ASTM D 6992 – Accelerated Tensile Creep and Creep-Rupture of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method- Testing Equipment

Description

Apparatus

6.1 Grips—Grips for SIM and R+H tests should be the same as the grips for ultimate strength tensile tests. Neither slippage nor excessive stress causing premature rupture should be allowed to occur.
6.2 Testing Machine—A universal testing machine or a dead-weight loading system with the following capabilities and accessories shall be used for testing.
6.2.1 Load measurement and control,
6.2.2 Strain measurement and control,
6.2.3 Time measurement,
6.2.4 Environmental temperature chamber to facilitate control of test conditions,
6.2.4.1 Temperature measurement and control facilities,
6.2.5 Other environmental measurement and control, and
6.2.6 Computer data acquisition and control.

Test Specimens

8.1 Geogrid specimens should be single ribs, unless otherwise agreed upon.
8.2 Yarn specimens of geogrids or geotextiles should be single ply or multiple ply strands, unless otherwise agreed upon.
8.3 Geotextile specimens should be 50 mm wide strips, unless otherwise agreed upon.
NOTE 2—Single geogrid ribs and narrow strip specimens are preferred to determine the effect of applied load on the tensile creep properties of the material separate from the effect of sample width on the tensile properties of the material. However, correlation between narrow geotextile strips or single geogrid ribs to wider representative specimens should be established. 8.4 The length of the test specimen is determined by the type of grip used. Refer to specific tensile test procedure for guidance.

8.5 Number of Tests:
8.5.1 A single specimen is usually sufficient to define a master creep or relaxation curve using the SIM. However, if only a single SIM test is to be performed, the location of the onset of creep strain or modulus curve should be confirmed using at least two short term creep (R+H) tests. 8.5.2 Generally 12 to 18 specimens are needed to define a stress-rupture curve representing multiple rupture times. Fewer specimens would be needed to define a specific region of the curve, for example the percent TULT at 1×10^6 h (= 110 year) rupture life.

Conditioning

9.1 Tensile and SIM testing shall be conducted using 20 ± 1°C as the reference or temperature standard. If the laboratory is not within this range, perform tensile tests in a suitable environmental chamber capable of controlled cooling and heating. The environmental chamber should have a programmable or set-point controller so as to maintain temperature to 20 ± 1°C. When agreed to, a

reference temperature other than 20°C can be utilized. Also, when agreed to, the results of testing under this standard can be shifted from one reference temperature to another.
9.2 Allow the specimen adequate time to come to temperature equilibrium in the laboratory or environmental chamber.
Generally this can be accomplished within a few hours (see Note 3).
9.3 Record the relative humidity in the laboratory or environmental chamber for all tests.

Selection of Test Conditions
10.1 The standard environment for testing is dry, since the effect of elevated temperature is to reduce the humidity of ambient air without special controls.
10.2 The standard reference temperature is 20°C unless otherwise agreed to. The individual reference temperature for each SIM test is the average achieved temperature of the first isothermal dwell.
10.3 Testing temperatures are to be within ± 2°C of the target test temperatures. It is critically important that the test specimen has equilibrated throughout its thickness so as to avoid nonisothermal conditions. Initial trials are necessary to establish this minimum equilibrium time.
NOTE 3—Laboratory experience has suggested that the use of calibrated thermocouples located near, affixed to or embedded within the test specimen may facilitate a successful temperature compliance test for the specimen material. It is suggested that the laboratory perform the planned SIM temperature steps using an unloaded sacrificial test specimen and, with the use of these thermocouples, measure the temperature change of the specimen at its thickest or most mass-dense region. The time required for the specimen to reach the target temperature is recorded and used as the minimum dwell time. The upper limit of the temperature ramp time is not known. Successful tests with some materials have been run with temperature ramp times of up to four minutes.
10.4 Test temperatures are to be maintained within ± 1.0°C of the mean achieved temperature.
10.4.1 Temperature steps and dwell times must be such that the steady state creep rate at the beginning of a new step is not so different from that of the previous that it cannot be established within the identified ramp time.

Procedures
11.1 The same or similar load or strain control shall be applied to the tensile tests and the load ramp portion of R+H and SIM (creep and creep-rupture) tests. The load rate control (in units of kN per min) that is applied shall achieve a narrow range of strain rates expressed in percent per minute, as agreed upon. Generally 10 ± 3 % per minute (or 20 ± 3 % per minute for European practice) will be satisfactory.
NOTE 4—A linear ramp of load versus time will not generally result in a linear strain versus time relationship because stress versus strain curves are not linear for most geosynthetic materials.

11.2 Achieve the test loads for R+H and SIM tests within ± 2 % of the target loads, and maintain any achieved load within ± 0.5 % of its values for the duration of the test. A brief overshoot of the target load that is within ± 2 % of the target load and limited to a 1 to 2 second time duration is acceptable for load control systems.
11.3 Replicate test loads for R+H and SIM tests should be within ± 0.5 % of the average of the achieved loads for a test set.
11.4 Pretensioning up in accordance with the governing tensile test is acceptable. The method used to define zero strain is to be identified and reported.
11.5 The same or similar grips shall be used for tensile, R+H and SIM tests. Care should be taken to

use grips that do not initiate failure or incur slippage at stress levels which may produce specimen rupture (for example, at loads greater than 55 % of TULT for polyester).

11.6 Inspect grips to insure loading surfaces are clean and that padding, if used, is free of defects and is secured properly.
11.7 Inspect the specimen installation to be sure the material is properly aligned with the grips and with the loading axis. 11.8 Insure that the load cell used is calibrated properly such that it will accurately measure the range of tensile loads anticipated.
11.9 Insure that the extensometer used (if any) is calibrated properly such that it will accurately measure the range of tensile strains anticipated. If rupture is anticipated, take precautions to insure that the rupture event will not damage the extensometer or create a hazard for the machine operator.
11.10 Unless otherwise agreed upon, a 100 mm gauge length shall be used for geosynthetic products and a 250 to 300 mm gauge length shall be used for precursor yam products. 11.11 Time, load and extension data shall be collected at a minimum rate of two readings per second during the initial loading ramp portions of tests and a minimum rate of two readings per minute during constant load portions of tests. If load is applied by means of dead weights, with or without a lever, regular measurement of load after the ramp is not necessary.
11.12 The environmental chamber and temperature cooler shall be capable of maintaining the specimen temperature within ± 1°C in range of 0 to 100°C, and of changing the specimen temperature by up to 15°C, within the identified ramp time (see Note 3).

11.13 Unless otherwise agreed upon, the temperature steps for SIM applied to polyester geosynthetics shall not exceed 14°C, The temperature steps for polyolefin geosynthetics shall not exceed 7°C.
NOTE 5—Examples that have been successful are a 14°C step with a 10 000 s dwell for PET, and a 7°C step with a 10 000 s dwell for HDPE.
11.14 Unless otherwise agreed upon, the isothermal dwell time for all SIM tests shall not be less than 10 000 s. Unless otherwise agreed upon, the total time for SIM tests not terminated in rupture shall not be less than 60 000 s.
11.15 The temperature data acquisition rate during SIM shall be a minimum of once per minute.
11.16 If desired, accelerated tensile property tests can be conducted in liquid, vapor, or gaseous mixtures to simulate unique environmental exposures.

Calculation
12.1 Tensile Results:
12.1.1 Calculate the tensile strength (TULT) and elongation of the sample.
12.1.2 Plot stress and secant modulus versus strain. It is recommended that the offset modulus method be used to "point" the curves.
NOTE 6—The offset modulus method is described in Test Method D 4595, Appendix X2 and has been used in a number of examples in Thornton, J. S., Sprague, C. J., Kloupmaker, J., and Wedding, D. B., "The Relationship of Creep Curves to Rapid Loading Stress-Strain Curves for Polyester Geogrids," Geosynthetics '99, V 01.2, Industrial Fabrics Association International: April 28-30, 1999, pp. 735-744.
12.1.3 Compute the stress levels to be achieved in R+H and creep and creep rupture tests in percent of UTS.
12.1.4 When specified, identify the range of elastic strains that correspond with the stress levels to be achieved in R+H, creep and creep-rupture tests.
12.2 Ramp and Hold (R+H) Results:

12.2.1 Plot stress and secant (creep) modulus versus strain, and strain and secant (creep) modulus versus linear and log time. Use the offset modulus method to point the curves as described in 12.1.2.
12.2.2 Identify the elastic strains at the ramp peaks and the initial rapid creep strain levels for comparison to the ramp and initial creep portions of the SIM results.
12.3 SIM Test Results (see Appendix for Examples):

12.3.1 Compute and plot stress and secant (creep) modulus versus strain for each specimen, using the offset modulus method to point the curve. Then plot creep strain, creep modulus, stress and temperature as a function of linear time. Inspect these plots to identify that the test objectives were achieved.
12.3.2 Plot creep modulus (or strain) versus log time after rescaling the elevated temperature segments to achieve slope matching as follows: The semi- logarithmic slopes of a modulus (or strain) curve at the beginning of a higher temperature dwell step should be adjusted to match the slope of the end of the preceding lower temperature by subtracting a time “t” from each of the dwell times of higher temperature steps.

12.3.3 Re-plot the creep modulus (or strain) versus log time after rescaling as above and after employing vertical shifts of the modulus (or strain) data for each elevated temperature to account for system thermal expansion.
12.3.4 Report the creep modulus and strain versus log time curves as rescaled and vertically shifted above and after employing horizontal shifts of the elevated temperature dwell segments to the right of the initial reference temperature dwell segment. The result of this final manipulation should be a smooth master curve for each specimen subjected to SIM. Identify ruptures, if any, at the termination of the master curve.
12.3.5 The rescaling, vertical shifting and horizontal shifting steps generally require some iteration to achieve smooth master curves.
12.3.6 Prepare a plot of the logarithm of the cumulative shift factor versus temperature.
12.3.7 For a creep rupture test series, plot rupture stress as a percentage of (TULT) versus log (accelerated) time to rupture. Perform linear regression analysis on the data set, selecting time as the dependent variable. If specified, compute the 90 % or 95 % one-sided confidence limits for the creep rupture data. 12.3.8 If specified, determine the instability strain limit (strain and time) as the onset of tertiary creep for each creep-rupture data point and plot this strain value versus log (accelerated) time to instability strain.
12.3.9 Compute the mean temperature and a measure of temperature variation such as standard deviation or extreme values for each temperature step.

APPENDIX

X1.1 The following table and graphs are typical of those used in the report section of the SIM test procedure. Figs. X1.1-X1.8 show the results for a polyester yam before and after scaling and shifting.

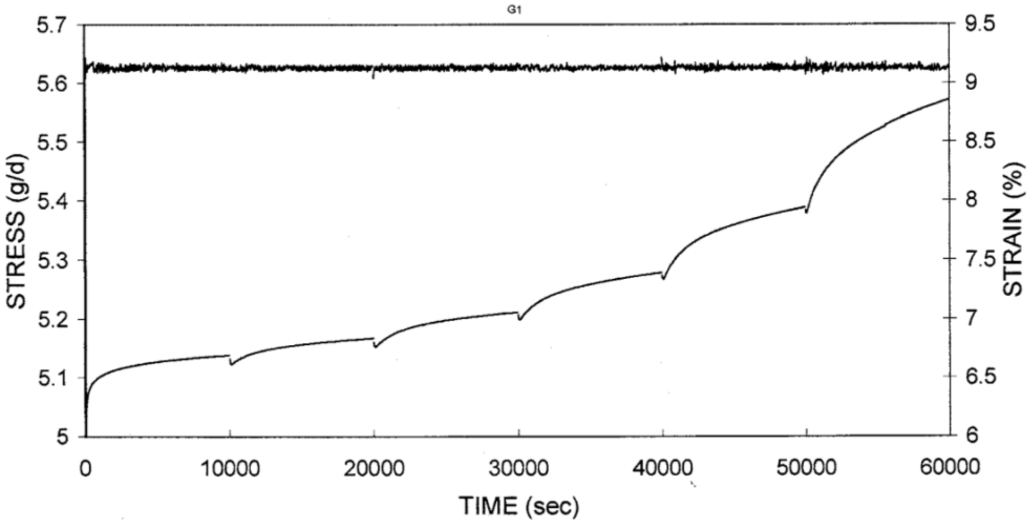

FIG. X1.1 Stress and Creep Strain versus Linear Time

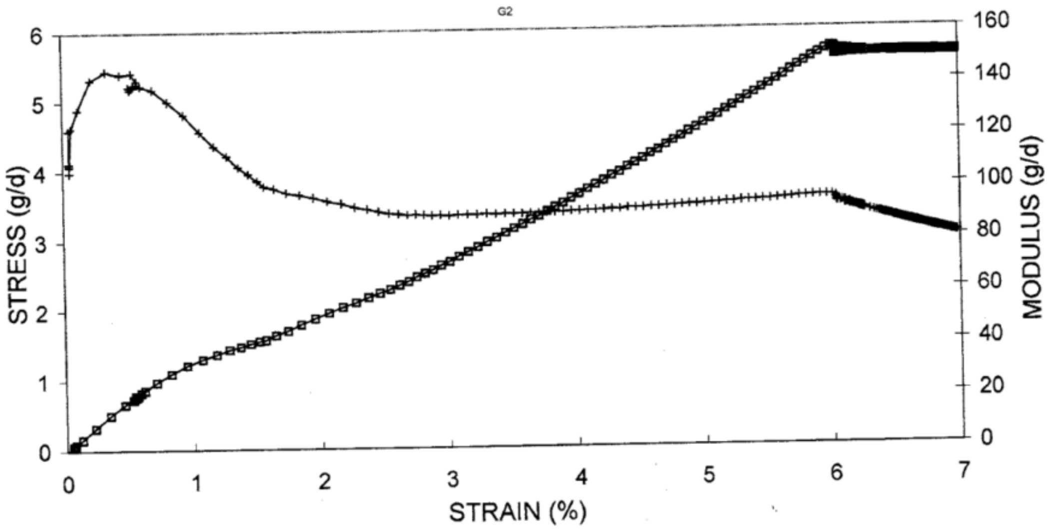

FIG. X1.2 Stress and Secant Modulus versus Strain

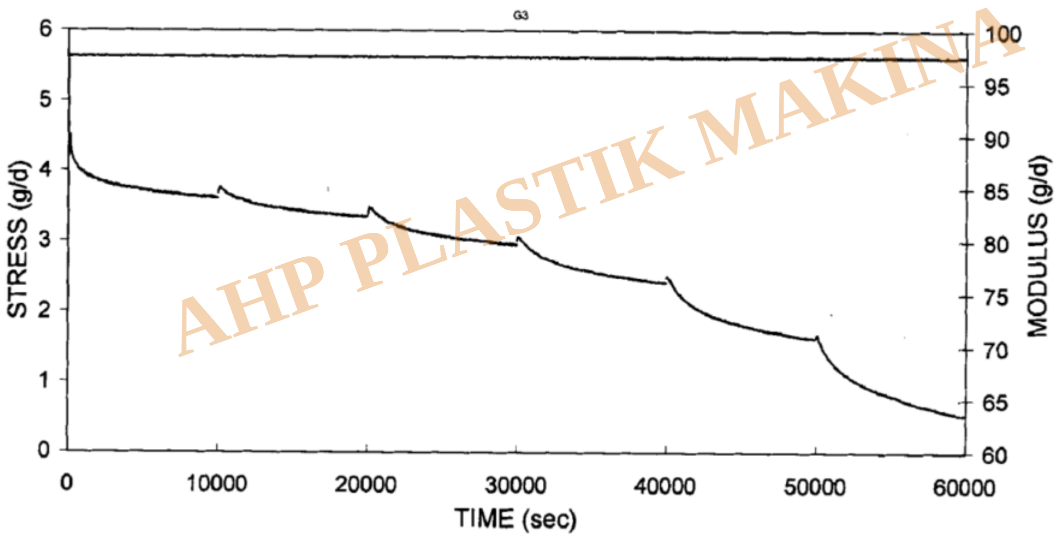

FIG. X1.3 Stress and Creep Modulus versus Linear Time

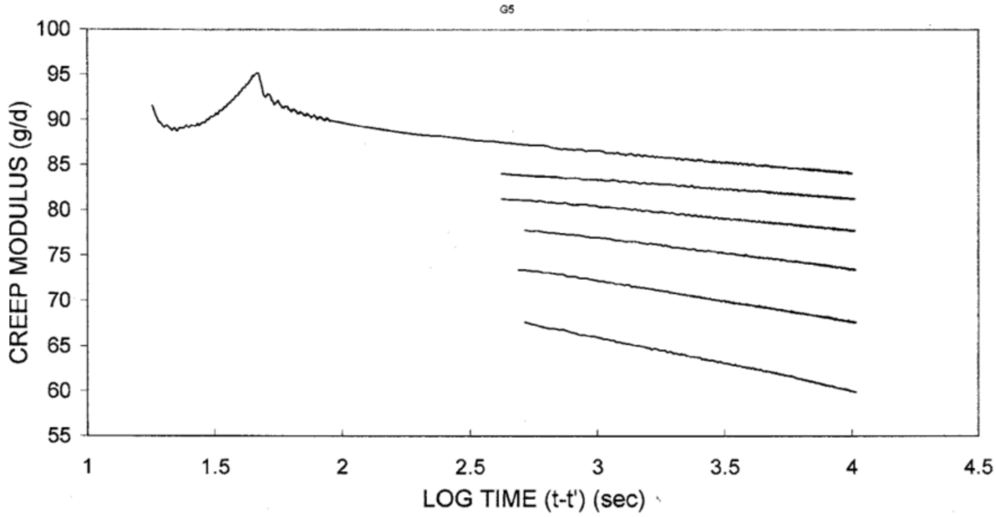

FIG. X1.4 Creep Modulus versus Log Time After Rescaling

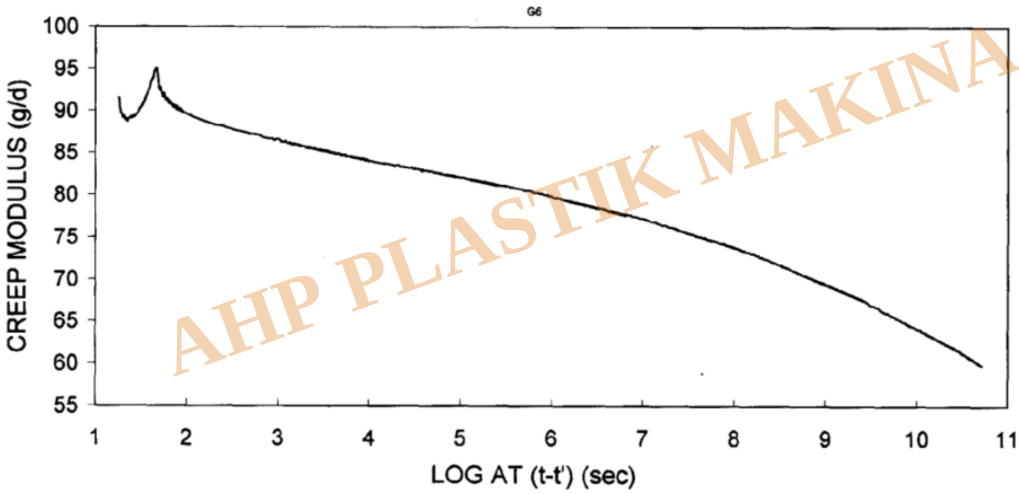

FIG. X1.5 Master Creep Modulus versus Log Time Curve at the Step One Reference Temperature

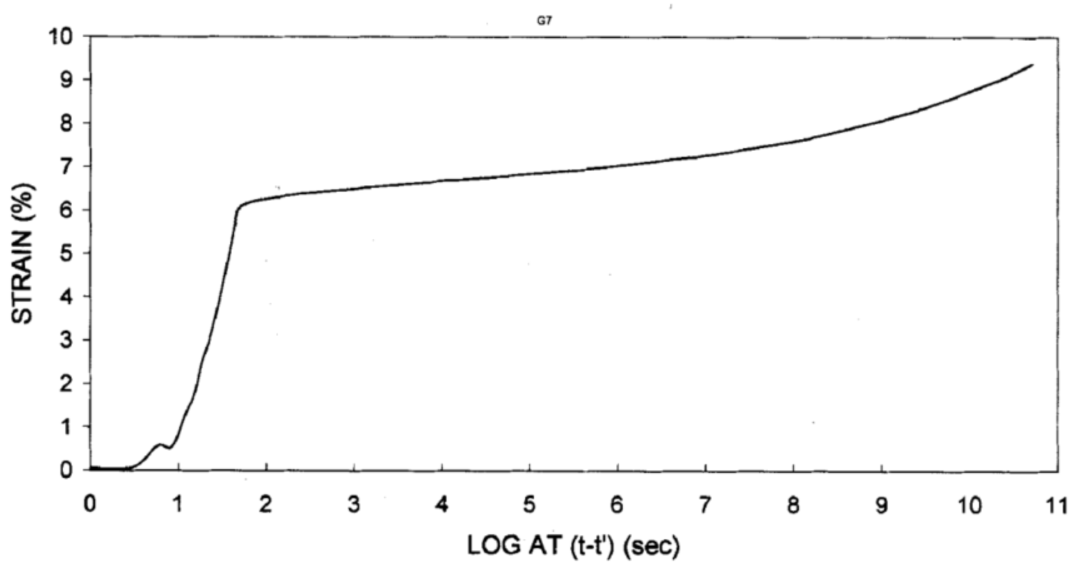

FIG. X1.6 Master Creep Strain versus Log Time at the Step One Reference Temperature

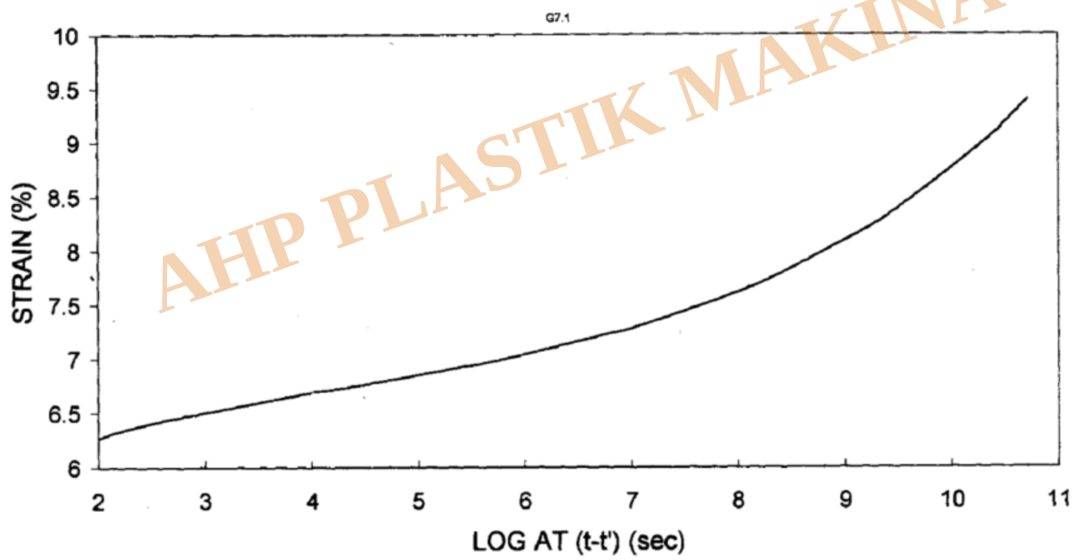

FIG. X1.7 Figure X.6 with Re-scaled Y-axis

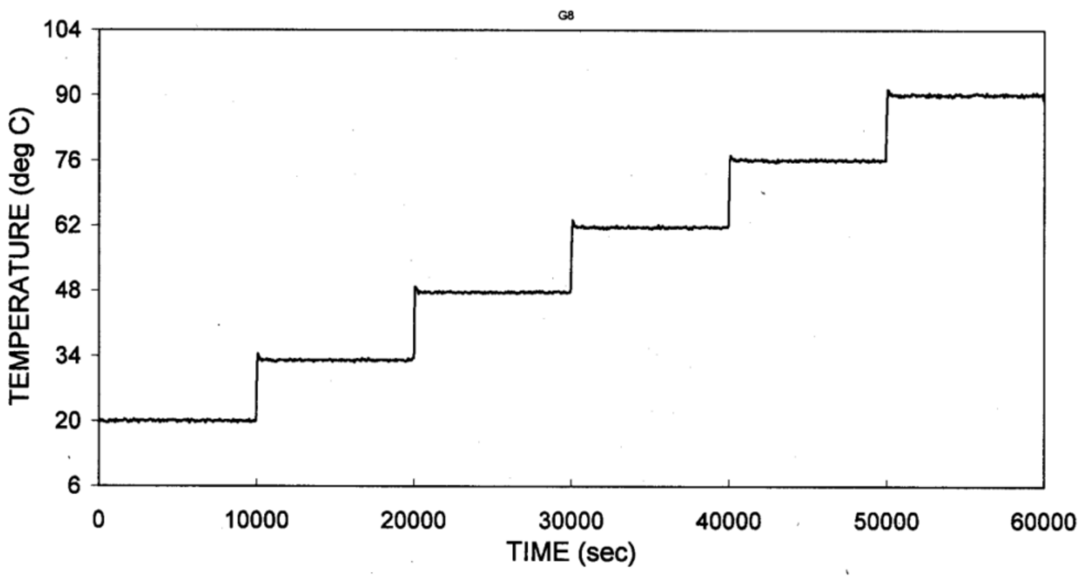

FIG. X1.8 SIM Temperature Steps versus Time Steps

Creep Tester According to ASTM D6992 (10KN force capacity)

- Servo controlled
- Force capacity 10KN
- Fixture for peel testing according to above standards
- Long travel extensometer (is as option in case of customer request)
- Ball screw
- Double column
- USB port for computer connection
- Windows based software is included
- Temperature up to 90C
- Computer will be quoted separately as per customer request
- Load resolution 1/10000

- Speed as per customer request
- Grips as per customer request for different products
- Easy operation and clear visualization (test curves, calculations)
- Easy to change the grips via male-female connection
- Accuracy ±0.5% of full scale
- Precise self-cleaning ball-screw
- Brush-less servo motor quarantine maintenance-free operation
- Easy calibration of load-cell
- Max tensile space 600mm
- 10KN loadcell capacity
- Grips width suitable for 50mm sample piece
- Computer is up to the customer (will be quoted separately in case of need)
- Software included
- Training video

Category

1. Equipment for Standards
2. Standards