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JIS

JAPANESE INDUSTRIAL STANDARD

Testing method for thermally stimulated current of plastic films

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In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

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Testing method for thermally stimulated current of plastic films

K 7131-1994

1. Scope This Japanese Industrial Standard specifies the testing method for thermally stimulated current (hereafter, referred to as "TSC") of plastic films.

Remarks: The following standards are cited in this Standard:

JIS B 7503	Dial gauges
JIS B 7507	Vernier, dial and digital callipers
JIS K 6900	Plastics — Vocabulary [ISO 472: 1988]
JIS K 7100	Standard atmospheres for conditioning and testing of plastics

2. Definitions For the main terms used in this Standard the definitions in JIS K 6900 apply, and the rest of the terms are as follows:

(1) thermally stimulated current (TSC) A current flowing through an external circuit biting a test piece of dielectric or insulation such as plastic when the test piece transfers to thermal equilibrium because frozen dielectric polarization and trapped electricity at low temperature are released due to raising temperature (see Fig. 1).

(2) poling electric field A d.c. electric field which is applied to a test piece in order to cause dielectric polarization or accumulation of an electric charge to be trapped.

(3) relaxation time A characteristic time constant which is a reference for time required for relaxation, which is expressed by the following formula:

$$\tau = \tau_0 \exp\left(\frac{H}{kT}\right)$$

where,
τ : relaxation time of dipole polarization (s)
τ_0 : a constant concerning vibrational angular frequency of bipole (s)
k : Boltzmann's constant [1.3807×10^{-23} (J/K)]
H : activation energy of orientation polarization of dipole (J)
T : absolute temperature (K)

(4) dipole polarization Polarization based on orientation of dipole moment of a polar molecule, which is expressed by the following formula:

$$P_0 = \frac{N\mu^2 E_p}{3kT_p}$$

where, P_0 : saturated polarization quantity (C/m^2)

N : density of dipole (m^{-3})

μ : dipole efficiency (C·m)

E_P : poling electric field (V/m)

T_P : poling temperature (K)

(5) dielectric constant A proportional constant ε when a relation between a dielectric flux density D and an electric field E is expressed by $D = \varepsilon E$.

(6) relative permittivity A ratio ε_r of a dielectric constant to a vacuum dielectric constant, which is expressed by the following formula:

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$$

where, ε_r : relative permittivity

ε : dielectric constant (F/m)

ε_0 : vacuum dielectric constant [8.854×10^{-12} (F/m)]

(7) relative dielectric loss factor In the case where phase lag exists in variation of dielectric flux density when an a.c. electric field is applied to a dielectric, the relative permittivity becomes a complex number. The relative dielectric loss factor is the imaginary number part which is expressed by the following formula:

$$\varepsilon_r = \varepsilon'_r - i\varepsilon''_r$$

where, ε_r : relative permittivity

ε'_r : real number part of complex relative permittivity

ε''_r : imaginary number part of complex relative permittivity

(8) poling temperature Temperature when a poling electric field is applied.

3. Principle of measurement When a poling electric field is applied to a plastic film containing a polar molecule through electrodes attached to both surfaces, dipole polarization is generated. The test piece is cooled under this state. After freezing the dipole polarization, the poling electric field is removed, and both electrodes are connected through an ammeter. Then, since freezing of the dipole polarization disappears as temperature of the test piece is gradually raised, plus and minus charges induced in both electrodes by polarization charge flow through the ammeter, and the TSC is measured (see Fig. 1).

4. Conditioning of test piece and temperature and humidity of laboratory

4.1 Conditioning of test piece A test piece shall be, as a rule, conditioned for 48 h or longer under the standard temperature condition grade 2 and standard humidity condition grade 2 which are specified in JIS K 7100 [23 ± 2°C temperature and (50 ± 5) % relative humidity] before the test.

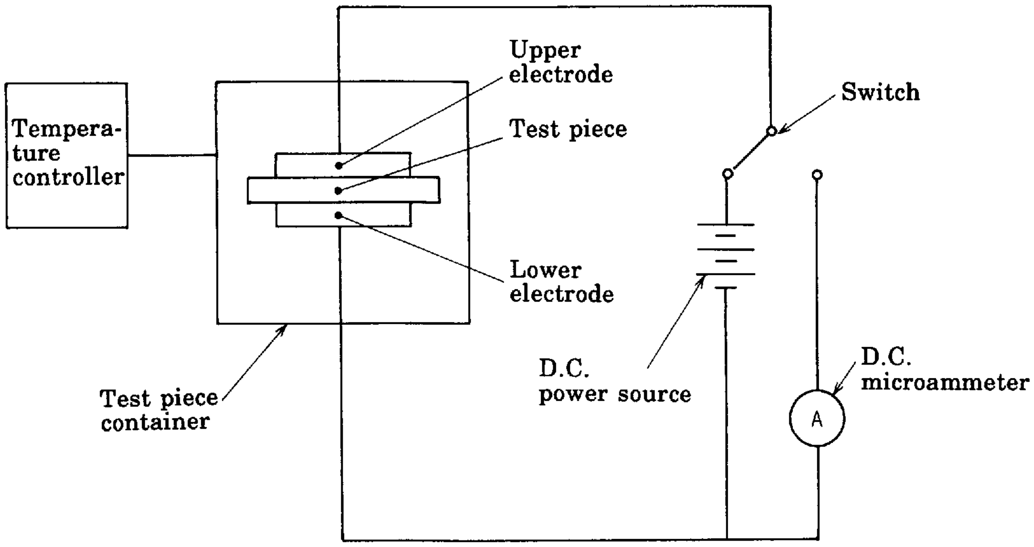
4.2 Temperature and humidity of laboratory A test shall be, as a rule, carried out in the laboratory of the temperature and humidity specified in 4.1.

5. Test apparatus

5.1 Tester A tester used for measurement of TSC shall be composed of a test piece container equipped with a temperature controller wherein temperature of a test piece can be kept at a specific temperature, rapidly cooled, and raised at a specific rate, a d.c. power source for polarization of the test piece, a d.c. micro-ammeter for measurement of TSC, a device which records temperature and a current simultaneously, etc.

Further, since the TSC depends on the test atmosphere, a device capable of keeping the test piece in a specific atmosphere shall be equipped to the tester. An example of the tester is given in Fig. 1.

Fig. 1. Example of construction of tester



(1) Test piece container A test piece container shall be equipped with a temperature controller which can set a specific temperature atmosphere. In the container, an upper electrode and a lower electrode which apply poling voltage to a test piece to measure TSC are provided so that respective virtual center lines coincide.

(2) Temperature controller A temperature controller can keep the temperature of a test piece in the test piece container at a specific temperature and can raise it at a specific rate.

It shall be equipped with an apparatus which can rapidly cool from poling temperature (for example, forced air cooling, water cooling, or liquid nitrogen cooling).