Depending on the power source classification of each circuit, one or more SAFEGUARDS are required either to reduce the likelihood of ignition or to reduce the likelihood of spread of fire beyond the equipment.

6.2.2 Power source circuit classifications

6.2.2.1 General

An electric circuit is classified PS1, PS2, or PS3 based on the electrical power available to the circuit from the power source.

The electrical power source classification shall be determined by measuring the maximum power under each of the following conditions:

– for load circuits: a power source under NORMAL OPERATING CONDITIONS as specified by the manufacturer into a worst-case fault (see 6.2.2.2);

– for power source circuits: a worst-case power source fault into the specified normal load circuit (see 6.2.2.3).

The power is measured at points X and Y in Figure 34 and Figure 35.

6.2.2.2 Power measurement for worst-case fault

With reference to Figure 34:

– the measurement may be performed without the load circuit L_{NL} connected, unless the maximum power is dependent on the connection of the load;

– at points X and Y, insert a wattmeter (or a voltmeter, V_A, and a current meter, I_A);

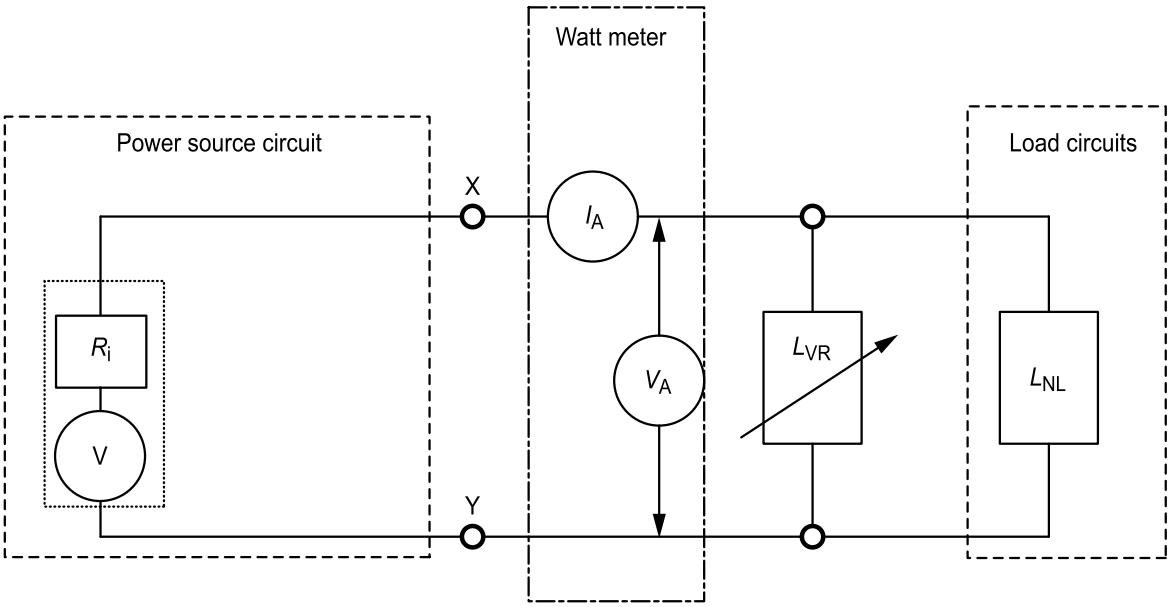
– connect a variable resistor, L_{VR}, as shown;

– adjust the variable resistor, L_{VR}, for maximum power. Measure the maximum power and classify the power source according to6.2.2.4, 6.2.2.5 or 6.2.2.6.

If an overcurrent protective device operates during the test, the measurement shall be repeated at 125 % of the current rating of the overcurrent protective device.

If a power limiting device or circuit operates during the test, the measurement shall be repeated at a point just below the current at which the power limiting device or circuit operated.

When evaluating accessories connected via cables to the equipment, the impedance of the cable may be taken into account in the determination of PS1 or PS2 on the accessory side.



Key

V voltage source

R_i internal resistance of the power source

I_A current from the power source

V_A voltage at the points where determination of PS power is made

L_{VR} variable resistor load

L_{NL} normal load

Figure 34

Power measurement for worst-case fault

6.2.2.3 Power measurement for worst-case power source fault

With reference to Figure 35:

– At points X and Y, insert a wattmeter (or a voltmeter, V_A, and a current meter, I_A).

– Within the power source circuit, simulate any SINGLE FAULT CONDITION that will result in maximum power to the circuit being classified. All relevant components in the power source circuits shall be short-circuited or disconnected one at a time at each measurement.

– Equipment containing audio amplifiers shall also be tested under ABNORMAL OPERATING CONDITIONS as specified in Clause E.3.

– Measure the maximum power as specified and classify circuits supplied by the power source according to 6.2.2.4, 6.2.2.5 or 6.2.2.6.

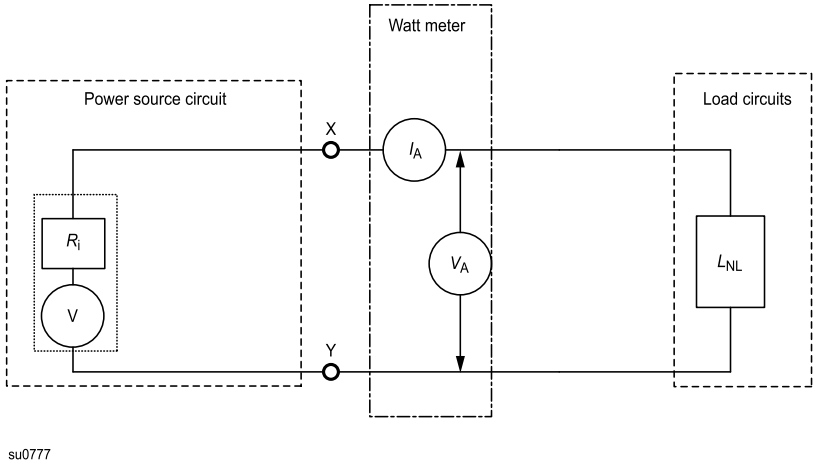
If an overcurrent protective device operates during the test, the measurement shall be repeated at 125 % of the current rating of the overcurrent protective device.

If a power limiting device or circuit operates during the test, the measurement shall be repeated at a point just below the current at which the power limiting device or circuit operated.

When the tests are repeated, a variable resistance may be used to simulate the component under fault.

To avoid damage to the components of the normal load, a resistor (equal to the normal load) may be substituted for the normal load.

NOTE Experimentation can be used to identify the single component fault that produces maximum power.



Key

V voltage source

R_i internal resistance of the power source

I_A current from the power source

V_A voltage at the points where determination of PS power is made

L_{NL} normal load

Figure 35

Power measurement for worst-case power source fault

6.2.2.4 PS1

PS1 is a circuit where the power source, (see Figure 36) measured according to 6.2.2, does not exceed 15 W measured after 3 s.

The power available from EXTERNAL CIRCUITS described in Table 13, ID numbers 1 and 2, are considered to be limited to PS1.

6.2.2.5 PS2

PS2 is a circuit where the power source, (see Figure 36) measured according to 6.2.2:

– exceeds PS1 limits; and

– does not exceed 100 W measured after 5 s.

6.2.2.6 PS3

PS3 is a circuit whose power source exceeds PS2 limits, or any circuit whose power source has not been classified (see Figure 36).

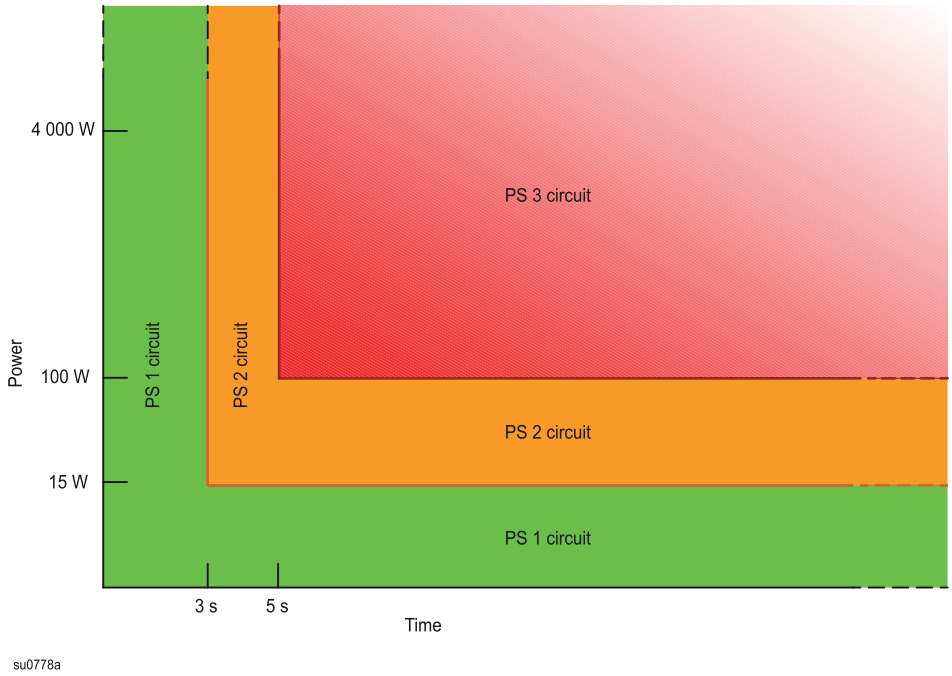


Figure 36

Illustration of power source classification

6.2.3 Classification of potential ignition sources

6.2.3.1 Arcing PIS

An ARCING PIS is a location with the following characteristics:

– an open circuit voltage (measured after 3 s) across an open conductor or opening electrical contact exceeding 50 V (peak) AC or DC; and

– the product of the peak of the open circuit voltage (V_p) and the measured RMS current (I_{rms}) exceeds 15 (that is, $V_p \times I_{rms} > 15$) for any of the following:

- a contact, such as a switch or connector;
- a termination, such as one made by a crimp, spring or solder termination;
- opening of a conductor, such as a printed wiring board trace, as a consequence of a SINGLE FAULT CONDITION. This condition does not apply if electronic protection circuits or additional constructional measures are used to reduce the likelihood that such a fault becomes an ARCING PIS.

An ARCING PIS is considered not to exist in a PS1 because of the limits of the power source.

NOTE 1 An open conductor in an electric circuit includes those interruptions that occur in conductive patterns on printed boards.

Reliable or redundant connections are not considered to be an ARCING PIS.

Redundant connections are any kind of two or more connections in parallel, where in the event of the failure of one connection, the remaining connections are still capable of handling the full power.

Reliable connections are connections that are considered not to open.

NOTE 2 Connections that could be considered reliable are:

– holes of solder pads on a printed board that are through-metallized;

– tubular rivets/eyelets that are additionally soldered;

– machine-made or tool-made crimp or wire-wrap connections.

NOTE 3 Other means to avoid the occurrence of an a can be used.

NOTE 4 Connection failure due to thermal fatigue phenomena could be prevented by selection of components with a coefficient of thermal expansion similar to that of the printed board material, taking into account the location of the component with respect to the fibre direction of the board material.

6.2.3.2 Resistive PIS

A RESISTIVE PIS is any part in a PS2 or PS3 circuit that:

– dissipates more than 15 W measured after 30 s under NORMAL OPERATING CONDITIONS; or

NOTE During the first 30 s there is no limit.

– under SINGLE FAULT CONDITIONS:

• dissipates more than 100 W measured for 30 s, disregarding the first 3 s, immediately after the introduction of the fault if electronic circuits, regulators or PTC devices are used; or

• dissipates more than 15 W measured 30 s after the introduction of the fault.

A RESISTIVE PIS is considered not to exist in a PS1 because of the limits of the power source.

6.3 Safeguards against fire under normal operating conditions and abnormal operating conditions

6.3.1 Requirements

Under NORMAL OPERATING CONDITIONS and ABNORMAL OPERATING CONDITIONS, the following BASIC SAFEGUARDS are required:

– ignition shall not occur; and

– no part of the equipment shall attain a temperature value greater than 90 % of the spontaneous ignition temperature limit, in Celsius, of the part as defined by ISO 871. When the spontaneous ignition temperature of the material is not known, the temperature shall be limited to 300 °C; and

NOTE This document currently does not contain requirements for flammable dust or liquids other than for INSULATING LIQUIDS.

– COMBUSTIBLE MATERIALS for components and other parts (including ELECTRICAL ENCLOSURES, MECHANICAL ENCLOSURES and decorative parts) not inside a FIRE ENCLOSURE shall comply with:

- HB75 CLASS MATERIAL if the thinnest significant thickness of this material is < 3 mm; or
- HB40 CLASS MATERIAL if the thinnest significant thickness of this material is ≥ 3 mm; or
- HBF CLASS FOAMED MATERIAL; or
- shall pass the Glow-Wire test at 550 °C according to IEC 60695-2-11.

These requirements do not apply to:

- parts with a volume of less than 1 750 mm^3;
- parts with a mass of COMBUSTIBLE MATERIAL of less than 4 g;
- supplies, CONSUMABLE MATERIALS, media and recording materials;
- parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers, ink tubes and material requiring optical characteristics; and
- gears, cams, belts, bearings and other parts that would contribute negligible fuel to a fire, including, labels, mounting feet, key caps, knobs and the like.

6.3.2 Compliance criteria

Compliance is checked by inspection of the data sheets and by test under NORMAL OPERATING CONDITIONS according to Clause B.2 and under ABNORMAL OPERATING CONDITIONS according to Clause . The temperatures of materials are measured continuously until thermal equilibrium has been attained.

NOTE See B.1.5 for details on thermal equilibrium.

Temperature limiting BASIC SAFEGUARDS that comply with the applicable requirements of this document or the applicable safety device standard shall remain in the circuit being evaluated.

6.4 Safeguards against fire under single fault conditions

6.4.1 General

This subclause defines the possible SAFEGUARD methods that can be used to reduce the likelihood of ignition or spread of fire under SINGLE FAULT CONDITIONS.

There are two methods of providing protection. Either method may be applied to different parts of the same equipment.

– REDUCE THE LIKELIHOOD OF IGNITION: Equipment is so designed that under SINGLE FAULT CONDITIONS no part shall have sustained flaming. This method can be used for any circuit in which the available steady state power to the circuit does not exceed 4 000 W. The appropriate requirements and tests are detailed in 6.4.2 and 6.4.3.

- PLUGGABLE EQUIPMENT TYPE A is considered not to exceed the steady state value of 4 000 W.
- PLUGGABLE EQUIPMENT TYPE B and PERMANENTLY CONNECTED EQUIPMENT are considered not to exceed the steady state value of 4 000 W if the product of the nominal MAINS voltage and the PROTECTIVE CURRENT RATING of the installation overcurrent protective device ($V_{mains} \times I_{max}$) does not exceed 4 000 W.

– CONTROL FIRE SPREAD: Selection and application of SUPPLEMENTARY SAFEGUARDS for components, wiring, materials and constructional measures that reduce the spread of fire and, where necessary, by the use of a second SUPPLEMENTARY SAFEGUARD such as a FIRE ENCLOSURE. This method can be used for any type of equipment. The appropriate requirements are detailed in 6.4.4, 6.4.5 and 6.4.6.

6.4.2 Reduction of the likelihood of ignition under single fault conditions in PS1 circuits

No SUPPLEMENTARY SAFEGUARDS are needed for protection against PS1. A PS1 is not considered to be capable of providing enough energy to result in materials reaching ignition temperatures.

6.4.3 Reduction of the likelihood of ignition under single fault conditions in PS2 circuits and PS3 circuits

6.4.3.1 Requirements

The likelihood of ignition under SINGLE FAULT CONDITIONS in PS2 circuits and PS3 circuits where the available power does not exceed 4 000 W (see 6.4.1) shall be reduced by using the following SUPPLEMENTARY SAFEGUARDS as applicable:

NOTE For PS3 circuits where the available power exceeds 4 000 W, see 6.4.6.

– an ARCING PIS or a RESISTIVE PIS shall be separated as specified in 6.4.7 with the ACCESSIBLE outer surface of the equipment considered to be covered with a COMBUSTIBLE MATERIAL;

– protective devices acting as a SAFEGUARD shall comply with G.3.1 to G.3.4 or the relevant IEC component standards;

– motors and transformers shall comply with G.5.3, G.5.4 or the relevant IEC component standard;

– varistors shall comply with G.8.2; and

– components associated with the MAINS shall comply with the relevant IEC component standards and the requirements of other parts of this document.

In addition, the tests of 6.4.3.2 apply.

EXAMPLES Components associated with the MAINS include the supply cord, appliance couplers, EMC filtering components, switches, etc.

6.4.3.2 Test method

The conditions of Clause B.4, that are possible causes for ignition, are applied in turn. A consequential fault may either interrupt or short-circuit a component. In case of doubt, the test shall be repeated two more times with replacement components in order to check that sustained flaming does not occur.

The equipment is operated under SINGLE FAULT CONDITIONS and the temperatures of materials are monitored continuously until thermal equilibrium has been attained.

If a conductor opens during a simulated SINGLE FAULT CONDITION, the conductor shall be bridged and the simulated SINGLE FAULT CONDITION shall be continued. In all other cases, where an applied SINGLE FAULT CONDITION results in interruption of the current before steady state has been reached, the temperatures are measured immediately after the interruption.

NOTE 1 See B.1.5 for details on thermal equilibrium.

NOTE 2 Temperature rise can be observed after interruption of the current due to thermal inertia.

If the temperature is limited by a fuse, under a SINGLE FAULT CONDITION:

– a fuse complying with the IEC 60127 series shall open within 1 s; or

– a fuse not complying with the IEC 60127 series shall open within 1 s for three consecutive times; or

– the fuse shall comply with the following test.

The fuse is short-circuited and the current that would have passed through the fuse under the relevant SINGLE FAULT CONDITION is measured.

If the fuse current remains less than 2,1 times the current rating of the fuse, the temperatures are measured after a steady state has been attained.

If the current either immediately reaches 2,1 times the current rating of the fuse or more, or reaches this value after a period of time equal to the maximum pre-arcing time for the relevant current through the fuse under consideration, both the fuse and the short-circuit link are removed after an additional time corresponding to the maximum pre-arcing time of the fuse under consideration and the temperatures are measured immediately thereafter.

If the fuse resistance influences the current of the relevant circuit, the maximum resistance value of the fuse shall be taken into account when establishing the value of the current.

Printed board conductors are tested by applying the relevant SINGLE FAULT CONDITIONS of B.4.4.

6.4.3.3 Compliance criteria

Compliance is checked by inspection, tests and measurements. See B.4.8 for compliance criteria.

6.4.4 Control of fire spread in PS1 circuits

No SUPPLEMENTARY SAFEGUARDS are needed for protection against PS1. A PS1 is not considered to be capable of providing enough energy to result in materials reaching ignition temperatures.

6.4.5 Control of fire spread in PS2 circuits

6.4.5.1 General

For the purposes of reducing the likelihood of fire spread in PS2 circuits to nearby COMBUSTIBLE MATERIALS, circuits that meet the requirements of Annex Q are considered to be PS2 circuits.

6.4.5.2 Requirements

A SUPPLEMENTARY SAFEGUARD is required to control the spread of fire from any possible PIS to other parts of the equipment as given below.

Conductors and devices that constitute a PIS shall comply with the following:

– printed boards shall be made of V-1 CLASS MATERIAL or VTM-1 CLASS MATERIAL; and

– wire insulation and tubing shall comply with 6.5.1.

Motors shall comply with G.5.4.

Transformers shall comply with G.5.3.

All other components in a PS2 circuit shall comply with one of the following:

– be mounted on V-1 CLASS MATERIAL or VTM-1 CLASS MATERIAL; or

– be made of V-2 CLASS MATERIAL, VTM-2 CLASS MATERIAL or HF-2 CLASS FOAMED MATERIAL; or

– comply with the requirements of Clause S.1; or

– have a size of less than 1 750 mm^3; or

– have a mass of COMBUSTIBLE MATERIAL of less than 4 g; or

– be separated from a PIS by the requirements of 6.4.7; or

– comply with the flammability requirements of the relevant IEC component standard; or

– be in a sealed ENCLOSURE of 0,06 m^3 or less, consisting totally of non-COMBUSTIBLE MATERIAL and having no ventilation openings; or

– the component shall not ignite during SINGLE FAULT CONDITIONS as specified in 6.4.3.2.

If the following materials and parts are not separated from a PIS according to the requirements of 6.4.7, then the materials and parts shall not ignite during SINGLE FAULT CONDITIONS as specified in 6.4.3.2:

– supplies, CONSUMABLE MATERIALS, media and recording materials; and

– parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers, ink tubes and material requiring optical characteristics.

6.4.5.3 Compliance criteria

Compliance is checked by testing or by inspection of the equipment and material data sheets.

6.4.6 Control of fire spread in a PS3 circuit

Fire spread in PS3 circuits shall be controlled by applying all of the following SUPPLEMENTARY SAFEGUARDS:

– conductors and devices within a PS3 circuit shall meet the requirements of 6.4.5;

– devices subject to arcing or changing contact resistance (for example, pluggable connectors) shall comply with one of the following:

- have materials made of V-1 CLASS MATERIAL, or
- comply with the flammability requirements of the relevant IEC component standard, or
- comply with the requirements of Clause S.1, or

• be mounted on material made of V-1 CLASS MATERIAL or VTM-1 CLASS MATERIAL and be of a volume not exceeding 1 750 mm^3 or have a mass of COMBUSTIBLE MATERIAL of less than 4 g; and

– by providing a FIRE ENCLOSURE as specified in 6.4.8.

Within the FIRE ENCLOSURE, COMBUSTIBLE MATERIALS that do not comply with the flammability requirements for PS2 or PS3 circuits shall comply with the flammability test of Clause S.1 or be made of V-2 CLASS MATERIAL, VTM-2 CLASS MATERIAL or HF-2 CLASS FOAMED MATERIAL. These requirements do not apply to:

– parts with a volume of less than 1 750 mm^3;

– parts with a mass of COMBUSTIBLE MATERIAL of less than 4 g;

– supplies, CONSUMABLE MATERIALS, media and recording materials;

– parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers, ink tubes and material requiring optical characteristics;

– gears, cams, belts, bearings and other parts that would contribute negligible fuel to a fire, including, labels, mounting feet, key caps, knobs and the like; and

– tubing for air or fluid systems, containers for powders or liquids and foamed plastic parts, provided that they are of HB75 CLASS MATERIAL if the thinnest significant thickness of the material is < 3 mm, or HB40 CLASS MATERIAL if the thinnest significant thickness of the material is ≥ 3 mm, or HBF CLASS FOAMED MATERIAL or pass the glow-wire test at 550 °C according to IEC 60695-2-11.

A FIRE ENCLOSURE is not necessary for the following components and materials:

– wire insulation and tubing complying with 6.5.1;

– components, including connectors, complying with the requirements of 6.4.8.2.1, and that fill an opening in a FIRE ENCLOSURE;

– plugs and connectors forming part of a power supply cord or interconnecting cable complying with 6.4.9, G.4.1 and Clause G.7;

– motors complying with G.5.4; and

– transformers complying with G.5.3.

Compliance is checked by inspection of the material data sheets or by test, or both.

6.4.7 Separation of combustible materials from a PIS

6.4.7.1 General

When required, the minimum separation requirements between a PIS and COMBUSTIBLE MATERIALS, in order to reduce the likelihood of sustained flaming or spread of fire, may be achieved by either separation by distance (6.4.7.2) or separation by a fire barrier (6.4.7.3).

Additional requirements for a FIRE ENCLOSURE or a fire barrier of COMBUSTIBLE MATERIAL located within 13 mm of an ARCING PIS or 5 mm of a RESISTIVE PIS are given in 6.4.8.4.