Attachment 101

TECHNICAL STANDARD FOR PROTECTION OF OCCUPANTS AGAINST HIGH VOLTAGE IN FUEL CELL VEHICLES

1. Scope

This technical standard shall stipulate the technical regulations in connection with protection against electrical shock for fuel cell vehicles (except motorcycles with or without sidecar) and shall apply to the entire power train (including the alternating current section) having a section where the operating voltage is DC 60V or greater.

However, this technical standard shall not apply to the section whose operating voltage is less than DC 60V, which is thoroughly insulated from the section whose operating voltage is DC 60V or greater and whose pole at one side, either positive or negative, is connected to the electrical chassis in electrical DC.

2. Definitions

In addition to the definitions described in Article 1 of the Safety Regulations, the terms appearing in this Technical Standard shall be defined in Paragraphs 2–1 through 2–15 given below:

2–1 The power train is an electric circuit containing the following items in Paragraphs 2–1–1 through 2–1–5.

2–1–1 Fuel cell stack

2–1–2 Drive battery

2–1–3 Electronic converter (referring to a device capable of controlling or converting power, such as electronic controller for drive motor and DC/DC converter)

2–1–4 Drive motor and associated wire harness, connector, etc.

2–1–5 Auxiliary devices related to running (e.g., heater, defroster, power steering, etc.)

2–2 The fuel cell stack is a device that directly generates electricity by causing hydrogen to react with oxygen.

2–3 The drive battery is an electrical power storage unit and its aggregate that are connected electrically for the purpose of supplying electric power related to the driving.

2–4 Direct contact refers to contact between the human body and energized components.

2–5 Energized components are conductive components whose purpose is to transmit electric current during normal applications.

2–6 Indirect contact refers to contact between the human body and exposed electroconductive components.

2–7 Exposed electroconductive components are conductive components (except conductive components, such as cooling devices in Paragraph 3–4) that do not normally conduct electricity, but may do so at the time of insulation failure, and that can be contacted easily without using tools. In this case, whether or not a component can be contacted easily shall be judged, in principle, by the confirmation method as to whether the construction of protection class IPXXB is provided or not.

2–8 Electrical circuit refers to an aggregate of connected energized components designed to facilitate the flow of electric current during normal operation.

2–9 Nominal voltage is the design voltage indicating the characteristics of an electrical circuit, specified by the vehicle manufacturer concerned.

2–10 Operating voltage is the maximum potential difference, specified by the vehicle manufacturer concerned, that might possibly arise between all conductive elements during normal operation or when the circuit is released.

2–11 Electrical chassis is an aggregate of electroconductive components that have been electrically connected to each other, whose potential is regarded as the standard.

2–12 The barrier refers to components placed so as to protect from energized components against direct contact from all conceivable directions of approach.

2–13 The enclosure is the component established to enclose internal units and protect against direct contact from all directions.

2–14 The service plug is a device for shutting off the electric circuit when conducting checks and services of the fuel cell stack, drive battery, etc.

2–15 Protection class IPXXB and protection class IPXXD refer to those defined in Attached Sheet 1 “Protection Against Direct Contact with Energized Components.”

3. Requirements for Protection from Electrical Shock

3–1 Protection against direct contact

3–1–1 The protection against direct contact with energized components shall comply with Paragraphs 3–1–1–1 and 3–1–1–2 by such things as a solid insulator, barrier or enclosure, etc. These protective elements must be attached securely and be sturdy. Furthermore, it must not be possible to open, dissemble or remove these elements without tools.

3–1–1–1 For protection against energized components in the passenger compartment or cargo compartment, in all cases protection class IPXXD must be satisfied at the very least. However, in the case of the service plug that can be opened, disassembled and removed without tools, it is acceptable if protection class IPXXB is satisfied under a condition where it is opened, disassembled or removed without tools.

3–1–1–2 For protection against energized components other than those in the passenger compartment and cargo compartment, the protection class IPXXB must be satisfied.

3–1–2 Vehicle Marking

Barriers and enclosures installed for protection against direct contact shall be marked in the manner of the example given in Attached Sheet 2 “Warning Sign for Protection Against Electrical Shock.”

However, this provision shall not apply to barriers and enclosures which are not accessible, unless the parts are removed by means of tools or the motor vehicle is lifted by means of a jack.

3–2 Protection Against Indirect Contact

3–2–1 For protection against electrical shock which could arise from indirect contact, the exposed electroconductive components, such as the electroconductive barrier and enclosure must be connected securely to the electrical chassis in electrical DC so that no dangerous potentials are produced. This shall be accomplished either by connection with electrical wire or ground cable, or by welding, or by connection using bolts, etc.

3–2–2 The resistance between the electrical chassis and all exposed electroconductive components shall be less than 0.1 ohm. This resistance shall be measured when there is current flow of at least 0.2 amperes. Such measurement is not required, however, when it is clearly evident that the DC electrical connection has been established adequately and securely by such means as welding.

3–3 Insulation Resistance

Insulation resistance (except the insulation resistance between the energized components and the electrical chassis of motor vehicles for which measures have been taken according to Paragraph 3–4–2, which will drop due to only the deterioration, etc. of the fuel cell stack refrigerant) between the energized components (except electroconductive sections that come in direct contact with the refrigerant to which Paragraph 3–4 applies) and the electrical chassis shall be 100 ohms or more per volt of nominal voltage when the measurement is conducted according to Attached Sheet 3 “Insulation Resistance Measurement Method” or a method equivalent to it. In this case, in vehicles where the insulation resistance between the energized components and the electrical chassis is monitored, if the vehicle is equipped with a device to warn the driver before insulation resistance has fallen to 100 ohms per volt of nominal voltage, and if it is confirmed that the said mechanism is in operation and the warning is not in operation, measurement is not required.

3–4 Protection Against Electrical Shock Due to Fuel Cell Stack Refrigerant

To prevent electrical shock due to the drop in insulation resistance caused by the deterioration, etc. of the fuel cell stack refrigerant, any one of the following measures prescribed in Paragraphs 3–4–1 through 3–4–3 must be taken for the electroconductive sections of the cooling device that come in direct contact with the refrigerant. In this case, the measures prescribed in Paragraphs 3–4–1 through 3–4–3 may be different, depending on the electroconductive materials that come in direct contact with the refrigerant.

3–4–1 Protection Against Contact with Electroconductive Materials That Are in Direct Contact with the Refrigerant

The measures complying with Paragraphs 3–1 and 3–3 in connection with energized components shall be taken for electroconductive materials coming in direct contact with the refrigerant. In this case, if the electroconductive barrier or enclosure is used, the measures complying with Paragraph 3–2 in connection with exposed electroconductive materials also shall be taken.

3–4–2 Monitor of Drops in Insulation Resistance

The requirements of Paragraphs 3–4–2–1 through 3–4–2–3 below shall be satisfied.

3–4–2–1 There must be a device to monitor the insulation resistance between the electric circuit of the fuel cell stack and the electrical chassis and to warn the driver before the insulation resistance drops to 100 ohms per volt of nominal voltage. Its function shall be confirmed by the method prescribed in Attached Sheet 4 “Confirmation Method for Functions of Monitor of Drops in Insulation Resistance” or a method equivalent to it.

3–4–2–2 The device to warn the driver shall be such one that it can be confirmed that its function is in operation at the driver’s seat under a condition where the vehicle is in stationary state.

3–4–2–3 With regard to electroconductive materials that come in direct contact with the refrigerant, that can be easily contacted without using tools, measures complying with Paragraph 3–2 in connection with exposed electroconductive materials shall be taken.

3–4–3 Power Supply Cutoff Upon Electrical Leakage

Whenever there is a leakage of electrical current, there must be a mechanism to cutoff the power supply immediately before the current can reach a level dangerous to the human body. Moreover, it is satisfactory if the shutoff part is provided in such a way that only the energizing of refrigerant and electroconductive materials that are in direct contact with the refrigerant may be shut off.

Requirements of power supply shutoff at the time of the electric leakage and the confirmation method of function are prescribed in Attached Sheet 5 “Function Confirmation Method of Power Supply Shut-off at Time of Electric Leakage.” In this case, the confirmation may be conducted by a method equivalent to the method prescribed in the said Attached Sheet.

Attached Sheet 1

PROTECTION AGAINST DIRECT CONTACT WITH ENERGIZED COMPONENTS

1. General Provisions

Protection class IPXXB and protection class IPXXD against direct contact with energized components shall be prescribed in this Attached Sheet. Furthermore, this Attached Sheet shall apply to the power train whose operating voltage does not exceed AC 1000V and DC 1500V.

Moreover, in this Attached Sheet, the energized sections provided for in Paragraph 2–5 of the main text as well as the sections described in Paragraphs 1–1 and 1–2 below shall be regarded as the “energized component” when the evaluation is conducted.

1–1 Energized components that are protected only by varnish or paint;

However, this provision shall not apply to those where varnish or paint has been used for the purpose of insulation.

1–2 Energized components that are protected through oxidation treatment or similar treatment.

2. Test Conditions

The test vehicle shall be in a state where the starting device is stopped.

2–1 Proximity probe, etc.

2–1–1 As regards the proximity probe to be used for the confirmation of protection class, those prescribed according to the protection class shown in Table 1 shall be used.

2–1–2 In checking for the presence/absence of contact between proximity probe and energized components inside the barrier, enclosure, etc., using the signal display circuit method, a low-voltage power supply (40V or more, but not exceeding 50V) is connected in series to a suitable lamp and between the proximity probe and the energized components.

2–1–3 In the case of the signal display circuit method, sections provided for in Items 1–1 and 1–2 above shall be covered with electroconductive metal foil and the said metal foil shall be connected electrically to regular energized components.

3. Test Methods

3–1 Using the force prescribed in the "Test force" column of Table 1, the proximity probe is pressed against the opening (referring to a gap or opening of the barrier, enclosure, etc. that already exists or can appear whenever the proximity probe is applied at the prescribed force) of the barrier, enclosure, etc.

3–1–2 If it is possible, the moveable parts in the enclosure are operated slowly.

3–1–3 When the proximity probe is inserted in whole or in part, it is applied to all sections where there is the possibility of contact. Then, confirmation shall be made as to whether or not there is contact (In the case of the signal display circuit method, the illumination condition of the lamp shall be confirmed (hereinafter the same in this Attached Sheet).). In this case, in conducting a test covering protection class IPXXB, the test shall be started with the articulated test needles in a straight line. Both joints must be bent sequentially until they are 90° against the axis of the node where the articulated test needles adjoin each other. Then, confirmation shall be made as to whether or not there is contact with all components where there is the possibility of contact.

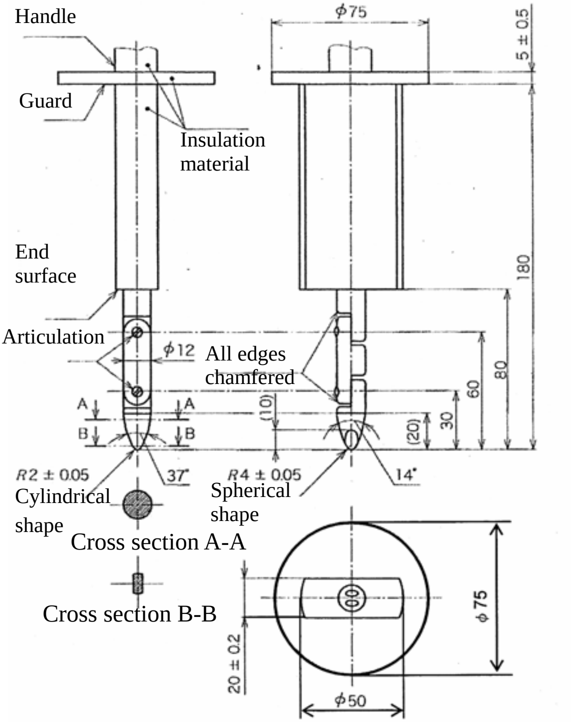
4. Assessment Criteria

4–1 The proximity probe must not contact the energized component.

4–2 Moreover, in all cases, the end surface of the proximity probe, in passing through the opening, must not be fully inserted.

4–3 In conducting the confirmation, using the signal display circuit method, the lamp must not glow.

Table 1　　Proximity Probe

<table>
<tr><th></th><th>Proximity probe</th><th>Test force</th></tr>
<tr><td>Test covering protection class IPXXB</td><td>

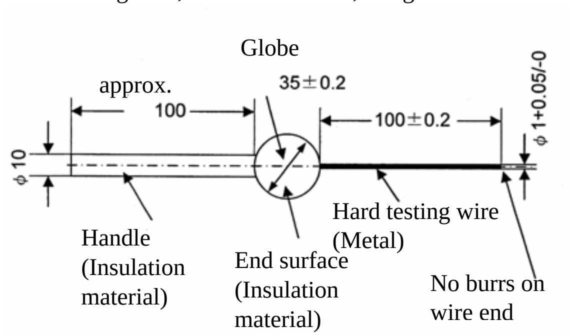
Materials: Metals, except for items stipulated in the figure

Linear dimension unit: mm

Tolerance of dimensions not stipulated in the figure
Angle: +0 min. / -10 min.

Linear dimension
25mm or less: +0 mm / -0.05 mm
over 25mm: +/-0.2 mm

It shall be possible to move both joints within the same surface, in the same direction, up to 90 degrees within a tolerance of -0 degrees to +10 degrees.</td><td>10N±10%</td></tr>
</table>

Test covering protection class IPXXD	Testing wire; Diameter 1.0mm; Length 100mm  Unit of dimension of straight line: mm	1N±10%

Attached Sheet 2

WARNING SIGN FOR PROTECTION AGAINST ELECTRICAL SHOCK

Fig. 1 shall show examples of marking on the barrier and enclosure to be installed for protection against direct contact.

Black on yellow or amber ground

Fig. 1 Example of Warning Sign

Attached Sheet 3

INSULATION RESISTANCE MEASUREMENT METHOD

The following shall prescribe the measurement of insulation resistance.

1. Handling of Measurement

The measurement of the insulation resistance shall be conducted by the methods of 1–1 or 1–2 below:

1–1 The insulation resistance may be measured for the whole vehicle;

1–2 The measurement may be performed by dividing according to each part or component unit (hereinafter referred to as the "divided measurement"). Then, the insulation resistance of the entire vehicle may be determined through calculation.

2. Measurement Method

As measurement method, Paragraph 2–1 shows the measurement method in which a DC voltage is applied from the outside, whereas Paragraph 2–2 shows the measurement method in which the inner DC voltage power supply source is used.

Moreover, this confirmation requires the operation of the high-voltage circuit directly. Therefore, utmost care must be exercised as to short circuit, electric shock, etc.

2–1 Example of measurement method in which DC voltage is applied from outside

2–1–1 Test vehicle conditions

The measurement shall be conducted, in principle, under a condition where the drive battery is disconnected and the fuel cell is in a stopped state.

2–1–2 Measurement instrument

An insulation resistance test instrument capable of applying a DC voltage higher than the operating voltage of the electrical circuit of the power train shall be used.

2–1–3 Measurement method

2–1–3–1 After confirming that no high voltage is applied, an insulator resistance test instrument shall be connected between the energized component and the electrical chassis. Then, the insulation resistance shall be measured by applying a DC voltage higher than the operating voltage of the power train. However, in the case of the measurement of insulation resistance of the electroconductive materials that are in direct contact with the refrigerant, if there are parts whose withstand voltage is low and there is the possibility that the parts become damaged during the measurement, it shall be permissible to perform the measurement below the operating voltage within a range not below the maximum voltage that can apply to the electroconductive materials concerned.

2–1–3–2 The measurement shall be conducted for all energized components. Then, the smallest value shall be regarded as the insulation resistance. However, with regard to energized components connected with the low DC resistance, which is clear from the circuit diagram, etc., it shall be acceptable if the measurement is conducted at least once at any of these points.

2–1–3–3 Moreover, in the case of the divided measurement, the resultant resistance shall be determined through calculation, taking into consideration the DC resistance existing intrinsically between the divided sections. This calculated value shall be regarded as an insulation resistance.

2–2 Example of measurement method in which inner DC voltage source is used

2–2–1 Test vehicle conditions

The drive battery shall be charged to such an extent that it functions normally.

2–2–2 Measurement instrument

The voltmeter to be used for the measurement shall be, in principle, a DC voltmeter whose inner resistance is 10 M ohms or greater.

In cases where a DC voltmeter whose inner resistance is less than 10 M ohms is used, it is permissible to insert an appropriate resistor in series so that the resultant series resistance becomes 10 M ohms or greater. In this case, however, the resistor to be inserted in series shall be such one that will unlikely be affected by temperature. Furthermore, the same voltmeter and same resistor shall be used for all voltage measurements.

2–2–3 Measurement method

2–2–3–1 First step

As shown in Fig. 1, measure the voltage V_1 between the negative terminal of the drive battery and the electrical chassis and V_1' between the positive terminal of the drive battery and the electrical chassis.

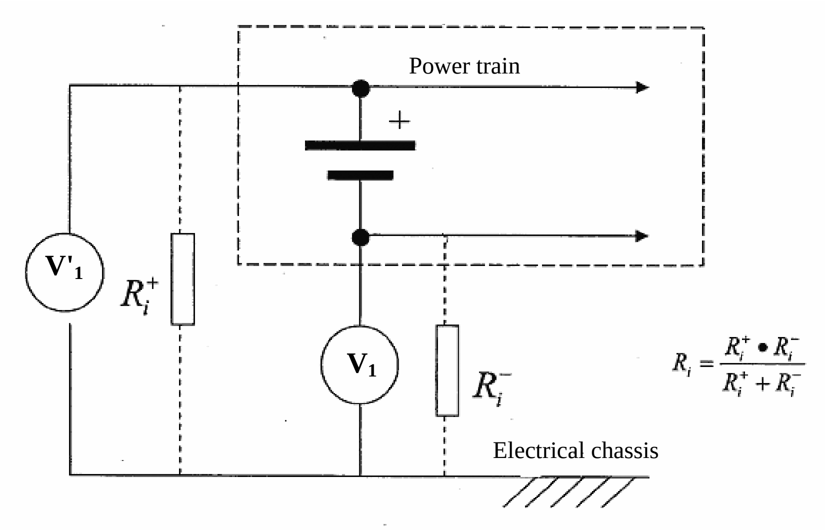


Fig. 1 Voltage measurement of first step

2–2–3–2 Second step

In cases where the voltage measurement of the first step results in $V_1 > V'_1$, as shown in Fig. 2, the resistor R_0 having 100 ohms per nominal voltage shall be connected between the negative terminal of the drive battery and the electrical chassis. Then, the voltage V_2 shall be measured between the negative terminal of the drive battery and the electrical chassis. In this case, the insulation resistance R_i shall be determined, using the following formula.

$$R_i = \frac{V_1 - V_2}{V_2} \times R_0$$

Furthermore, in cases where the voltage measurement of the first step results in $V_1 < V'_1$, as shown in Fig. 3, the resistor R_0 having 100 ohms per nominal voltage shall be connected between the positive terminal of the drive battery and the electrical chassis. Then, the voltage V_2 shall be measured between the positive terminal of the drive battery and the electrical chassis. In this case, the insulation resistance R_i shall be determined, using the following formula.

$$R_i = \frac{V'_1 - V_2}{V_2} \times R_0$$

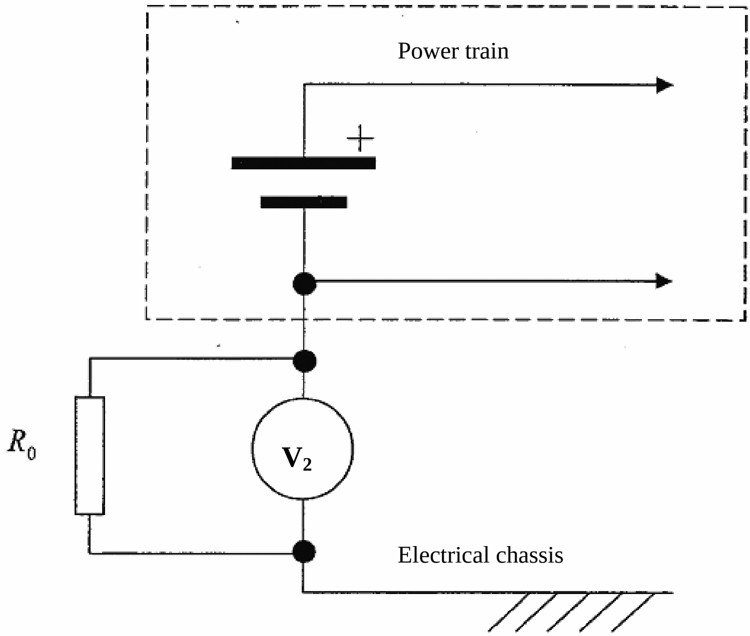


Fig. 2 Voltage measurement of second step (case of $V_1 > V'_1$)

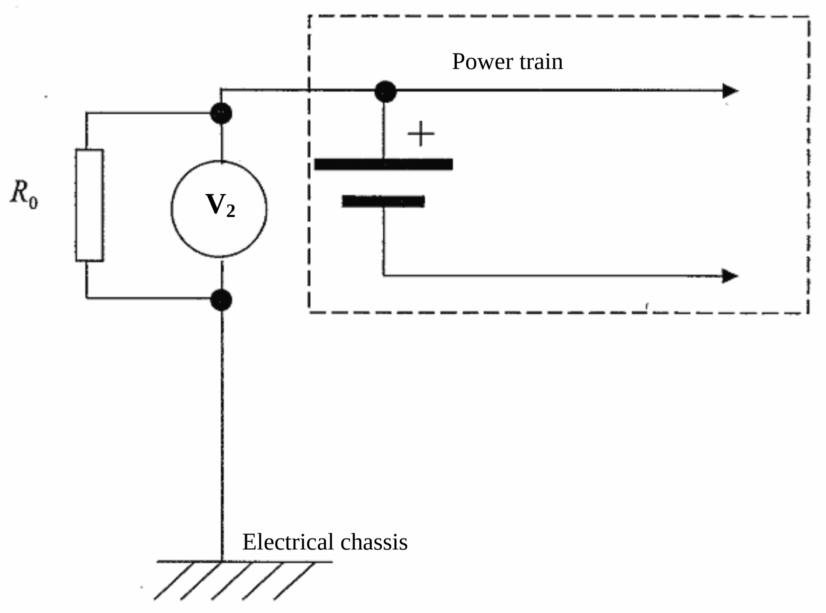


Fig. 3 Voltage measurement of second step (case of $V_1 < V'_1$)

Attached Sheet 4

CONFIRMATION METHOD FOR FUNCTIONS OF MONITOR OF DROPS IN INSULATION RESISTANCE

As an example of the confirmation method for functions of monitor of drops in insulation resistance, Paragraph 1 shows an example of the confirmation method in which a resistor is inserted in parallel. Paragraph 2 gives an example of the confirmation method in which pseudo signal is added.

Moreover, this confirmation requires the operation of the high-voltage circuit directly. Therefore, utmost care must be exercised as to short circuit, electrical shock, etc.

1. Example of confirmation method in which a resistor is inserted in parallel in the high-voltage circuit

In principle, this test confirms that, when such a resistor that makes the combined resistance with the measured insulation resistance 100 ohms per nominal voltage when connected in parallel thereto is inserted between the monitoring terminal and the electrical chassis, the driver is warned in an easily understandable way.

However, in cases where the combined resistance cannot be set to 100 ohms per nominal voltage due to the resistance of a resistor to be inserted in parallel, the setting shall be made to the smallest possible resultant resistance of 100 ohms or greater per nominal voltage.

2. Example of confirmation method in which pseudo signal is inputted

In cases where the relationship between the input value and output voltage of the sensor is clear through the data of characteristics of the sensor being used, etc., this test confirms that, when a pseudo voltage corresponding to the output voltage equivalent to 100 ohms per nominal voltage is applied instead of the output of the sensor concerned, the driver is warned in an easily understandable way.

Attached Sheet 5

FUNCTION CONFIRMATION METHOD OF POWER SUPPLY SHUT-OFF AT TIME OF ELECTRIC LEAKAGE

The following shall prescribe the function confirmation method and requirements of power supply shut-off at time of electric leakage.

1. Confirmation method for functions of power supply shut-off at time of electric leakage

As an example of the confirmation method for functions of power supply shut-off at time of electric leakage, Paragraph 1.1. shows an example of the confirmation method in which leakage of electric current is caused by the resistor. Paragraph 1–2 gives an example of the confirmation method in which pseudo signal is added.

Moreover, this confirmation requires the operation of the high-voltage circuit directly. Therefore, utmost care must be exercised as to short circuit, electrical shock, etc.

1–1 Example of confirmation method in which leakage of electric current is caused by resistor

An appropriate resistor shall be inserted between the terminal for which the leaking electric current is monitored and the electrical chassis. At this time, the relationship between the electric current flowing in the resistor and the time elapsed until the shutting-off, shall be measured. The measurement shall be conducted with various electric currents by changing the resistance of the resistor connected.

1–2 Example of confirmation method in which pseudo signal is inputted

In cases where the relationship between the input value and output voltage of the sensor is clear through the submitted data of characteristics of the sensor being used, etc., the relationship between the pseudo voltage being applied and the time elapsed until the shutting-off shall be measured when a pseudo voltage corresponding to the output voltage equivalent to the shutting-off limitation indicated in Fig. 1 is applied instead of the output of the sensor concerned.

2. Requirements of power supply shut-off at time of electric leakage

The shut-off requirements shall be prescribed according to the leaking electric current and continuation time. Shutting-off shall take place below 200 mA when the continuation time is 10 msec or less; below the electric current determined from the following formula according to the continuation time when the continuation time is between 10 msec and 2 seconds; and below 26 mA when the continuation time is 2 seconds or more. (see Fig. 1.)

$$I = 10^{-0.38507 \log_{10} t + 2.6861}$$

where:

I : Leaking electric current (mA)

t : Continuation time (msec)

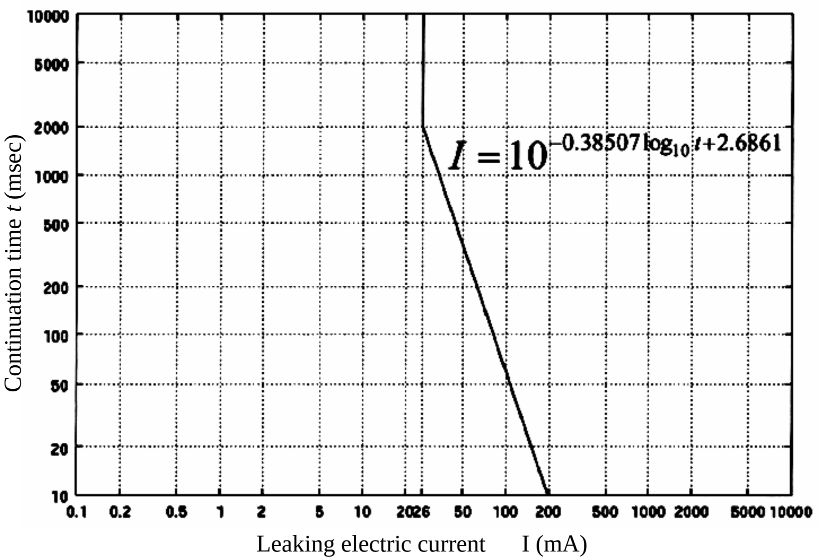


Fig. 1 Requirements of Power Supply Shut-off at Time of Electric Leakage