POLIPLEX® PE100

TESTING

FIELD ACCEPTANCE TESTING

On completion of any pipe installation, it is normal practice to apply a pressure test to the system as a check for leaks. For linearly elastic materials this is normally a sustained pressure test over a defined time period whereby the "make-up" water necessary to maintain pressure over that period must not exceed a certain value. However this type of test is not suitable for viscoelastic materials such as polyethylene which exhibit strain creep and stress relaxation. When such a pipe is sealed at a particular test pressure there will be a reduction in pressure over time (or pressure decay) even in a leak free system, as a result of the creep characteristics of the material.

The behaviour is non-linear as shown in Fig. 1.0, but a logarithmic graph will be a straight line, and the slope of this line can be interpreted so as to indicate whether or not there is a leak in the system. In Figure 2.0 line AB indicates an ideal pipeline with no leaks, but a steeper line AC indicates a more rapid pressure decay with the possibility of leakage. If air was in the pipeline this would have been compressed as the test pressure built up, and then later expanded with very little pressure loss (as with an accumulator) as represented by line AD.

It is important then when filling the pipeline, that special attention be paid to the elimination of any potential air pockets. All air valves must be installed in appropriate locations along the pipeline and must be fully operational.

PREPARATION

1. Testing should, where possible, be between closed ends rather than isolating valves, as with the latter it may not be possible to check for internal leakage past the gates. The test section may range up to several kilometres in length, but shorter lengths may be selected due to site related factors. Large differences in elevation should be avoided in a single test section as this could create high static heads at the lowest point in the section. It is not recommended that welded joints be left exposed on a buried installation, but flanged and mechanical joints usually require visual inspection under the test pressure.

2. Ideally the pipeline should be filled and pressure tested from the lowest point.

3. A high pressure/low flow test pump should be selected with adequate capacity for the length and diameter of pipeline being tested. Pressure gauges should be capable of being read to ± 10 kPa. The reduced levels of the pressure gauges/data logger location should also be established

4. After filling, the pipeline should be left to stabilise at its temperature for a period of time which will vary with the pipe size and weather conditions. A minimum of 2-3 hours should be allowed although it is preferable to delay testing until the following day.

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FIGURE 1.0

Typical pressure delay curve for an unrestrained PE pipeline

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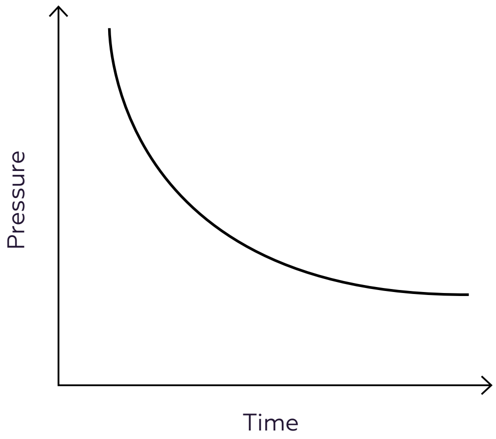

FIGURE 2.0

Schematic diagram of the analysis of a pressure decay curve

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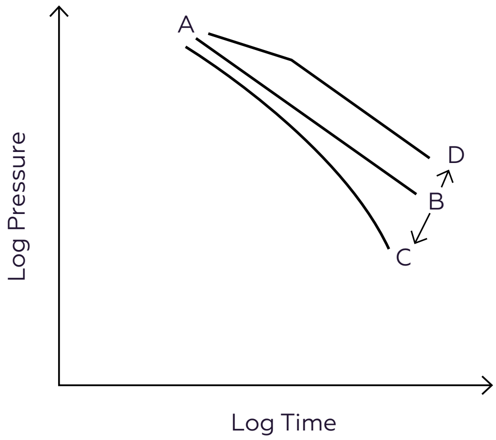

TEST PRESSURE AND APPLICATION RATE

For PE pipe systems, James Hardie Pipelines recommends maximum test pressures as follows:

- for PN6 and PNlO systems, 1.3 times the **rated pressure**, of the pipes installed;
- for PN12 bar and PN16 systems, 1.3 times the designed **working pressure** of the pipeline;
- the maximum test pressure should not exceed 1.3 times the **maximum** rated pressure of the lowest rated component.

(Note the WRc suggests test pressures of up to 1.5 in all the above situations.)

The rate at which the test pressure is applied, ie. the time taken to raise the pipeline to the selected test pressure, from the starting pressure, is important. Pressure should be applied to the main by pumping continuously at a sensibly constant rate with respect to volume/time. Volume may be determined by directly measuring the water quantity being drawn from a container or estimated by the number of full strokes of a piston.

The pressure rise should be monitored and recorded and its characteristic analysed to aid in identifying whether air is present. The relative proportion of air in the system can be gauged by the time taken to pressurise the main for a given pumping rate and the response during this pressurisation phase.

Figure 3.0 identifies the changes in curve form with increasing volumes of air in the test section. If there was no air in the system, the response is linear (line A - B). With increasing amounts of air in the system the response becomes more curvilinear, eg. A - C, A - D and A - E.

If the analysis above indicates significant volumes of air, then the test should be terminated and procedures adopted to remove air. Failure to do this is likely to invalidate the pressure test.

If the analysis above indicates a linear relationship (line A - B) then the pressure test can be continued. It is possible to predict, for a given test section, probable air volumes which would give a significant effect. This would be an aid in identifying the likely presence of air the system. An analysis procedure is identified in the sample calculation in this section for determining air volumes .

TESTING

PRESSURE TEST MONITORING

On reaching the test pressure and satisfying the condition for minimal air entrapment, the pipeline is isolated and the pressure allowed to decay. The pressure loading time (t_L) to achieve test pressure is used as a reference. The natural pressure decay readings at predetermined times are then recorded in minutes from the moment of valve closure.

The analysis will be more comprehensive with larger numbers of readings being taken throughout the test.

Since the pipeline begins to relax within the period of pressurisation, a correction factor has to be applied to allow for this. Experience suggests that this correction should be $0.4t_L$. A typical sequence of readings is illustrated in Figures 4.0.

THREE POINT ANALYSIS

To demonstrate that the PE pipeline is sound, an analysis of the pressure test is carried out as follows:
As the pressure decay is of exponential form, the use of logarithms is necessary when comparing readings taken during the test but the use of a pocket calculator is all that is required for 'on site' calculations.

Take a first reading of pressure P_1 at t_1, where t_1 is equal to the pressure loading time (t_L).

Take a second reading of pressure P_2, at a time of approximately 7 x t_L ; Let this be t_2.

To allow for stress relaxation behaviour of PE pipelines, calculate the corrected values of t_1 and t_2;

Calculate corrected t_1

$t_{1c} = t_2 + 0.4t_L$

Calculate corrected t_2

$t_{2c} = t_2 + 0.4t_L$

The measure of the slope of the pressure decay curve between t1 and t2 is then calculated as the ratio n_1.

Calculate n_1 =

$$\frac{\log P_1 - \log P_2}{\log t_{2c} - \log t_{1c}}$$

For a sound main, experience suggests that the ratio n_1 should be:

a) 0.08 - 0.10 for pipes without constraint (eg. pipelines which are above ground, ungrouted slip liners or before backfilling),

b) 0.04 - 0.05 for pipes with compacted backfill. Bearing in mind the identified compaction, if the values are significantly less than the minimum for (a) or (b), then the volume of air in the main is too great. This air will have to be removed before a satisfactory test can be performed.

Take a further reading of pressure P_3 at a decay time not less than 15 x t_L. Let this be t_3. Again to allow for the stress relaxation behaviour of PE pipelines, calculate the corrected value for t_3.

$t_{3c} = t_3 + 0.4t_L$

The measure of the slope of the pressure decay curve between t_2 and t_3 is then calculated as the ratio n_2

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To allow for stress relaxation behaviour of PE pipelines, calculate the corrected values of t_1 and t_2;

$$\text{Calculate } n_2 = \frac{\log P_2 - \log P_3}{\log t_{3c} - \log t_{2c}}$$

For a pipe system with no leakage and bearing in mind the identified compaction, then the ratio of n_2 should be as for n_1, ie:

a) 0.08 - 0.10 for pipes without constraint,

b) 0.04 - 0.05 for pipes in compacted backfill.

Figures 5.0 and 6.0 show the results of tests (using graphical analysis with multiple results from a data logger) on mains without leaks in unconstrained and constrained situations respectively. Typical calculations are given in the 'worked examples' of this section.

The sensitivity of the test can be increased by extending the value of t_3, ie. extending the test duration.
The procedure detailed so far outlines the principles involved. However, it is strongly advised that the slopes n_1 and n_2 be obtained from more than three points.

To allow an early indication of problems such as leakage or air entrapment, a supplementary analysis can be carried out during the pressure test. This necessitates comparing the recorded pressure at any point in time with the predicted pressure since the logarithmic plot of pressure decay in an ideal PE pipeline system should be linear. Any deviation from linearity indicates the possibility of leakage or air entrapment.

The predicted pressure can be calculated from

$$P = P_L \left[2.5 \frac{t}{t_L} + 1\right]^{-n}$$

where

P = predicted pressure at time t

P_L = test pressure (at start of test when the test pressure is first reached)

t = time (from reaching the test pressure)

t_L = loading time

Experience has been shown that:

for pipes installed in compacted soil n = 0.04

for pipes installed without support n = 0.10

If the actual pressure recorded was found to differ significantly from the predicted value, a formal slope analysis using all the data collected up to that stage should be conducted.

That is the data is plotted on log paper or converted to logs prior to plotting on normal paper. The resultant graph should be similar to Figure 2.0. If the graph shows an increasing slope with time (A - C) ie. the actual recorded pressures were less than the predicted values, leakage is probable. If the graph shows a decreasing slope with time (A - B) ie. the actual recorded pressure were greater than the predicted values, air entrapment is the likely cause. If the slope is linear but between the slopes identified (ie. 0.04 - 0.05 and 0.08 - 0.1) it is an indication of poor backfill compaction, but not a failed test.

Note: It is possible to predict leakage rates as a function of water volume added. A procedure for possible analysis is identified in the worked examples.

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FIGURE 3.0

Typical pressure/volume characteristic during pressurisation
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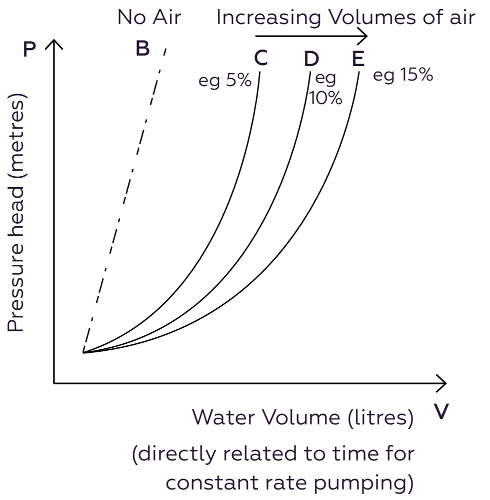

FIGURE 4.0

Diagramatic illustration of a sequence of pressure readings
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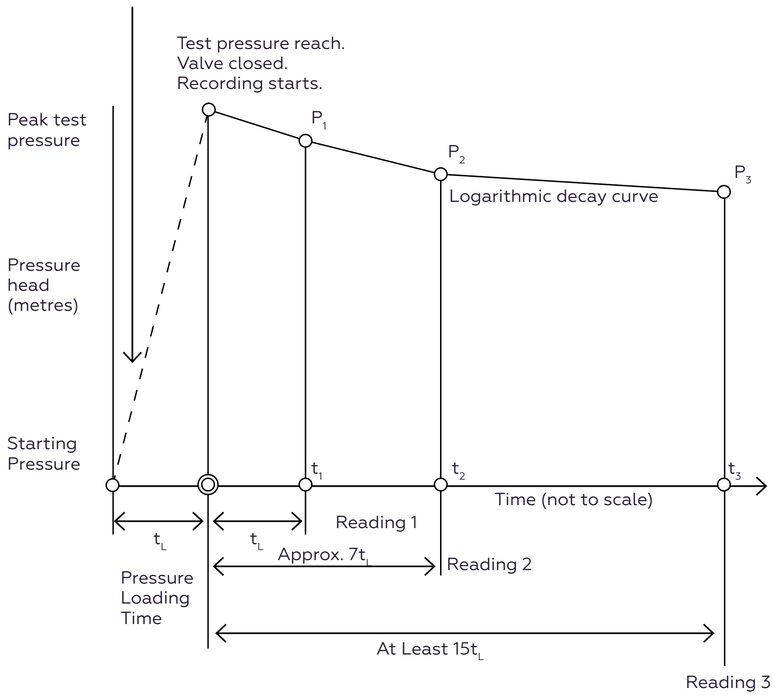
Analyse pressure rise to identify possible air entrapment



PRESSURE TEST - GENERAL

For the straightforward pressure test analysis or the more detailed supplementary analysis, the use of data loggers is strongly recommended.

Data loggers are available with inbuilt data processing facilities. These can simplify the mechanics of the pressure test and can facilitate an early detection of leakage. Data loggers make available:

- the on-site analysis of pressure decay at any point in time
- the detailed analysis of the complete pressure rise and pressure decay curves
- a record of pressure tests for subsequent interrogation
- the use of software to aid analysis and complete the calculations

If at any stage during the pressure test an unacceptable leak is indicated, it is advisable to check all mechanical fittings before visually inspecting the fusion joints. Any defect in the installation revealed by the test should be rectified and the test repeated.

On completion of a test sequence, the remaining pressure should be released slowly until the pipeline returns to its pre-test conditions.

In the event of a further test being required on the pipeline, such a test should NOT be attempted before sufficient time has elapsed for the pipeline to recover from the previously imposed conditions.
This recovery time will depend upon individual circumstances but a period equivalent to 5 times the previous total test period may be taken a guide.

TESTING

COMMISSIONING

The commissioning of new or repaired distribution mains is normally carried out in the following sequence:

- cleaning and/or swabbing of the main
- filling and flushing
- sterilisation and/or neutralisation
- refilling the main
- bacteriological sampling
- acceptance certification
- introduction of the main into service

The sequence for PE systems includes these basic procedures but may be adapted to meet particular conditions (eg. pre-chlorination of sliplined mains). In all cases, the procedures must comply with the requirements of the local water authority.