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Shell boilers - Part 11: Acceptance tests

Großwasserraumkessel - Teil 11: Abnahmeversuche

Chaudieres a tubes de fumée - Partie 11: Essais de réception

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27.060.30	Grelniki vode in prenosniki toplote	Boilers and heat exchangers

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Shell boilers - Part 11: Acceptance tests

Chaudières à tubes de fumée - Partie 11: Essais de réception

Großwasserraumkessel - Teil 11: Abnahmeversuche

This European Standard was approved by CEN on 24 July 2003.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 12953-11:2003) has been prepared by Technical Committee CEN/TC 269 “Shell and water-tube boilers”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2004, and conflicting national standards shall be withdrawn at the latest by March 2004.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association. This European Standard is considered as a supporting standard to other application and product standards which in themselves support an Essential Safety requirement of a New Approach Directive and will appear as a normative reference in them.

The European Standard EN 12953 concerning shell boilers consists of the following Parts:

- *Part 1: General.*
- *Part 2: Materials for pressure parts of boilers and accessories.*
- *Part 3: Design and calculation for pressure parts of the boiler.*
- *Part 4: Workmanship and construction of pressure parts of the boiler.*
- *Part 5: Inspection during construction, documentation and marking of pressure parts of the boiler.*
- *Part 6: Requirements for equipment for the boiler.*
- *Part 7: Requirements for firing systems for liquid and gaseous fuels for the boiler.*
- *Part 8: Requirements for safeguards against excessive pressure.*
- *Part 9: Requirements for limiting devices of the boiler and accessories.*
- *Part 10: Requirements for boiler feedwater and boiler water quality.*
- *Part 11: Acceptance tests.*
- *Part 12: Requirements for grate firing systems for solid fuels for the boiler.*
- *Part 13: Operating instructions.*

CR 12953-14: *Guideline for the involvement of an inspection body independent of the manufacturer.*

Although these Parts can be obtained separately, it should be recognized that the Parts are interdependent. As such, the design and manufacture of shell boilers requires the application of more than one Part in order for the requirements of the European Standard to be satisfactorily fulfilled.

The annex A of this European Standard is informative. The annex B of this European Standard is normative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This Part of this European Standard specifies a concise procedure for conducting thermal performance tests, using the indirect (losses) procedure for boilers for steam or hot water. Test results are based on either the gross or net calorific value of the fuel.

This concise procedure provides a convenient means for assessing boilers which are thermodynamically simple, i.e. having a single major source of heat input and a simple circuit for water, steam or high temperature heat transfer fluid.

NOTE 1 The use of the direct method is not advocated, because the estimated measuring error is three to four times greater than with the indirect method.

NOTE 2 An acceptance test may be required:

a) after the commissioning of new plant or after the recommissioning of modified plant in order to verify compliance with a specification or contractual obligation;

b) whenever the user wishes to determine the current performance of the plant either on a routine basis or due to change of load or other operating conditions or when a change of fuel or a modification to the plant is being considered;

c) whenever the user wishes to check combustion conditions.

Regular tests in accordance with this European Standard will enable boiler plant to be monitored in normal operation for optimum efficiency in the interests of fuel conservation.

This procedure does not cover condensing boilers. The application of boilers, where heat is extracted from waste gases is specified in annex B.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 1: General principles and requirements (ISO 5167-1:2003).*

ISO 157, *Coal — Determination of forms of sulfur*.

ISO 334, *Solid mineral fuels — Determination of total sulfur — Eschka method.*

ISO 589, *Hard coal — Determination of total moisture.*

ISO 609, *Solid mineral fuels — Determination of carbon and hydrogen — High temperature combustion method.*

ISO 625, *Solid mineral fuels — Determination of carbon and hydrogen — Liebig method.*

ISO 1928, *Solid mineral fuels — Determination of gross calorific value by the bomb calorimetric method, and calculation of net calorific value.*

ISO 1988, *Hard coal — Sampling.*

ISO 3170, *Petroleum liquids — Manual sampling.*

ISO 6976, *Natural gas — Calculation of calorific values, density, relative density and Wobbe index from composition.*

3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply.

3.1
indirect method (Heat loss method)
determination of all accountable heat losses. The efficiency is then equal to 1 minus the ratio of the sum of all heat losses to the sum of heat in the fuel plus heat credits

3.2
standard condition
condition at p_n = 0,101325 N/mm^2 and t_n = 0 °C

3.3
assessed losses
any thermal losses established from predetermined data

3.4
gross calorific value (GCV)
amount of heat liberated by the complete combustion, under specified conditions, of unit volume of a gas or unit mass of a solid or liquid fuel in the determination of which the water produced by combustion of the fuel is assumed to be completely condensed and its latent and sensible heat made available

3.5
net calorific value (NCV)
amount of heat generated by the complete combustion, under specified conditions, of unit volume of a gas or unit mass of a solid or liquid fuel in the determination of which the water produced by combustion of the fuel is assumed to remain as a vapour

3.6
heat input
heat content of the fuel used during the test based on the gross or net calorific value plus the sensible heat in the fuel above reference temperature plus the sensible heat in the combustion air above reference temperature

3.7
heat output
heat gained by the heat carrier from the boiler during the period of the test

3.8
measured loss
any thermal losses calculated from actual measurements made during the test

3.9
radiation, convection and conduction losses
losses from water, steam, combustion air, or gas-backed surfaces prior to the flue gas temperature measurement point and directly from flame to the floor and surroundings of the unit

3.10
test error
combined error due to sampling, measurements, calculations and assumptions used to obtain test results. The overall effect may be positive or negative

3.11
thermal efficiency
the difference between 100 % and the total percentage losses based on either the gross or net calorific value of the fuel which is equivalent to the ratio of the useful heat output to the heat input expressed as a percentage

3.12
turn-down ratio
the ratio of maximum and minimum fuel inputs for continuous firing in unit time specified by the manufacturer which can also be expressed in terms of boiler output provided the appropriate efficiencies are known.

4 Symbols and abbreviations

4.1 Symbols and units

For the purposes of this European Standard the symbols and abbreviations given in EN 12952-1:2002, table 4-1 and the following table 4.1-1 and the subscripts given in table 4.1-2 shall apply.

Table 4.1-1 — Symbols

Symbol	Description	Unit
c	Specific heat capacity [a]	kJ/(kgK)
$\bar{c}$	Integral specific heat capacity [a]	kJ/(kgK)
H	Calorific value (CV)	kJ/kg
h	Specific enthalpy	kJ/kg
i	Number of samples	—
J	Enthalpy of flue gas or combustion air related to fuel mass flow	kJ/kg
L	Latent heat (heat of vaporization)	kJ/kg
l	Single loss	—
l_u	Ratio of unburned combustibles to supplied fuel mass flow	kg/kg
M	Molar mass	kg/kmol
m	Mass	kg
$\dot{m}$	Mass flow	kg/s
n	Air factor at boiler outlet	—
p	Pressure	N/mm^2
$\dot{Q}$	Heat flow	kW
T	Thermodynamic temperature	K
t	Temperature Celsius	°C
u	Unburned combustibles content (by mass)	kg/kg
V	Combustion air and flue gas volume (per unit mass of fuel)	m^3/kg
x	Flue gas/combustion air components content by mass	kg/kg
y	Content by volume	m^3/m^3
η	Thermal efficiency	—
γ	Fuel content (by mass)	kg/kg
ν	Volatile matter content of ash	kg/kg
ρ	Density	kg/m^3
μ	Combustion air/flue gas mass to fuel mass ratio	kg/kg

NOTE 1 $1\ N/mm^2 = 1\ MN/m^2 = 1$ Mpa

NOTE 2 The units shown are those normally used. Conversion may be necessary for use in the dimensionless equations.

[a] 'specific heat', for short.

Table 4.1-2 — Subscripts

Symbol	Description
A	Air
Ash	Ash
B	Boiler
C	Carbon
CO	Carbon monoxide
CO2	Carbon dioxide
d	Dry (basis)
E	Useful, effective
FA	Flu dust (fly ash)
F	Fuel, burned fuel
Fo	Fuel supplied
Fw	Feed water
G	Flue gas (combustion gas)
(G)	Gross value
H	Hydrogen
H2O	Water
i	Number of components
m	Average
meas	Measured
min	Minimum
N	Nitrogen
(N)	Net value
n	Standard condition
o	Stoichiometric
O2	Oxygen
p	Constant pressure
r	Reference temperature
RC	Radiation and convection
S	Sulfur
SF	Ash and flue dust
ST	Live steam
tot	Total
u	Unburned matter
Z	Heat input
^	Maximum
0	at 0 °C
1	in
2	out

4.2 Coefficients

For the purposes of this European Standard the coefficients given in Table 4.2-1 shall apply.

Table 4.2-1 — Coefficients

Designation	Symbol	Value	Unit
Specific latent heat at 25 °C	L_r	2 442,5	kJ/kg
Specific heat of steam between 25 °C and 150 °C	$\bar{c}_{pSt}$	1,884	kJ/(kg K)
Specific heat of water between 25 °C and 150 °C	$\bar{c}_{pW}$	4,21	kJ//kg K)
Specific heat of air between 25 °C and 150 °C	$\bar{c}_{pA}$	1,011	kJ//kg K)
Specific heat of ash and flue dust between 25 °C and 200 °C	$\bar{c}_{Ash}$, $\bar{c}_{FA}$	0,84	kJ//kg K)
CV of unburned matter:			
Hard coal	$H_{(N)u}$	33,0	MJ/kg
Brown coal	$H_{(N)u}$	27,2	MJ/kg

5 General

5.1 Where a thermal performance assessment is to be carried out after the commissioning of new plant or after the recommissioning of modified plant, it shall be decided at the plant tendering or ordering stage on the test data required and on the accuracy and hence the instrumentation to be used.

It is necessary for the parties concerned to decide whether the test shall be carried out by the contractor or by an independent body and by whom is to be witnessed.

5.2 Tests shall represent the intended method and system of operation of the plant under the intended conditions of installation and normal operation. The determination of electrical consumption is not part of this European Standard.

5.3 Tests shall be carried out at predetermined firing rates, as agreed between the parties concerned.

6 Basic test conditions

6.1 General conditions

Tests shall be carried out whilst the boiler is fired continuously under steady state conditions established prior to the test (see 6.2).

NOTE An outline of the procedure for calculating the heat output from test measurements is shown in Figure 6.1-1.

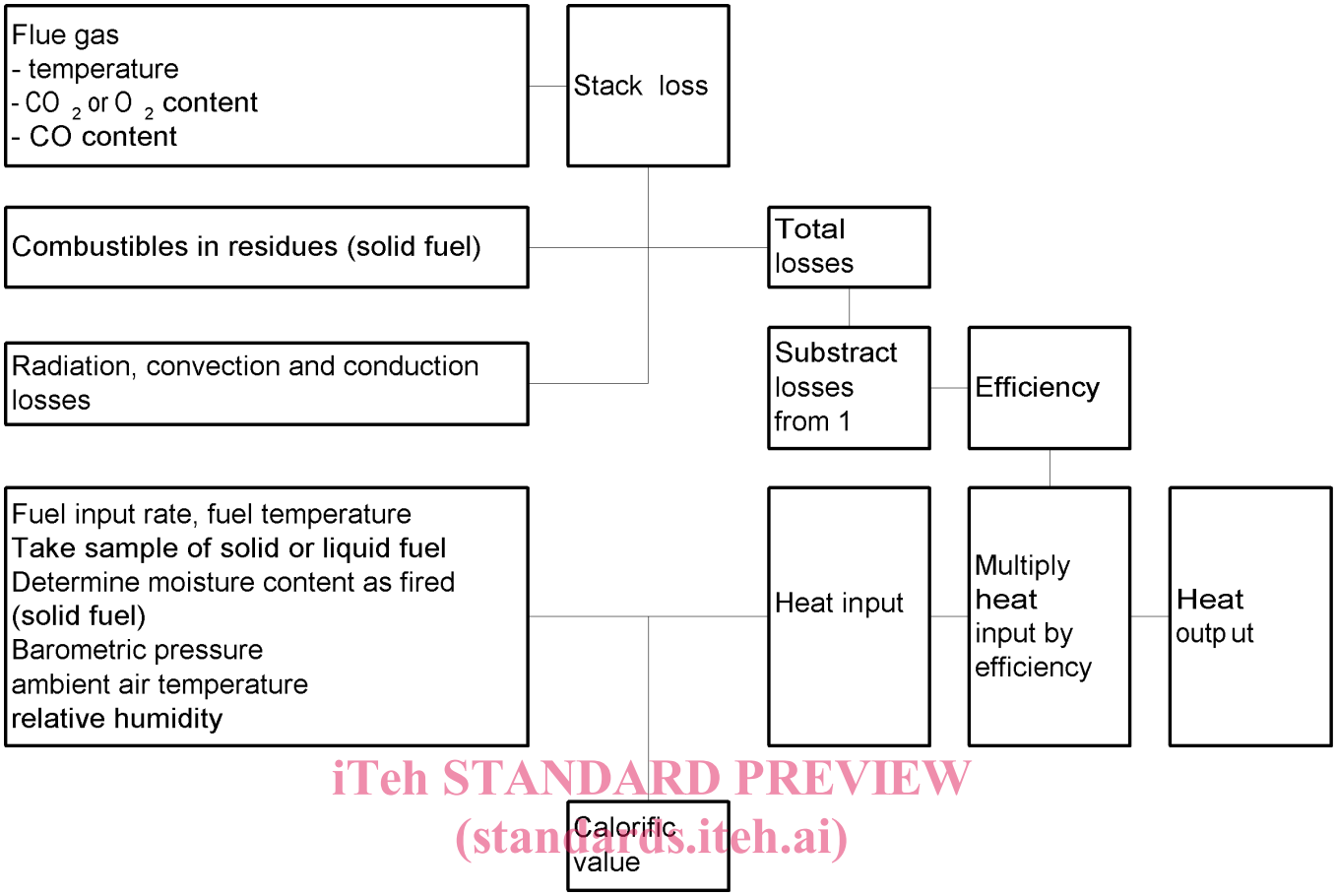

Figure 6.1-1 — Outline of the procedure for calculating the heat output from the test measurement

6.2 Steady-state conditions

6.2.1 Steam pressure, steam and feed water temperature or, for hot water generator, the flow and return temperatures, together with the relevant flow rates, shall be held as steady as possible and at levels close to normal operating conditions. These measurements shall be taken at the boiler exit or as closed as practical at the (same) test prior.

NOTE During the operation of a boiler the various factors contributing to heat losses can vary from their intended values as a result of the absorption of heat by the boiler structure as it acquires the conditions determined for the test and as a result of the operation of automatic controls. The most important variables are the exhaust gas temperature and the CO_2 or O_2 content of the exhaust gases. It is therefore essential that tests are conducted only after steady-state conditions have been achieved.

6.2.2 For the purposes of this standard, steady-state conditions shall be deemed to have been reached for solid fuel fired boilers with continuous fuel and ash flows and for liquid and gaseous fuel-fired boilers, when during the period of the test, variation in exhaust gas temperature remains within 10 C and variation of oxygen content within 0,5 % from the mean value.

6.3 Test procedure

6.3.1 It shall be confirmed that the water treatment is being carried out in accordance with the instructions of the boilermaker and the supplier of the water treatment plant. Where necessary during the preliminary running of the boiler prior to the test, except when testing under 'as found' conditions (see 6.3.2), the gas side surfaces shall be cleaned, the fuel input and fuel air ratio shall be set and adjustment of the combustion chamber draught or pressure shall be made to conditions laid down by the boilermakers before establishing steady-state conditions.

6.3.2 When testing under 'as found' conditions, e.g. whenever the user wishes to determine the current performance of the plant, no adjustments to the firing equipment shall be made and no cleaning of the gas-side surfaces shall be carried out prior to the commencement of the test.

NOTE Factors relating to maladjustment of the firing equipment, grit and dust emission, fouled heat transfer surfaces or the formation of CO be shown up by such tests and will be a guide to improvements in operation, which should be confirmed by retest. A comparison with the manufacturer's performance data should be made.

6.4 Requirements during test

During the running of the test, the blowdown of steam boilers shall be avoided and the water level in the gauge glasses shall be held as steady as possible during the establishment of steady-state conditions and during the subsequent test.

Where automatic high/low or fully modulating firing equipment is fitted, no manual adjustment of combustion settings during the overall test period shall be carried out (see 5.2).

6.5 Duration of tests

Following the establishment of the steady state, the test shall be of sufficient duration for at least six complete sets of readings of fuel input, flue gas temperature and flue gas analysis. The readings shall be within the variations permitted by the strict terms of steady conditions (see 6.2).

6.6 Procedure for the determination of exhaust gas temperature and CO, CO_2 and O_2 content

The procedure for the determination of exhaust gas temperature and CO, CO_2 and O_2 content shall be in accordance with the methods in clause 7.

6.7 Undetermined losses

Undetermined losses, i.e. losses which are neither measured nor assessed, can occur but shall be regarded as insignificant for the purpose of this European Standard.

7 Instrumentation and methods of measurements

7.1 Instruments

All measurements shall be made with suitable calibrated instruments. Portable or mobile instruments shall be used unless it can be shown that the sensors of installed instruments have been located correctly and the system checked for accuracy.

Only such measuring instruments and/or transducers shall be used whose indications and/or output values are verifiable and whose limits of error are known. These shall include:

a) instruments for which a verification certificate (calibration certificate issued by an authority) is submitted;

b) verifiable instruments which have been calibrated before and after the test with the readings both rising and falling, preferably under conditions simulating those existing during the test, and compared with the instruments as per item a) above;

c) standard instruments with known limits of error;

d) other approved instruments with known limits of error, the use of which has been agreed upon by the parties to the test.

The measuring equipment shall not be subject to any appreciable permanent changes during the test.

Analog or digital readings may be taken, and the data shall be recorded manually or automatically. The test report shall detail the instruments used and their limits of error.

If the data are recorded by automatic equipment, random checks shall be made to verify that the signals are correctly processed.