# Florida Method of Test for Predicting Long-Term Modulus of HDPE Corrugated Pipes

## Designation, FM 5-577

## 1. SCOPE

1.1 This test method is used to predict the long-term modulus of high density polyethylene corrugated pipes in view of Florida DOT 100-year design service life requirement.

1.2 The test utilizes stress relaxation data obtained from ***ASTM D2412*** test method on corrugated pipes with diameter less than 24 inches.

1.3 The tests shall be performed at a minimum of six elevated temperatures in an air incubation environment.

1.4 The stress relaxation data obtained from the elevated temperatures are shifted to a lower site specific temperature using the equations defined by Popelar, et al., (1991)

## 2. REFERENCED DOCUMENTS

2.1 ASTM Standards:

D1600 Terminology for Abbreviated Terms Relating to Plastics

D 2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

2.2 Other Documents:

Popelar, C.H., Kenner, V.H., and Wooster, J.P. (1991) "An Accelerated Method for Establishing the Long Term Performance of Polyethylene Gas Pipe Materials", Polymer Engineering and Science, Vol. 31, No. 24, pp. 1693-1700.
Selig, E.T (1995), "Long-Term Performance of Polyethylene Pipe under High Fill", Geotechnical Report No. PDT95-424F, Technical Report – Part 2, Research Project No. 88-14, Pennsylvania Department of Transportation, Harrisburg, PA.

## 3. STRESS RELAXATION TEST

3.1 The stress relaxation test shall be performed based on ***ASTM D 2412*** procedure with modifications as follows:

3.1.1 Compress the pipe specimen at a constant rate of 0.5 in/min until deflection reaches 5% of the average inside diameter of specimen.

**Note 1**: The test apparatus can be simple metal frame equipment with a load cell that has the appropriate capacity to measure the changing load with time. Figure 1 is a test apparatus that was used by Selig (1995) for stress relaxation test on 24 inch corrugated pipes.

3.1.2 Hold the pipe at 5% deflection and monitor load changes with time.

3.1.3 Terminate the test after 1,000 hours.

**Note 2**: The testing time may need to be extended depending on the resulting Master curve at 23°C after shifting. The duration of the Master curve shall not be shorter than 100-years.

3.2 The stress relaxation tests shall be tested in an air environment at five temperatures, ranging from 23 to 63°C at 10°C intervals.

3.4 Each test temperature shall be held at an accuracy of ±2°C.

**Note 3:** The temperature chamber can be made from extruded polystyrene foam panels and are placed around the test pipe. The elevated temperatures can be achieved by forcing hot air into the incubation chamber.

## 4. DATA ANALYSIS

4.1 At each test temperature, the load changes with time shall be recorded for a duration of 1000 hours.

4.2 The pipe stiffness, *PS*, shall be calculated according to Eq. (1) which is defined in ***ASTM D 2412***.

$$PS = \frac{F}{\Delta y}\left(1 + \frac{\Delta y}{2d}\right)^3 \qquad (1)$$

where:

*F* = applied load per unit length (lb/in)
$\Delta y$ = inside vertical diameter change (in), and
*d* = initial inside vertical diameter

4.3 The flexural modulus of the pipe at 5% deflection shall be calculated using Eq. (2) which is defined in ***ASTM D 2412***.

$$E = \frac{0.149r^3(PS)}{I} \qquad (2)$$

where:

$E$ = flexural modulus
$r$ = half the sum of the inner diameter and one corrugation depth
$I$ = bending moment

4.4 Present test data in graphic form by plotting the logarithm of modulus versus the logarithm of the testing time for each temperature. An example of the results is shown in Figure 2.

4.5 The four sets of stress relaxation data obtained from the elevated temperatures (33 to 63°C) are shifted to a 23°C temperature according to Eqs. (3) and (4) that are defined by Popelar, et al., (1991), yielding a master curve at 23°C. An example of the results is shown in Figure 3.

$$a_T = \exp[-0.109(T - T_R)] \qquad (3)$$

$$b_T = \exp[0.0116(T - T_R)] \qquad (4)$$

where:

*$a_T$ = horizontal shift function (time function)*
*$b_T$ = vertical shift function (stress function)*
*$T$ = temperature of the test*
*$T_R$ = target temperature (in this case this is site temperature)*

4.6 The duration of the resulting master curve must be longer than 100-year. If the duration of the master curve is shorter than 100-year, a new set of stress relaxation tests shall be performed by extending the individual testing time from 1000 hours to 10,000 hours.

4.7 The master curve at 23°C shall be fitted with a power law equation, as displaced in Figure 3, from which the 100 year modulus value can be predicted.

## 5. REPORTING RESULTS

Test report shall include the following information:

5.1 All details necessary for complete identification of the material tested (***AASHTO M 294*** cell class).

5.2 Test temperatures and modulus versus time curve at each temperature.

5.3 Report the shifted data, fitted power law equation and shifted graph with master curve.

5.4 Report predicted modulus value at 100-year using the power law equation.

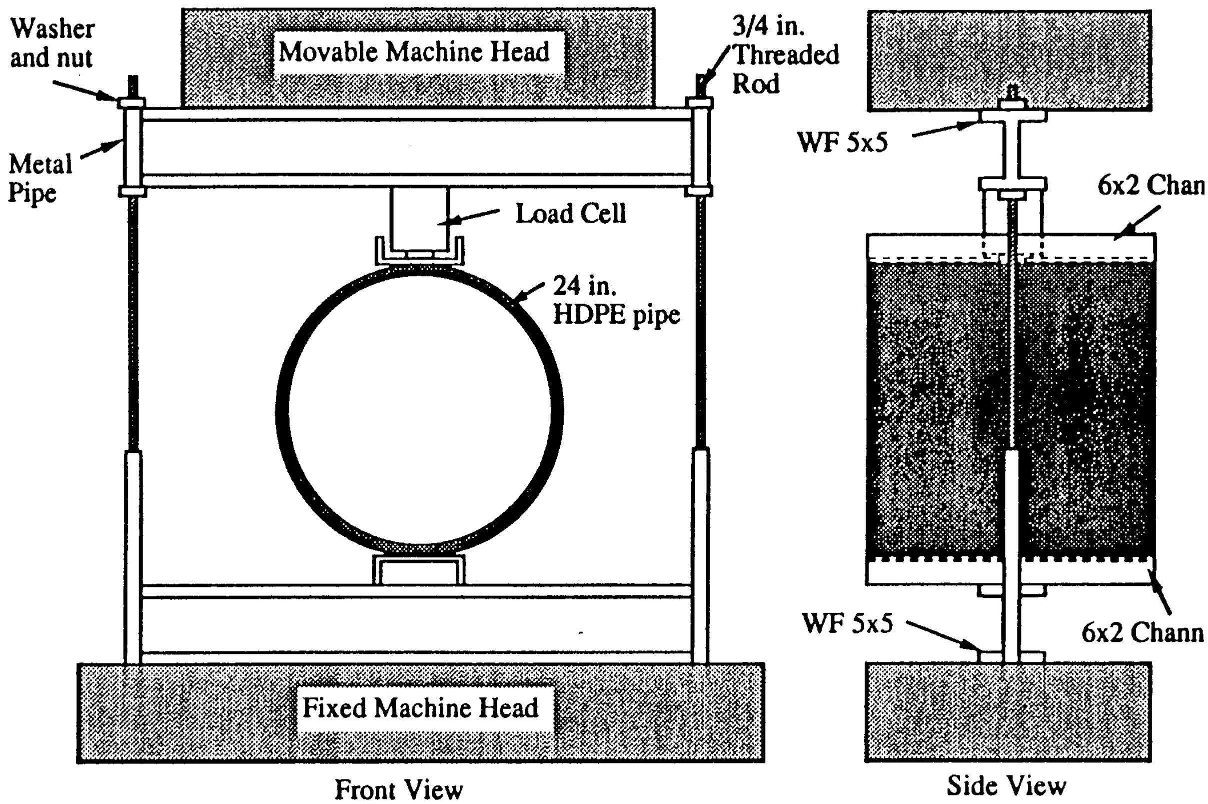


**Figure 1** Parallel Plate test set up for stress relaxation test of corrugated pipe, (Selig, 1995)

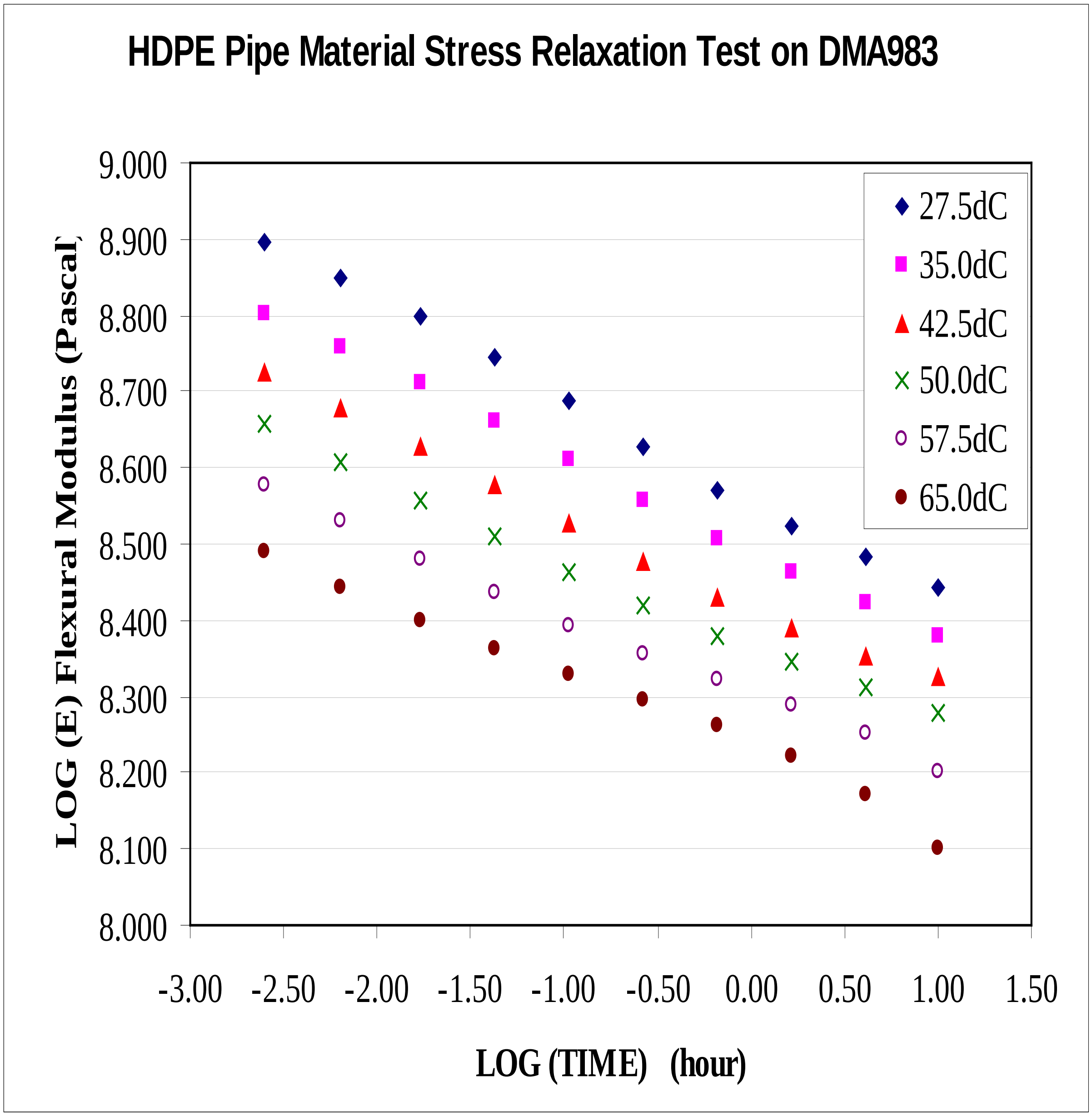


**Figure 2** Stress relaxation curves resulted from the DMA test-1

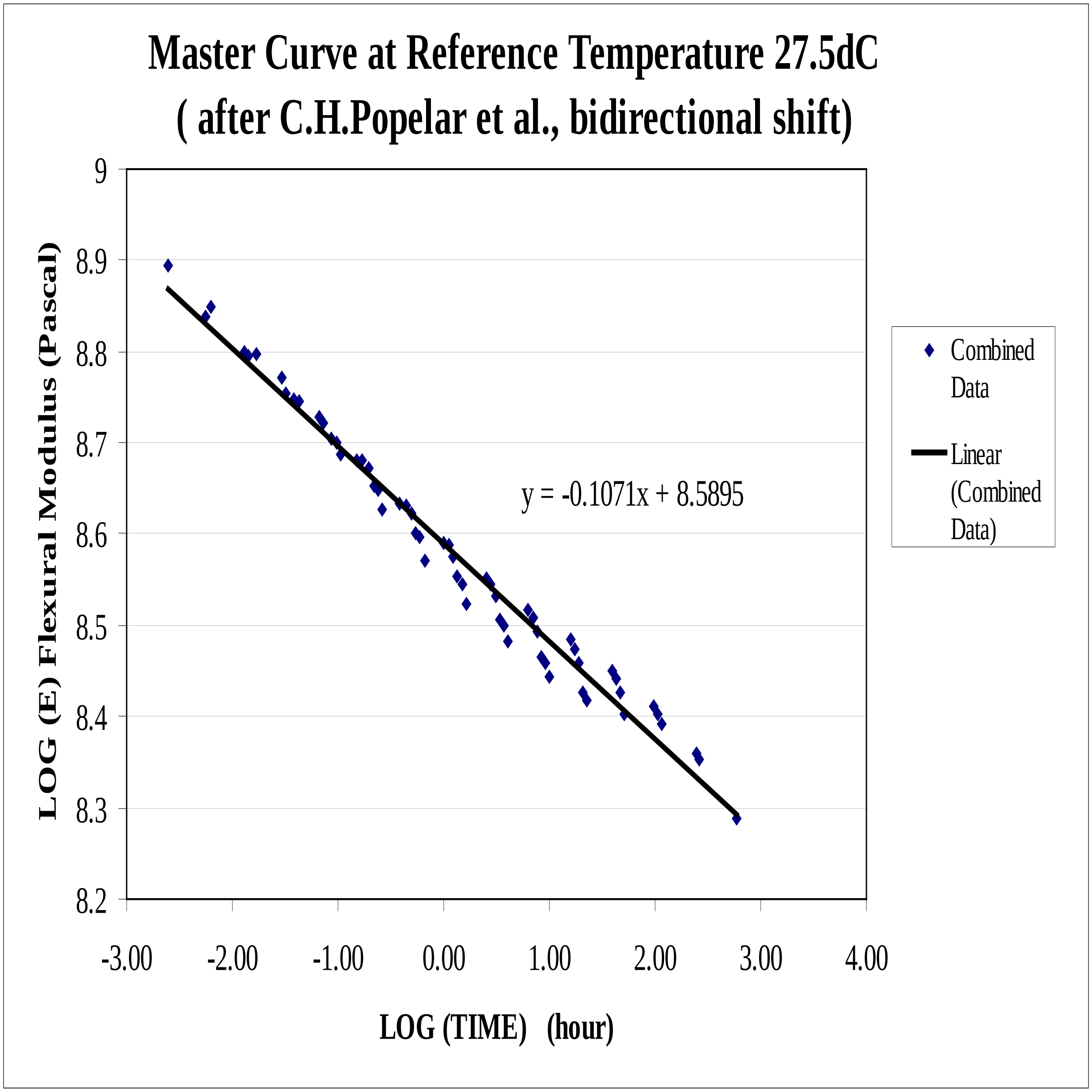


**Figure 3** - Master curve at 27.5 after shifted using Popelar factors