**GENERAL ADVANTAGES OF MISR Elnour UPVC PIPES**

**Resists chemicals** - because upvc is chemically inert; it resists attack by acids, alkalis, salt solutions and many other chemicals.

**Resists electrolytic and galvanic corrosion** – upvc is an excellent electrical insulator and is used extensively as an insulation on electrical wires. Because of this characteristic, upvc piping is not susceptible to either electrolytic or galvanic corrosion.

**Strength** – upvc piping material has the highest long-term hydrostatic strength of any of the major thermoplastics being used for piping.

**Low thermal conductivity** - upvc has low co-efficient of thermal conductivity reduces heat loss or gain. Under some conditions this will reduce deposition of dissolved materials.

**Flow efficiency** – the smooth internal surface of the upvc pipe ensures low flow resistance clean internal surfaces and a minimum loss of head pressure. The corrosion resistance of upvc means that smooth surfaces will be maintained during prolonged service. Upvc water piping after 15 years of service shows no reduction of flow capacity.

**Cost** – upvc is one of the cheapest materials used in the manufacture of pipes and fittings.

**Fire proof** – upvc pipes will not support combustion. In the event of fire, flames are unable to travel along the pipe. It is self-extinguishing.

**Sanitary** – upvc pipes are entirely non-toxic. It will not affect the taste smell or color of water or liquid nor react with any liquid to cause a precipitant.
Easy joining – although upvc piping can be joined by a variety of methods such as threads, flanges and other types of joints, the most widely used methods are the solvent cement joint and the rubber gasket push-on joint. The latter is used extensively in both pressure and non-pressure underground piping systems.

Light weight- assembly of upvc piping is made easier because it light weight. Assemblies can be produced in a shop and tested before delivery to the installation site. Often these assemblies are light enough to be handled without power equipment. The lightweight offers economic advantages in every handling operation for all sizes of pipe in the larger sizes; this sometimes even eliminates the need for a second piece of motor – driven equipment.

Resists-Rodent- Termite and bacterial attack- rodents will not attack upvc pipe unless they are so confined that there is no other access to food or water. There has been no evidence of failures cared termite attack tests had shown that upvc material does not nourish bacteria. In fact, rigid PVC in very thin sheet form is used as trickling filter media for waste treatment plants. Layers of bacteria and fungi coat the upvc media and assimilate the organic material. Tests after eight years of service show no changes in physical properties of the upvc.
APPLICATIONS OF MISR EL NOUR UPVC PIPES

WATER SUPPLIES: Non-Toxic MISR EL NOUR UPVC PIPES will not affect the taste, color, or smell of drinking water. They will never corrode and are therefore extremely sanitary. Deposits and scales will not build up inside as in conventional steel pipes. Their strength is greater than that of asbestos pipes.

IRRIGATION: MISR EL NOUR UPVC PIPES are ideal for agricultural irrigation and sprinkler systems. Non-corrosive MISR EL NOUR UPVC PIPES are perfect for carrying water, which contains chemical fertilizers and insect inhibitors.

Industry: resistant to most chemicals, MISR EL NOUR UPVC PIPES have an important role to play in the world of chemicals. light non-corrosive, and easy to assemble, they allow more complex piping work than with steel or cast-iron pipes.

Drainage, waste, and ventilation: Waste lines for corrosive gases ventilation for office buildings and factories: drainage systems for private homes and elevated highways.

Mining plant: MISR EL NOUR UPVC PIPES particularly well suited for draining corrosive liquids found in mines. They make an ideal vent line for pits because they are easily installed in hard-to-reach places.

Conduits: since MISR ELNOUR upvc pipes are themselves an integral insulator, there is an ever-increasing demand for them as an electrical conduit. To facilitate work a full line of fittings is available and constructed from the same material as the pipes.
GENERAL INFORMATION AND STANDARDS

1. **Production Specification:**

   MISR EL NOUR CO. products according to:
   - DIN 8061/8062 and Egyptian Standard 848 for Water Supply and Irrigation.
   - DIN 19534 and Egyptian Standard 1717 for Draining and Sewerage under Gravity.
   - DIN 19531 for Inside Buildings Waste and Vent.
   - BS 3505 for Threaded Pipes supply and Irrigation water pressure 9 bar
   - T.C. 161A for Telephone Duct according to ARENTO.
   - ASTM D1785 SCHEDULE 40&80 for home sewerage and pressure.

2- **RANGE OF PRODUCTION**

   a) UPVC pipes of DIN and ARE production range from 10mm up-to 710mm for the time being.
   
   b) UPVC PIPES of ASTM standard production range from ½ inch up to 8 inches in different wall thickness and pressure schedule.

3- **joint type:**

   UPVC PIPES of DIN and ARE standard can be proposed in both solvent welded joint and rubber joint.

   Sizes of 16mm to 40 mm produced as solvent welded joint.

   Sizes from 40 mm to 110 mm could be produced either solvent welded joints or rubber ring joint according to the requirements of the customer.

   Sizes from 110 mm to 710 mm produced as rubber joint.
4. **Length:**

   All UPVC PIPES according to different standard generally produced in 6 meter long. Other length may be supplied to special order.

5. **Color:**

   MISR EL NOUR UPVC PIPES in DIN standard are dark gray in color and opaque. Other colors are available on special request.

   MISR EL NOUR UPVC PIPES in ASTM standard are white and gray.

6. **Marking:**

   MISR EL NOUR UPVC PIPES marked automatically during the process of production, each pipes printed (UPVC PIPE MISR EL NOUR-size-wall thickness-standard-time-date of production)
PHYSICAL PROPERTIES

UPVC- stands for -Vinyl Chloride.

- GENERAL :-
The raw materials used for making plastic pipes have definite and controllable mechanical properties; pipes made from them can therefore be engineered to cater for a wide variety of applications and conditions.

It is important to realise, from the outset, that plastic pipes are essentially flexible pipes and under load they tend to “creep“. This characteristic leads to a loss in mechanical strength with time but is by now a well-known documented phenomenon and is allowed for in the pipe design.

It is probably correct to state that more research and experiment has taken place with plastic piping than with any other piping material, to the extent that the behaviour of plastic pipe is fully predictable.

The advantages of flexible pipe for outweigh its disadvantages. Unlike a rigid pipe it will not fail catastrophically it will yield to superimposed forces.

*THE IMPORTANT ADVANTAGES OF PLASTIC PIPES ARE:*

a) They can be manufactured to very close tolerances e.g., 110mm MISR EL NOUR UPVC pipe is made to an outside diameter of 110mm +0.3mm-0.0mm. This allows joints to be made by both the solvent weld method and by rubber ring seals.

b) Plastic pipes do not corrode and are totally unaffected by acid waters, acid soils and electrolytic corrosion from any source in this respect they outclass any other pipe material, including stainless steel.
c) They are made to internationally accepted standards.

d) Plastic pipes have extremely smooth bores jointing systems are made to fine tolerances reducing turbulence to a minimum cavitation is also minimised.

e) Contraries to certain opinion plastic pipes are not susceptible to attack from rodents or bacteria.

f) Plastic pipes are lightweight and easy to install correct installation will result in the reliable service for the needs of many generations. The very nature of plastic piping tempts one to discard the essential principle of pipe lying. Plastic pipes should be handled with care and not thrown to the ground the basic principles applicable to the lying of any pipe material must be applied to plastic pipe as well.

g) Maintenance is minimal.
# PHYSICAL AND MECHANICAL PROPERTIES OF MISR EL NUOR UPVC PIPES.

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>TEST METHOD</th>
<th>UNIT</th>
<th>CHARACTERISTIC VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>ASTM D792</td>
<td>-</td>
<td>1.43</td>
</tr>
<tr>
<td>Density</td>
<td>-</td>
<td>Kg/m³</td>
<td>1.4*10³</td>
</tr>
<tr>
<td>Hardness</td>
<td>ASTM D785</td>
<td>Rockwell R</td>
<td>90</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>DIN 8061</td>
<td>ng/cm²</td>
<td>&lt;4</td>
</tr>
<tr>
<td>Tensile Strength At 15 c</td>
<td>ASTM D 638-60T</td>
<td>MPa</td>
<td>45</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>ASTM D 695</td>
<td>MPa</td>
<td>55</td>
</tr>
<tr>
<td>Elongation at Ultimate Tensile Strength</td>
<td>ASTM D 638</td>
<td>%</td>
<td>100-170</td>
</tr>
<tr>
<td>Modulus Of Elasticity</td>
<td>ASTM D 747</td>
<td>MPa</td>
<td>3000</td>
</tr>
<tr>
<td>Impact Strength (Charpy)</td>
<td>ASTM D 256-56</td>
<td>-</td>
<td>Excellent</td>
</tr>
<tr>
<td>Coefficient Of Linear Expansion</td>
<td>ASTM D 696</td>
<td>°C</td>
<td>7*10⁻⁵</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>-</td>
<td>Kcal/m.h.°C</td>
<td>0.11-0.14</td>
</tr>
<tr>
<td>Flame Resistance</td>
<td>ASTM D 635-56T</td>
<td>-</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>Dielectric Strength</td>
<td>-</td>
<td>V/m</td>
<td>2*10⁷</td>
</tr>
<tr>
<td>Softening Temperature (VSP 5 kgf)</td>
<td>BS 2782</td>
<td>°C (°F)</td>
<td>82 (180)</td>
</tr>
<tr>
<td>Electrolytic Corrosion</td>
<td>-</td>
<td>-</td>
<td>Not Affected</td>
</tr>
</tbody>
</table>
SPECIFIC DESIGN
Hoop stress and creep rupture strength.

“Creep” in plastics, is an important factor to consider when evaluating working pressure and its effect on the expected working life of a pipe. The rate of creep in response to a given stress gradually decreases with the passage of time so it is necessary to study the creep rupture strength of plastics for a considerable period of time in order to allocate adequate safety factors for the lifetime required. In potable water systems this is usually 50 years at a temperature of 20ºc.

Creep rupture analysis data lends itself to extrapolation and results obtained at various temperatures over relatively short periods of time can be extrapolated to predict the longer-term behavior at 20ºc once a pattern of behavior has been established.

A commonly used method for obtaining these results is to place a number of plastics pipes made from the same material under a known hydraulic pressure in a controlled environment, usually water, and to measure the time to rupture.

The stress on the material at any given pressure can be calculated from Barlow’s formula for thin walled pipe.

\[
\sigma = \frac{Q (d_e - e)}{2e}
\]

Where 
- \(Q\) = hoop stress in pipe wall (Mpa)
- \(\sigma\) = internal pressure (Mpa)
- \(d_e\) = external diameter (mm)
- \(e\) = wall thickness (mm)
It will be noted that wall thickness is proportional to the pressure for any given size of pipe. This leads to reducing bores as the pressure rating increase; (De is constant for any given size). A reduction, which becomes significant in class 10 and class 16 pipe, this is allowed for in the flow rate charts given in the appendix.

**Pressure variation and sewerage**

The stress regression curves are derived using constant stresses; in pipelines the stress on the material is rarely constant, varying as the pressure varies and as superimposed loads vary. The latter usually stabilise fairly quickly; at least within the first year of the network life but pressure variations are there forever. As with any other pipe material due allowance for this must be made in designing a water reticulation network with plastic pipes and antisurge devices such as air vessels, non return valves, programmed use of pumps etc., should be incorporated.
Lower surge pressures develop due to surge wave velocities in plastic pipes that are appreciably lower than in cast iron or asbestos cement pipes (approximately one third the velocity) due to their moduli of elasticity.

This has enabled UPVC pipes to be used in areas where water hammer has caused iron and A/C pipes to fracture.

Considerable research has been done on the fatigue properties of plastic pipelines. Recently work has been published on fatigue properties of UPVC related to actual site conditions in water distribution systems.

It is concluded that UPVC pipes will not fail under conditions of dynamic and static stress within 50 years provided the total stress does not exceed 12.5 MPa and the stress amplitude over one million pressure cycles (the maximum likely to occur in a 50 years lifetime) is below 3.0 Mpa.

MISR EL NOUR UPVC pipes are designed for a maximum working stress of 10.0 Mpa at 20°c so provided the stress amplitude does not exceed 2.5 Mpa, ±25% of the designed working pressure, and the variation does not exceed the safe working pressure they will conform with the above requirements, which is based on a safety factor of 2.0 at 50 years at 20°c.

**Effect of temperature change**

**A) Working pressure.**

20°c is the standard design temperature for plastic pipes and working pressures are usually quoted for this temperature, UPVC function perfectly well below 20°c right down to freezing point and can, in fact, withstand higher pressures than those quoted at these lower temperatures. It is recommended however that the working pressures at 20°c be applied even if the average water temperature is well below this figure.

Above 20°c, as can be seen from the regression curves, the creep rupture strength diminishes with increasing temperature and working pressures must be down-rated if the same factors of safety are to be held.
The following reduction factors should be applied.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Multiplying working pressure by:-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UPVC</td>
</tr>
<tr>
<td>25ºc</td>
<td>1.0</td>
</tr>
<tr>
<td>30ºc</td>
<td>0.9</td>
</tr>
<tr>
<td>35ºc</td>
<td>0.8</td>
</tr>
<tr>
<td>40ºc</td>
<td>0.7</td>
</tr>
<tr>
<td>45ºc</td>
<td>0.6</td>
</tr>
</tbody>
</table>

B) Sub zero temperatures
Water has been known to freeze in plastic pipes without causing fractures, but permanent strain can result, leading to severe reduction in the working life of the pipe. Hence plastics pipes – like other pipes- should be protected against sub zero temperatures.

C) Expansion and contraction
All plastics have high co-efficient of expansion and contraction, several times those of the metals. This must be allowed for in any installation by the use of expansion joints, expansion loops, “snaking” the pipe in the trench etc.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>CO-EFFICIEAT OF EXPANSION (K-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPVC</td>
<td>$6 \times 10^{-5}$</td>
</tr>
<tr>
<td>STEEL</td>
<td>$1.2 \times 10^{-5}$</td>
</tr>
<tr>
<td>COPPER</td>
<td>$2.0 \times 10^{-5}$</td>
</tr>
<tr>
<td>Length of pipeline mtr</td>
<td>Temperature variations in °c</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
<td>5 deg mm</td>
</tr>
<tr>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>2</td>
<td>0.6</td>
</tr>
<tr>
<td>3</td>
<td>0.9</td>
</tr>
<tr>
<td>6</td>
<td>1.8</td>
</tr>
<tr>
<td>9</td>
<td>2.7</td>
</tr>
<tr>
<td>10</td>
<td>3.0</td>
</tr>
<tr>
<td>15</td>
<td>4.5</td>
</tr>
<tr>
<td>20</td>
<td>6.0</td>
</tr>
<tr>
<td>50</td>
<td>15.0</td>
</tr>
<tr>
<td>100</td>
<td>30.0</td>
</tr>
<tr>
<td>500</td>
<td>150.0</td>
</tr>
</tbody>
</table>
Thermal expansion in the system must be taken into consideration when jointing pipes and fittings practical tests have shown that the thermal expansion for the system is 6.10-m/m and °c.

The table shown above is thermal expansion for various temperature differences and pipe lengths.

**The Effect of Ultra Violet Light:**

Most plastics are affected by UV light.

UPVC pipes have pigments and light stabilisers incorporated in their formulation but if pressure pipes have to be exposed they should be painted, preferably with one coat of white.

Apart from UV degradation, there are many other reasons why plastic pipes should buried in the ground and we recommended that this be the standard practice where ever possible.

**CHEMICAL RESISTANCE:**

UPVC are generally chemically inert and are used for the used for the conveyance of a large number of chemicals and chemical solutions. They have been used by the chemical industry for over 40 years.

There are nevertheless a few chemicals that cannot be conveyed by these pipes. They include certain aromatic organic liquids, ketones and chlorinated hydrocarbons.

<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Material</th>
<th>Maximum permissible Temperatures (water)</th>
<th>remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Constant</td>
<td>Short term</td>
</tr>
<tr>
<td></td>
<td></td>
<td>°c</td>
<td>°c</td>
</tr>
<tr>
<td>UPVC</td>
<td>Unplasticised Poly-Vinyl Chloride</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>
INSTALLATION METHODS OF UPVC PIPES

A-Method of solvent welded joint:

1- The matting surfaces of the spigot and socket must be wiped with cleaning fluid to remove any adhering mud and grit.

2- Mark on the spigot the full depth of insertion into the socket lightly roughen the penetration length of the spigot and the interior of the socket with emery cloth.

3- Using a clean rag or absorbent paper and cleaning fluid thoroughly clean the matting surfaces of both spigot and socket ensure that no moisture remains on the areas to be jointed.

4- Apply solvent cement sparingly in an even layer, to the internal surface of the socket apply solvent cement liberally to the matting surface of the spigot. Use a new, inexpensive paint brush of suitable size. Always lay on the solvent cement lengthwise and not with a circular motion.

5- With the initial pipe length suitably anchored, immediately push, the spigot end fully home, without turning the pipe. Wipe off with a rag surplus cement around the outside of completed joint.

6- The completed joint should not be disturbed for about five minutes, after which it may be handled with reasonable care.

Hydraulic testing to 1 ½ times working pressure may take place 24 hours after completion of joint; working pressure may be applied after 8 hours.
NOTE:
Close the open tin of solvent cement when not in use, do not work near a naked flame and do not mix cleaning fluid with the solvent cement.

B- Method Of Rubber Ring Joint:

Procedure in making the joint

Assemble the following materials
- clean cloth
- penknife
- lubricant
- medium tooth saw and mitre box or wheel cutter designed to cut plastic (if cutting is anticipated)
- medium file (if cutting is anticipated)

JOINT ASSEMBLY:
A) Check the pipe spigot end and remove any burrs that may occur on the spigot end of the spigot end of the pipe
B) Check the entire spigot end of the pipe marking sure that it is correctly chamfered to 15° to the pipe axis.
C) The LYNG ring and insert are fitted in the factory check that both are seated correctly and that they are free from dirt or mud deposits.
D) The LYNG ring and polypropylene insert are shown separately in picture3 (insert not required for 50mm pipe)

E) Clean the spigot end of the pipe checking to see that the surface is smooth and free from indentations or deep scratches. If the end has
any indention or deep scratches place pipe length to one side for inspection by a factory technical representative.

F) Apply lubricant evenly around the spigot end to approximately half the distance between the pipe end and the mark that indicates the depth of entry.

G) Position the spigot end of the pipe so that the leading edge rests against the rubber ring in the socket.

H) Check the horizontal and vertical alignment of the pipe and socket. The long land canal of the mouth of the LYNG socket facilitates easy of the pipe. The white insert ring prevents dislodgment of the LYNG rubber ring during assembly.

I) As the flexibility of the pipe in sizes of 110mm and below may prevent correct alignment during assembly, the force required to
assemble the joint should be applied as near to the spigot end as possible with the socket held firmly in position.

J) Push the pipe into the socket and position it so that the depth of entry mark is just visible. This procedure should be done in one fluid movement a twisting action will aid entry the joint is now complete.

**Important point to remember about mechanical joints:**
If undue force is necessary to make the joint, the spigot should be withdrawn from the socket and the seating position of the ring should be checked. It is advisable that the depth of entry marks is checked along the length of the pipeline during installation to ensure all are visible.

**APPROXIMATE CONSUMPTION OF SOLVENT CEMENT, CLEANER AND LUBRICANT FOR 100 JOINTS**

<table>
<thead>
<tr>
<th>NOMINAL SISZ</th>
<th>50</th>
<th>63</th>
<th>75</th>
<th>90</th>
<th>110</th>
<th>125</th>
<th>140</th>
<th>160</th>
<th>200</th>
<th>225</th>
<th>250</th>
<th>315</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOLVENT CEMENT- KG</td>
<td>1.7</td>
<td>2.5</td>
<td>3.5</td>
<td>4.5</td>
<td>6.3</td>
<td>7.8</td>
<td>9.6</td>
<td>12.2</td>
<td>17</td>
<td>26</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>CLEANER-KG</td>
<td>0.7</td>
<td>1.1</td>
<td>1.5</td>
<td>2.0</td>
<td>2.7</td>
<td>3.5</td>
<td>4.3</td>
<td>5.5</td>
<td>7</td>
<td>10</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>LUBRICANT-KG</td>
<td>0.16</td>
<td>0.20</td>
<td>0.25</td>
<td>0.33</td>
<td>0.40</td>
<td>0.48</td>
<td>0.60</td>
<td>0.94</td>
<td>1.14</td>
<td>1.88</td>
<td>4.50</td>
<td></td>
</tr>
</tbody>
</table>
LAYING OF UPVC PIPES

1- TRENCHING:
Trench should not be opened for too great a time in advance of pipe lying. The minimum width of the trench base should be the O.D of the pipe plus 300mm. Excavation depth should be 100mm below final invert level of drainpipe.
Soft spots must be tempered hard using broken stone or gravel and large objects such as flints, tree roots, etc., should be removed.
Depth of cover should be at least 1m from top of pipe to ground surface.

2-BEDDING AND PIPE LAYING:
Lay a minimum 100mm bed of suitable material on the trench bottom to the correct fall of the drain. (Many finely grained soils such as course sand, gravel or loam, as excavated from the trench are suitable for bedding provided that they are free from large or sharp stones). Clay and hard chalk are not suitable and in their place imported granula material should be used such as gravel or broken stone 5 to 10mm in size. The drain is laid on the prepared bed and care should be taken to ensure the pipe is supported throughout its entire length. Bricks, etc., should not be used as temporary support for the pipes. Directional changes in the pipe can be achieved by using pre-formed bends, but very small deflections can be accommodated by using rubber ring joints to avoid ingress of dirt and foreign matter.
3- BACK FILLING
Place further bedding material at the sides of the pipe and compact well. Cover the crown of the pipe to a depth of 100 mm with a similar material (larger diameter pipes should have a 150mm cover of compacted well). Excavated material can now be returned to the trench. This should be compacted by hand up to 300mm above the crown of the pipe after which a mechanical hammer may be used.

4- PIPE ANCHORS AND THRUSTBLOCKS:
The function of thrust block is to prevent deflection or extension of the pipeline under the action of internal fluid pressure and to transfer resultant forces to surrounding ground of load bearing quality. Protection works such as concrete blocks or anchor should be arranged at stress points such as bends, blank ends, branching parts, valves, hydrant tees so that when torque is applied, it is not transmitted to the pipe line.
NOTE:
When partially or completely surrounding UPVC pipe with a rigid material (e.g. concrete) the pipe should be wrapped with a compressible material e.g. heavy duty polyethylene to accommodate hoop strain induced by the application of internal pressure.

5- LAYING SPECIAL CASES
A- PIPING UNDER RAILROAD AND ROADS.
When laying UPVC pressure pipes in a protection pipe of steel, the sockets must be protected against abrasion when pushing the piping through the protection pipe. As the socket joints of rubber pipes are not thrust proof, it is recommended to use the pressure pipe with cementing joints in case that more than two pipe length are used within the protection pipe. To protect against eventual shearing stresses occurring at both ends of the protection pipe an adequate sub soil foundation under the UPVC pressure pipes is to be provided at these spots.

B- PIPING IN MOOR OR MARSHY SOILS.
To prevent the sagging of the pipe line in unstable soils, one of the following steps is recommended to drain the soil or to build up a foundation on piles, or to bed the pipe line on a board walk or to lay a
stone riprap with a fine gravel fill. Spot supporting of the pipeline is not permitted.

**FILETED LIELED: -**

Water pressure tests should be performed at least every one-kilometer. It is advisable to pressure test the pipeline at each stage of lying to ensure that it has been lid and jointed correctly. Thus, any fault is immediately evident and can at once be corrected before the line is pressured in service.

1- Back fill the line, leaving joints and fittings exposed.

2- Fill with water, ensuring that no air is left in the pipe.

3- Solvent cemented joints, should be left for 24 hours before being pressure tested.

4- Ends can be blanked off using detachable couplings such as flange adapters and these should be supported to contain end thrust against pressure.

To insure against bursts, all air should be purged from the pipe before testing. This can be achieved by filling the line with water from its lowest point and inserting bleed valves at the highest points. For normal waterworks practice test pressure need must exceed one and half times the safe working pressure of the pipe.

The elasticity of the pipe itself will cause slight expansion under pressure. A slight initial fall in the pressure reading will not necessarily indicate a fault. Likewise, thermal expansion caused by sudden temperature changes may affect the initial pressure reading slightly after checks of all joints and repairs of any leakage parts if there is any pressure down on pressure gauge. Backfill all joints and fittings exposed completely.

**REPAIR: -**
Cast Iron repair couplings are designed to slide over MISR EL NOUR pipe in order to effect a repair. The couplings are rated to class 16 and are easily installed on the smooth constant outside diameter of the PVC pipe. The following diagrams indicate the method of use.

1- BROKEN PIPE

2- REMOVES BROKEN SECTION

3- After chamfering ends with file, measure half of repair coupling and mark each pipe end as shown. Using lubricant liberally, install repair couplings.

5- Cut and chamfer new section of pipe and make the same marks equal to approximately half the coupling length as shown.

6- Tap couplings into place using rubber mallet or hammer and drift.
UPVC Double LYNG Sockets

Double sockets are used to connect plain-ended pipes. Although it is uncommon, there are sometimes short lengths of plain-ended pipes required before or after fittings, such as tees, bends, etc. In these cases the most economical method of connection is to use a double LYNG jointed socket. The following sizes are available:

Saddles

Saddles are manufactured from SG iron, have galvanized bolts and nuts, two straps and a rubber gasket which seats in a races under the saddles. The standard drilling and tapping is 25mm BSP. Tapings up to 40mm BSP can be ordered.

HANDLING, STORAGE & TRANSPORT
UPVC PIPES

1. HANDLING:-

UPVC PIPES are light but should not be handled roughly. One man can easily handle 6m length up to 6” class III and two man can handle up to 12” class V. Mechanical aid will be required for larger sizes and heavier classes. Care should be taken especially when being unloaded for stacking, or when being distributed on site when pipes are lifted mechanically, web or rope slings should be used. Pipes should not be dragged along the ground as this can damage the pipe by scoring the spigot or socket, causing difficulty with jointing and testing.

2. STORAGE: -

UPVC PIPES can be stored in open air, but it is recommended to choose a location out of direct sunlight and with good ventilation. If the location is constantly used for pipe storage, be sure to provide a roof.

UPVC PIPES should be stacked on a flat surface previously cleared of any debris. Side supports having a minimum bearing width of 75mm should be placed at intervals of 1m centers.

Pipes of different sizes and thickness should be segregated to separate stacks, but if this is not practicable, then the larger diameter and or thicker walls should be at the bottom.
When spigot and socket pipes are being stacked, the bottom layer of sockets should be prevented from making direct contact with the ground either by a shallow excavation under the socket area or by the use of transverse supports.

Successive pipe layers should have sockets protruding at alternate ends of the stack so that pipe barrels are then evenly supported by one another along their entire length.

When pipes are temporarily stored in the field, care must be taken to ensure that the ground is level and free from loose stone.

Make sure that the area is free from dry grass or any material likely to constitute a fire hazard.

Be sure to store the sealing rings separated in cold and dark place.

3. **TRANSPORT:**

When loading pipes on vehicles, care must be taken to avoid their coming into contact with any sharp corners such as cope iron, loose nail heads, etc., as pipe may be damaged by being rubbed against these during transit.

While in transit, pipes shall be well secured over their entire length and not allowed to project unsecured over the railboard of the lorry.

Pipes should never be thrown from vehicles.
DESIGN

This section has been introduced to cover certain important aspects of pipeline design, which are particularly applicable to PVC pressure pipes these are:

1- water hammer & surge
2- expansion and contraction
3- design of buried pipe
4- longitudinal bending
5- thrust blocks
6 -some notes regarding basic friction loss calculations.

This section is offered as information for your consideration in specifying MISR EL NOUR UPVC pressure pipes. It is intended to be an aid to, and not a substitution for your own investigation and evaluation of the product in each application or installation.

1-WATER HAMMER & SURGE

The pressure rise in a UPVC pressure pipe as a result of power failure or valve shutoff, is usually lower than conventional materials, because of the increased energy dissipation due to the flexibility of the plastic pipe.

The pressure rise $\Delta h$ is calculated from the Joukowsky Equation:

$$\Delta h = \frac{a}{g} \Delta v$$

Where $a =$ wave celerity in m/s
$g = 9.81 \text{ m/s}^2$
And $\Delta v =$ velocity of flow in pipe in m/s

Wave celerity is the speed at which the pressure wave travels back along the pipe.
This is calculated from the formula:

$$a = \frac{1}{\sqrt{\frac{m}{g} \left( \frac{1}{k} + \frac{cd}{Ey} \right)}}$$

Where

- $a$ = wave celerity in m/s
- $m$ = 10000 N/m² = specific mass of water
- $g$ = 9.81 m/s² = gravitational acceleration
- $k$ = 2200*10⁶ pa = bulk modulus of water at 20°C
- $c$ = 0.9 = end fixity
- $E$ = 3000x10⁶ pa = short term modulus of elasticity for UPVC
- $d$ = internal dia. In mm
- $y$ = wall thickness in mm

For UPVC pipes manufactured in accordance with SABS 966 the ration for the lager diameters, is materially constant within each pressure class irrespective of diameter.

Therefore the wave celerity is virtually constant for each pressure class of pipe, as listed in the table below:

<table>
<thead>
<tr>
<th>CLASS</th>
<th>d/y</th>
<th>WAVE CELERITTY(a) m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>39.5</td>
<td>282</td>
</tr>
<tr>
<td>6</td>
<td>27.9</td>
<td>333</td>
</tr>
<tr>
<td>10</td>
<td>18.6</td>
<td>403</td>
</tr>
<tr>
<td>16</td>
<td>10.0</td>
<td>531</td>
</tr>
</tbody>
</table>

The following example will illustrate the use of the formula.
EXAMPLE 1

A sewer rising main is required to carry 14 l/s from sump level to a settling tank, 30m above the pump station. A flow of 14 l/s in a 140mm class 10 PVC pipeline would result in a fluid velocity of 1.1 m/s (obtained from class 10 MISR EL NOUR pressure pipe flow charts).

Friction loss over 1500m would be 12m (8kpa /100m- from flow chart)

The wave celerity in a class 10 pipe is 403 m/s, therefore the pressure rise from joukowskys equation is

\[
\frac{403 \times 1.1}{9.81} = 45.2 \text{ metres}
\]

Max. head \( H = h_s + \Delta h \)

\[
= 30 + 45.2
\]

\[
= 75.2 \text{m}
\]

A CLASS 10 PIPE is therefore suitable

The wave celerity in a rigid pipe is much higher than in a UPVC pipe because of the greater rigidity. In the above example, a rigid equivalent of our 140mm class 10 UPVC pipe would be a 125mm class C C.O.D. Asbestos cement pipe.

Using the same formula, the wave celerity can be calculated at 1087 m/s and the pressure rise would then be:

\[
\frac{1087 \times 1.1}{9.81} = 121.9 \text{ metres}
\]

UPVC pressure pipe to SABS 966, has a design stress (of 10Mpa and is suitable to be subjected to continuous) internal pressures not exceeding the safe working pressure per class of pipe it is also suitable to be subjected to cyclic variations in internal pressure of up to + or – 25% of the continuous internal pressure
2- EXPANSION & CONTRACTION

A in the case of buried UPVC pressure pipes incorporating LYNG rubber ring joints, expansion and/or contraction is catered for during installation and in service. A UPVC pipe will expand or contract 0.06mm per meter per °c change in temperature. 30°c temperature rise will therefore result in a 10.8mm expansion of a 6m pipe the depth of the socket of the LYNG joint, behind the LYNG seal ring is designed to cater for any such expansion and contraction. This dimension varies from 60 mm in the 50mm socket to 130mm in the 400 mm socket. In practice the pipes are laid out next to the trench, prior to installation and become warm due to exposure to the sun.

On installation and subsequent immediate backfilling, the pipe will contract and the depth of entry mark will be a short distance from the mouth of the socket.

E.g. a 160 mm pipe lying in the sun has a surface temperature of 60°c and after installation and backfilling has cooled down to 20°c. the temperature decreases of 40°c will cause a contraction of 14.4 mm. The distance between the depth of entry mark and the mouth of the socket will therefore be 14.4 mm. In fact this distance could be as much as 40mm and the joint would still operate satisfactorily. (Depth of socket behind rubber ring in 160mm pipe is 86mm).

It is important to note that a 50mm cover of soil over a PVC pipe in a trench is sufficient to cool the pipe in minutes. For this reason we require that a PVC pipe be backfilled immediately after installation to stabilise the expansion/contraction which takes place in a trench during day and night. (A long pipeline left exposed in a trench will expand during the hot day and contract during the cool night, and this movement invariably does not take place evenly the result is that a pipe may pull out of a joint in the middle of this long pipeline making it very difficult to re connect.)
In the case of a backfilled pipeline, the temperature is stabilised and this does not happen).

B- Expansion and contraction allowances must be correctly designed in the case of above ground installation. It is usual to use the solvent weld method of jointing in this instance, and expansion loops and allowances for movement must be incorporated in the installation.

The LYNG rubber ring jointed pipes are sometimes used in above ground installation. In these cases the socket end of each pipe must be fixed, either in a holderbat or wall bracket, while the rest of the pipe is contained in such a way as to allow movement, e.g. a ring around the pipe, fixed to the wall or a bracket. The pipe must be able to move through the ring, while each socketed end remains fixed.

**3- Design of buried pipe**

a) **basis of design**

Flexible UPVC pipes do not fail in the “cracking followed by collapse” mode that is characteristic of rigid pipes. Instead the pipes will deflect under the influence of external loads and the reactive support of the surrounding material it is well known that for slender flexible pipes the stiffness of the surrounding material is more important in limiting deflection than the stiffness of the pipe itself.

The design consists of determining a load and ensuring by means of specific bedding that acceptable deflection is not exceeded. For plastic pipes the deflection limit is generally set at 5% which provides an adequate factor of safety relative to the 30% at which inverse curvature is likely to commence. it also ensures that material strain will be minimal and can be disregarded. In the case of PVC pressure pipes, The wall thickness of classes 10 and 16 are fairly substantial and play a large part in prohibiting deflection. Internal pressure also helps to reduce any deformation caused by external loading.
b) Loads

The calculation of load on flexible pipes depends on a large number of factors and is outside the scope of this section.

The pertinent formulas are:

1- Trench conditions - \( w = d_d \partial BD \) (load per unit length)

\[
3ph^3
\]

2- Point loads - \( w = \frac{3ph^3}{2.5} \) (load per unit area)

\[
\frac{2n(h^2 + x^2)}{in \, mpa}
\]

In practice most installation codes require that pipes be laid in trench conditions, which serve to considerably reduce the load on the pipes. We will consider the effect of a 0.1 Mpa pressure, which is the max. Pressure that would be caused by axle loads of 450 KN, And the earth load, provided the depth of cover was between 1m and 4m.

C- Deflection:

Deflection can be calculated from:

\[
\frac{\Delta d}{d} = \frac{10.0w}{8Ei + 0.043 ES} \]

(Stephenson: municipal engineer, march, 1980)

Where \( \frac{\Delta d}{d} \) = relative deflection in %

\( E \) = pipe material modulus in MPa

\( = 1650 \) MPa for UPVC at 3 years

\( i \) = wall moment of inertia in \( mm^4/mm \)

\( = \frac{t^3}{12} \) (\( t \) = wall thickness in mm)

\( w \) = pressure in MPa = 0.1 MPa in this case (load per unit area)

\( d \) = outside diameter in mm

\( Es \) = soil modulus in MPa

For plastic pipes, the standard dimension ratio SDR, the ratio between the outside diameter and the wall thickness, can be taken as constant for each pressure class.
\[ SDR = \frac{d}{t} \]

Where \( t \) = wall thickness

I.e. \( t = \frac{d}{SDR} \)

Now \( I = \) Moment of inertia

\[ I = \frac{t^3}{12} \]

\[ = \frac{d^3}{12 (SDR)^3} \]

Substituting from the deflection formula

\[ \frac{8E_I}{d^3} = \frac{8Ed^3}{d^5 (SDR)^3} \]

\[ = \frac{8*1650}{(SDR)^3} \]

\[ = \frac{1100}{(SDR)^3} \]

Which is independent of diameter.

The following table shows the percentage deflection under a pressure of 0.1 MPa for various values of Es (soil modulus).

<table>
<thead>
<tr>
<th>Pressure class</th>
<th>SDR</th>
<th>8 EI/d3</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>51</td>
<td>8.28*10^-3</td>
</tr>
<tr>
<td>6</td>
<td>34</td>
<td>2.80*10^-2</td>
</tr>
<tr>
<td>10</td>
<td>23</td>
<td>9.04*10^-2</td>
</tr>
<tr>
<td>16</td>
<td>13</td>
<td>5.01*10^-1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deflection (%) under pressure of 0.1 MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>class</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>16</td>
</tr>
</tbody>
</table>

Note:

1. The deflection is linear with load so that deflection under any other load can be easily evaluated.
   \[ W = c_d \alpha BD \]
   Where \( W = \) load per unit length of pipe
   \( C_d = \) load co-efficient
\[ = 1 - e^{\frac{2k (\tan \theta) H}{B}} \]

where  
\( k \) = ratio of lateral to vertical pressure within the soil  
\( \theta \) = angle of friction between backfill and sides of trench  
\( H \) = height of fill above pipe  
\( B \) = trench width  
\( D \) = pipe diameter  
\( \alpha \) = unit weight of backfill

The graph below indicates values of \( c_d \), the load coefficient.

2- the pressure at which the pipe can be expected to fail by buckling should be checked and can be calculated from the CIRIA formula:

\[ W_b = \frac{2 \sqrt{8EI \cdot E_s}}{d^3} \]

Where  
\( W_b \) = buckling pressure in MPa  
\( E \) = pipe material modulus in MPa  
\( = 1650 \text{ MPa for UPVC at 3 years} \)  
\( I \) = wall moment of inertia in \( \text{mm}^4/\text{mm} \)  
\( d \) = outside diameter in mm  
\( E_s \) = soil modulus in Mpa
### BUCKLING PRESSURE IN MPA

<table>
<thead>
<tr>
<th>PRESSURE CLASS</th>
<th>SOIL MODULUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS</td>
<td>1.4</td>
</tr>
<tr>
<td>4</td>
<td>0.21</td>
</tr>
<tr>
<td>6</td>
<td>0.33</td>
</tr>
<tr>
<td>10</td>
<td>0.71</td>
</tr>
<tr>
<td>16</td>
<td>1.68</td>
</tr>
</tbody>
</table>

### AVERAGE VALUES OF MODULUS SOIL REACTION,
FOR INITIAL FLEXIBLE PIPE DEFLECTION

<table>
<thead>
<tr>
<th>Soil type- pipe bedding material (Unified) Classification System (1)</th>
<th>E, for Degree of Compaction of Bedding, in pounds per square inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine- grained Soils( LL &gt;50) Soils with medium to high plasticity CH,MH,ch-MH</td>
<td>No data available consult a competent soils engineer, otherwise use E = 0</td>
</tr>
<tr>
<td>Fine – grained soils (LL&gt;50) Soils with medium to no plasticity CL,ML,ML,-CL, with less than 25% coarse-grained particles</td>
<td>(03)</td>
</tr>
<tr>
<td>Fine – grained Soils (LL&gt;50) Soils with medium to no plasticity CL,ML,ML,-CL with more than 25% coarse-grained particles Coarse-grained Soils with Fines GM,CC,SM SC contains more than 12% fines</td>
<td>(0.3)</td>
</tr>
<tr>
<td>Coarse-grained soils with little or No Fines GWGP,SW,SP Contains less than 12% fines</td>
<td>(1.4)</td>
</tr>
<tr>
<td>Crushed Rock</td>
<td>1000</td>
</tr>
<tr>
<td>Accuracy in Terms of percentage deflection</td>
<td>±2</td>
</tr>
</tbody>
</table>

aSTM designation D-2487. USBR designation E-3.

LL= liquid limit.
or any borderline soil beginning with one of these symbols (i.e., GM – GC- SC).
For ± 1% accuracy and predicted deflection of 3%, actual deflection would be between 2% and 4%.

Note:
Values applicable only for fills less than 50ft (15m). Table does not include any safety factor. For use in predicting initial deflection only, appropriate Deflection Lag Factor must be applied for long-term deflections. If bedding falls on the borderline between two compaction categories, select lower E value or average the two values percentage Proctor based on laboratory maximum dry density from test standards using about 12.500 ft-LB/cu ft (598.000 j/m³) (ASTM D-698, AASHO T-99, USBR Designation E-11) 1 psi = 6.9 kn./m.

**LONGITUDINAL BENDING**

The response of UPVC pipe to longitudinal bending is considered a significant advantage in buried applications. Longitudinal bending may be done deliberately in PVC pipe installation to make changes in alignment to avoid obstruction. It may also occur in response to various unplanned conditions or unforeseen changes in conditions in the pipe soil system, such as:

A) Settlement of a valve in a manhole, or fitting to which pipe is rigidly connected.
B) Uneven settlement of the pipe bedding.
C) Ground movement as result of high water table.
D) Erosion of bedding due to movement of underground water.
E) Improper installation procedures, eg unstable bedding or inadequate compaction.

Though longitudinal bending upvc pipe provides the ability to deform or bend or move away from external pressure concentrations. The use of flexible joint also enhances a pipes ability to yield to these forces thereby reducing the risk of damage or failure. Good engineering design and
proper installation will eliminate longitudinal bending from being a critical design consideration.

**Allowable longitudinal bending**

When installing upvc pipe, some changes in direction may be necessary which which can be accomplished without the use of elbows, bends or other direction-change fittings. Controlled longitudinal bending within acceptable limits can be accommodated by upvc pipe this is accommodated through a combination of joint deflection and axial flexure of the pipe. The following table indicates the allowable longitudinal bending of 6m UPVC pipes including allowing allowance for joint deflection.

**TABLE SHOWING ALLOWABLE LONGITUDINAL BENDING (ANGLE A) OVER 6m PIPE LENGTHS (SEE DIAGRAM)**
Including allow acne for joint deflection

<table>
<thead>
<tr>
<th>PIPE SIZE</th>
<th>ALLOWABLE AANGLE (A) PER PIPE CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4°</td>
</tr>
<tr>
<td>50mm</td>
<td>35°</td>
</tr>
<tr>
<td>63mm</td>
<td>33°</td>
</tr>
<tr>
<td>75mm</td>
<td>27°</td>
</tr>
<tr>
<td>90mm</td>
<td>23°</td>
</tr>
<tr>
<td>110mm</td>
<td>16°</td>
</tr>
<tr>
<td>125mm</td>
<td>15°</td>
</tr>
<tr>
<td>140mm</td>
<td>14°</td>
</tr>
<tr>
<td>160mm</td>
<td>11°</td>
</tr>
<tr>
<td>200mm</td>
<td>8°</td>
</tr>
<tr>
<td>250mm</td>
<td>6°</td>
</tr>
<tr>
<td>315mm</td>
<td>3°</td>
</tr>
<tr>
<td>355 &amp; 400mm</td>
<td>2°</td>
</tr>
</tbody>
</table>
It can be seen that it is not necessary to use a special 22 ½ bend up to 75mm including 90mm classes 4&6. Similarly 11- ¾ bends are not required up to size 140 mm, including 160mm classes 4&6.

**DIAGRAMS SHOWING ALLOWABLE LONGITUDINAL BENDING ANGLE.**

\[
\text{ANGLE A: } \quad \frac{180 \times L}{\pi \times R}
\]

eg. \(\text{ANGLE 11} = \frac{180 \times 6m}{\pi \times R}\)

\[
R = \frac{180 \times 6}{\pi \times 11} = 31.25m
\]

Generally a bending radius of \(R = \pm 300 \, D\), where \(D\) is the outside diameter of the pipe, is recommended.

**THRUST BLOCKS**

The intention is to provide a guide to thrust block sizes, as it is necessary to install thrust blocks at all changes of direction. This is to neutralise the thrust caused by any vertical or horizontal change of direction of the water in the pipe. Thrust blocks must be placed between the fitting which is to be supported, and the undisturbed wall of the trench, of preferably keyed into the side wall of the trench.

The size of the thrust block depends on:
The pipe size
The line pressure
The type of fitting
The degree of bend
& The type of soil.

<table>
<thead>
<tr>
<th>PIPE SIZE</th>
<th>90 BENDS A*B</th>
<th>45 BENDS A*B</th>
<th>TEES</th>
<th>END CAPS SLUICE VALVES REDUCERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>50mm-90mm</td>
<td>0.2*0.2</td>
<td>0.2*0.2</td>
<td>0.25*0.25</td>
<td>0.25*0.6</td>
</tr>
<tr>
<td>110mm</td>
<td>0.3*0.3</td>
<td>0.3*0.25</td>
<td>0.3*0.3</td>
<td>0.3*0.6</td>
</tr>
<tr>
<td>125mm&amp;140mm</td>
<td>0.3*0.45</td>
<td>0.3*0.3</td>
<td>0.3*0.4</td>
<td>0.3*0.65</td>
</tr>
<tr>
<td>160mm</td>
<td>0.3*0.6</td>
<td>0.3*0.4</td>
<td>0.3*0.45</td>
<td>0.3*0.7</td>
</tr>
<tr>
<td>200mm</td>
<td>0.45*0.7</td>
<td>0.3*0.7</td>
<td>0.45*0.6</td>
<td>0.45*0.8</td>
</tr>
<tr>
<td>250mm</td>
<td>0.6*0.9</td>
<td>0.6*0.6</td>
<td>0.45*0.8</td>
<td>0.45*0.85</td>
</tr>
<tr>
<td>315mm</td>
<td>0.6*1.3</td>
<td>0.6*0.9</td>
<td>0.6*0.9</td>
<td>0.6*1.0</td>
</tr>
<tr>
<td>355mm</td>
<td>0.8*1.5</td>
<td>0.6*1.2</td>
<td>0.6*1.4</td>
<td>0.6*1.4</td>
</tr>
<tr>
<td>400mm</td>
<td>1.0*1.6</td>
<td>1.0*1.2</td>
<td>0.8*1.5</td>
<td>0.8*1.5</td>
</tr>
</tbody>
</table>

Sizes in metres

Thrust block sizes are generally specified in contract documents and for this reason the above table is intended as a guide only.
Some notes regarding basic friction loss calculations.

Friction and Flow through Pipes
Water is subjected to a resistance when flowing through a pipe. This resistance is known as friction and the energy lost in overcoming friction is known as the head loss due to friction, or hf.

Gravity pipelines
Consider water flowing in a long pipe from Tank A to Dam B.

Figure 1

The final or lower level of the water is taken as the datum line xx. The difference between the water level in the Tank A and the water level in the Dam B is Hs or static head. L is the length of the pipeline and the line drawn between the top water level (in Tank A) and the bottom water level (in Dam. B) is the hydraulic Gradient.

Water in Tank A has potential energy because of its height above Dam B. The potential energy of this system fig.1 is at maximum at Tank A and as the water flows down the pipeline towards Dam B, so the potential energy is reducing because of the fall and the loss of head due to friction. This energy line is called the hydraulic gradient. The slope of this line is equal to the difference in water levels in meters or hs (static head) divided by the length of the pipeline (per 100 meters).

This figure is the friction loss, which is expressed on our flow charts as kpa/100 metres. (1 m = 10kpa)
In figure 2, Tank A and Dam E are separated by a hill and the pipeline has to flow over the hill with highest point at C.

The pressure energy at any section of the pipeline is represented by the vertical distance between the hydraulic gradient and the centerline of the pipe.

**Observations**

1- if the pipeline is below the hydraulic gradient the pressure is above atmospheric.

2- where the pipeline crosses the hydraulic gradient the pressure is equal to atmospheric

3- in section B to C to D the pipeline is above the hydraulic gradient and the pressure is negative or below atmospheric.

4- A pipe, which rises above the hydraulic gradient, is known as a syphon.

5- In both figures 1 and 2 it would be inadvisable to install a valve on the pipeline at Tank A. A control valve or isolating valve would always be situated at Dam E, thereby avoiding the danger of the pipe being flattened due to vacuum. A minimum of a class 10 pipe is recommended for negative pressure or vacuum conditions.

6- If the pipeline rises at C more than 8m above its hydraulic gradient, separation of the water column will occur for at this negative pressure the water commerce to vapourise. This phenomenon is similar to the same negative condition, which causes cavitation at the eye of the
impeller of a centrifugal pump resulting in tremendous damage and finally failure.

If a pipeline falls 45 meters, the total head at the lower end when the pipe is full of water and the water is not flowing is 45 meters or 450 kpa. Therefore a class 6 pipe would have to be used in the lower section, because class 6 has a working pressure of 600-kpa or 60 meters head.

Similarly class 10 is 1000 kpa 100m
Similarly class 4 is 400 kpa 40m
Similarly class 16 is 1600 kpa 160m

It is not uncommon to find different classes of pipe in a gravity pipeline starting with the thinner wall pipes at the top, and increasing in class to the lower level. If valve C figure 1 is closed, the pressure in the pipeline is at its maximum with the greatest the point in the line immediately above the valve. When water is flowing in the pipeline the pressure at the lower end drops to atmospheric or zero.

N.p friction losses through fittings are minimal and have been ignored in this discussion. Allowance for these losses must be made however, particularly in the case pump suction lines.

EXAMPLE 1:

Farmer a has a spring situated 450m from a cattlekraal and his intention is to store water in a reservoir near the kraal. He requires a flow into the reservoir of at least 28 cubic meters per hour, as he will use this for irrigating a nearby pasture. The fall from the spring to the proposed reservoir is 22.5 meters what size and class of pipe does he requiring.

Firstly, establish the slope of the hydraulic gradient, which equals the difference in height divided by the length of the pipeline.

Difference in height or static fall = 22.5m
Length of pipeline (proposed) = 450m
Slope = 0.05 meters/meter
But the slope of hydraulic gradient on the charts is expressed as kpa/100m and as 10kpa = 1m, it is required to establish the slope as friction loss in meters/100m.

Length of pipeline = 4.5*100m

\[
\frac{22.5}{4.5} = 5.0\text{m/100m}
\]

Or 50 kpa/100m

28 cubic meters/hour = 28000 l/hour

= 7.8 l/s

Because the total fall is only 22.5 meters, a class 4 pipe may comfortably be used. Using the class 4 flow charts read horizontally on the 50kpa/100m line to the point where it intersects the vertical 7.8 l/s line. You will note that the next larger pipe size is 75mm and that the velocity in the pipeline is approx. 2.0 m/s

The requirement is:

75 lengths of 75mm class 4 MISR EL NOUR pipes in 6m lengths complete with one LYNG joint per length.

He must be warned against the installation of an isolating valve at his spring, because (assuming the pipe is to be buried) the combination of soil loading and vacuum from a closed valve can result in a collapsed pipe!

**EXAMPLE 2**

Mine manager S requires 30/s for his chilled water plant on level 24 and the only reservoir he can top is on level 23,80m higher. The pipeline would have to be 3600m long. The water is required to enter the chilled water plant under a pressure of about 220kpa. What size and class of pipe does he need?
The total fall is 80m, therefore maximum pressure in the line will not exceed 80m-use class 10 pipe.

\[
\text{Difference in levels} \quad = \quad \frac{\text{drop in pressure}}{1} \\
= \text{slope of hydraulic gradient} \\
\frac{80\text{m}-22\text{m}}{1} = 58\text{m} \\
\Rightarrow \frac{58\text{m}}{36\text{ (*100m)}} = 1.61 \text{ m/100m} \\
= 16.1 \text{ kpa/100m}
\]

Reading off flow chart, a 160mm pipe can be used to transport 301/s through 3600m of pipeline to the chilled water plant.