful remedial action will, in actual fact, create a higher transient pressure as the increase in volumetric flow rate without the corresponding increase in pipe diameter will escalate the transient pressure created. As such, the plastic pipes will experience more frequent failures and that will lead the installer to believe that the plastic pipes are truly useless as they fail even more frequently despite the lower pump discharge pressure.

The correct remedial action will be to match the pump operation to the design requirements all the way as shown in Figure 8. This can be achieved with the use of a variable speed pump with the lowest and highest speed, n_1 and n_{max} , calibrated to match duty points D and C respectively. This will ensure that whatever transient pressure created will be lower than the rated working pressure of the plastic pipes.

A similar failure arising from the transient pressure can also occur in the dropper especially when there is insufficient or inappropriately sized PRV installed. In addition, bad PRV installation, as shown in Figure 9, where the PRV installed is without pressure gauges can also create havoc in the system. It is common knowledge that a proper PRV installation maintains



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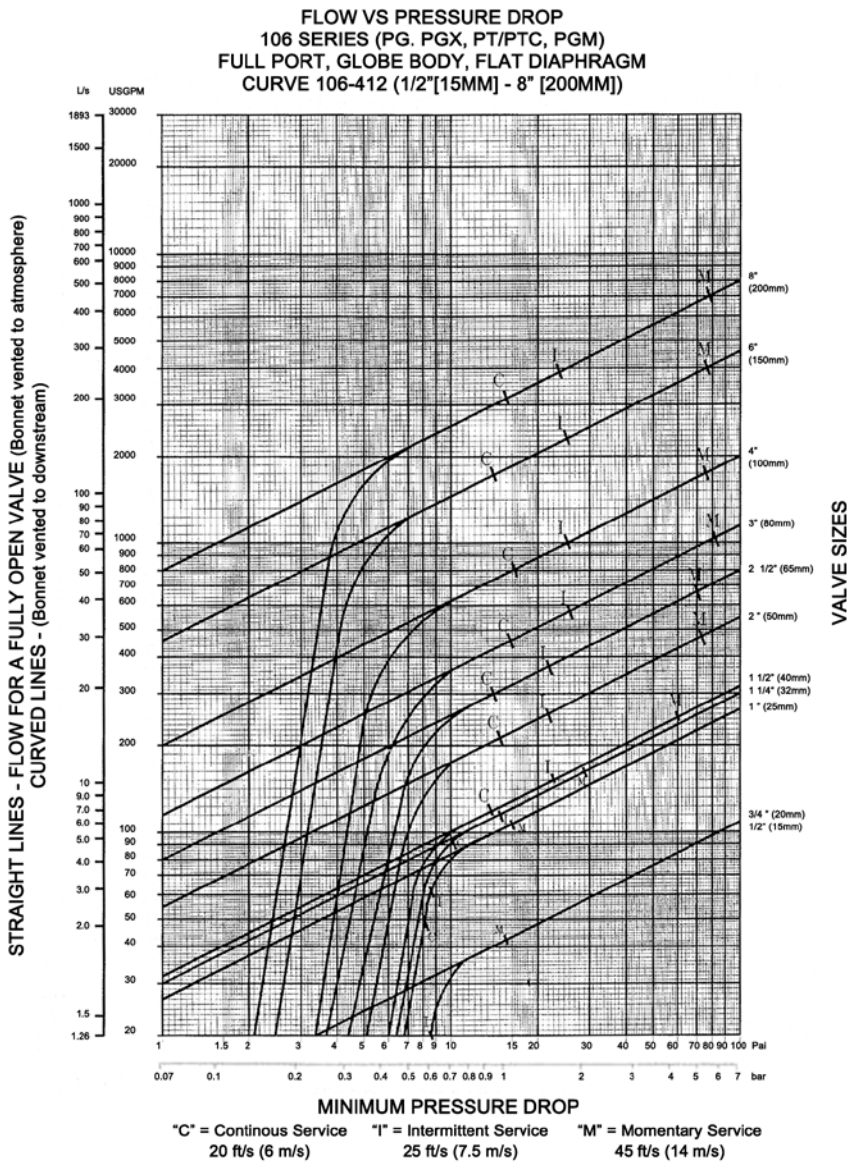


Figure 9: Singer Valve
 (Source: Singer Valve Canada, www.singervalue.com)

constant downstream pressure, which is lower than the upstream pressure. So how can one set the pressure if a PRV is installed without pressure gauges?

It is also important to note that a PRV must have the feature to cater for small usage, without which the PRV will start hunting when the situation arises. During this operating condition, the velocity of flow through the PRV can be as high as 14ms^{-1} (see Figure 10). Under this condition, the transient pressure created can be very high which, again, will lead to the premature failure of the plastic pipes.

The other option is to install a series of smaller PRVs against a single big PRV in the dropper. Of course, the smallest PRV can cater for the small usage and the bigger units will cut in during higher demands. This arrangement will reduce the velocity of flow in the system which, in turn, will reduce the transient pressure to a more manageable level.

Plastic pipes are not suitable for outdoor installation

The general understanding is that plastic pipes are not suitable for outdoor installation as the pipes will become brittle. The fact is, all plastics are susceptible to UV attack. This includes water tanks, pipes and valves that are made from plastic. Regardless of the claims from some manufacturers that they have added a UV inhibitor into their products, all exposed installation of plastic products will meet their untimely demise if they are not properly protected. This is because the UV inhibitor that is added to the products is always finite and sacrificial in nature. So once the added UV inhibitor is fully consumed, the material will be attacked by UV and, over time, the plastic products will degrade and fail prematurely.

Therefore, it is always a wise practice to protect the plastic products by coating them with a layer of water-based paint. This paint will shield the product and thus prevent the material from being attacked and degraded by UV.

The other aspect is the thermal expansion or contraction, particularly for exposed plastic pipe installed over a long distance. Most are unaware that plastics, in general, expands and contracts more than steel. In addition, dark coloured plastic pipes such as HDPE and ABS will yield a higher surface temperature during a hot sunny afternoon. From experience, the measured surface temperature of exposed ABS pipe installed on a rooftop can reach a high of 60°C . At night, it can fall to 20°C . The wide delta

T will result in the expansion/contraction of the pipeline and, if this is not taken care of, will invariably cause a



Figure 10: PRV installed without pressure gauges
 (Source: <http://www.azeetapipe.com>)

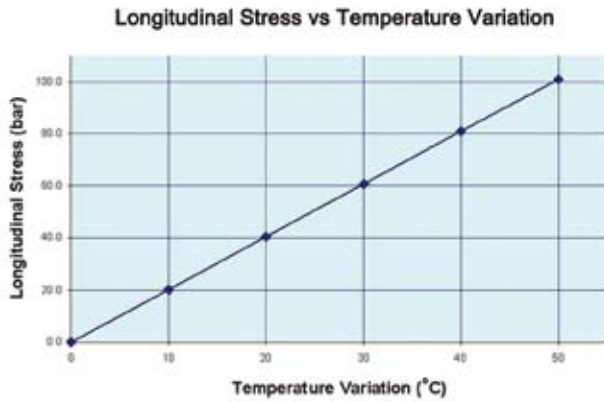


Figure 11: The relationship between the longitudinal stress of the ABS pipe against temperature
(Source: <http://www.azeetapipe.com>)



Figure 12: Exposed ABS pipe secured firmly with cement mortar
(Source: <http://www.azeetapipe.com>)

premature failure of the plastic pipeline. Figure 11 shows the relationship between the longitudinal stress of the ABS pipe against temperature.

More often than not, the installer will install the exposed and unprotected plastic pipes, and secure it firmly with cement mortar (Figure 12). Such installation will definitely

kill the pipeline as there is no allocation for the pipeline to move in a pre-engineered manner.

Plastic pipe manufacturers will be able to provide the coefficient expansion of their respective materials and a simple calculation will yield the necessary expansion/contraction that needs to be allocated in the pipeline with a suitably chosen anchor point.

SUMMARY AND CONCLUSION

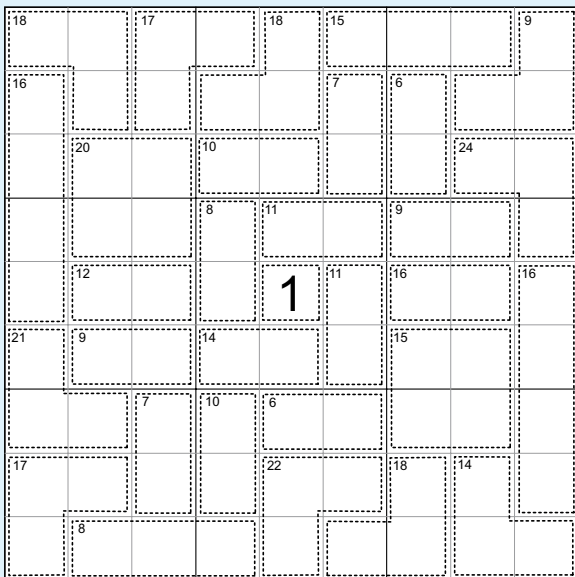
In view of the explanation, it is clear that the premature failure of plastic pipes is not due to their inherent material weaknesses, but instead is caused by poor installation, lack of understanding of the characteristics of the plastic materials and the mismatch of pumping equipment.

Although plastic pipes have some distinct advantages over steel pipes, they also have their weaknesses. Their main weakness is the lower Modulus of Elasticity as compared to steel which renders them unable to withstand the high transient pressure created in the system.

Nevertheless, this weakness can be easily overcome by proper engineering to avoid excessive transient pressure in the system so that the plastic pipeline will not fail prematurely.

Of course, it is also important to identify unscrupulous manufacturers and avoid buying their products however cheap their products may be. On the other hand, the authority concerned can request for all plastic products to be produced in their natural resin colour of which any addition of colour will be considered as adulteration and thus will be rejected. This will help reduce or eliminate the opportunity for unscrupulous manufacturers to use recycled or adulterated materials.

In conclusion, it is possible to design and install a plastic piping system that can survive a design life of 50 years with the most optimal cost. In order to achieve that, we must equip ourselves with the appropriate technical knowledge and understanding of the characteristics of plastic materials. ■



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