

Test methods of plasma equipment for electroheat and electrochemical applications

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National foreword

This Draft for Development is the UK implementation of IEC/TS 60680:2008.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature. It should be applied on this provisional basis, so that information and experience of its practical application can be obtained.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the international organization responsible for its conversion to an international standard. A review of this publication will be initiated not later than three years after its publication by the international organization so that a decision can be taken on its status. Notification of the start of the review period will be made in an announcement in the appropriate issue of *Update Standards*.

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into an international Standard, to extend the life of the Technical Specification or to withdraw it. Comments should be sent to the Secretary of the responsible BSI Technical Committee at British Standards House, 389 Chiswick High Road, London W4 4AL.

The UK participation in its preparation was entrusted to Technical Committee PEL/27, Electroheating.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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TECHNICAL SPECIFICATION

Test methods of plasma equipment for electroheat and electrochemical applications

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TEST METHODS OF PLASMA EQUIPMENT FOR ELECTROHEAT AND ELECTROCHEMICAL APPLICATIONS

1 Scope and object

This Technical Specification specifies test methods for

- a) thermal plasma torch systems:
 - arc plasma systems;
 - inductive plasma systems;
- b) installation using thermal plasma torch systems:
 - spraying equipment;
 - solid, liquid and gaseous charge heating and thermochemical treatment equipment.

Test methods for plasma torches for welding, cutting and allied processes are specified in IEC 60974-7.

The object of this specification is to standardize the test methods and conditions for determining the main parameters and technical characteristics of thermal plasma torch systems and of installations (or equipment) using one or more plasma torch systems.

Not all the tests specified are applicable to every type of equipment, covered by this specification. It is necessary to select those tests which are applicable to a specified plasma torch system or installation. This selection is effective in the specification.

Safety requirements for systems and installations or equipment specified in a) and b) are given in IEC/TS 60519-5.

2 Normative references

The following referenced documents are 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.

IEC 60050-841:2004, *International Electrotechnical Vocabulary – Part 841: Industrial electroheat*

IEC 60398:1999, *Industrial electroheating installations – General test methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-841 and the following apply.

3.1

plasma

any ionized gas consisting of free electrons, ions and neutral particles (atoms and/or molecules and/or radicals), electrically neutral on a macroscopic scale and electrically conductive

[IEV 841-31-01, modified]

3.2**thermal plasma**

plasma in local thermodynamic equilibrium, at around atmospheric pressure or above

NOTE In IEC standards, related to equipment or installations, the use of the plain word "plasma" for "thermal plasma" is tolerated.

[IEV 841-31-07]

3.3**plasma heating**

method of heating using thermal plasma as a heat source

[IEV 841-31-02]

3.4**arc plasma****arc thermal plasma**

thermal plasma generated by an electric discharge between electrodes in a fluid

NOTE The plasma arc column is characterized by high current density, up to 100 A/mm², at pressures of the same order as atmospheric pressure.

[IEV 841-31-10]

3.5**inductive plasma**

thermal plasma in which ionization is obtained by excitation of a gas in a high-frequency electromagnetic field

[IEV 841-31-12, modified]

3.6**plasma gas**

any gas, vapour or fluid to be brought to the state of plasma

[IEV 841-31-14]

3.7**plasma torch**

electroheat equipment in which an inlet gas stream is converted by electric energy supplied to a plasma flow prior to its ejection

[IEV 841-31-29]

3.8**arc plasma torch**

electroheat equipment in which an inlet gas stream is converted to a plasma flow by electric energy supplied from an arc discharge prior to its ejection

NOTE Arc plasma torches can be supplied either by AC or DC current.

[IEV 841-31-30]

3.9**transferred arc plasma torch**

arc plasma torch in which the main arc is maintained between an internal electrode (contained within the torch) and a liquid or solid medium (or a solid workpiece), electrically conductive, constituting or including an external electrode for current return

[IEV 841-31-32]

3.10

non-transferred arc plasma torch

arc plasma torch in which the main arc is maintained between two or more electrodes regarded as torch components

[IEV 841-31-31]

3.11

plasma jet

high velocity plasma flow supplied by a non-transferred arc plasma torch or by an inductive plasma torch

[IEV 841-31-18]

3.12

non-electrode plasma torch

plasma torch with no electrode, supplied by high frequency source of inductive or capacitive type

[IEV 841-31-36)

3.13

induction plasma torch

plasma torch in which the plasma flow is generated by an a.c. high-frequency magnetic field produced by a high-frequency current established in a coil

[IEV 841-31-38, modified]

3.14

ignition of a plasma torch

initiation of the transition from non-ionized plasma gas to plasma state, carried into effect by a starting-up equipment

[IEV 841-31-15, modified]

3.15

high-frequency ignition device (of a plasma torch)

device used in an arc plasma torch to ignite the arc by a high voltage and high-frequency electric discharge between the electrodes

[IEV 841-31-16, modified]

3.16

short-circuit ignition device (of a plasma torch)

device used in an arc plasma torch to ignite the arc by creating a short circuit between the electrodes

[IEV 841-31-17]

3.17

nozzle (of a plasma torch)

part of a plasma torch allowing shaping the plasma flow prior to its ejection in order to increase its speed and/or its energy density

[IEV 841-31-40, modified]

3.18

cathode (of a non-transferred or transferred plasma torch)

negative electrode of a d.c. arc plasma torch

NOTE 1 The cathode may be made of a high electrical and thermal conductivity material, such as copper(water cooled) or of a refractory metal, such as wolfram, or of graphite, water cooled if necessary.

NOTE 2 The return current electrode of a transferred plasma torch serves sometimes as the cathode.

[IEV 841-31-42, modified]

3.19

anode (of a non-transferred or transferred plasma torch)
positive electrode of a d.c. arc plasma torch

NOTE 1 The anode is usually made of a high electrical and thermal conductivity material, such as copper, and water cooled.

NOTE 2 The return current electrode of a transferred plasma torch serves in most cases as the anode.

NOTE 3 In a non-transferred plasma torch, the anode is often the torch nozzle.

[IEV 841-31-41]

3.20

normal operation of a plasma torch

operation characterized by reproducible working conditions defined by the type and composition of the gas, its mass flow rate and the arc current

3.21

specified current of a plasma torch

maximum current which can be used (for a given plasma gas) by a plasma torch

3.22

specified power of a plasma torch

maximum power which can be used (for a given plasma gas) by a plasma torch

3.23

thermal power of a plasma torch

thermal power delivered by the torch, defined as the gas mass flow rate multiplied by its average enthalpy

3.24

energy efficiency of a plasma torch

ratio of delivered thermal power to the active input power

3.25

plasma temperature

instantaneous local temperature within a plasma

[IEV 841-31-45]

3.26

plasma average enthalpy

plasma mean enthalpy

quotient of the power delivered by the plasma torch by the plasma gas mass flow rate

[IEV 841-31-44]

3.27

plasma system

equipment for the production of thermal plasma, consisting of the plasma torch, its power supply, gas and cooling utilities and a control unit

3.28

plasma furnace

electroheat equipment comprising a refractory lined chamber in which a charge is heated by one or more plasma torches and generally used to melt or to smelt materials at high temperatures

[IEV 841-31-25]

3.29

plasma reactor

electroheat equipment comprising a chamber for a thermochemical processing of material by plasma torches

[IEV 841-31-27]

3.30

plasma installation

installation to carry on the plasma process, consisting of a plasma system and, in most cases of a plasma furnace or reactor, including all necessary auxiliary equipment for heating or thermally treating materials

3.31

plasma spraying

coating in which material introduced in the form of powder or wire and melted in a plasma jet is sprayed onto a surface

[IEV 841-31-24]

3.32

powder deposition efficiency

ratio of the mass flow rate of powder consolidated on a substrate to the mass flow rate of powder fed to the torch

4 Type and general conditions of tests

4.1 List of tests and measurements applicable to thermal plasma torch systems

4.1.1 Arc plasma systems

Arc plasma systems shall be subjected to the following tests and measurements.

4.1.1.1 Arc power supply tests

Power supplies used for arc plasma generation are generally either a.c. of 50 Hz or 60 Hz, or d.c., obtained by using semiconductor devices, for example thyristors, IGBT (Insulated Gate Bipolar Transistor) or IGCT (Integrated Gate Commutated Thyristor).

For a.c. and d.c. type supply, the following tests are applicable:

- a) verification of equipotential bonding by measurement;
- b) measurement of insulation resistance;
- c) dielectric test;
- d) regulation mode test:
 - off-load test,
 - on-load test;
- e) determination of energy efficiency;