Long-Term Compression Strength Testing Machine for Plastic Underground Boxes â€“ EN 17151

Description

Overview

The **Long-Term Compression Strength Testing Machine** is designed to evaluate the creep rupture behaviour and long-term compression strength of thermoplastic underground boxes used in non-pressure drainage, stormwater management, infiltration and storage systems.

The test is performed according to **EN 17151:2019 â€“ Plastics piping systems for non-pressure underground conveyance and storage of non-potable water â€“ Test method for determination of long-term compression strength of boxes**.

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Unlike conventional short-term compression tests, this method evaluates the behaviour of plastic boxes under sustained compressive loading over extended periods. The results are used to determine the relationship between applied compressive stress and time to rupture, enabling the prediction of long-term compression performance.

The method is applicable to thermoplastic boxes that maintain linear behaviour over the specified evaluation period.

1. Principle of the Test

According to Clause 5 of EN 17151:2019, creep rupture tests are performed at different constant compression load levels.

Each specimen is subjected to a specified compressive load until rupture occurs or until the selected test duration is reached.

The time to rupture is recorded for each load level.

The resulting data are evaluated by plotting applied compressive stress against time to rupture using a logarithmic time scale.

Statistical extrapolation of the experimental data is subsequently used to determine the **long-term compression strength**, expressed as the lower 95% confidence limit (LCL) for a design life of 50 years.

The test provides information about:

- Compression creep rupture behaviour
- Time-dependent deformation under sustained loading
- Relationship between compressive stress and rupture time
- Long-term compression strength
- Predicted performance over a 50-year design period

2. Testing Machine Requirements

Clause 6 of EN 17151:2019 specifies the essential requirements for the compression testing apparatus.

2.1 Constant Load Application System

The compression testing machine shall be capable of applying a constant compressive load to the test specimen using flat compression plates.

The required load accuracy is:

Â±1% of the applied load throughout the test.

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The load may be applied directly or indirectly, including through a lever-arm arrangement.

If a force multiplication mechanism is used, the resultant force applied to the specimen shall be validated using a calibrated load cell in accordance with EN ISO 7500-1:2018, Class 2.

Maintaining a stable compressive load throughout the test is essential for obtaining reliable creep rupture results.

2.2 Compression Plates

The machine shall be equipped with two parallel compression plates.

The compression plates shall meet the following requirements:

- Flat, smooth and clean contact surfaces
- No deformation during the test that could influence the results
- Sufficient rigidity to maintain the required loading conditions
- Suitable dimensions for the test specimen

The length and width of each compression plate shall be greater than the corresponding dimensions of the specimen.

For the loading arrangement, the plates shall provide adequate support to the box, including its outermost structural components.

2.3 Plate Alignment

The compression plates shall remain parallel throughout the test.

The permitted parallelism deviation is: **2% of the shortest dimension of the compression plate.**

Correct alignment is important for preventing unintended eccentric loading and uneven stress distribution.

2.4 Dimensional Measurement

Dimensional measuring instruments shall comply with EN ISO 3126.

They shall be capable of determining the relevant specimen dimensions with an accuracy of: **Â±1 mm.**

2.5 Displacement Measurement

The testing system shall be capable of continuously measuring and recording the distance between the compression plates.

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The required displacement measurement accuracy is: **0.1 mm.**

Continuous displacement monitoring enables evaluation of the deformation behaviour of the specimen throughout the test.

2.6 Load Measurement

The testing apparatus shall be capable of continuously measuring and recording the compressive load applied to the specimen.

The load measuring system shall comply with EN ISO 7500-1:2018, Class 2 or better.

2.7 Additional Measurement Equipment

The test procedure also requires suitable weighing instruments for determining specimen mass and, where applicable, additional load plate mass.

The weighing instrument shall provide an accuracy better than 0.1% of the specimen weight.

For additional load plates, the measurement capability shall be better than 0.5% of the plate mass.

3. Test Specimen Requirements

3.1 Specimen Configuration

The test specimen shall consist of a complete box with its integral components, representing the weakest unit of the final construction.

Testing only an isolated component may not adequately represent the mechanical behaviour of the assembled box.

3.2 Test Direction

The preferred loading direction is the vertical installation direction, identified as the Z-direction in EN 17151.

Where required, testing may also be performed in the X- or Y-direction.

The selected test direction shall be clearly identified in the test report.

3.3 Number of Specimens

Unless otherwise specified by the referring product standard, the number of test specimens shall be one per individual creep rupture test.

However, multiple specimens are required to establish the relationship between applied stress and rupture time.

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3.4 Specimen Age

At the start of testing, the specimens shall be at least: **21 days old.**

3.5 Conditioning

Before testing, specimens shall be conditioned in air at the selected test temperature for at least: **24 hours.**

4. Test Procedure According to EN 17151

Step 1 â€“ Specimen Identification and Measurement

Before testing, identify the specimen and record its relevant details.

Measure the initial dimensions, including height, length and width, with an accuracy of 1 mm.

Determine the specimen mass and the mass of any additional loading plates.

Step 2 â€“ Specimen Positioning

Position the test specimen between the two parallel compression plates.

Ensure that the compression load is distributed evenly over the specimen.

The specimen shall be aligned with the selected loading direction.

Step 3 â€“ Application of Preload

Apply an initial compressive stress corresponding to: **5 kN/mÂ² to 10 kN/mÂ².**

The preload shall be applied within one minute.

The specimen height shall be recorded after application of the preload.

This measured height is used as the reference for subsequent displacement measurements.

Step 4 â€“ Application of Test Load

Increase the compressive load from the preload level to the selected test load.

The required test load shall be reached in less than: **1 minute.**

For practical reasons, the test load should be applied in the shortest possible time.

Once the selected load level is reached, it shall remain constant throughout the creep rupture test.

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Step 5 â€“ Continuous Monitoring

During testing, continuously monitor and record:

- Applied compression load
- Displacement between compression plates
- Elapsed test time
- Test temperature
- Rupture time or test termination time

The displacement measurement interval shall not exceed 0.1 mm.

The system shall be capable of identifying rupture or excessive deformation during the test.

Step 6 â€“ Rupture Detection

The rupture point is reached when either of the following conditions occurs:

1. A defined strain limit is reached.
2. The deformation rate exceeds the specified threshold.

EN 17151 specifies a deformation-rate criterion of **0.5 mm/h**, evaluated using the defined time interval and measurement conditions.

The rupture criterion and corresponding rupture time shall be recorded.

Step 7 â€“ Test Completion

After rupture or completion of the selected test duration, record the final results.

If a test is terminated without rupture, this condition shall be identified in the test data and subsequent statistical analysis.

5. Test Duration and Number of Tests

According to Clause 8.1, at least **10 creep rupture tests** shall be performed until failure.

The tests shall cover different load levels to obtain rupture times distributed over the required duration intervals.

The test duration distribution is divided into two periods:

Test duration period	Time to rupture	Minimum number of specimens
TDP1	100 h to 500 h	4
TDP1	More than 500 h to 1,000 h	3
TDP2	More than 1,000 h to 2,000 h	1
TDP2	More than 2,000 h to 4,380 h	1
TDP2	More than 4,380 h	1

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A test lasting longer than 4,380 hours may be terminated without rupture under the conditions described in the standard.

The test programme shall provide sufficient experimental data for the required long-term extrapolation.

6. Calculation of Long-Term Compression Strength

The compression stress is determined from the applied compressive force and the relevant specimen dimensions.

The test results are evaluated by establishing the relationship between applied compression stress and rupture time.

The long-term compression strength is determined using the statistical procedure described in Annex B of EN 17151.

The analysis includes:

- Logarithmic transformation of rupture time
- Linear regression of the experimental data
- Evaluation of regression uncertainty
- Calculation of the lower 95% confidence limit
- Extrapolation to a design life of 50 years

The calculated long-term compression strength is expressed in kN/mÂ².

Annex B provides the methodology for evaluating the long-term performance using the experimental creep rupture results.

7. Test Report Requirements

According to Clause 9, the test report shall include the following information:

- Reference to EN 17151
- Manufacturer identification
- Product name and commercial designation
- Material information
- Specimen dimensions and production date
- Test direction
- Test temperature
- Test start date
- Applied preload and test load
- Additional loading plate mass, where applicable
- Creep rupture curves and rupture data
- Test duration and rupture time
- Calculated long-term compression strength
- Any deviations, interruptions or unusual observations during testing

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Complete documentation is essential for traceability and technical evaluation of the results.

8. Recommended Machine Configuration for Long-Term Testing

For the development of an EN 17151 compression creep testing system, the following features are recommended:

Mechanical system

- High-rigidity compression frame
- Parallel compression plates
- Adjustable test space for different box dimensions
- Stable long-term load application mechanism

Measurement and control

- Calibrated load measurement system
- Continuous displacement measurement
- Digital load monitoring
- Automatic test timing
- Data acquisition and storage
- Load stability monitoring

Software and reporting

- Real-time force and displacement monitoring
- Time-dependent deformation curves
- Automatic recording of test duration
- Rupture event detection
- Data export for statistical evaluation
- Test report generation

These features are recommended engineering capabilities for a dedicated testing machine. The final equipment configuration should be selected according to the specimen dimensions, required compression capacity and intended test programme.

9. Applications

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The EN 17151 compression creep testing method is applicable to thermoplastic underground box systems used in:

- Stormwater infiltration systems
- Underground water storage systems
- Drainage and attenuation systems
- Modular plastic infiltration boxes
- Non-pressure underground water management systems

The test is particularly relevant when evaluating the long-term structural performance of plastic boxes subjected to sustained compressive loads.

11. Annex A â€“ Test Method for Determining Linear Behaviour (Informative)

11.1 Purpose and Principle

Annex A of EN 17151:2019 describes an informative procedure for confirming the linear behaviour of thermoplastic underground boxes.

The method is based on the principles of ISO 9080 and uses a combination of short-term compression tests and creep rupture tests performed at different temperatures.

The objective is to determine whether the relationship between applied compressive stress and logarithmic time to rupture can be represented by a linear model.

This verification is important because the long-term compression strength calculation described in Annex B assumes linear behaviour.

11.2 Test Programme

Annex A describes a seven-test programme comprising two short-term compression tests and five creep rupture tests.

Test 1 â€“ Short-Term Compression at 23Â°C

Perform a short-term compression test at 23Â°C according to Method A of EN 17150:2019.

Record the short-term compression strength.

Test 2 â€“ Short-Term Compression at Elevated Temperature

Perform a short-term compression test at an elevated temperature according to Method A of EN 17150:2019.

The elevated temperature is selected using the temperature relationship specified in Annex A.

Record the corresponding short-term compression strength.

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Test 3 â€“ Creep Rupture Test at 23Â°C

Perform a creep rupture test according to Clause 8.2 of EN 17151 at 23Â°C.

The test duration should be approximately 100 hours.

Record the applied compressive stress and time to rupture.

Test 4 â€“ Creep Rupture Test at 23Â°C

Perform a second creep rupture test at 23Â°C with a duration of approximately 4,500 hours.

Record the corresponding compressive stress and rupture time.

Test 5 â€“ Creep Rupture Test at Elevated Temperature

Perform a creep rupture test at the selected elevated temperature.

The approximate test duration is 100 hours.

Test 6 â€“ Creep Rupture Test at Elevated Temperature

Perform a creep rupture test at the selected elevated temperature with a duration of approximately 4,500 hours.

Test 7 â€“ Extended Creep Rupture Test

Perform an additional creep rupture test at the selected elevated temperature with a duration of approximately 2,000 hours.

11.3 Evaluation of Linear Behaviour

The results obtained from the short-term compression and creep rupture tests are used to evaluate the stressâ€“time relationship.

The analysis considers:

- Short-term compression strength at different temperatures
- Creep rupture stress at different durations
- Influence of temperature on rupture behaviour
- Logarithmic relationship between rupture time and applied stress
- Consistency of the fitted linear model

Annex A provides equations for evaluating the linearity of the stressâ€“time relationship using the results obtained from the seven tests.

The calculated relationships are compared to determine whether the material behaviour supports linear extrapolation.

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11.4 Importance for Long-Term Compression Testing

Verification of linear behaviour is particularly important when experimental creep rupture data are extrapolated to a 50-year design period.

If the material exhibits significant nonlinear behaviour, the extrapolation method used for calculating long-term compression strength may not be appropriate.

The procedure described in Annex A therefore provides additional technical evidence supporting the validity of the long-term strength evaluation.

12. Annex B â€“ Determination of Long-Term Compression Strength for a 50-Year Design Life (Informative)

12.1 Purpose

Annex B of EN 17151:2019 provides a statistical procedure for analysing creep rupture test results and determining the long-term compression strength of thermoplastic underground boxes.

The method is based on regression analysis of experimental rupture data.

The objective is to calculate the compressive stress corresponding to a 50-year design life, using the lower 95% confidence limit (LCL).

12.2 Required Experimental Data

The analysis requires experimental results obtained from creep rupture tests according to Clause 8.

Each test provides two principal values:

- Applied compressive stress, expressed in kN/mÂ²
- Time to rupture, expressed in hours

The test data shall be evaluated using the logarithm of the rupture time.

For extrapolation purposes, the same statistical treatment is applied to the relevant rupture data, including data used to establish the long-term regression relationship.

12.3 Linear Regression Model

The relationship between applied compressive stress and logarithmic time to rupture is represented by a straight-line equation:

logâ‚•â‚€(t) = a + bÏƒ

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Where:

- **t** = time to rupture, in hours
- **Ïƒ** = applied compressive stress, in kN/mÂ²
- **a** = regression intercept
- **b** = regression slope

The regression coefficients are determined using the least-squares method.

The fitted model describes the relationship between compression stress and rupture time over the experimental data range.

12.4 Least-Squares Regression

The regression coefficients are calculated by minimizing the sum of squared differences between the measured logarithmic rupture times and the values predicted by the regression model.

The analysis includes:

1. Calculation of the mean applied stress
2. Calculation of the mean logarithmic rupture time
3. Determination of the regression slope
4. Determination of the regression intercept
5. Evaluation of the residual variance

All experimental data points are assigned equal weight in the regression analysis.

The resulting regression equation is subsequently used for long-term extrapolation.

12.5 Extrapolation to a 50-Year Design Life

The design life considered in Annex B is:

50 years = 438,300 hours

The corresponding logarithmic time is:

logâ‚•â‚€(438,300) â‰ˆ 5.642

The regression equation is rearranged to calculate the projected compressive stress at the specified design life.

Ïƒâ‚, â‚€ = [logâ‚•â‚€(438,300) â€“ a] / b

Where:

- **Ïƒâ‚, â‚€** = projected mean compression strength for a 50-year design life
- **a** = regression intercept
- **b** = regression slope

This value represents the projected mean long-term compression strength before applying the statistical confidence limit.

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12.6 Calculation of the Lower 95% Confidence Limit

Annex B requires the calculation of the lower 95% confidence limit for the projected compression strength.

The statistical analysis considers:

- Number of experimental data points
- Regression coefficients
- Residual variance
- Uncertainty in the regression intercept
- Uncertainty in the regression slope
- Covariance between the regression coefficients
- Studentâ€™s t-distribution

The standard error of the projected compression strength is calculated using the regression uncertainty parameters.

The lower confidence limit is then determined as:

LCL = Ïƒâ‚, â‚€ â€“ t Ã— u(Ïƒâ‚, â‚€)

Where:

- **LCL** = lower 95% confidence limit of compression strength
- **Ïƒâ‚‚â‚…â‚€** = projected mean compression strength at 50 years
- **t** = applicable Studentâ€™s t-distribution factor
- **u(Ïƒâ‚‚â‚…â‚€)** = standard uncertainty of the projected compression strength

The Studentâ€™s t-factor is selected for a two-tailed t-distribution with N âˆ’ 2 degrees of freedom, as specified in Annex B.

The calculated LCL represents the conservative long-term compression strength used for evaluating the performance of the plastic box.

12.7 Importance of Test Duration

Long-term extrapolation depends strongly on the quality and distribution of the experimental rupture data.

The test programme should include rupture times covering both shorter and longer test durations.

EN 17151 requires test durations extending beyond 4,380 hours as part of the experimental programme.

Annex B also recommends obtaining additional long-duration results, particularly when these results can improve the reliability of the extrapolation.

A wider distribution of rupture times generally improves the statistical basis of the long-term prediction.

12.8 Data Analysis and Reporting

The statistical evaluation should include:

- Individual applied stress values
- Individual rupture times
- Logarithmic rupture time values
- Stress versus logarithmic rupture time graph
- Regression equation and coefficients
- Number of experimental data points
- Regression uncertainty parameters
- Projected mean compression strength at 50 years
- Lower 95% confidence limit
- Final calculated long-term compression strength

The calculated results should be documented together with the original experimental data to ensure traceability.

12.9 Software Requirements for Long-Term Compression Analysis

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For automated analysis of EN 17151 test results, suitable testing software may include the following functions:

- Importing creep rupture test data
- Calculating applied compression stress
- Converting rupture time into logarithmic values
- Generating stressâ€“rupture time graphs
- Performing least-squares linear regression
- Calculating regression coefficients and uncertainty
- Extrapolating compression strength to 50 years
- Calculating the lower 95% confidence limit
- Exporting statistical results and graphs
- Generating detailed technical reports

These are recommended software capabilities for implementing the analysis described in Annex B and should not be interpreted as mandatory hardware requirements.

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13. Conclusion

EN 17151:2019 provides a structured method for determining the long-term compression strength of thermoplastic underground boxes.

The main test procedure establishes the experimental relationship between applied compression stress and time to rupture.

Annex A provides an additional procedure for evaluating linear material behaviour, while **Annex B** describes the statistical analysis required to determine the projected long-term compression strength at a 50-year design life.

Accurate load control, continuous displacement monitoring, reliable long-duration operation and appropriate statistical evaluation are essential for obtaining meaningful test results.

AHP PLASTIK MAKINA provides engineering solutions for polymer and plastic testing applications, including the development of testing systems designed around the requirements of relevant international standards.

14. AHP PLASTIK MAKINA â€“ Compression Testing Solutions

AHP PLASTIK MAKINA develops and manufactures testing equipment for plastic and polymer materials.

For long-term compression testing applications according to EN 17151, the required machine configuration can be evaluated based on the specimen dimensions, loading capacity, measurement accuracy and intended test duration.

A properly designed testing system should combine stable load application, accurate displacement measurement and reliable long-term data recording.

Contact AHP PLASTIK MAKINA to discuss the technical requirements for an EN 17151 long-term compression strength testing system.

Website: https://ahp-makina.com

Pallet and Box Compression Tester-100KN-150x150x60

Category

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