Long-term Design Properties of Corrugated HDPE Pipe

August 10th, 2011

Current Long-term Properties

- Tensile Strength
  - Short term value = 3000 psi
  - Long term value = 900 psi
- Modulus
  - Short term value = 110,000 psi
  - Long term value = 20,000 psi

Proposed Test Methods

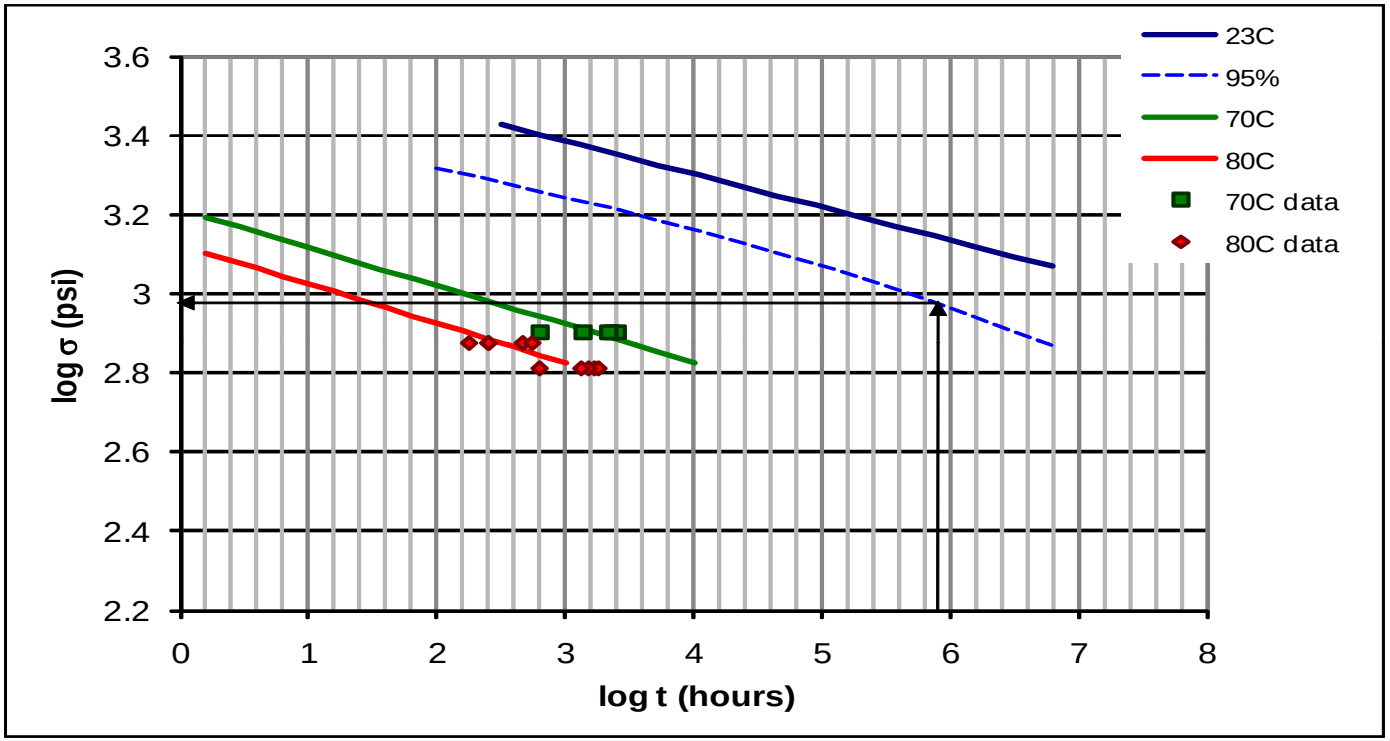
- Long-term Tensile Strength will be determined by FM 5-572, Procedure B on pipe junction specimens.

- Long-term modulus will be determined by FM 5-577 on pipe liner.

Long-term Tensile Strength

- Establish the SCR curves using FM 5-572, Procedure B.
- Perform tests at temperatures of 70 and 80^{o}C and applied stresses of 650 and 450 psi, or others.
- Extrapolate test data to generate the SCR curve at 23^{o}C with 95% confidence.
- Determine the applied stress corresponding to 100 year from the predicted 23^{o}C curve.

Predicted Life Time of at 23C



The 100-year tensile strength for corrugated HDPE pipe is predicted to be 800 psi.

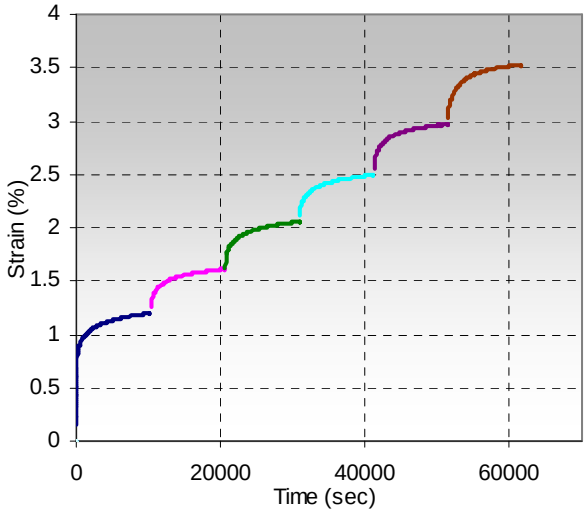
Long-term Tensile Strength

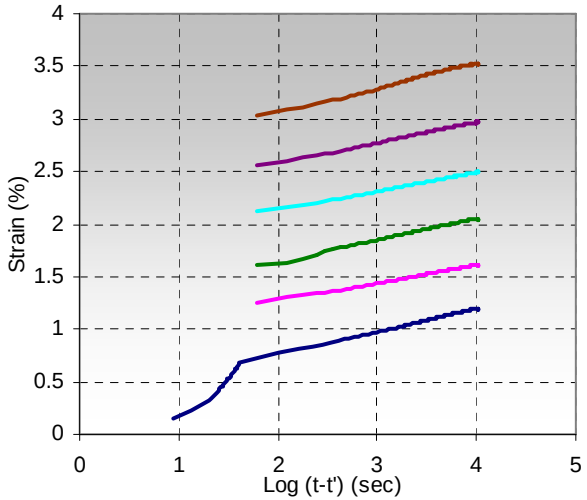
If industry would like to increase the recommended 100-year tensile strength, an interlaboratory test program should be carried out using slightly higher applied stresses defined in Section 948.

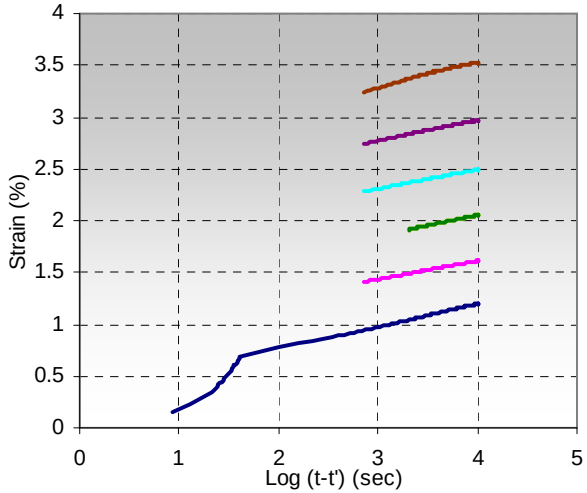
Acceleration Creep Test to Determine the Long-term Modulus

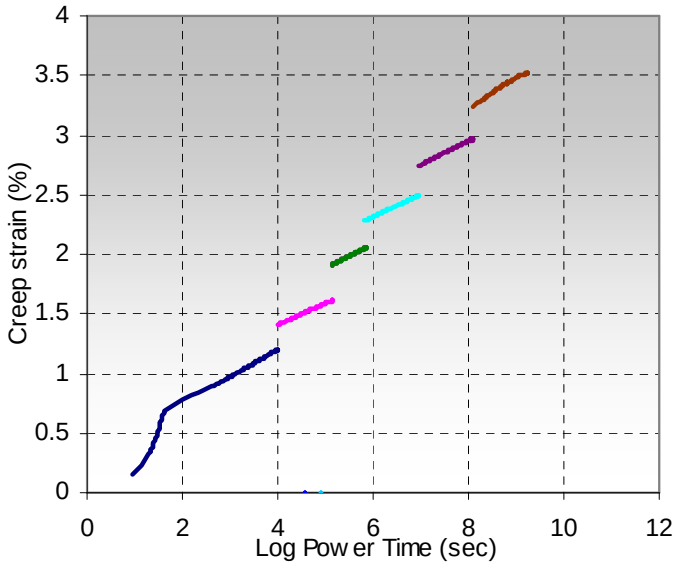
Stepped Isothermal Method (SIM)

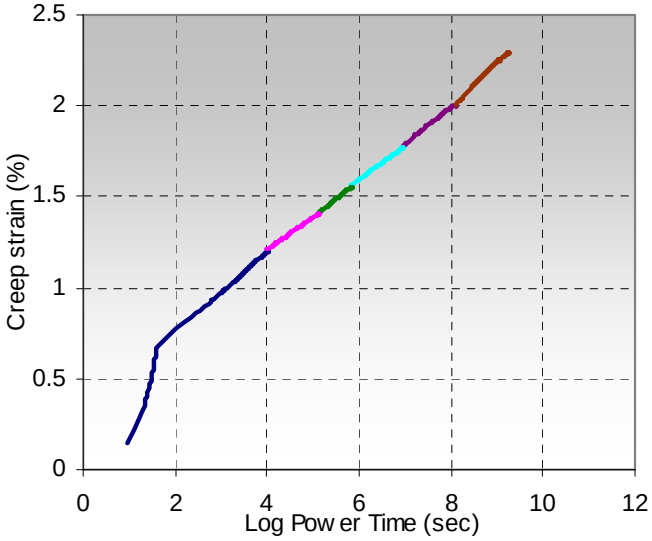
- It is a national standard test method, ASTM D6992
- The method has been successfully used to evaluate creep property of HDPE and PET geogrids.
- Single test specimen is subjected to a series of temperature steps under a constant stress.
- Master creep curve at 23^{o}C can extend to 100 years.


Strain (%)
Time (sec)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
20000
40000
60000


Strain (%)
Log (t-t') (sec)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
1
2
3
4
5


Strain (%)
Log (t-t') (sec)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
1
2
3
4
5


Creep strain (%)
Log Pow er Time (sec)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
2
4
6
8
10
12


Creep strain (%)
Log Pow er Time (sec)
0
0.5
1
1.5
2
2.5
0
2
4
6
8
10
12

Round Robin Programs

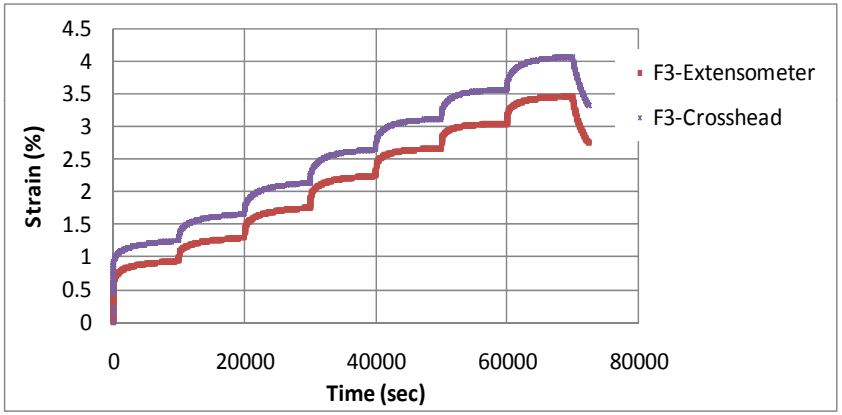
RR-#1

- Identify the discrepancy of test procedure and apparatus among the four participating labs.
- Determine the appropriate method to measure the creep strain: cross-head movement of the tensile machine vs. strain gauge.

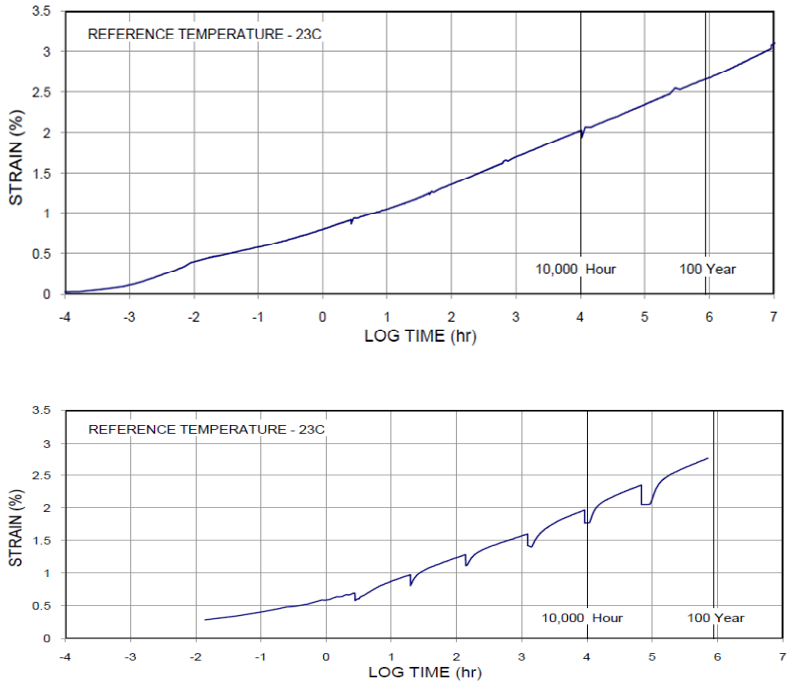
Strain Measurement Method	Strain Gauge	Cross-head Movement
Test Specimen	ASTM D 638, Type IV (Dumbbell specimen)	ASTM D 882 (1-inch strip specimen)
Gauge Length	1-inch	2-inch
Grip Distance	2.5-inch	2-inch

Test Results

SIM tests on 1-inch strip specimens



Strain gauge shall be used to measure creep strain



Time to equilibrium at each temperature step is essential.

Findings

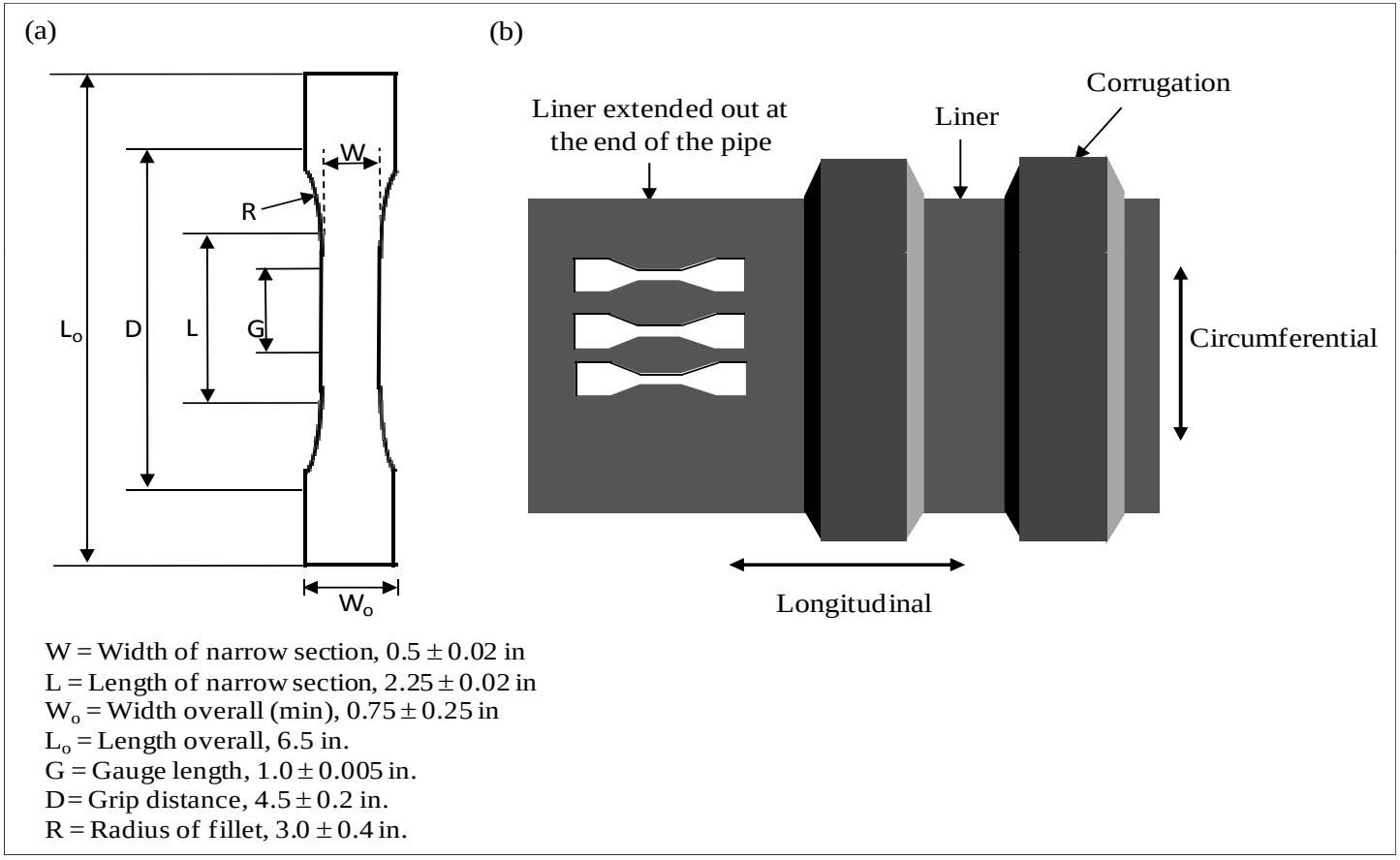
- Strain gauge must be used to measure the creep strain.
- The duration to reach equilibrium at each temperature step should be within 15 minutes.

Round Robin Programs

RR-#2

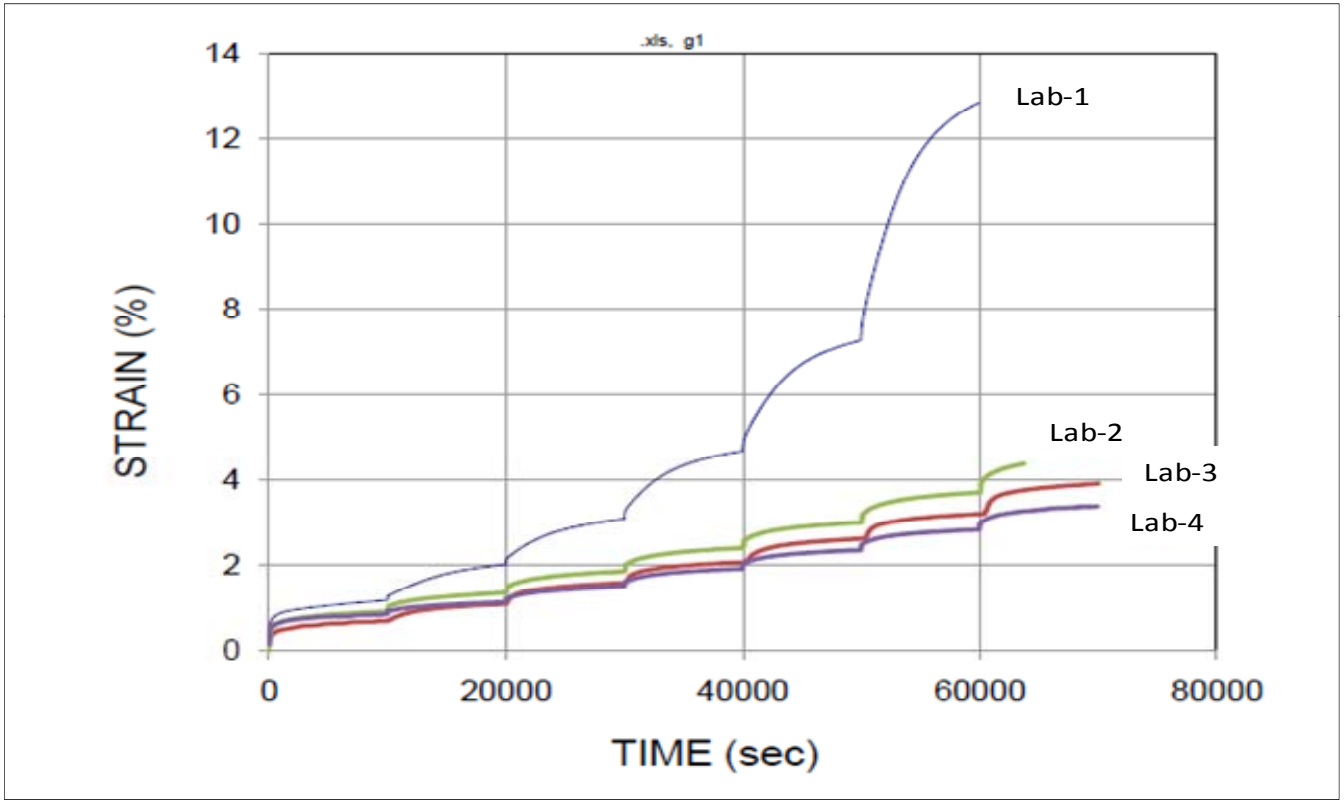
- Investigate the variability of temperature control and strain gauge.
- Use the “top-hat” material of the pipe instead of the pipe liner portion of the pipe.

Location of Test Specimen



W = Width of narrow section, 0.5 ± 0.02 in
L = Length of narrow section, 2.25 ± 0.02 in
W_o = Width overall (min), 0.75 ± 0.25 in
L_o = Length overall, 6.5 in.
G = Gauge length, 1.0 ± 0.005 in.
D = Grip distance, 4.5 ± 0.2 in.
R = Radius of fillet, 3.0 ± 0.4 in.

Test Results



Lab-1 used load cell to control the applied force.
Others used dead load to apply the force to the specimen

Findings

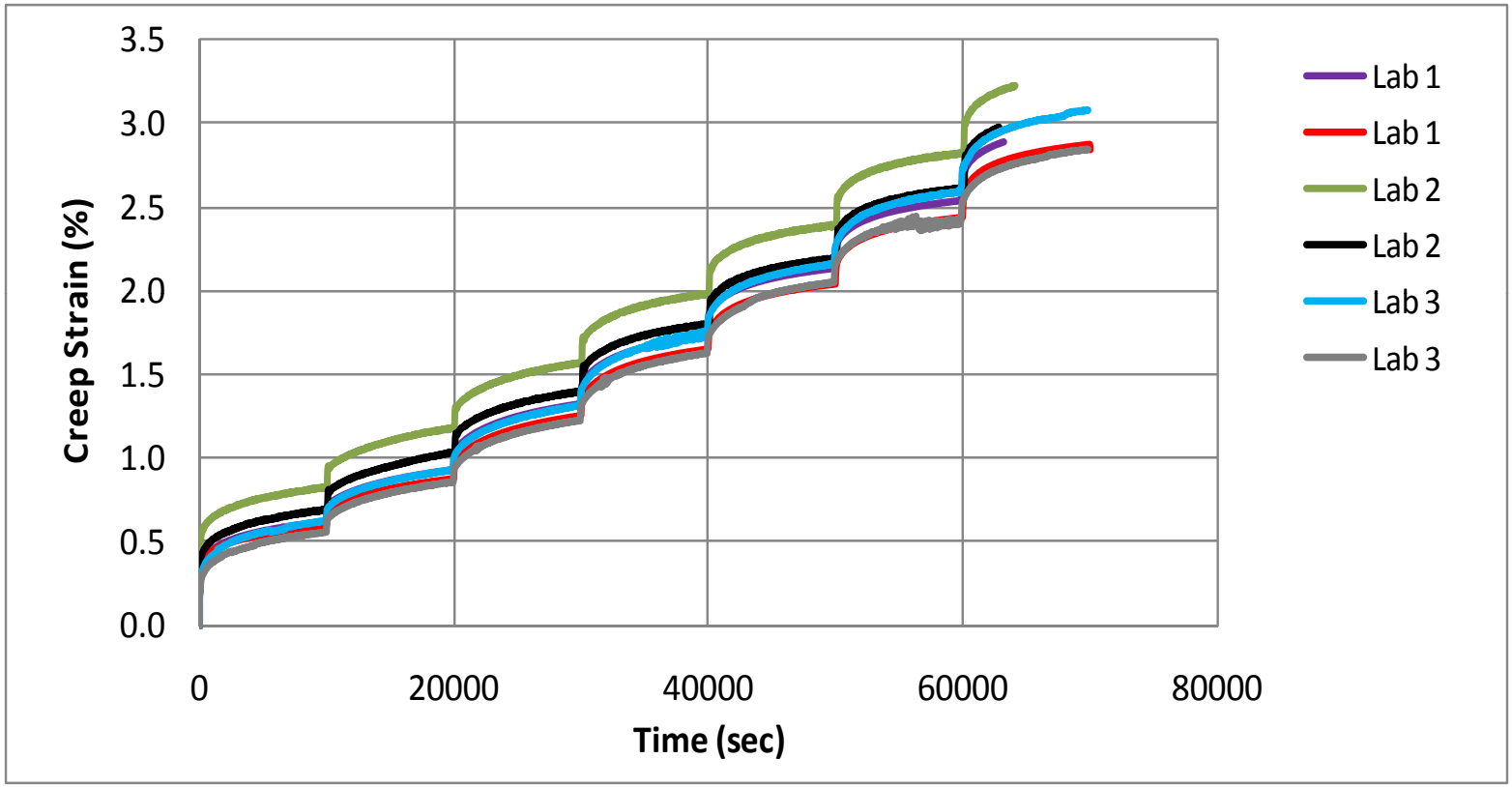
- The top-hat material is too thin to be used for the SIM test. A compressive stress may be introduced by attaching the strain gauge to such thin material subsequently affecting the creep strain.
- Dead-load must be used to apply force to the test specimen in the SIM test.

Round Robin Programs

RR-#3

- Isolate the variability contributed by the test equipments from that by the test specimens.
- Test specimens were taken from the compressive molded plaques instead of pipe liner.

Test Results



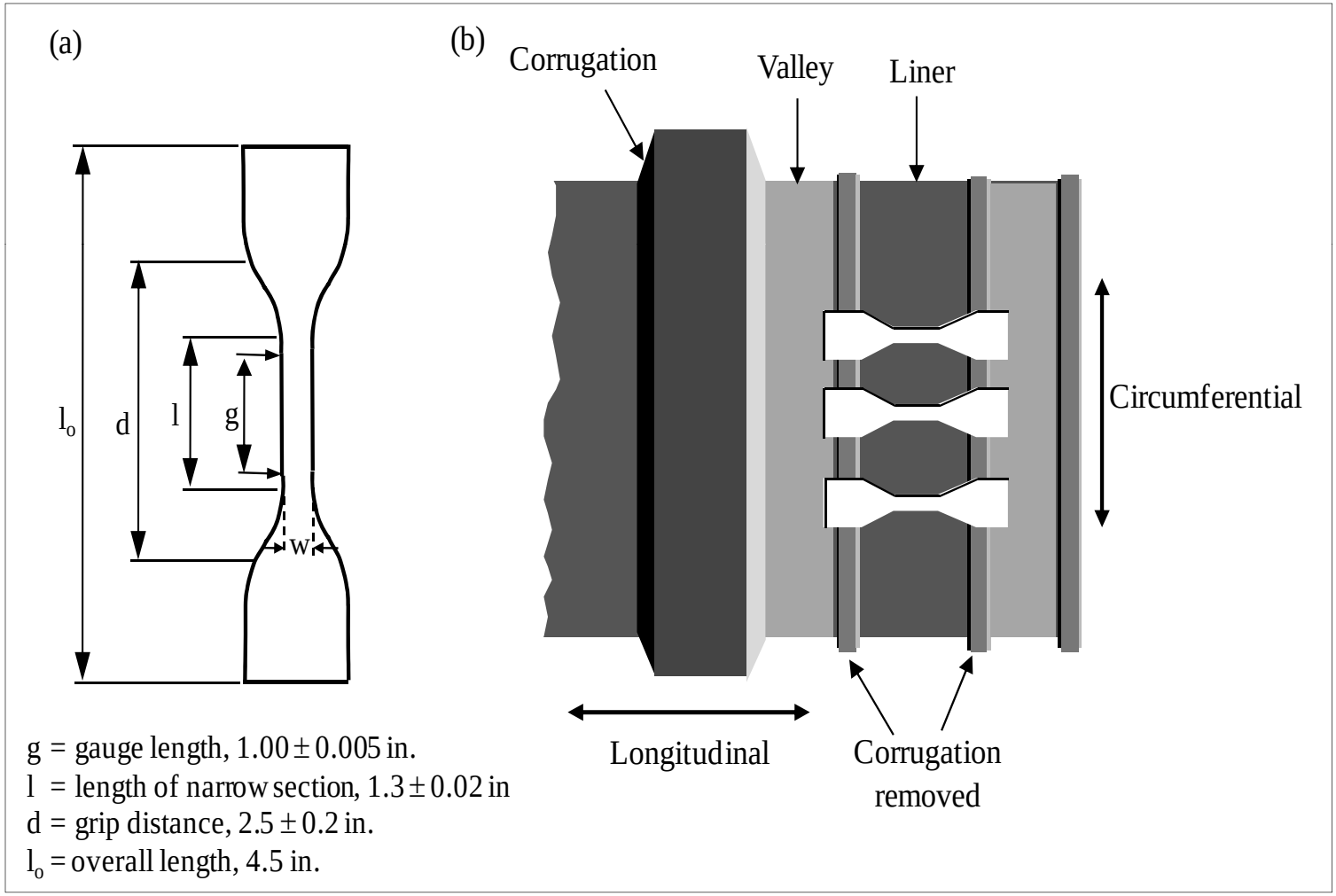
Waiting for the results from Lab. 4

Round Robin Programs

RR-#4

- Test specimens will be taken from the liner part of the pipe.
- Three types of resins and two manufacturing processes will be evaluated.
- Results will be used to determine the long-term modulus value with 95% confidence.

Location of Test Specimen



g = gauge length, 1.00 ± 0.005 in.
l = length of narrow section, 1.3 ± 0.02 in
d = grip distance, 2.5 ± 0.2 in.
l_o = overall length, 4.5 in.

Summary

- The test methods to determine long-term tensile strength and modulus have been established.
- Long-term tensile strength value has been recommended.
- Long-term modulus value will be established in couple months (October, 2011).