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Thermoplastics pipes for the conveyance of fluids — Determination of the stress-rupture resistance of moulding materials using plain strain grooved tensile (PSGT) specimens

Tubes en matières thermoplastiques pour le transport des fluides — Détermination de la résistance à la rupture sous contrainte des matériaux de moulage, au moyen d'éprouvettes de traction rainurées à déformation plane

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Contents

Page

Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 23228 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 5, *General properties of pipes, fittings and valves of plastic materials and their accessories — Test methods and basic specifications*.

Introduction

ISO/TC 138 provides test methods for determining the resistance to internal pressure which are essential for assessing the properties and durability of thermoplastics piping system parts. These test methods constitute a basis for the determination of short-term and long-term strength characteristics. However, with regard to moulding materials for pipes and fittings, until the publication of this International Standard, no satisfactory test method has existed in which the material can be exposed to stress conditions that mimic internally pressurized pipes.

The method specified here has been demonstrated to replicate the stress conditions of internally pressurized end-capped pipes by the use of plaque specimen having a reduced section in the form of a groove positioned perpendicular to the uniaxial loading direction. This method is useful for evaluating the stress-rupture resistance of moulding materials and experimental resins being developed for pipes and fittings as well as for those pipes that are difficult to test, such as larger diameter pipes.

Thermoplastics pipes for the conveyance of fluids — Determination of the stress-rupture resistance of moulding materials using plain strain grooved tensile (PSGT) specimens

1 Scope

This International Standard specifies a method for the determination of the time-to-failure of thermoplastics resins and compounds for piping and fitting applications by the use of a plane strain grooved tensile specimen in a stress-rupture test.

The grooved tensile specimen produces a biaxial state of stress on uni-axial loading, which is taken to be indicative of the stress conditions found in pressurized solid-wall plastics pipes. The ratio of the stress in the axial direction to the transverse direction approximates that for a pressurized end-capped solid-wall pipe specimen[4]–[7].

It is intended that the data generated on these specimens be utilized to determine the stress-rupture (time to failure) resistance of moulding materials for pipes and fittings as well as experimental piping resins.

This method is also applicable to stress-rupture evaluations of pipes which are difficult to test, e.g. larger diameter pipes, including their batch release tests.

This International Standard is not intended to replace the stress-rupture test of ISO 1167[2], which uses internally pressurized end-capped pipes.

2 Normative references

The following referenced document is indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1
stress-rupture test
test at which a constant nominal stress is applied and maintained until specimen rupture (failure)

3.2
failure time
t_f
time at which a specimen fails by gross yielding or by through thickness slow crack propagation on stress-rupture loading

NOTE The failure time is expressed in hours.

3.3
applied nominal stress
σ_n
applied stress calculated using the undeformed minimum groove cross-sectional area

NOTE The applied nominal stress is expressed in megapascals.

3.4
plane strain condition in the groove
zero strain condition in the groove axis where there exists no change in displacement along the groove on load application perpendicular to the groove axis

NOTE In PSGT specimens, the stress biaxiality is developed in the groove as a result of the plane strain condition in the groove. Plane strain condition also occurs in the end-capped pipe when internally pressurized.

3.5
long-term hydrostatic strength
σ_{LTHS}
quantity with the dimensions of stress, which represents the predicted mean hydrostatic hoop strength at a temperature, T, and failure time, t_f

NOTE The long-term hydrostatic strength is expressed in megapascals.

3.6
long-term strength
σ_{LTS}
quantity with the dimension of stress, which represents the predicted mean strength at a temperature, T, and failure time, t_f

NOTE 1 The long-term strength is expressed in megapascals.

NOTE 2 Long-term strength σ_{LTS} is similar to long-term hydrostatic strength σ_{LTHS}; however, they differ in the mode of loading, tensile versus hydrostatic.

4 Principle

A plane strain grooved tensile (PSGT) specimen is made from a moulded flat plaque of finite width and length dimensions having reduced area (see Figures 1 and 2). The concave grooves are made along the width of the specimen and perpendicular to the axis of the direction of uni-axial loading. The plane strain condition in the groove is induced by the deformation constraint in the groove. This is the result of the difference between the reduced thickness, e_g, of the groove and unreduced thickness, e, of the test specimen, as illustrated in Figure 2.

With the appropriate dimensions applied (see Table 1 and Figure 2) a plane strain condition, and hence biaxial stress state, is generated in the groove on uniaxial loading. After conditioning in the test medium, the specimen is subjected to a specified constant load for sustained time duration until the test specimen fails, at which point the stress and corresponding rupture time are recorded. In this manner, it can be tested in various controlled environments, and at specified constant temperatures, in order to obtain the long-term strength capacity of moulding materials for pipes and fittings. Such a controlled environment can be accomplished by, but is not limited to, immersing the specimens in a controlled-temperature water bath or circulating-air oven.

The PSGT stress-rupture data obtained from moulding materials, experimental piping resins and samples obtained from pipes and fittings can be extrapolated in accordance with a method such as that specified in ISO 9080[3] for providing estimations on their long-term strength properties. For estimating the effect of extrusion processing on pipes, the results from PSGT specimen can be compared with the results generated with pipes according to ISO 1167[2].

5 Apparatus

5.1 Loading system

Any device that is capable of continuously applying constant load on the specimen may be used. The device shall be capable of reaching the test load without exceeding it and holding it to within ±1 % of the applied load throughout duration of the test. A loading system that utilizes an electro-pneumatic device was found to be suitable. Other constant loading systems may also be used, such as those described in ISO 899-1[1]. It is important to maintain the straight sample alignment with the load-train to avoid any bending and/or twisting of the specimen.

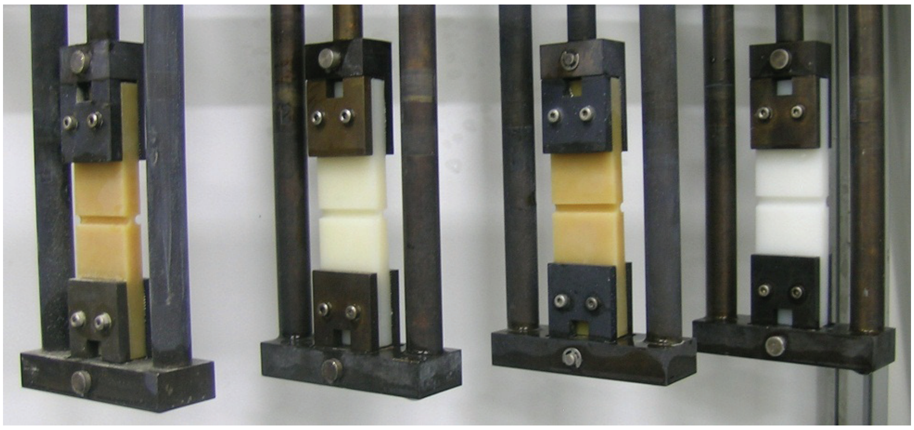

Figure 1 — PSGT specimens undergoing stress-rupture test

5.2 Constant temperature system

A reservoir capable of maintaining a fluid at a uniform temperature and which ensures complete immersion of the test specimen shall be used. The construction material for the reservoir shall not affect the environment or vice versa. If evaporation affects the medium condition, a lid shall be part of the construction so as to prevent this phenomenon. If water or other liquid medium is used, agitation is permitted to stabilize the temperature throughout the reservoir. If an air or other gaseous environment is used, provision shall be made for adequate circulation. The temperature of the environment shall be controlled to maintain the specimens at $(T \pm 1,0)$ °C, where T is the specified test temperature, in case of a liquid bath and $\left(T^{+2}_{-1}\right)$ °C when an oven system is used.

Control and measurement of the temperature in the test medium shall be done with a calibrated thermometer, thermocouple or thermistor to an accuracy of ±0,1 °C.

5.3 Timing device

A suitable timing device that can monitor time accumulation shall be used. The accuracy of the measurement shall be better than ±1 % of the elapsed time.

5.4 Failure detection device

Any device that can detect failure due to gross yielding of the sample or slow crack propagation through the groove thickness shall be utilized.

5.5 Sample grips

By means of an appropriate system, grips shall be installed at the ends of the specimen to allow transfer of the applied load to the specimen without causing slippage, damage or any other adverse effect on the test specimen during the test.

5.6 Calibration and accuracy of the apparatus

The temperature and load control systems and the equipment for measuring temperature, load and time shall be capable of maintaining the values within the specified limits and shall be calibrated regularly to maintain the required accuracy.