

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS C 8802 : 2003

**Accelerated life test methods for
phosphoric acid fuel cell**

ICS 27.070

Reference number : JIS C 8802 : 2003 (E)

PROTECTED BY COPYRIGHT

Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

Date of Establishment: 2003-03-20

Date of Public Notice in Official Gazette: 2003-03-20

Investigated by: Japanese Industrial Standards Committee
Standards Board
Technical Committee on Electricity
Technology

JIS C 8802:2003, First English edition published in 2003-10

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

© JSA 2003

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Printed in Japan

PROTECTED BY COPYRIGHT

Contents

	Page
Introduction	1
1 Scope	1
2 Normative reference	1
3 Definitions	1
4 Outline of life test methods	2
5 Tests	2
5.1 Classification of tests	2
5.2 Test methods	2
6 Calculation of life	2
6.1 Calculation procedures of cell stack life	2
6.2 Calculation method of life by means of short stack accelerated test	4
6.3 Calculation of cell stack life	5
Annex 1 (normative) Small single cell test	6
Annex 2 (normative) Accelerated life test methods for short stack	12
Annex 3 (normative) Calculation method for acceleration coefficient	18
Annex 4 (informative) Technical base of accelerated life test methods for phosphoric acid fuel cell	21

Accelerated life test methods for phosphoric acid fuel cell

Introduction This Japanese Industrial Standard specifies the test methods to evaluate accelerated life of cell stacks in a phosphoric acid fuel cell plant. Many factors affect the life of phosphoric acid fuel cells. However this Standard especially specifies the test methods of the life of cell stacks resulted from the activation polarization and diffusion polarization of electrodes. This is not intended to be used as a completed design manual or instruction manual.

To obey this Standard does not exempt any person, organization or enterprise from the compliance with the relevant regulations.

1 Scope This Standard specifies the test methods for evaluation of the life characteristic of cell stack in phosphoric acid fuel cells by means of small single cell test and accelerated life test of short cell stacks, and for calculation of cell stack life.

Remarks : The life of a phosphoric acid fuel cell stack is determined by the voltage decay, corrosion degradation of structural materials, etc. However, in this Standard the object is the method to evaluate the cell stack life due to the voltage decay mainly resulted from the increase of activation polarization and diffusion polarization among the factors stated above.

2 Normative reference The following standard contains provisions which, through reference in this Standard, constitute provisions of this Standard. The most recent edition of the standard (including amendments) indicated below shall be applied.

JIS C 8800 *Glossary of terms for fuel cell power plant*

3 Definitions For the purpose of this Standard, in addition to the definitions stated in JIS C 8800, the following principal definitions apply:

- a) **cell stack life** The time from the instant of starting the operation to the instant where the voltage drops by 10 % under the reference conditions.
- b) **reference conditions** The operating conditions to be used as the reference for the evaluation of cell stack life characteristic.
- c) **small single cell** A single cell in which the area of electrode is smaller than that of a single cell in a cell stack.
- d) **short stack** A laminated cell assembly made by using single cells and cooling plates which constitute a cell stack but the number of laminated cells is smaller as compared with a cell stack.
- e) **block** An element composed of plural cells located between the cooling plates in a cell stack or a short stack.
- f) **reactant part of cell** The effective part of a cell which is composed of fuel electrode, air electrode and matrix and which contributes to the power generation.

- g) **voltage decay rate** The inclination of a straight line by which the change of cell voltage with time is approximated on a graph where the cell voltage is shown on the ordinate and the common logarithm of operating time is shown on the abscissa.
- h) **operating temperature** The temperature which represents the temperature of a single cell, short stack or cell stack under operation.
- i) **acceleration coefficient (multiplier for accelerated life test)** The ratio of the voltage decay rate under the reference conditions to that under the conditions for accelerated life test (abbreviated as accelerate conditions).
- j) **mean cell voltage** The mean value of individual cell voltages in a cell stack or a block.

4 Outline of life test methods The voltage decay rate is larger when the operating temperature is higher. A life test method is offered in which the accelerated life test of a short stack is carried out at an operating temperature higher than the temperature in the reference conditions and the life of the short stack is calculated by utilizing the dependency on temperature stated above. In this procedure the correlation between the operating temperature and the acceleration coefficient shall be obtained from the tests of plural small single cells with the temperature as the parameter.

5 Tests

5.1 Classification of tests The test methods are classified as follows:

- a) Small single cell test
- b) Short stack accelerated test (accelerated life test for short stack)

5.2 Test methods

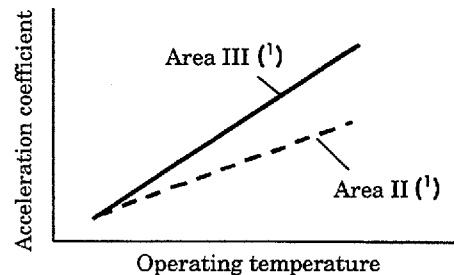
- a) **Small single cell test** The small single cell test shall be as stated in Annex 1.
- b) **Short stack accelerated test** The short stack accelerated test shall be as stated in Annex 2.

6 Calculation of life

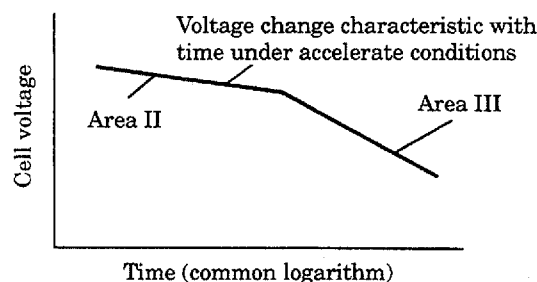
6.1 Calculation procedures of cell stack life The calculation procedures of cell stack life are shown in Fig. 1.

- a) **Calculation of acceleration coefficient** The acceleration coefficient in area II and area III shall be obtained by means of the small single cell tests with the operating temperature as the parameter. The definitions of area II and area III and the method of obtaining the acceleration coefficient shall be as given in Annex 3.
- b) **Execution of accelerated life test** An operating temperature at which the evaluation of acceleration is possible is obtained from the correlation between the operating temperature and the acceleration coefficient obtained in a), and the short stack accelerated test shall be carried out at the temperature so obtained for about ten thousand hours. The method for obtaining the operating temperature shall be as stated in Annex 2.

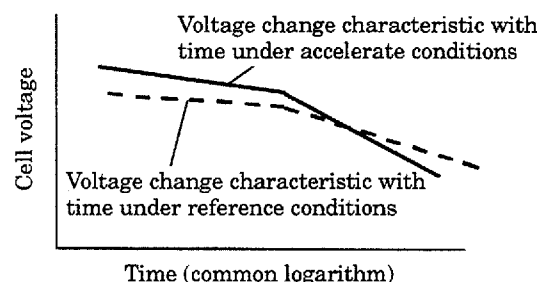
- c) **Voltage change characteristic with time under reference conditions (calculation)** The voltage change characteristic with time under the reference conditions shall be calculated from the short stack accelerated test, based on the acceleration coefficient obtained in the small single cell test.
- d) **Calculation of life** A point where the cell voltage drops by 10 % from the cell voltage at the starting point of area II is obtained by using the voltage change characteristic with time under the reference conditions calculated above and the time from the start of operation to the said point shall be taken as the cell stack life.



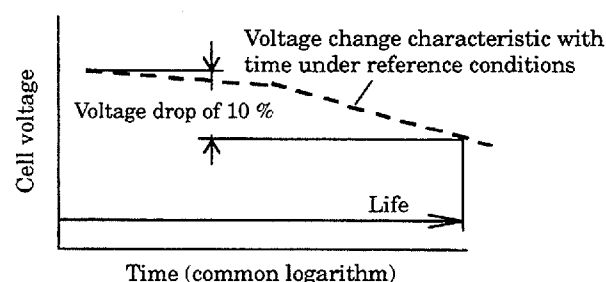
a) **Calculation of acceleration coefficient**



b) **Execution of accelerated life test**



c) **Voltage change characteristic with time under reference conditions (calculation)**



d) **Calculation of life**

Note (1) Refer to Annex 3.

Fig. 1 Calculating procedures of cell stack life

6.2 Calculation method of life by means of short stack accelerated test The life of cell stack shall be obtained from the results of short stack accelerated test by the following method:

- a) The voltage change with time is indicated on a graph by expressing the cell voltage at the set current for accelerate conditions on the coordinate and the common logarithm of time on the abscissa. L_2 and L_3 (solid lines) in Fig. 2 correspond to the voltage change with time under the accelerate conditions [in Fig. 2, the indication of the voltage change with time in area I, (L_1) is omitted. For the details, Annex 3 should be referred].
- b) On this graph, point a_1 indicates the starting point of area II and point b_1 , that of area III under the accelerate conditions, and the respective time points are denoted as t_a and t_b . The voltage at time t_a is denoted as V_{a1} .
- c) The voltage under reference conditions at t_a in Fig. 2 (V_{a2}) is estimated from the difference between the voltage under reference conditions in the early stage of operation and the voltage immediately after transfer to accelerate conditions which are obtained from the short stack accelerated test, and point a_2 is determined.

$$V_{a2} = V_{a1} - (\text{voltage immediately after transfer to accelerate conditions} - \text{voltage under reference conditions at early stage of operation})$$

- d) The voltage which decreases by 10 % with V_{a2} being the reference is taken as the voltage at the life (V_c) and the life reference line is drawn.

$$V_c = V_{a2} \times 0.9$$

- e) Based on the acceleration coefficient obtained from the test results of small single cell test (see 2.2 of Annex 3) and the voltage decay rate under accelerate conditions, the voltage decay rates under reference conditions in area II and area III are calculated by using the following formulae:

Voltage decay rate in area II under reference conditions:

$$\varepsilon_{VII2} = \varepsilon_{VII1}/m_{II}$$

Voltage decay rate in area III under reference conditions:

$$\varepsilon_{VIII2} = \varepsilon_{VIII1}/m_{III}$$

where, ε_{VII1} : voltage decay rate in area II under accelerate conditions

ε_{VIII1} : voltage decay rate in area III under accelerate conditions

m_{II} : acceleration coefficient in area II

m_{III} : acceleration coefficient in area III

- f) Straight line L_2' (broken line) with an inclination of $-\varepsilon_{VII2}$ is drawn from point a_2 as the start point to time t_b , and the cross point of time t_b and straight line L_2' is denoted as point b_2 .
- g) In the similar way, straight line L_3' with an inclination of $-\varepsilon_{VIII2}$ is drawn from point b_2 as the start point and the cross point of this line and the life reference line is denoted as point c.

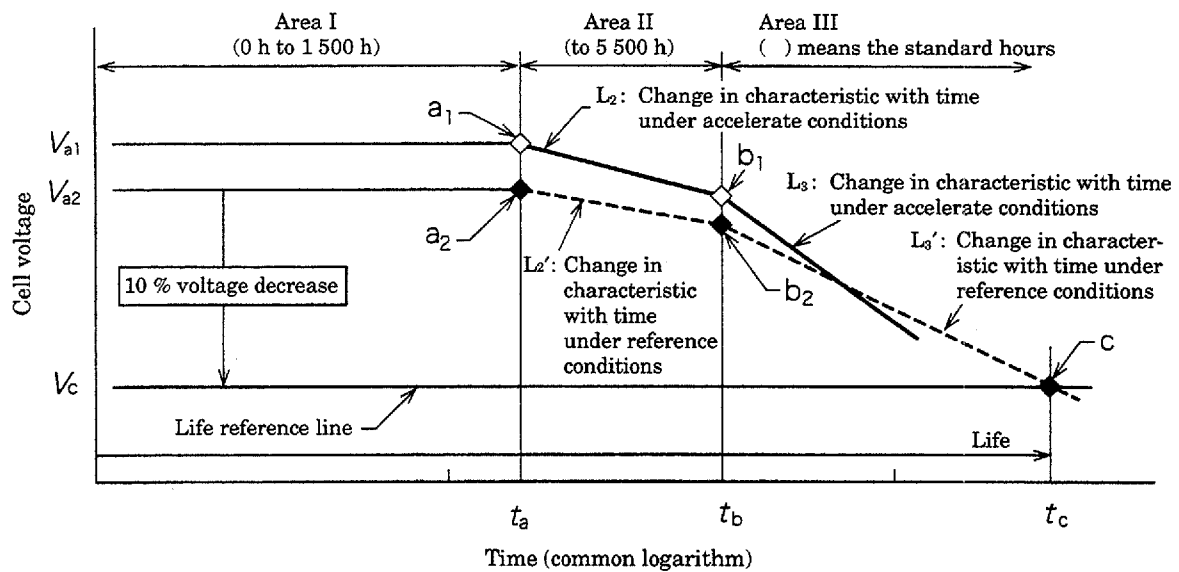
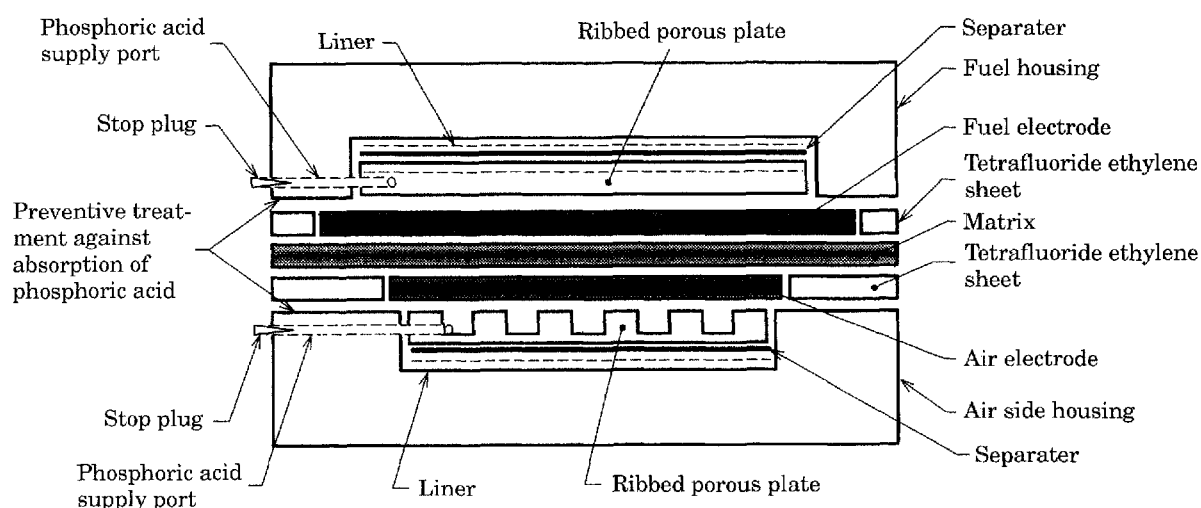


Fig. 2 Calculation method of cell stack life

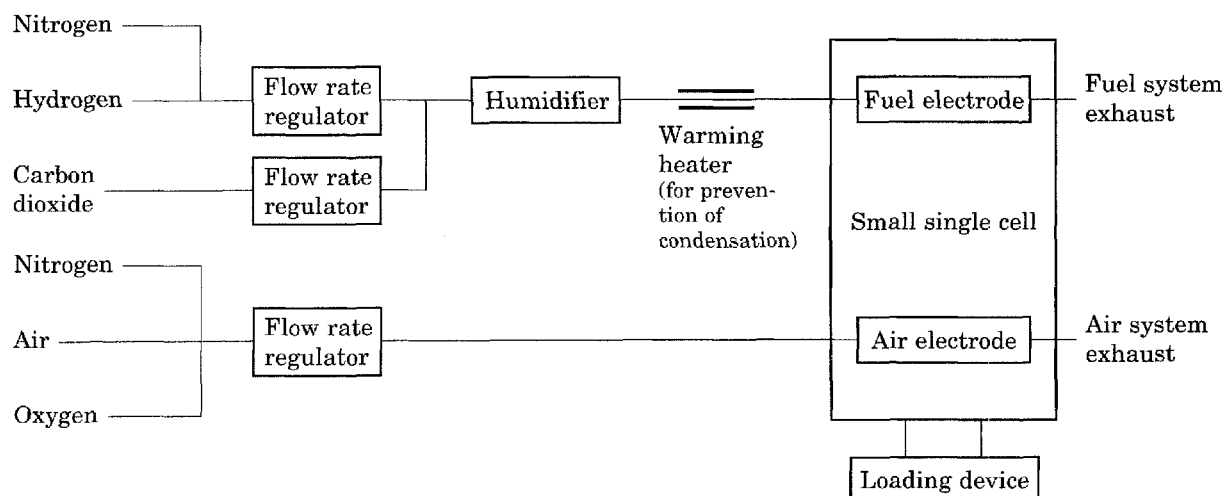
6.3 Calculation of cell stack life The time t_c from start of operation to cross point c shall be expressed as the life of cell stack under the reference conditions.

evaluation test are shown in Annex 1 Attached Table 1. An example of the reference values is given in Annex 1 Attached Table 3.

- c) Continuously operate the cell which has satisfied the reference values under the accelerate conditions (including the reference conditions). An example of accelerate conditions is shown in Annex 1 Attached Table 4.
- d) After the above operation, carry out the characteristic evaluation test at every about 1 000 h.
- e) After completion of the operation under the accelerate conditions, return the operating conditions to the reference conditions, then carry out the characteristic evaluation test and complete the small single cell test under the accelerate conditions in question. This characteristic evaluation test is carried out for the purpose of confirming no abnormality in the operating site by examining the outline of the important factor of cell voltage change.

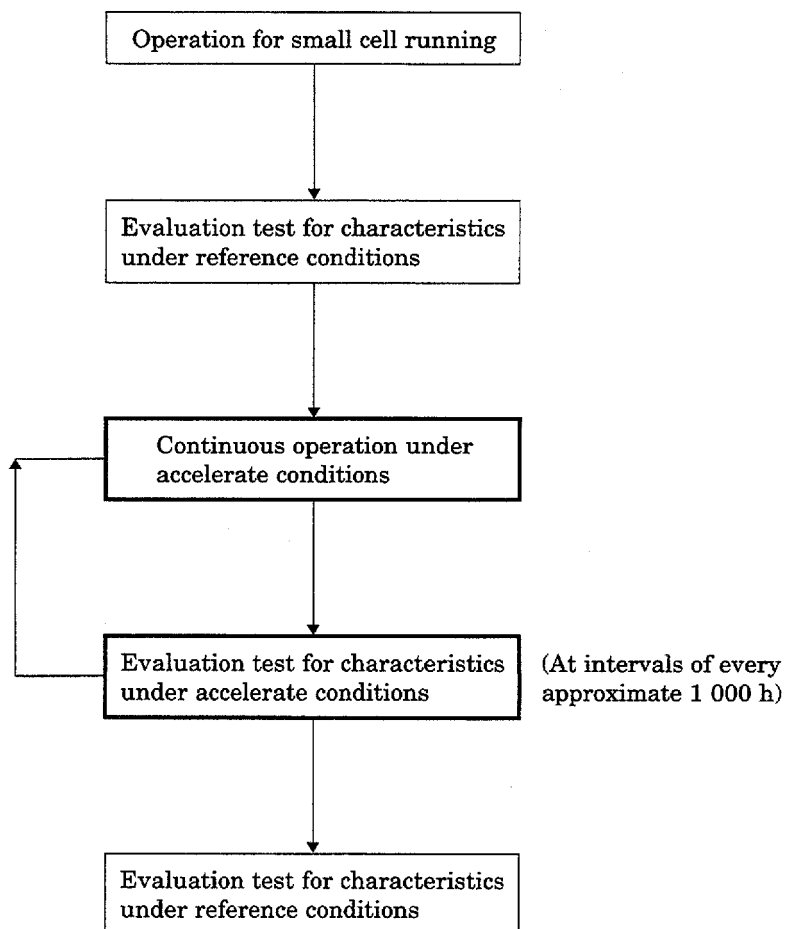


Annex 1 Attached Fig. 1 Example of sectional structure of small single cell



Annex 1 Attached Fig. 2 Example of composition of small single cell testing device

: Reference conditions : Accelerate conditions

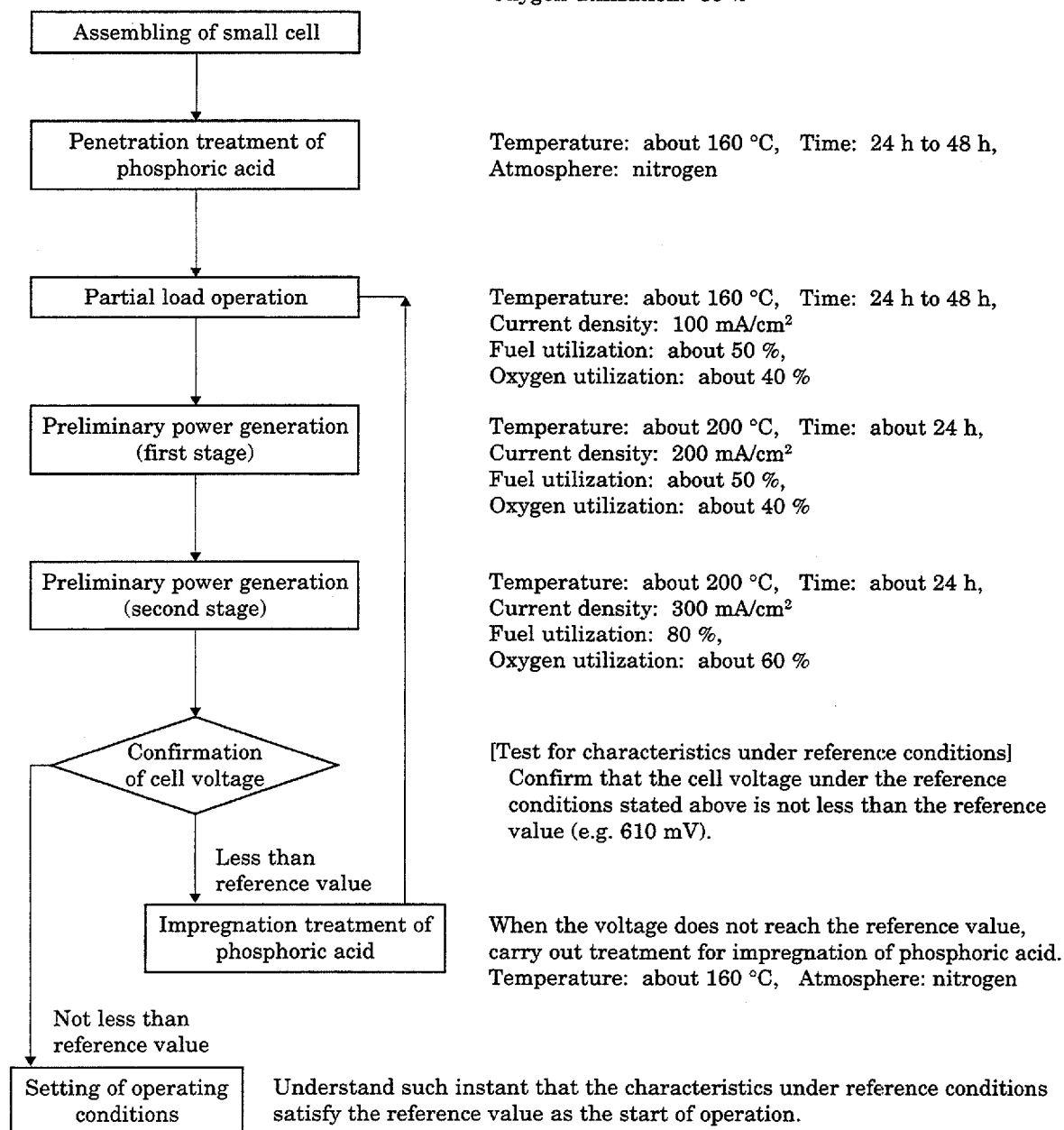


Remarks : Example of reference conditions is shown in Annex 1 Attached Table 2 and that of accelerate conditions in Annex 1 Attached Table 4.

Annex 1 Attached Fig. 3 Test procedures of small single cell

Example of reference conditions

Operating temperature: 200 °C,
Operating pressure: ordinary pressure,
Current density: 300 mA/cm²,
Fuel utilization: 80 % (hydrogen: carbon dioxide = 80:20),
Oxygen utilization: 60 %



Annex 1 Attached Fig. 4 Example of operation for small single cell running

Annex 1 Attached Table 1 Example of test items and conditions for evaluation of characteristics of small single cell

Item	Current density mA/cm ²	Hydrogen concentration %	Fuel utilization %	Oxygen concentration %	Oxidant utilization %
Current-voltage characteristic test ⁽²⁾	(50) to 300	80	80	21	60
Test for dependency on fuel utilization	300	80	80 ± 10	21	60
Test for dependency on oxidant utilization	300	80	80	21	60 ± 10
Test for dependency on hydrogen gain	300	80 100	80 64 ⁽³⁾	21	60
Test for dependency on oxygen gain	300	80	80	21 100	60 12.6 ⁽⁴⁾

Notes ⁽²⁾ The current density in the current-voltage characteristic stays within such a range that the voltage does not exceed 800 mV and does not show rapid decrease. Therefore this table shows approximate standard.

⁽³⁾ In the test for dependency on hydrogen gain, the hydrogen flow rate at 100 % hydrogen concentration shall be equal to the fuel flow rate at 80 % hydrogen concentration.

⁽⁴⁾ In the test for dependency on oxygen gain, the oxygen flow rate at oxygen concentration 100 % shall be equal to the air flow rate at oxygen concentration 21 %.

Annex 1 Attached Table 2 Example of reference conditions

Current density	300 mA/cm ²
Concentration of fuel hydrogen	80 %
Humidifying condition of fuel	50 °C saturation
Fuel utilization	80 %
Oxidant utilization	60 %
Operating temperature	200 °C
Pressure	Normal pressure