IEC 60811-403 Electric and Optical Fibre Cables – Test Methods for Non-Metallic Materials –Ozone Resistance Rest on Cross-Linked Compounds- Testing Equipment

Description

4.2 Apparatus
The following apparatus shall be used:
a) a device for generating a controlled amount of ozone;
b) a means for circulating ozonized air under controlled conditions of humidity and temperature through a chamber containing the test pieces to be tested;
c) a means for the determination of ozone concentration;
d) a suitable device for the clamping and elongation of test pieces;
e) cylindrical mandrels consisting of wood or metal;

f) a desiccator filled with silica gel or equivalent material;
g) an accurate laboratory balance reading to 0,1 mg.

4.3 Pre-conditioning of the samples
All the tests shall be carried out not less than 16 h after the extrusion or cross-linking, if any, of the insulating or sheathing compounds.
If the test is carried out at ambient temperature, the test pieces shall be kept for at least 3 h at a temperature of (23 ± 5) °C.

4.4 Sampling and preparation of test pieces
4.4.1 Sampling of insulation
Whether the cable is single or multicore, only one core needs to be tested. Sufficient length of core shall be cut from a position not less than 1,5 m from the end of the length of cable to provide two test pieces, unless the core has an extruded semi-conductor layer on the outside, in which case sufficient length for four test pieces shall be taken.
Any sample that shows signs of mechanical damage shall not be used for the tests.
4.4.2 Sampling of sheath
One sample of the cable or cord to be tested, or of the sheath removed from the cable, shall be taken of sufficient size to provide a minimum of two test pieces.
Any sample that shows signs of mechanical damage shall not be used for the tests.
4.4.3 Preparation of test pieces from insulation
Any protective coverings present on the core shall be removed without damaging the insulation, unless they were applied directly to the insulation prior to vulcanization and are adherent to it. If the core has a semi-conducting layer in the form of tape on the outside, this shall be removed.
If the core has an extruded semi-conducting screen on the outside, this shall be removed from two test pieces and left in position on the other two.

4.4.4 Preparation of test pieces from sheath

Two dumb-bell test pieces shall be prepared in accordance with IEC 60811-501. The minimum test piece thickness shall be 0,6 mm. In the case of cables of such small size that it is not possible to prepare dumb-bell test pieces, the test method used shall be that specified for insulation.

4.5 Conditioning and deformation procedure of test pieces

4.5.1 Test pieces of insulation

If the core does not have an extruded semi-conducting screen, one test piece shall be bent in the direction and plane of its existing curvature, without twisting, for one complete turn around a mandrel, and bound with twine or tape where the ends cross, and a second test piece of the same core shall be bent similarly in the plane of its existing curvature but in the opposite direction.

If the core as manufactured has an extruded core screen on the outside, two test pieces, one with the semi-conducting layer removed and one with the semi-conducting layer left in position, shall be bent, as above, in each direction.

The bending shall be carried out at temperature 20 °C to 28 °C using a brass, aluminium or suitably treated wooden mandrel with a diameter according to Table 1.

Table 1 – Mandrel diameters

Outside diameter of insulated core d mm	Mandrel diameter (as a multiple of the outside diameter of insulated core)
$d \leq 12,5$	4 ±0,1
$12,5 < d \leq 20$	5 ±0,1
$20 < d \leq 30$	6 ±0,1
$30 < d \leq 45$	8 ±0,1
$45 < d$	10 ±0,1

If the test piece is too rigid to permit the ends to be crossed, it shall be bent and tied so that at least 180° bend round a mandrel of the specified diameter is obtained.

The surface of each test piece shall be wiped with a clean cloth to remove dirt or moisture. The bent test pieces on their mandrels shall be kept in air at ambient temperature without any further treatment for 30 min to 45 min before being tested.

4.5.2 Test pieces of sheath

The surface of each test piece shall be wiped with a clean cloth to remove dirt or moisture. The test piece shall then be stored in the desiccator for at least 16 h at (23 ± 5) °C.

Clamp both ends of the test piece in the clamping device, and elongate it by (33 ± 2) % and keep the test piece elongated in the clamping device.

NOTE To avoid possible ozone cracks near the clamps, the test pieces may be covered locally by a suitable
ozone resistance lacquer.

4.6 Exposure to ozone

The conditioned test pieces prepared as in 4.4 shall be placed in the middle of the test chamber fitted with a test cock; the test pieces shall be at least 20 mm from each other. The test pieces shall be maintained at a temperature of (25 ± 2) °C, unless otherwise specified in the cable standard, and exposed to a circulating current of dry air with the required ozone concentration.
The ozone concentration and the exposure time shall be as specified in the relevant cable standard.
The ozone concentration shall be measured inside of the test chamber in accordance with 4.8.
The air with the required ozone concentration shall have a flow rate of between 280 l/h and 560 l/h, and the air pressure shall be maintained slightly above atmospheric pressure.

4.7 Evaluation of results
After the specified test duration, the test pieces shall be removed from the test chamber and examined with normal or corrected vision without magnification.
The insulation in the 180° section of the bent portion furthest from the tie shall be free from cracks.
The surfaces of the central narrow portions of the dumb-bell test pieces shall be free from cracks.
Any cracks near the clamps shall be disregarded.

4.8 Determination of ozone concentration
4.8.1 Chemical analysis
4.8.1.1 Reagents
The reagents shall be of a recognized analytical reagent quality.
Distilled water shall be used throughout the test.
a) Starch indicator solution: 1 g of soluble starch shall be stirred into 40 ml of cold water and heated to boiling point with constant stirring until the starch is completely dissolved. This dissolution shall be diluted with cold water to about 200 ml and 2 g of crystallized zinc chloride added. The solution shall be allowed to settle and the supernatant liquid poured off for use. If being used repeatedly, the solution shall be renewed every two or three days.
Alternatively, a fresh solution of 1 g of soluble starch in 100 ml of boiling water may be prepared.
When either of these starch solutions is used as indicator, a few drops of 10 % acetic acid shall be added to the solution being titrated.
b) Standard iodine solution: 2 g of potassium iodide (KI) and 10 ml of water shall be placed in a weighing tube, which shall then be weighed. Iodine shall be added directly to the solution in the tube on the balance pan until the total iodine in solution is about 0,1 g. The solution with the added iodine shall be accurately weighed and the amount of added iodine determined. The solution shall then be poured into a beaker; the weighing tube, held over the beaker, shall be washed with water. The solution shall be poured from the beaker into a flask calibrated at 1 000 ml, the beaker rinsed with water into a flask and the solution in the flask diluted to 1 000 ml.

NOTE This solution is fairly stable if kept in a cool dark place in a well-stoppered brown bottle. c) Sodium thiosulphate solution: Sodium thiosulphate ($Na_2S_2O_3$) solution of approximately the same strength as the standard iodine solution shall be prepared by placing about 0,24 g of $Na_2S_2O_3$? 5 H_2O in a 1 000 ml flask and diluting to 1 000 ml. Since it gradually loses its strength, the solution shall be standardized against the iodine solution on the day of the ozone test.
The strength, E, of the $Na_2S_2O_3$ solution, calculated as iodine equivalence and expressed as

milligrams of iodine per millilitre of the solution is:

$$\frac{F \times C}{S}$$

where

F is the volume of the iodine solution in millilitres;

C is the concentration of iodine in milligrams per millilitre;

S is the volume of the $Na_2S_2O_3$ solution used to titrate the solution.

d) Potassium iodide solution: about 20 g of pure KI shall be dissolved in 2 000 ml of water.
e) Acetic acid: a 10 % solution (by volume) shall be prepared.

4.8.1.2 Procedure
A measured volume of the air containing ozone shall be bubbled from the test chamber through the KI solution, or a measured volume of the air containing ozone shall be collected and mixed with the KI solution by a suitable means.
Two alternative methods which may be employed are described below:
a) A sampling bottle containing 100 ml of KI solution is connected to the sampling cock of the test chamber on one side and to a 500 ml gas burette on the other. The glass tube connecting the sampling bottle to the sampling cock of the gas chamber reaches well below the level of the KI solution in the sampling bottle. The two-way stop-cock on the burette is opened to the atmosphere and the burette filled to its full mark with water by lifting the aspirator connected to the bottom of the burette. The stop-cock on the burette is then closed to the atmosphere and opened to the sampling bottle and the sampling cock on the test chamber is opened to the bottle. The aspirator is then lowered until the water is emptied from the burette. When this point is reached, 500 ml of the gas from the test chamber will have bubbled through the KI solution. The stop-cocks are then closed and the bottle withdrawn for titration.
b) A separating funnel of 400 ml capacity is filled with the KI solution and the filling hole is connected to the test cock of the test chamber. The test cock and the stop-cock on the bottom of the separating funnel are opened simultaneously until about 200 ml of the KI solution have drained into a graduated cylinder placed below it. The test cock and stopcock are quickly closed and the separating funnel, which then contains a volume of gas equal to the volume of KI solution in the measuring cylinder, is removed and stoppered. The separating funnel shall be shaken to produce complete reaction with the KI solution. The solution in the graduated cylinder shall be tested with a starch indicator for the presence of free iodine and if any is detected, the gas sample shall be rejected and another collected. The KI solution which has reacted with a known volume of gas from the test chamber, by whatever method adopted, shall be titrated with the standardized Na2S2O3 solutions using the starch indicator.

4.8.1.3 Calculation
Since 1 mg of iodine is equivalent to 0,1 ml of ozone at room temperature and pressure (within the accuracy of this method of analysis at average room temperature and pressure), the ozone concentration can be calculated as follows:

$$\text{Ozone \% by volume} = \frac{10 \times S \times E}{V}$$

where

S is the volume of the $Na_2S_2O_3$ solution used to titrate the solution in millimetres;

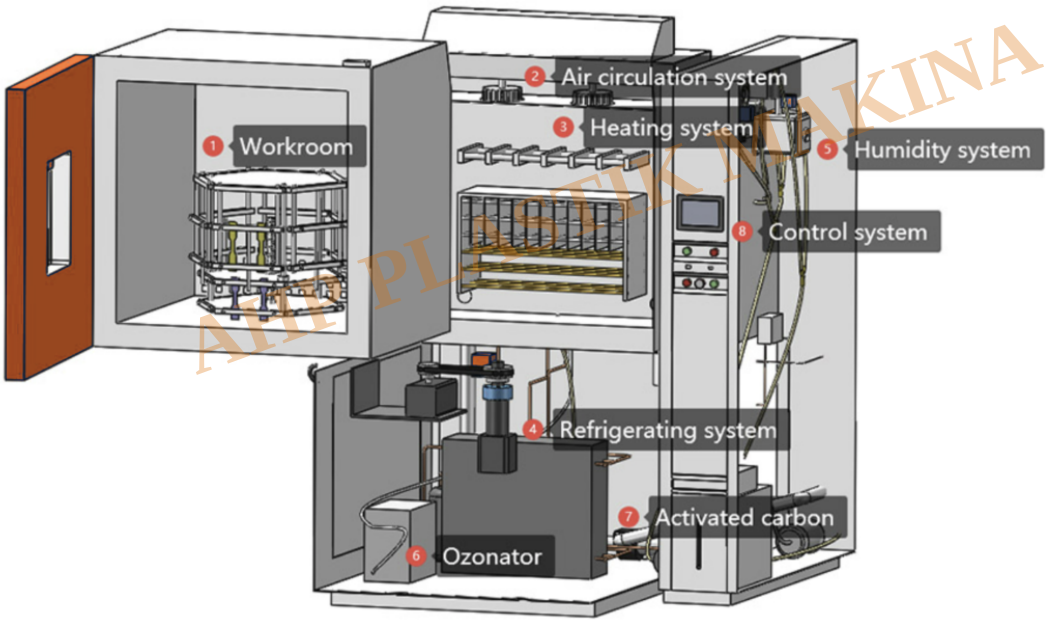
E is the iodine equivalent of the $Na_2S_2O_3$ solution in milligrams of iodine per millilitre of $Na_2S_2O_3$;

V is the volume of the gas sample collected in millilitres.

4.8.2 Direct measurement with an ozone meter

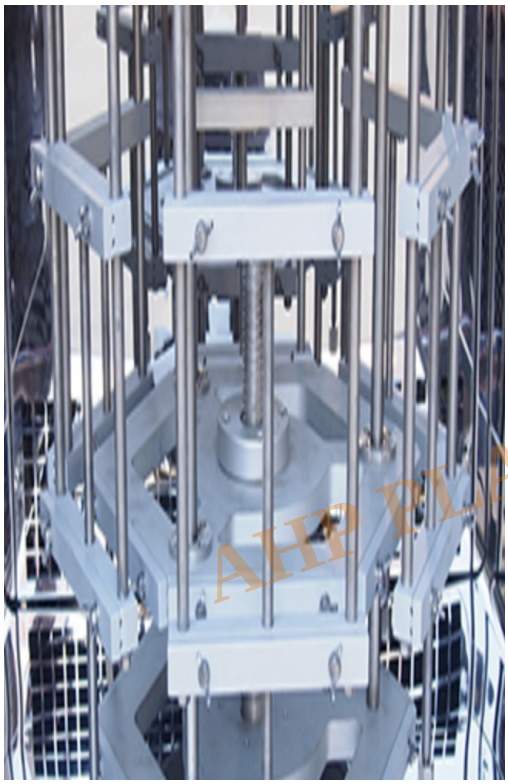
As an alternative to the chemical analysis, the ozone concentration may be measured directly with an ozone meter which has been calibrated by comparison with results obtained by the chemical method.

Ozone Test Chamber

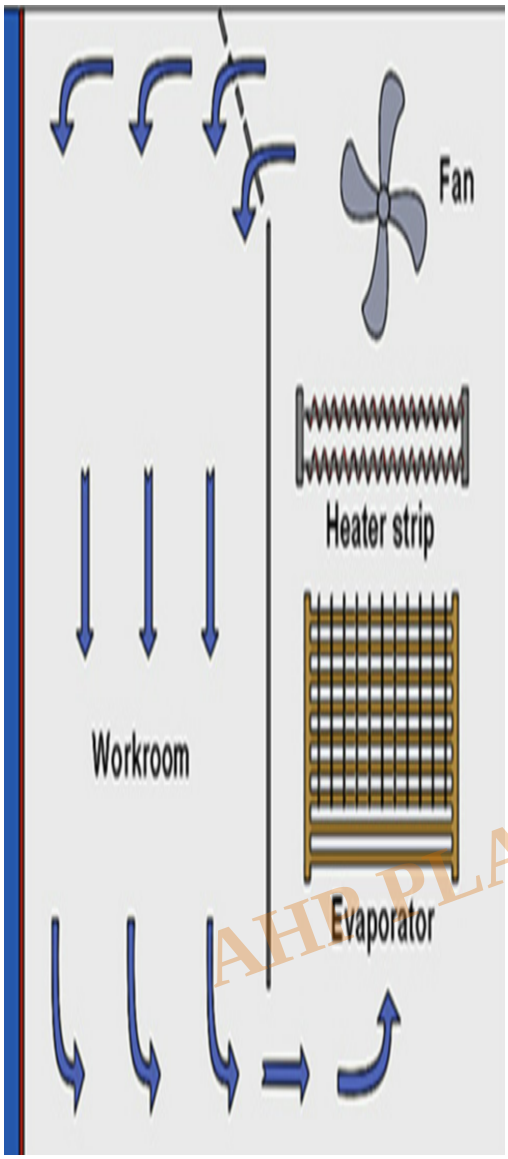


- Chamber size: 60*60*70 cm
- Temperature range: Room temperature-70C (Refrigeration is as option)
- Temperature fluctuation: ± 0.5 ?
- Temperature Deviation: ± 2.0 ?
- Humidity Range: 40-95% RH
- Humidity Deviation: ± 3% RH
- Ozone Concentration: 1?500PPM (Other ranges as per customer request)
- Sample Holder Rotate Speed: 0~10 r/min
- Airflow Rate: 280 l/h and 560 l/h
- Cooling system: Mechanical compression refrigeration system (is as option-It is not included in basic model)
- Ozone digital indicator

- Temperature-Hum-time digital indicator (HMI is as option-it is not included in basic model)
- Water supply system: Automatic water supply,Water purification system
- Humidifier: stainless steel surface evaporation humidifier
- Gas Sensor: Ozone gas sensor
- Ozone Generator: Silent discharge type ozone generator
- Air Circulation: Centrifugal wind fan
- Inside chamber SS304
- Fan rotational speed control
- Rotational drum sample holder



- The operation of the fan makes the ozone gas, temperature and humidity are evenly distributed



- The use of nickel-chromium alloy heating wire

- Evaporative humidifiers

- The use of silent discharge method to produce ozone

- Adsorption treatment of residual ozone in the chamber after the test to prevent ozone leakage from causing harm

Category

1. Equipment for Standards
2. Standards