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Gas turbines — Acceptance tests

AMENDMENT 1: Acceptance tests for combined-cycle power plants

Turbines à gaz — Essais de réception

AMENDEMENT 1: Essai de réception pour des installations de puissance à cycle combiné

Reference number
ISO 2314:1989/Amd.1:1997(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Amendment 1 to ISO 2314:1989 was prepared by Technical Committee ISO/TC 192, *Gas turbines.*

Annex A forms an integral part of ISO 2314.

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

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Gas turbines — Acceptance tests

AMENDMENT 1

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Add the following annex.

Annex A

(normative)

Acceptance tests for combined-cycle power plants

A.1 SCOPE

A.1.1 This annex specifies standard procedures and rules for the conduct and reporting of acceptance tests in order to determine and/or verify the power and the thermal efficiency of combined cycle power plants. It provides information on methods of measurement and on methods for correcting results obtained under test conditions to guaranteed or otherwise specified conditions.

A.1.2 The purpose of the acceptance test is to determine the performance of the combined cycle in relation to the guaranteed performances as:

a) power under specific operating conditions of the whole plant (gas and steam section) in a common contract or of the bottoming cycle only, if the gas turbine part was supplied under a separate contract.

b) thermal efficiency, heat rate or specific fuel consumption under specific operating conditions (only when contract for the total combined cycle)

A.1.3 This annex is applicable to unfired combined-cycle power plants. With suitable adjustments, it may also be used as a general guideline for combined-cycle plants with supplementary firing or other combined-cycle configurations.

The case where all components are part of different contracts is not considered here as it should be covered by corresponding pertinent standards to each equipment.

A.2 NORMATIVE REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this annex. At the time of publication, the editions indicated were valid. All standards are subject of revision, and parties to agreements based on this annex are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3977-1:—[1], *Gas turbines — Procurement — Part 1: General introduction and definitions*

ISO 11086:1996, *Gas turbines — Vocabulary*

[1] To be published.

IEC 953-1:1990, *Rules for steam turbine thermal acceptance tests — Part 1: Method A — High accuracy for large condensing steam turbines*

IEC 953-2:1990, *Rules for steam turbine thermal acceptance tests — Part 2: Method B — Wide range of accuracy for various types and sizes of turbines*

A.3 CYCLE NOMENCLATURE

For relevant definitions, see ISO 3977-1 and ISO 11086.

Figure A.1 shows the basic nomenclature used in this annex. The station numbers refer to locations corresponding to mass or energy fluxes across the control surface.

The numbering is chosen so that all fluxes entering the same surface have the same number. The differentiation is made by using letters for the different fluids. Where the same fluid is crossing the same surface (different pressure levels for instance) an additional digit is used, for instance 10.1_S, 10.2_S for two steam pressure levels.

Stations 1 through 8 are identical to figure 1 of this International Standard.

Station 9 refers to the inlet to the heat recovery steam generator.
On the gas side (g) the additional digit is used to differentiate the heat exchange surfaces within the heat recovery steam generator (HRSG) if necessary.

Station 10 refers to the outlet of the HRSG.
The different steam pressure levels are characterized by the additional digit.

Station 11 refers to all inlets to the steam turbine.

Station 12 refers to all outlets of the steam turbine.

Station 13 refers to the inlets of the condenser.

Station 14 refers to the outlets of the condenser.

Station 15 refers to the inlets of the cooling tower.

Station 16 refers to the outlets of the cooling tower.

Station 17 refers to the inlets of the deaerator/feedwater tank.

Station 18 refers to the outlets of the deaerator/feedwater tank.

In addition to this nomenclature and to the designations in 3.2.4 of this International Standard, the following letters designate the type of fluid in the various part of the cycle:

s = steam
cw = cooling water
ca = cooling air
g = exhaust gas
w = water
a = air
f = fuel

A.4 TEST PROGRAMME

A.4.1 The acceptance tests shall normally be carried out immediately after the completion of the commissioning by the supplier and, in any event, not later than three months after the start of the demonstration period (reliability run) if any is negotiated, unless otherwise agreed by both parties. For a base load plant, the demonstration period may typically extend up to 30 days. In any case, before the tests, the plant shall be placed at the disposal of the manufacturer for examination and cleaning.

If the tests have to be delayed for any reason, agreement shall be made for consideration of degradation or fouling up to the test date

A.4.2 The following test activities should be scheduled.

a) Preparation for the tests
Any pipes, ducts or valves are to be set so as to produce conditions specified in the guarantee.

Dimensions and physical conditions of any part of the plant required for test purposes shall be determined and recorded prior to the test.

Installation and verification of the required calibrated instrumentation and data acquisition equipment for the test.

Isolation of the cycle organized and the adequate operation and control of the plant verified.

b) Preliminary test
A preliminary test shall be run for the purpose of

i) verifying whether the plant and related equipment are in suitable condition for the conduct of an acceptance test and satisfactorily operating at the specified load

ii) checking the instrumentation

iii) familiarization with the test procedure

After a preliminary test is made, it may, by agreement between the purchaser and the contractor, be deemed an acceptance test.

c) Performance tests to agreed procedure
d) Computation of results
e) Test report

A.5 OPERATING CONDITIONS FOR THE TEST

A.5.1 General

The provisions stipulated under 5.1 of this International Standard shall be extended accordingly to the entire combined-cycle plant. In particular special care is to be taken with regard to

a) load of the gas turbines
b) process steam extraction conditions

c) number of auxiliaries in service (pumps, etc.)
d) operating conditions of air cooled condenser or cooling tower (number of fans operating, speed, etc.)
e) settings and operating conditions of all controls.

For reasons of convenience the permissible deviations for test conditions from design or specified conditions according to IEC 953-2 are recalled in Table A.1.

Table A.1 Maximum deviation from specific conditions
(see also Table 2)

Variable	Maximum permissible deviation of test from that specified (IEC 953-2)
Steam extraction pressure (regulated)	± 5 %
Steam exhaust pressure	
- for back pressure turbines	± 5 %
- for condensing turbines	± 25 % if condenser is not included in the guarantee
Steam extraction flow rate	± 10 %
Cooling water flow	± 15 % if condenser is part of the supply
Cooling water inlet temperature	± 5 K if condenser is part of the supply

Reasonable effort shall be devoted to ascertain that these deviation ranges are respected. If, in spite of this, no success can be achieved, agreement has to be made on additional uncertainties of the results and whether the tests should proceed.

A.5.2 Operating conditions

Prior to any readings, the plant operation shall be stabilized at a constant load.

Stability will be achieved when continuous monitoring indicates that readings have been within the maximum permissible fluctuations for a period of time which shall be agreed upon by the parties to the test.

The measurement period shall take one hour, divided typically into three reading sets.

The maximum permissible fluctuations are half the permissible deviations given in Table A.1 except for the output which may vary by ± 3 %

A.6 INSTRUMENTS AND METHODS OF MEASUREMENT

A.6.1 General

This clause describes the type, the methods of measurement and the precautions to be taken at the different stations behind the gas turbine as defined in figure A.1.

The extent and the quality (accuracy) of the measurements may be influenced greatly depending on the scope of supply and the division of work.

Measurements within one scope of supply are made essentially for a check of the operation conditions and therefore may be performed in a more simple manner.

Measurements for stations at limit of supply are, on the other hand, needed for verification of contractual performance and need great care and accuracy.

A.6.2 Measurements at Station 9

A.6.2.1 Gas-side measurements

This station defines the energy input to the heat recovery steam generator in terms of gas mass flow, gas analysis and gas temperature.

The exhaust gas mass flow of large size gas turbines in general cannot yet be measured directly with sufficient accuracy, however, in most cases it can be determined with sufficient accuracy either:

- by carrying out a careful heat balance calculation around the gas turbine (see 8.5 of this International Standard) or

- by carrying out a heat balance over the heat recovery steam generator using the gas temperature measurements at Stations 9 and 10 and additional accurate measurements of feedwater flow and water/steam temperatures and pressures.

For detailed analysis of performance figures or when the sensors for the exhaust gas temperature are to be located where velocity and temperature are not homogenous, the exhaust gas mass flow may be determined from measurements of the energy distribution in the exhaust duct section (see A.8.1.2).

Special attention shall be paid to ensure sufficient pressure, temperature and velocity measurements for a true picture of the mass averaged gas temperature in the exhaust duct.

Alternatively the gas analysis for an unfired heat recovery steam generator may be measured at station 10 g, where the temperature level does not require special equipment.

Additionally the pressure loss across the heat recovery steam generator may be verified by use of station 10 g static pressure.

Intermediate temperature measurements along the HRSG may be made for verification purposes when multi-pressure cycles are considered.

These optional temperature measurements are intended to help verify the steam generator internal heat and mass balances

A.6.2.2 Water-side measurements

In order to define the heat and the mass balances of the heat recovery steam generator, the feed water mass flow and the feedwater temperature shall be measured.

When separate feedwater pumps are used for each pressure level, corresponding measurements shall be made on each line.

A.6.3 Measurements at Station 10

A.6.3.1 Gas-side measurements

The energy at the outlet of the HRSG is defined at this station for use in heat balance calculations of the heat recovery steam generator. Besides temperature measurements, gas analysis can be measured here for convenience as stated in A.6.2.

NOTE: Optional measurements at Station 10 may be made for the same purpose as the measurements at Station 9.

A.6.3.2 Steam-side measurements

The steam parameters - especially pressure, temperature, mass flow - are measured here. Station 10 has to be defined for each pressure level where steam leaves the steam generator to the steam turbine or for heating purpose.

If no feedwater is diverted or recirculated, the feedwater mass flow measurements shall be taken (because of the higher accuracy), in preference to steam flow measurements.

Any spray water injection used to control the final steam temperature can be determined by carrying out a heat balance around the attemperator using measurements of steam and water temperatures, pressures and feed flow.

A.6.4 Measurements at Station 11

Measurements at Station 11 define the steam flow to the steam turbine and the steam conditions.

A.6.5 Measurements at Station 12

Measurements at Station 12 are intended to define the steam flow delivered by the steam cycle for any external process use and/or for NO_x reduction in the gas turbine combustion chamber. In addition the energy level (pressure, temperature) at which this transfer occurs is defined:

Measurements at the exhaust of the steam turbine are usually only for internal check purposes since the condenser station is the preferred station

A.6.6 Measurements at Station 13

The cooling water flow is to be derived or measured and the inlet temperature is to be measured at this station.

The cooling water flow rate is not normally measured. It is derived by heat balance calculations around the steam turbine and condenser.

The cooling water flow needs only to be measured or derived from calculation when separate performance verification for the steam turbine, the condenser or the cooling tower are required.

This is the case when these components are provided by different suppliers.

In the case of an air cooled condenser, the ambient air temperature is to be measured here.

The make-up water is preferably brought into the condenser when limited process steam amounts are to be delivered. This is the normal location for cycles with no process steam supply.

A.6.7 Measurements at Station 14

The cooling water outlet temperature is measured at this station.

The condition of the main condensate is measured at this station.

When an air cooled condenser is considered, the temperature of the air leaving the condenser is measured here.

All these measurements are made for verification purposes only.

A.6.8 Measurements at Station 15

The conditions of the cooling water and the air entering the cooling tower are defined at this station. The air temperature and humidity are important parameters when guarantee includes the performance of the cooling tower.

A.6.9 Measurements at Station 16

The conditions of the air and the cooling water leaving the cooling tower are measured here.

All these measurements are for verification purposes only.

A.6.10 Measurements at Station 17

When large amounts of make-up water are required (process steam extraction, NO_x steam or hot water injection into the gas turbine) the mass balance of the system is usually carried out at the feedwater tank station.

Since heating steam is involved, make-up water temperature has to be measured. Where the extraction steam is entirely lost, the make-up water flow does not need to be measured since it corresponds to the extraction flow, which does have to be measured.

A.6.11 Measurements at Station 18

The hot water extraction flow and condition is measured at this station. Hot water may be used for injection into the combustion chamber, for fuel preheating, for the fuel treatment plant or some other purpose.

A.7 TEST METHODS

A.7.1 General

The description of the test procedure is flexibly structured based on phased testing to allow application of this standard to determine plant performance in the various combined cycle applications, for instance phased construction, retrofit, etc.

The following test phases are considered.

Phase I: Simple-cycle performance test of the gas turbine using the bypass stack, if available.

Phase II: Combined-cycle performance test of the whole plant.

For combined-cycle plants with no provision for simple-cycle operation without the bottoming cycle, Phase I and Phase II are performed concurrently.

A.7.2 Phase I test (simple-cycle mode)

This test demonstrates gas turbine plant power and thermal efficiency for comparison to guarantee values.

The Phase I test shall be conducted according to the rules set in the main part of this International Standard.

Air flow reference data are calculated from the test data or set by appropriate measurement for use in determining change of gas turbine compressor air flow between Phase I and Phase II.

A.7.3 Phase II test (combined-cycle mode)

The Phase II test shall be performed while the bottoming cycle of the combined cycle is in a new and clean condition. The test shall be conducted when the combined-cycle plant and all test instrumentation are functioning satisfactorily and in a steady-state condition.

The Phase II test results combined with those of the Phase I test demonstrate the total combined-cycle plant power and thermal efficiency for comparison to guarantee values, whereby the different boundary conditions (GT exhaust mass flow, temperature and pressure) are taken into account.

The HRSG and the whole steam cycle shall be isolated in such a way that uncontrolled (not quantified) steam and water losses can be avoided. The HRSG is operated with zero blow-down.

A.8 COMPUTATION OF RESULTS

A.8.1 Calculation of measurement-derived data

Several data which have to be defined at different stations are not directly measured but have to be derived and calculated from other measurements.

The calculation methods are defined here in order to ensure a common understanding.

A.8.1.1 Exhaust gas enthalpy

Although the basic gas data are derived for the main part from a common data base, the detailed implementation is made essentially on a proprietary basis by means of various interpolation methods or by defining specific polynoms.

The results of all these methods are quite consistent for a general use. However, for purposes of performance testing, the differences may be quite important.

It is therefore recommended to the parties concerned to agree upon the gas data to be used.

NOTE:
For information, the following tables, or other appropriate ones, may be used:

a) J.H. Keenan and J. Kaye

b) JANAF — Thermodynamic table

c) FDBR-Richtlinien — Leistungsnachweis von Abhitzeanlagen (D) (F. Brandt)

d) JSME — Thermodynamic table

e) ASME — Performance Test Code PTC 4.4

Of equal importance is the definition of the reference temperature used to define the gas enthalpy.

A.8.1.2 Exhaust gas mass flow

The determination of the exhaust gas mass flow from measurements of the energy distribution in the exhaust gas duct section is based on the following theoretical background.

These measurements are defined by the fact that within a control surface across the exhaust gas flow the mean temperature ($\overline{T}_t$) over the time is a function of the mean enthalpy ($\overline{h}_t$) over the time.

$$\overline{h}_t = \frac{1}{q_m} \iint h_t \cdot \mathrm{d}q_m$$

h_t = $f(T_t)$

$\mathrm{d}q_m$ = $\rho \cdot c_n \cdot \mathrm{d}A$

where c_n is the velocity normal to the control surface
ρ is the density
$\mathrm{d}A$ is the area of an element of the control surface

q_m is the mass flow rate across the control surface

When the flow can be considered as homogeneous, the temperature expressed in a polar coordinate system is merely dependent on the position.

$$T = f(\varphi, r)$$

In the case of a non-homogeneous flow pattern, the density and the velocity will also depend on the position

$$\rho,\ c_n,\ T = f(\varphi, r)$$

In this case combined probes (for temperature and pressure) are to be considered.

A.8.2 Correction of measurement results to guarantee conditions

The correction of measurement results, e.g. power and heat input or thermal efficiency, is normally made by using correction curves provided by the supplier. For convenience, these curves shall also be provided in tabulated form or defined by equations.

These curves should be made to reflect the scope of supply. If the plant configuration allows for simple cycle operation, separate curves for the gas turbine and for the combined cycle will be provided.

In multi-stage uncontrolled district heating plant, the load distribution over the district heaters depends on the steam flow distribution within the steam turbine which is in turn a function corresponding to the steam turbine load, of the district heating load and of the actual district heating temperatures.
In this case, the relationship between energy into the steam cycle and the power/ heat from the cycle is a function of many variables.

In such cases the use of computer simulation for determining the corrections of the steam portion of the cycle is recommended. This procedure is described under A.8.2.3.

A.8.2.1 Power output correction parameters

The power output of the whole combined cycle plant is influenced by various parameters. The most important ones, for which corrections from test to guarantee conditions shall be made:

a) *Ambient temperature*

The ambient temperature has an influence on the gas turbine output and by influencing the gas turbine exhaust conditions (mass flow and temperature), affects the bottoming steam cycle.

Where an air cooled condenser is considered or when a cooling tower is part of the supply, the ambient temperature affects the performance of the cooling system and therefore the steam turbine output.

b) *Barometric pressure*

Barometric pressure affects the gas turbine compressor air flow and therefore the gas turbine power output. Generator steam flow will change and consequently the steam turbine output.

c) *Power factor*

The power factors of both the gas turbine and the steam turbine generators have an influence on the active power output.

d) *Air humidity*

The air humidity has some influence on the gas turbine output and to a larger extent affects the performance of wet cooling towers.

e) *Net specific energy*

If the net specific energy of fuel gas deviates essentially from the specified values, the gas turbine output and the gas turbine exhaust conditions (due to the fuel gas flow) will differ.

f) *Deviation of frequency*

Generally there is no major impact on the deviation or the frequency from a specified value when a stable large grid is available. Frequency deviations have an influence on the performance of the gas turbine. In the same way changes in exhaust mass flow influence the output of a steam turbine.

g) *Degradation and fouling of the gas turbine*

The power output of the gas turbine is directly affected by fouling of the gas turbine compressor and by the degradation of the gas turbine. As the gas turbine exhaust conditions (mass flow and temperature) are influenced too, the steam turbine output will vary as well.

These parameters are of importance when the performance test is overduly delayed or when phased construction or retrofit applications are considered.

The above mentioned parameters a, b, d, e and f have a bearing on the exhaust gas flow, temperature and analysis. Consequently they also influence the performances of the bottoming cycle.

For detailed analysis, related correction curves should be provided.

Some parameters do influence only the steam cycle output. These are:

h) *Cooling water inlet temperature*

The steam turbine back pressure and therefore the steam turbine output depend strongly on the cooling water inlet temperature. If the cooling system is out of the scope, the steam turbine back pressure has to be considered as correction parameter.

i) *Process steam conditions*

When process steam extraction is envisaged, the steam pressure (for automatic extraction) and the steam mass flow have to be considered as influencing the steam turbine output.

j) *Make-up water temperature*

When process steam extraction applies, the make-up water temperature has a perceivable influence on the steam turbine output.

k) *District heating conditions*

In the case of district heating applications, the operating conditions of the district heating system can influence the steam turbine load when no direct relationship between steam turbine electrical load and the district heating load exists.

In the case of retrofit applications and when phased construction is applied, influence on the gas turbine of different pressure losses resulting from changed exhaust path configuration are to be considered.

These pressure losses depend on the cycle configuration behind the gas turbine. They are taken into account when evaluating the results of the Phase I and Phase II tests.

A.8.2.2 Gross power correction with curves

The corrected gross electrical power is defined in the following way:

$$P_{corr} = (k_a \cdot k_b ... k_k)\, P_m$$

where:

P_{corr} is the corrected power for comparison with the appropriate guarantee, e.g. gas turbine, steam cycle, whole combined cycle;

P_m is the measured power for the considered scope;

$k_a \cdot k_b ... k_k$ is the correction factors for the applicable correction parameters applied to the considered scope as per correction curves provided by the supplier.

A.8.2.3 Gross power correction with computer simulation

Where computer simulation has to be taken into consideration, it will be applied only to the steam cycle. The gas turbine output will be corrected according to A.8.2.2.

The basic procedure consists of two computer calculation steps:

1) Calculation performed for the guarantee conditions of the steam cycle as reference calculation
2) Calculation, without change of the design data of the components of the cycle, performed with the measured data at the interface of the steam cycle.

The energy input into the steam generator will be, for reason of better accuracy, determined by using correction curves for changes of exhaust gas mass flow and temperature vs. ambient temperature and barometric pressure.

The global correction factor for the ST-output for consideration of all parameters as per A.8.2.1 is then determined:

$$k_s = \frac{P_{calc} \text{ (under guarantee condition)}}{P_{calc} \text{ (under test condition)}}$$

The correction factor for the heat load delivered to the district heating network is determined in the same way.

A.8.2.4 Correction of auxiliary power

The responsibility for the equipment influencing the auxiliary power consumption is specific to each project. In general, only the auxiliary power consumption of the equipment which is in continuous operation and absolutely necessary for power generation would be taken into account. The measuring and the correction procedures shall therefore be agreed upon by the parties prior to the test.

A.8.2.5 Correction of heat input from the fuel

In unfired combined-cycle power plants, the heat input occurs only at the gas turbine level.

The heat input to the plant is therefore affected essentially by the same parameters influencing the power output of the gas turbine.

The total power output of the cycle, as the sum of the gas and steam turbines outputs, has no definite relation to the heat input any more.

It is therefore necessary to first make a correction of the heat input of each individual gas turbine and then calculate the corrected heat rate (or the efficiency) of the combined cycle.

The corrected heat input will be determined in the same way as for the corrected power as described in A.8.2.2.

A.8.2.6 Corrected gross heat rate

The corrected gross heat rate is defined by

$$\mathrm{HRG}_{\mathrm{corr}} = \frac{\mathrm{HI}_{\mathrm{corr}}}{P_{\mathrm{corr}}}$$

where $\mathrm{HI}_{\mathrm{corr}}$ is the corrected heat input.

A.8.2.7 Corrected net heat input rate

The corrected net heat rate is defined by:

$$\mathrm{HRN}_{\mathrm{corr}} = \frac{\mathrm{HI}_{\mathrm{corr}}}{P_{\mathrm{corr}} - P_{\mathrm{aux,corr}}}$$

where $P_{\mathrm{aux,corr}}$ is the corrected auxiliary power consumption.

A.8.3 Typical generalized correction curves

Correction curves are basically dependent on the machine technology applied and on the configuration of the bottoming cycle.

However, considering a combined-cycle power plant with a straight condensing steam turbine, the basic shape of the correction curves can be defined. The slope of the curves may vary with the steam parameters chosen, e.g. steam pressure and temperature, number of pressure levels, etc., and with the gas turbine, method control.

The shape of the curves may also depend on whether steam extraction, for process supply, for NO_x control etc., is considered.

In order not to overload this work with only informative material, only correction curves for the entire combined-cycle plant are attached.

Gas turbine curves are considered in the main part of this International Standard. The steam bottoming cycle alone is to be considered for retrofit applications. In these cases no standard application can be defined.

The curves depicted have correction factors on the *Y*-axis and are defined in the text, e.g. multiplying factors for correction of measured data to guarantee conditions. The effect of anti-icing and evaporative cooling on the gas turbine is excluded.

The following curves are included:

Figure
- A.2 - Correction curve of CC-output vs. ambient temperature (direct cooling)
- A.3 - Correction curve of CC-output vs. ambient temperature and relative humidity (cooling tower)
- A.4 - Correction curve of CC-output vs. ambient temperature (air cooled condenser)
- A.5 - Correction curve of CC-output vs. atmospheric pressure
- A.6 - Correction curve of CC-output vs. air relative humidity
- A.7 - Correction curve of CC-output vs. cooling water temperature deviation
- A.8 - Correction curve of CC-heat rate vs. ambient temperature (direct cooling)
- A.9 - Correction curve of CC-heat rate vs. relative humidity (cooling tower)
- A.10 - Correction curve of CC-heat rate vs. ambient temperature (air cooled condenser)
- A.11 - Correction curve of CC-heat rate vs. atmospheric pressure
- A.12 - Correction curve of CC-heat rate vs. air relative humidity
- A.13 - Correction curve of CC-heat rate vs. cooling water temperature deviation

When the performance test is overduly delayed or phased construction is considered, the correction curves of figures A.14 and A.15 show the corrections to be made for consideration of the influence of GT degradation on the CC-output and CC-heat rate.

A.9 MEASUREMENT UNCERTAINTY

A.9.1 General

The measurement of each value entering into the computation of the test result is liable to some degree of error, depending on the quality of the measuring instruments and the conditions of the measurement. The test result is therefore subject to a degree of uncertainty depending on the combined effect of all the errors of measurement.

The confidence limits of any measurement can be assessed

a) from measuring recommendations and standards;

b) from the accuracy classes of the measuring instrument or measurement, chain;

c) from the accuracy of calibration of a measuring instrument or transducer;

d) from the influence of unavoidable installation error;

e) from general measuring experience;

f) from fluctuating test conditions.

Due to the many causes involved, the assessment of the measuring uncertainty shall be made by calculation for each case.

A.9.2 Guiding values

The guiding values set in Table A.2 are an indication of the magnitude of measuring uncertainties which are to be expected for a properly run acceptance tests.

Providing no specific contractual agreement is documented relative to measuring tolerances, the measurement uncertainties as determined after the test shall be considered in evaluating the results of the test.

Table A.2

Measurement	Uncertainty		Comments
Power	less than	± 0,50 %	for each measurement
Fuel mass flow	oil	± 0,60 %	
	gas	± 1,00 %	
Calorific value		± 0,50 %	oil and gas
Heat rate	oil	± 1,30 %	1 GT to 1 ST
	gas	± 1,50 %	1 GT to 1 ST

A.10 TEST REPORT

The test report shall present sufficient information to demonstrate that all the objectives of the test have been achieved.

The detailed report shall include, in the main part or as an annex, the following information:

a) presentation of the test results and comparison with the guarantees

b) object of test, guarantee and stipulated agreement

c) schematic diagram of the cycle

d) brief history of the operation of the plant and corrective measures to be taken to restore satisfactory operation conditions

e) description of the test, arrangements, equipment, instruments and their location and operating conditions

f) summary of relevant measurements and observations

g) essential calibration curves of instruments used in the test

h) reference to method of calculation

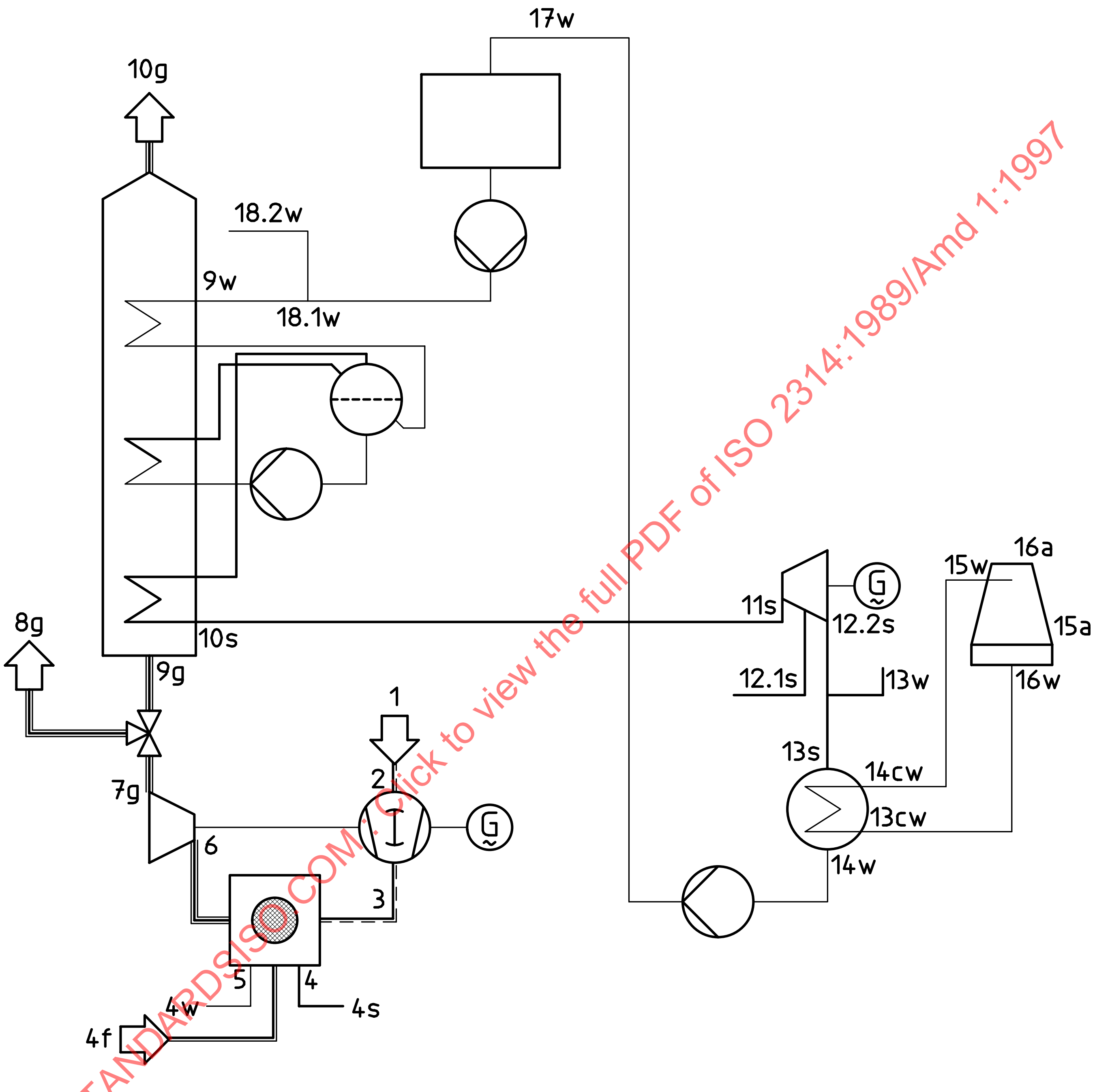
i) correction factors to be applied for taking account of different test conditions than specified

j) calculations of measuring uncertainty

k) special agreements in respect of tolerances or errors

l) test results corrected to specified conditions

m) discussion of the test, its results and conclusions.



w : water
f : fuel
s : steam
g : gas
ca : cooling air
cw : cooling water

Figure A.1 — Basic cycle nomenclature