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**Test methods for measuring
performance of cogeneration unit**

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Contents

	Page
1 Scope	1
2 Normative references	1
3 Terms and definitions	3
4 Classification of test and test item	4
4.1 Classification of test	4
4.2 Test item	4
4.3 Product conformance test	5
4.4 Acceptance test	11
5 Test procedure	13
5.1 Starting test	13
5.2 Protective relay operational test	14
5.3 Speed governing performance test and voltage fluctuation characteristic test	15
5.4 Load operation test	17
5.5 Continuous operation test	19
5.6 Exhaust gas discharge characteristic test	20
5.7 Noise measurement test	20
5.8 Vibration measurement test	21
5.9 Parallel operation test	22
5.10 Grid connected operation test with commercial electric power system	22
6 Conversion of performance	24
6.1 Conversion of performance for gas engine and diesel engine	24
6.2 Conversion method for gas turbine	27
7 Conversion of exhaust gas concentration	31
Annex A (informative) Test certificate form	33

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Center for Promotion of Natural Gas (CPNG)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS B 8122:2001** is replaced with this Standard.

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Test methods for measuring performance of cogeneration unit

1 Scope

This Japanese Industrial Standard specifies the test methods for measuring performance of cogeneration unit (hereafter referred to as “CGU”) which supplies both electric power and heat by taking a diesel engine, a gas engine and a gas turbine as a prime mover.

The range of CGU includes a prime mover, a generator, a heat recovery facility and pollution abatement equipment for exhaust gas and a cooling facility required for the operation of the prime mover, and a control and monitoring devices required for their operation.

This Standard is not applicable to the stand-alone equipment such as a prime mover, a generator and a heat recovery facility and the reciprocating internal combustion engine driven alternating current generating sets which have been already tested in accordance with other Japanese Industrial Standards and/or International Standards.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 0108-1 *Reciprocating internal combustion engines—Vocabulary—Part 1: Terms for engine design and operation*

NOTE : Corresponding International Standard: ISO 2710-1 *Reciprocating internal combustion engines—Vocabulary—Part 1: Terms for engine design and operation* (MOD)

JIS B 0108-2 *Reciprocating internal combustion engines—Vocabulary—Part 2: Terms for engine maintenance*

NOTE : Corresponding International Standard: ISO 2710-2 *Reciprocating internal combustion engines—Vocabulary—Part 2: Terms for engine maintenance* (MOD)

JIS B 0128 *Glossary of terms for thermal power plants—Gas turbine and auxiliary equipment*

JIS B 0149 *Glossary of terms and definitions of engine—Driven generating sets*

JIS B 8002-1 *Reciprocating internal combustion engines—Performance—Part 1: Declarations of power, fuel and lubricating oil consumptions, and test methods—Additional requirements for engines for general use*

NOTE : Corresponding International Standard: ISO 3046-1 *Reciprocating internal combustion engines—Performance—Part 1: Declarations of power, fuel and lubricating oil consumptions, and test methods—Additional requirements for engines for general use* (IDT)

JIS B 8002-3 *Reciprocating internal combustion engines—Performance—Part 3: Test measurements*

NOTE : Corresponding International Standard: ISO 3046-3 *Reciprocating internal combustion engines—Performance—Part 3: Test measurements* (MOD)

JIS B 8002-4 *Reciprocating internal combustion engines—Performance—Part 4: Speed governing*

NOTE : Corresponding International Standard: ISO 3046-4 *Reciprocating internal combustion engines—Performance—Part 4: Speed governing* (MOD)

JIS B 8002-5 *Reciprocating internal combustion engines—Performance—Part 5: Torsional vibrations*

NOTE : Corresponding International Standard: ISO 3046-5 *Reciprocating internal combustion engines—Performance—Part 5: Torsional vibrations* (MOD)

JIS B 8002-6 *Reciprocating internal combustion engines—Performance—Part 6: Overspeed protection*

NOTE : Corresponding International Standard: ISO 3046-6 *Reciprocating internal combustion engines—Performance—Part 6: Overspeed protection* (MOD)

JIS B 8002-7 *Reciprocating internal combustion engines—Performance—Part 7: Codes for engine power*

JIS B 8003 *Internal combustion engines—Determination and method for the measurement of engine power—General requirements*

NOTE : Corresponding International Standard: ISO 15550 *Internal combustion engines—Determination and method for the measurement of engine power—General requirements* (IDT)

JIS B 8005 *Reciprocating internal combustion engines—Measurement of emitted airborne noise—Engineering method and survey method*

NOTE : Corresponding International Standard: ISO 6798 *Reciprocating internal combustion engines—Measurement of emitted airborne noise—Engineering method and survey method* (IDT)

JIS B 8008 (series) *Reciprocating internal combustion engines—Exhaust emission measurement*

JIS B 8009-5 *Reciprocating internal combustion engine driven alternating current generating sets—Part 5: Generating sets*

NOTE : Corresponding International Standard: ISO 8528-5 *Reciprocating internal combustion engine driven alternating current generating sets—Part 5: Generating sets* (MOD)

JIS B 8009-9 *Reciprocating internal combustion engine driven alternating current generating sets—Part 9: Measurement and evaluation of mechanical vibrations*

NOTE : Corresponding International Standard: ISO 8528-9 *Reciprocating internal combustion engine driven alternating current generating sets—Part 9: Measurement and evaluation of mechanical vibrations* (IDT)

JIS B 8009-10 *Reciprocating internal combustion engine driven alternating current generating sets—Part 10: Measurement of airborne noise by the enveloping surface method*

NOTE : Corresponding International Standard: ISO 8528-10 *Reciprocating internal combustion engine driven alternating current generating sets—Part 10: Measurement of airborne noise by the enveloping surface method* (MOD)

JIS B 8041 *Gas turbines—Acceptance tests*

NOTE : Corresponding International Standard: ISO 2314 *Gas turbines—Acceptance tests* (MOD)

JIS B 8043-1 *Gas turbines—Exhaust gas emission—Part 1: Measurement and evaluation*

NOTE : Corresponding International Standard: ISO 11042-1 *Gas turbines—Exhaust gas emission—Part 1: Measurement and evaluation* (MOD)

JIS B 8121 *Terms and definitions of cogeneration systems*

JIS Z 8808 *Methods of measuring dust concentration in flue gas*

ISO 8528-1 *Reciprocating internal combustion engine driven alternating current generating sets—Part 1: Application, ratings and performance*

ISO 8528-2 *Reciprocating internal combustion engine driven alternating current generating sets—Part 2: Engines*

ISO 8528-3 *Reciprocating internal combustion engine driven alternating current generating sets—Part 3: Alternating current generators for generating sets*

ISO 8528-4 *Reciprocating internal combustion engine driven alternating current generating sets—Part 4: Controlgear and switchgear*

ISO 8528-5 *Reciprocating internal combustion engine driven alternating current generating sets—Part 5: Generating sets*

NOTE : **JIS B 8009-5** is corresponding to this International Standard; however, **5.4.1** of this Standard refers to the International Standard of the latest.

ISO 8528-6 *Reciprocating internal combustion engine driven alternating current generating sets—Part 6: Test methods*

3 Terms and definitions

For the purposes of this Standard, the terms and definitions given in **JIS B 0108-1**, **JIS B 0108-2**, **JIS B 0128**, **JIS B 0149** and **JIS B 8121** shall apply.

4 Classification of test and test item

4.1 Classification of test

The classification of test shall be as follows.

- a) **Product conformance test** The test for confirming whether the manufacturing unit satisfies the requirements for the presented design specification or the certificate of approval or not.
- b) **Acceptance test** The test for confirming the manufacturing quality comprehensively and confirming that the contract matters from the orderer are satisfied completely.

Although a series of matters on execution of the test such as testing item, testing location and specification at the time of the test are determined upon the agreement between the parties concerned with delivery, a part of the acceptance test may be omitted for the content executed by the product conformance test. Furthermore, the test may be executed by combining a part or all of the product conformance tests with the acceptance test.

4.2 Test item

Items to be measured shall be as given in table 1. However, it is not necessary to perform the measurement one more time for the stand-alone equipment such as a prime mover, a generator and auxiliaries already tested in accordance with other Japanese Industrial Standards and/or International Standards before the integration into CGU.

Table 1 Test items of cogeneration unit

Test item		Classification of prime mover						Test clause
		Diesel engine		Gas engine		Gas turbine		
		Product conform- ance test	Accept- ance test	Product conform- ance test	Accept- ance test	Product conform- ance test	Accept- ance test	
a) Starting test		○	○	○	○	○	○	5.1
b) Protective relay opera- tional test	Main protective relay	○	○	○	○	○	○	5.2
	Other protective relay	△	△	△	△	△	△	
c) Speed governing performance test and voltage fluctuation characteristic test		○	○	○	○	○	○	5.3
d) Load operation test		○	△	○	△	○	△	5.4
e) Continuous operation test		△	○	△	○	△	○	5.5
f) Exhaust gas discharge characteristic test		△	△	△	△	△	△	5.6
g) Noise measurement test		△	△	△	△	△	△	5.7
h) Vibration measurement test		△	△	△	△	△	△	5.8
i) Parallel operation test			△		△		△	5.9
j) Grid connected operation test with commercial electric power system			△		△		△	5.10
The test shall be executed for the mark of ○, and should be executed for the mark of △.								

4.3 Product conformance test

4.3.1 General requirements

- The product conformance test of CGU shall be executed under the bench test conditions of the manufacturer's factory.
- In the test, the rated power factor load should be used as the load; however if it is impracticable, the test may be executed at power factor = 1 for convenience. In this case, the agreement between the parties concerned with delivery shall be required.

4.3.2 Measurement item and measurement position

- The tolerances shall be specified for all the measurement items by considering the following factors which may become causes of measurement errors.
 - Accuracy of measuring instrument
 - Rightness of mounting position of measuring instrument

- 3) Rightness of use condition of measuring instrument
 - 4) Accuracy of reading
 - 5) Variation of reading of measuring instrument during measurement
- b) The instrument integrated in CGU shall be used for the measuring instrument used for the product conformance test; however, when it is not integrated or the instrument integrated does not satisfy the accuracy given in table 2, a proper measuring instrument shall be prepared.
- c) The measuring instrument in the product conformance test shall have the accuracy given in table 2, and shall be in a state in which it has been calibrated beforehand.
- d) Although the measurement item and the measurement position shall be as given in table 3 and figure 1, the measurement item may be changed upon the agreement between the parties concerned with delivery.

Table 2 Accuracy of measuring instrument in product conformance test

Item	Accuracy or tolerance	NOTE
Current	$\pm 1.5 \%$	See JIS B 8009-6 .
Voltage	$\pm 1.5 \%$	
Power factor	$\pm 3.0 \%$	
Electric power	$\pm 1.5 \%$	
Frequency	$\pm 0.5 \%$	
Temperature	$\pm 2 \text{ K}^{\text{a)}}$	See JIS B 8003 .
Temperature for exhaust gas	$\pm 15 \text{ K}^{\text{a)}}$	
Pressure	$\pm 5 \%$ ^{a)}	
Atmospheric pressure	$\pm 0.5 \%$ ^{a)}	
Fuel consumption	$\pm 3.0 \%$ ^{a)}	
Flow rate	$\pm 2 \%$	
Noise	$\pm 1.5 \text{ dB}$	See JIS C 1509-1 . (except that the measurement is performed in accordance with JIS B 8005 or ISO 10494)
Vibration	$\pm 1 \text{ dB}$	See JIS C 1510 .
Note ^{a)} Tolerances on measurement.		

4.3.3 Test certificate

The test certificate of the product conformance test shall be as follows.

- a) The following matters shall be filled in the beginning of the test certificate.
- 1) Test certificate number
 - 2) Test date
 - 3) Test item

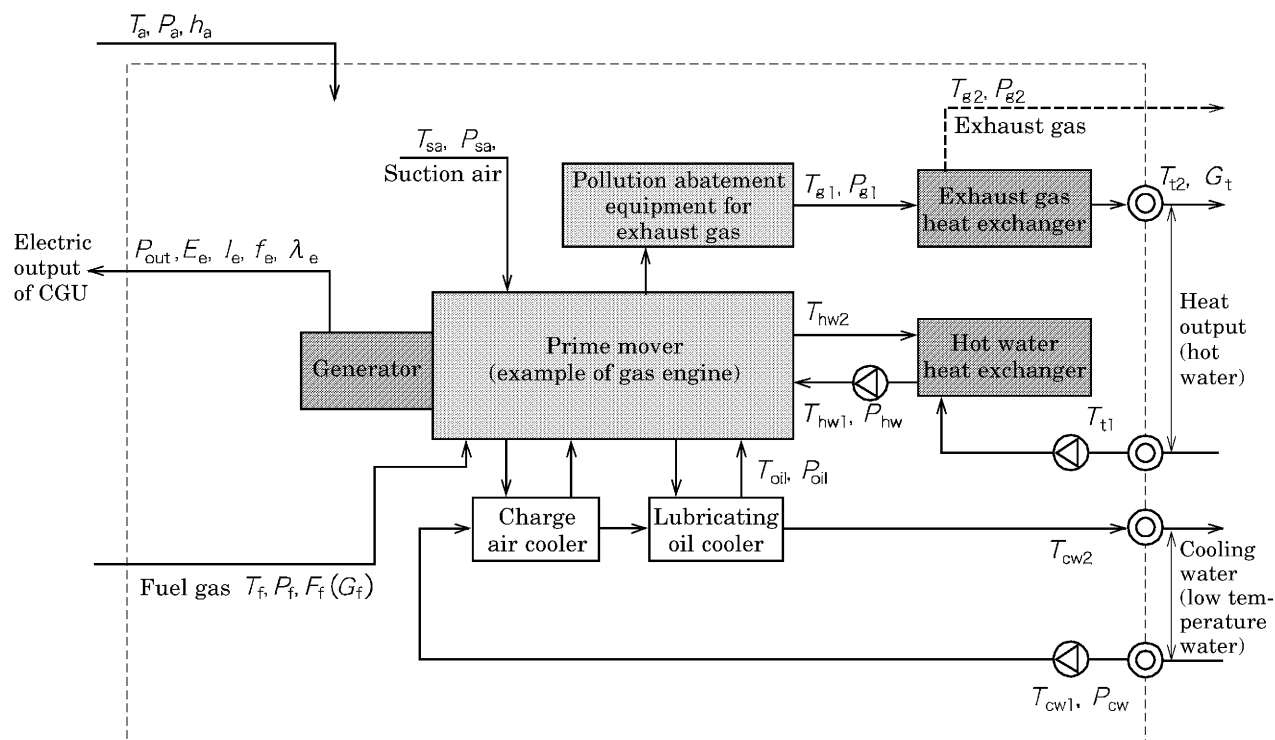
- 4) Location in which test is executed
- 5) Manufacturer's name
- 6) Type and manufacturing number
- 7) Name of person in charge of test
- 8) Name of preparer of test certificate
- 9) Preparation date of test certificate
- b) Purpose of test and outline of result
- c) Matters to be described in test certificate
 - 1) Specifications, outline drawing, flow diagram, etc. of CGU
 - 2) Outline of progress and special affairs after startup
 - 3) Test procedure, equipment, measuring instrument, installation location, operating condition, etc.
 - 4) Outline of measuring method and monitoring method
 - 5) Outline of formula
 - 6) Reference condition, correction factor and corrected test result of performance
 - 7) Matters concerning tolerance range and error
 - 8) Table and graph which show test results
 - 9) Discussion and result
 - 10) Other special affairs

Table 3 Measurement item and measurement position

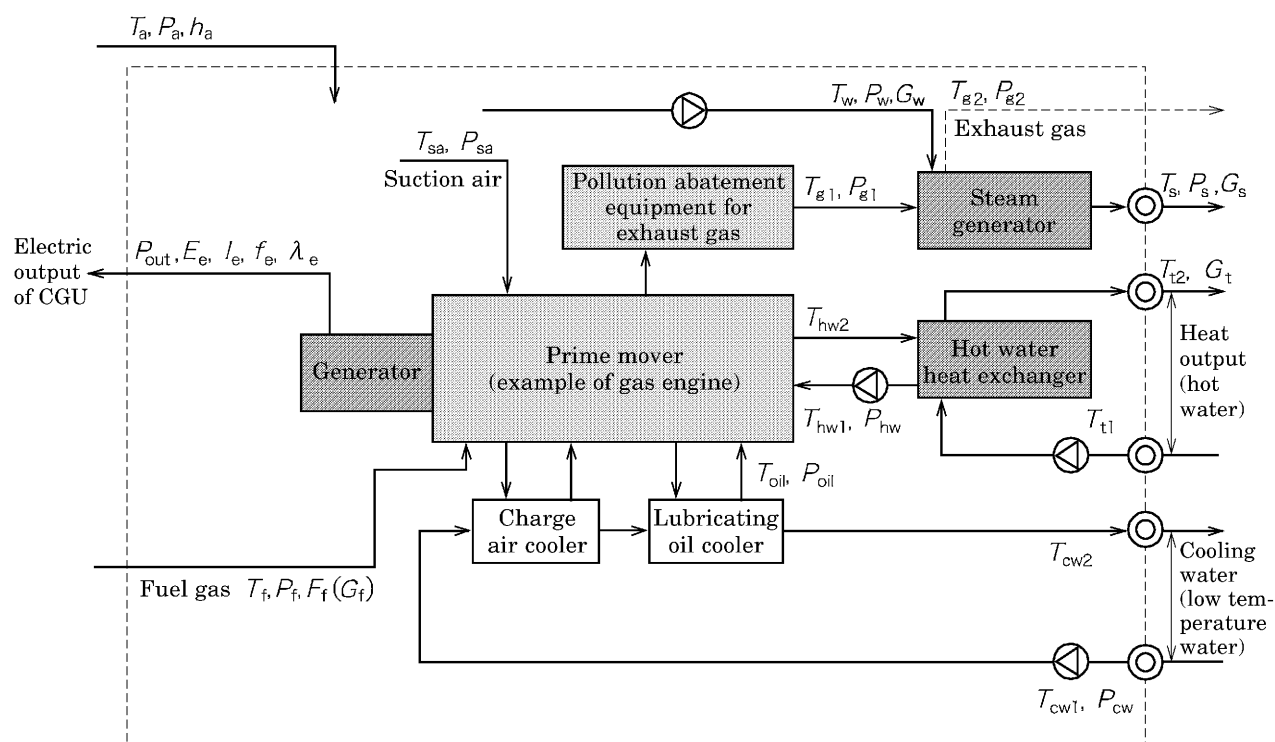
Object		Item	Sym- bol	Unit	Measurement position	NOTE
Atmospheric air		Temperature	T_a	K	Measured at the place near the testing location, and at the place in which the measurement is not affected by direct sunlight, radiation heat and exhaust gas of an engine, etc.	
		Pressure	P_a	kPa		
		Humidity	h_a	%		
Prime mover (diesel engine, gas engine, gas turbine)	Fuel	Flow rate	F_f	m ³ N/h	Measured at the inlet of a prime mover (for that equipped with a compressor, at its inlet side or its outlet side). The pressure and temperature shall be measured near the flowmeter, but the measurement may be omitted for the pressure and temperature compensated flowmeter.	
		Flow rate	G_f	kg/h		
		Pressure	P_f	kPa		
		Temperature	T_f	K		
	Suction air (supply air)	Temperature	T_{sa}	K	Measured near the opening of the suction port of a prime mover.	
		Pressure	P_{sa}	kPa	Measured near the inlet of the suction port of a prime mover. When a flowmeter, a special filter, etc. are attached, measured in their downstream side.	
	Exhaust gas (prime mover)	Temperature	T_g	K	Measured at the exhaust gas outlet of a prime mover, or at the exhaust gas outlet of supercharger and pollution control device whichever located most downstream.	
		Pressure component	P_g	kPa	In accordance with JIS Z 8808 .	
	Cooling water (high temperature)	Temperature	T_{hw}	K	Measured at the inlet and/or the outlet of a prime mover.	
		Pressure	P_{hw}	kPa	Measured at the inlet or the outlet of a prime mover.	
	Cooling water (low temperature)	Temperature	T_{cw}	K	Measured at the inlet and/or the outlet of a prime mover.	
		Pressure	P_{cw}	kPa	Measured at the inlet or the outlet of a prime mover.	
	Lubricating oil	Temperature	T_{oil}	K	Measured at the point of the lubricating oil system determined by the manufacturer of prime mover.	
		Pressure	P_{oil}	kPa		
	Exhaust gas (heat recovery facility)	Temperature	T_g	K	Measured at the inlet and the outlet of a heat recovery facility. When either one of them is close to a gas engine or diesel engine side exhaust gas thermometer, it may be omitted. In addition, when either one of them is close to a gas turbine exhaust gas thermometer, the temperature of the former may be substituted by the measured value of the latter.	
		Pressure	P_g	kPa		

Table 3 (concluded)

Object		Item	Sym- bol	Unit	Measurement position	NOTE
Prime mover (diesel engine, gas engine, gas turbine)	Heat output (hot water)	Temperature	T_t	K	Measured at the inlet and the outlet of a CGU, and at the inlet and the outlet of each heat recovery facility of cooling water and exhaust gas. When they are mutually close, either one may be omitted.	
		Flow rate	G_t	kg/h	Measured by connecting a flowmeter to the outlet of CGU.	
	Heat output (steam)	Temperature	T_s	K	Measured at the outlet of a steam generator (exhaust heat recovery facility).	When flowmeter is available
		Pressure	P_s	kPa		
		Flow rate	G_s	kg/h		
	Water supply	Temperature	T_w	K	Measured at the inlet of a steam generator (exhaust heat recovery facility).	
		Pressure	P_w	kPa		
		Flow rate	G_w	kg/h		
	Electric output	Output	P_{out}	kW	Measured by the measuring instrument of a generator panel, or at a generator output end.	
		Voltage	E_e	V		
		Current	I_e	A		
		Frequency	f_e	Hz		
		Power factor	λ_e	—		



a) For hot water output



b) For steam + hot water output

Figure 1 Measurement point of cogeneration unit (example)