AGREEMENT

Number:	V-DK-004
Titel:	**Guideline for tests and inspections in accordance with the German Ordinance on Industrial Safety and Health (BetrSichV) to be performed on shell boilers and similar boiler types and related pressure vessels and piping**
Signatories:	BDH FDBR Vd-TÜV VGB
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Agreement of Steam Boilers 004
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between

BDH Bundesindustrieverband Deutschland Haus-, Energie- und Umwelttechnik e. V., Köln

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Guideline for tests and inspections in accordance with the German Ordinance on Industrial Safety and Health (BetrSichV) to be performed on shell boilers and similar boiler types and related pressure vessels and piping

Preamble

This agreement is intended to supplement the pertinent rules and regulations. It is a collection of experience made, recommendations and, where required, a concretization of the rules and regulations, which, to the best of our knowledge, reflects the state-of-the-art at its date of publication. This agreement aims at ensuring the operational safety of steam boiler plants and their components.

No liability will be taken for the correctness of the contents of this agreement. Patents and other protective rights shall be clarified under the responsibility of the user.

The associations having participated in the establishment of this guideline will appreciate the support and further development of its contents through other national and international associations/institutions.

Contents

1 Scope

This guideline applies to

- Tests and inspections prior to first putting into service**
- Tests and inspections upon an essential change
- Tests and inspections upon changes
- Periodic inspections of plant and plant components including supplementary tests/examinations within periodic internal inspections

on steam boiler plants with shell boilers for the generation of hot water with a maximum allowable temperature exceeding 120 °C and for the generation of steam with a maximum allowable pressure exceeding 1 bar, with the boilers falling under categories III and IV to the Pressure Equipment Directive (PED) 97/23/EC Annex II, diagram 5.

This guideline describes the total extent of tests and inspections to be performed on plants. Tests and inspections already performed under the responsibility of the manufacturer are not covered by this guideline.

2 Symbols, abbreviations and units

F_P	=	test pressure factor	
P_B	=	allowable working pressure	bar
P_P	=	test pressure	bar
$R_{p0,2/RT}$	=	0.2% proof stress at room temperature	MPa
$R_{p0,2/TS}$	=	0.2% proof stress at design temperature	MPa

Note on working pressure and test pressure:

- *TRBS 2141, item 2: "The allowable working pressure (P_B) may differ from the maximum allowable pressure (PS) to the PED 97/23/EC."*
- *The test pressure (P_P) may differ from the test pressure (PT) to the PED 97/23/EC.*

3 Tests and inspections to be performed in accordance with the Ordinance on Industrial Safety and Health

The tests and inspections shall be performed in accordance with the Ordinance on Industrial Safety and Health (BetrSichV) and the related technical rules TRBS 1201 and 1201-2. The diagram in Figure 1 contains an overview.

* (Translator's note: "Putting into service*" always means commissioning by the plant owner/user)

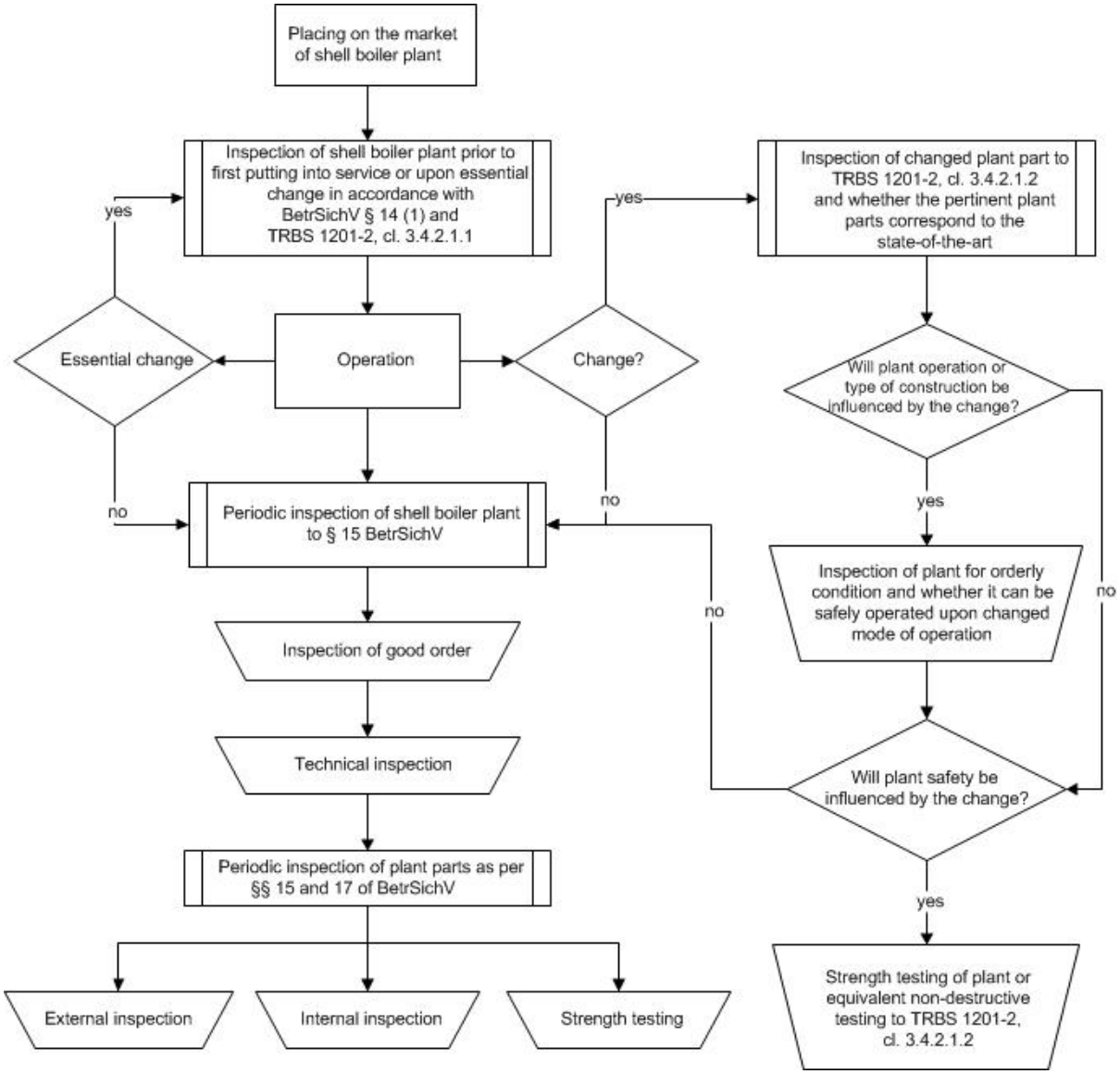

Figure 1: Test and inspection sequence plan in dependence of the type of inspection/testing

The boundaries of the shell boiler plant shall be fixed by the employer/user within the risk assessment/safety assessment procedure which shall also cover the related pressure vessel installations and piping. It is purposeful to establish pertinent test and inspection sequence plans on the basis of the test and inspection requirements of this guideline. When establishing the boundaries of the steam boiler plant, TRBS 2141 clause 2 (11) shall be taken into account.

As regards the hazard categories relating to steam and pressure, the tests and inspections shall be performed by the accredited inspection body (ZÜS). Deviating here from, the inspection prior to putting into service for boilers of category III with a pressure-volume product ≤ 200 bar • l and the periodic inspections for boilers with a pressure-volume product ≤ 1000 bar • l may be performed by a competent person for the purpose of TRBS 1203.

Tests and inspections relating to other hazard categories shall be performed by competent persons as laid down in the Ordinance on Industrial Safety and Health (BetrSichV). Their delimitation with respect to the total extent of tests and inspections shall be agreed between employer/user and the accredited inspection body.

The tests and inspections described hereafter contain the requirements of the Ordinance on Industrial Safety and Health (BetrSichV) and of the Technical Rules for Operational Safety (TRBS).

In addition, information on tests and inspections as well as fixed periods, if any, laid down in operating instructions shall be considered.

Where the accredited inspection body (ZÜS)/competent person detects defects by which employees or third persons may be endangered, he shall inform the user and, in the case of considerable defects, the competent authority without delay.

4 Tests and inspections prior to first putting into service*

4.1 Tests and inspections prior to first putting into service* or upon essential change

4.1.1 General requirements

The inspection prior to first putting into service* or upon an essential change of the pressurised plant liable to supervision, as laid down in § 14 cl. 1 of BetrSichV as well as TRBS 1201-2, covers the inspection of the orderly condition for the intended mode of operation. During this inspection, the assembly, erection, installation conditions as well as the functions of the safety-relevant equipment shall be checked.

It is assumed that the accredited inspection body (ZÜS)/competent person is able to make statements on the safety-relevant proper condition of the pressurized plant without having examined whether each individual safety requirement laid down by the fabrication requirements has been met. Where required, the accredited inspection body (ZÜS)/competent person may support their inspections and statements with inspection results and statements of third persons in which case the accredited inspection body (ZÜS)/competent person shall evaluate such inspection results and statements. The certificates including the related documents on the acceptance of pressure equipment/assemblies of pressurized plants by the manufacturer or notified body shall serve as basis document for the accredited inspection body (ZÜS)/competent person and be submitted prior to the first putting into service*.

By taking appropriate preparatory measures, the employer/user shall ensure that all test and inspection tests (e.g. functional tests of equipment parts) required prior to the first putting into service* can be performed within reasonable period of time. Where required for the evaluation, schematic flow diagrams with the required degree of detailing, e.g. to DIN EN ISO 10628, wiring diagrams, schematic circuit diagrams or logic circuits shall be used. The aforementioned diagrams and plans and, where required, also descriptions, shall be submitted in time to the accredited inspection body (ZÜS)/competent person prior to the first putting into service*.

As a rule, the inspection prior to first putting into service* covers the evaluation of the documentation and of tests and inspections performed on the plant liable to supervision, as shown hereafter:

(1) Check whether the required documents are available and conclusive, e.g. manufacturer's operating manual or operating instructions (if the plant was constructed by the plant owner) and, where required, further technical documents such as documents showing the design of safeguards against excessive pressure,

(2) Examination whether the test object is employed and utilized to correspond to the results of the risk assessment/safety evaluation, e.g. suitability of the pressure equipment for the intended mode of operation in due consideration of the safety concept laid down in the pipework and instrumentation diagram (P&I diagram)

(3) Check whether the directions fixed by the authority in accordance with the Ordinance on Industrial Safety and Health are contained in the licence or notice of approval

(4) Visual examination of external condition of the pressurized plant

(5) Check whether the documentation matches the actual state, e.g. nameplate and whether, where required, the CE marking and declaration or certificate of conformity can be assigned to the test object.

(6) Examination of orderly erection and anchoring of the pressure equipment

(7) Examination of orderly installation of connected piping

(8) Examination regarding observance of protective distances

(9) Check for observance of safety distances to objects to be protected in case of vessels for the storage of combustible (highly flammable, easily flammable, flammable) or noxious or very noxious gases

(10) Examination of safety-relevant items of equipment for appropriate selection as to its intended use, for correct installation, dimensioning, setting/adjustment, arrangement, and functioning unless certified by the plant manufacturer.

(11) Examination regarding safe discharge of vapours/steam, gases, dust, and liquids from safety devices

(12) Examination regarding observance of other installation requirements, e.g. ventilation, accessibility, ground formation, protection of rooms, duct inlets, escape routes, self-ignition, influences of the weather, earthquakes

(13) Examination of accessibility for maintenance work/periodic inspections

The evaluation shall be made to the state-of-the-art in which case additional information gained from known cases of damage shall also be considered. In the case of assemblies to the PED 97/23/EC (Pressure Equipment Directive) the installation conditions shall be checked. The erection and installation aspects covered by the EC declaration of conformity will no more be checked if the assembly is utilized to satisfy the manufacturer's requirements and is marked accordingly to ensure traceability. The safe functioning of safety-relevant items of the assembly and of equipment serving safe operation shall be checked if the test/inspections have not been certified within the declaration of conformity/conformity assessment procedure.

Where the construction is made by the plant owner himself, the tests and inspections required during manufacturing shall be performed by the accredited inspection body/competent person in addition to the tests performed during erection and installation. In this case, Annex I of the PED 97/23/EC is considered the state-of-the-art as regards the fabrication requirements. The conformance of the pressurized plant and/or its components with the essential safety requirements of the PED 97/23/EC shall be ascertained within an inspection to be performed in accordance with the Ordinance on Industrial Safety and Health (BetrSichV), § 12 para. 2 item 2.

Where the construction is made by the plant owner himself, e.g. the following tests and inspection are required:

- Evaluation of pressure equipment that has neither been subjected to a conformity assessment nor to a CE marking, nor has been placed on the market to meet other legal prescriptions, nor is not part of an assembly to the PED, to meet the requirements of Annex I of the PED 97/23/EC,
- Evaluation of the assembled various individual components of the pressurized plant (including e.g. pumps, compressors) in acc. with the PED 97/23/EC, Annex I, clauses 2.3, 2.8 and 2.9 if the assembled components have not yet been subjected to a conformity assessment as assembly.
- Evaluation regarding the protection against exceeding the allowable operational limits as per the PED 97/23/EC, Annex I, clauses 2.10, 2.11 and 3.2.3 if the protective devices of the assembled pressure equipment have not yet been subjected to a conformity assessment.

Random checks will suffice if the accredited inspection body (ZÜS)/competent person is able to evaluate the safe condition of the plant components to be tested/inspected from the results obtained from these random checks.

The random checks shall be performed such that no dangerous conditions or damage arises in the plant.

The accredited inspection body/competent person shall establish a certificate/report on the inspection prior to putting into service* to include any defects relevant to the evaluation of plant safety. The inspection certificate/report shall contain the basic test and inspection requirements, the extent and results of tests and inspections. Where required, this inspection certificate/report shall be supplemented by certificates/records established by third persons, on which the inspection prior to putting into service* is based. Further documentation on which the inspection prior to putting into service* is based shall be indicated in or added to the inspection certificate/report. A statement shall be made whether safety-relevant objections against the putting into service* exist or not. In the case of deficiencies not precluding the putting into service*, a time-limit shall be fixed for the removal of such deficiencies.

4.1.2 Additional requirements for the steam boiler plant

Where tests or inspections can only be performed on cold boilers out of operation, they shall be performed on the cold boiler prior to first putting into service* unless they have been performed before within the manufacturing process.

The accredited inspection body (ZÜS)/competent person shall examine, in addition to clause 4.1.1 and in due consideration of the risk assessment/safety evaluation performed by the employer/user, the following aspects:

Erection:

(1) Erection of the steam boiler and all components of the steam boiler plant
(2) Accessibility of the cleaning, inspection and access openings and their items of equipment
(3) Freeze protection of outdoor items of equipment where plant safety may be impaired.

Operation:

(1) Width and height of operating floors
(2) Escape routes, their marking and lighting
(3) Accident-proof construction of pits, depressions, stairways, platforms, and landings
(4) Heat insulation of feed water, boiler water and steam piping as well as of flue gas ducts within traffic areas
(5) Lighting, venting and ventilation of the boiler room
(6) Safe discharge outlets of drain, vent and discharge devices
(7) Possibility of isolation of common steam, feed water, drain lines, and other lines as well as of flue gas ducts, where required for safe access and inspection.

Availability of the certificates on the other tests and inspections to be performed prior to putting into service*. These generally are:

(1) Certificate on final inspection and strength testing of the steam boiler and the feed water heaters and superheaters located in the flue gas path.
(2) Acceptance certificate of pressure vessels and piping belonging to the steam boiler plant
(3) Certificate on leak tightness and/or strength testing of lines for liquid, gaseous and pulverized fuels
(4) Certificate on leak tightness testing of pressurized flue gas ducts
(5) Certificate on the inspection of the lightning protection system, where required under the licence
(6) Inspection certificate of the tank system for storing liquid fuels
(7) Certificate on conformance of the electrical installation to the VDE regulations, unless subject to the conformity assessment procedure. Otherwise, a manufacturer’s certificate that the electrical safety circuit has been designed and inspected according to DIN EN 50156-1 (VDE 0116-1) as well as a certificate of the proper local installation shall be submitted.
(8) Identification marking of parts and components for which a specific reliability is required and is proved by type approval, EC design-examination, VdTÜV component or type testing

(9) Fire protection systems (e.g. in the case of wood and pulverized fuel firing systems)
(10) Further proofs and reports, e.g. on checks of fire-proofing measures, safety at work, etc.

Items of equipment on the water and steam side which are relevant to plant safety:

(1) Measuring and indicating instruments for water level, pressure, temperature, water and steam flow rates: attachment, arrangement and function in due consideration of the plant mode of operation (manual and/or automatic operation):
(2) Operational controls, also in case of automatically controlled steam boilers where manual operation is possible: Arrangement and functioning to conform to operating requirements
(3) Devices for limiting water level, pressure, temperature, furnace temperature and flow rate; controls only if they have safety functions: assessment of reliability and ascertainment of trip set points of limiters:
(4) Instruments for monitoring water quality (e.g. turbidity, conductivity, hardness, pH value)
(5) Feed pumps:
Pumping capacity and differential pressure to conform to nameplate marking or data sheets; type of drive; readiness for change-over in case of electric drive with possibility to change over to second net, where required; readiness for operation of standby pumps
(6) Circulating pumps:
Pumping capacity and differential pressure to conform to nameplate marking or data sheets; type of drive; response of alarm system if minimum flow rate is less than required; readiness for change-over in case of electric drive with possibility of change-over to second net, where required
(7) Safeguards against excessive pressure:
set pressure; sufficient discharge capacity to conform to documentation; safeguarding against unintentional adjustment, drainage
(8) Pressurization devices for hot water boiler plants with external pressure generation: ascertainment of trip set points and check of change-over function, where required
(9) Check valves, isolation and drain devices: identification; operability; safeguarding of valve bodies against excessive pressure in the case of gate valves with pressure sealed covers.

Items of equipment of the firing system relevant to plant safety, as regards design and functioning:

(1) Items of equipment of fuel tanks
(2) Safety devices of fuel oil heaters
(3) Fuel lines and devices including valves for easily flammable and all pulverized, liquid and gaseous fuels
(4) Quick-closing devices/valves and leak tightness control devices
(5) Fuel feeding devices and burner; shut-off and regulating devices for combustion air; air fail-safe devices; ignition devices; flame monitoring devices; fuel-air ratio controls; safety devices initiating shut-off in consideration of the possible mode of operation; safety, waiting, purge and ignition periods;
(6) Furnace observance ports, burner linings and flame pattern
(7) Measuring and indicating instruments for air pressure and static head.

Electrical safety circuit:
The safety circuit shall be checked for possible defects that cannot be detected during functional testing of the equipment parts. To this end, the following is required:

(1) a check whether the output contacts are correctly fused and line sections are dimensioned accordingly,
(2) a check of the correct wiring of monitors and limiters,
(3) a visual examination of proper installation of lines and wiring
(4) a check whether the operating conditions correspond to the design assumptions
(5) a documentation of the total of checks performed in the case of safety-relevant electronic controls

Mode of operation:

(1) availability of feed water for steam generators or make-up water for hot water generators, with the water quality corresponding to the respective guidelines
(2) observance of the respective performance characteristics (e.g. firing rate, steam and heat output)

4.1.3 Additional requirements for pressure vessel installations

The accredited inspection body/competent person shall ascertain whether

(1) the pressure vessel is correctly identified,
(2) the pressure vessel has been provided with a test mark/check note,
(3) the documents presented for the first putting into service* relate to the pressure vessel to be inspected.

In addition to clause 4.1.1 the accredited inspection body/competent person shall check

(1) the suitability and correct indication of pressure and temperature measuring instruments,
(2) on firing systems for liquid, gaseous or pulverized fuels the suitability and setting of safety devices used for maintaining the allowable operating temperature of the pressure vessel and for avoiding deflagrations,
(3) on waste-gas or electrically heated pressure vessels the suitability and setting of devices used for maintaining the allowable operating temperature of the pressure vessels, in the case of combustible waste gases the devices used for preventing ignition,
(4) whether other valves, measuring and control devices serving the operation of the pressure vessel impair the function of the required items of safety-relevant equipment, especially with respect to the fluids to be discharged and their safe discharge; where these items of equipment are driven or actuated electrically or electronically, also their functioning, even in the case of loss of energy, e.g. by simulation; should this be the case, the accredited inspection body/competent person shall check whether and how this impairment has been taken into account,
(5) connecting lines between pressure vessels and their items of equipment whether the functioning of safety-relevant items of equipment can be affected by the connecting lines; should this be the case, the accredited inspection body/competent person shall check whether and how this impairment has been taken into account,
(6) the orderly erection/installation as regards the specific requirements arising e.g. from environmental conditions, such as protective measures during start-up, prevention of ground water-induced buoyancy, corrosion (e.g. cathodic corrosion protection).

4.1.4 General requirements for piping

The accredited inspection body/competent person shall ascertain whether

- the piping is identifiable,
- the required documents on tests/inspections performed by the manufacturer or the acceptance test performed by the notified body are available for the piping to be examined,
- the required certificates, e.g. on the orderly storage, examination of the corrosion protection system, examination of electrical installations in potentially explosive areas are available.

In addition to clause 4.1.1 the accredited inspection body/competent person shall check:

(1) the fabricated or installed piping as regards the assembly, installation and erection conditions
(2) the safety-relevant items of equipment as regards their correct selection for the intended use, correct installation, dimensioning, arrangement and functioning unless certified by the plant manufacturer. In this case, the safe discharge of gases, dust and liquids from safety devices shall be checked,
(3) whether other valves, measuring and control devices serving the operation of the piping impair its safety or the function of the required items of safety-relevant equipment,

(4) whether the functioning of items of equipment having safety functions, which are driven or controlled by external energy (e.g. electrical, pneumatic, hydraulic), is still maintained in case of loss of energy or whether impairment of the functions by loss of energy has appropriately been taken into account,
(5) on trace-heated piping, the suitability and adjustment of devices used to maintain the allowable operating temperature of the piping.

4.2 Tests and inspections prior to putting into service* upon a change

Acc. to §12 (2) of the Ordinance on Industrial Safety and Health (BetrSichV) the following applies:

“Plants liable to supervision shall only be put into service again upon a change if they correspond to the state-of-the-art as regards the plant parts subjected to such change.“

In this case, an inspection prior to putting into service* upon a change is required to satisfy §14 (2) BetrSichV. Referring to the plant parts affected by such change the inspection shall be performed analogously to clause 4.1 in due consideration of TRBS 1201-2.

Acc. to §2 (5) BetrSichV the following applies: ”A change of a plant liable to supervision for the purpose of this ordinance is any measure by which plant safety is affected. Any maintenance work by which plant safety is affected is also considered a change.“

Repair measures should be agreed with the manufacturer and shall be agreed with the accredited inspection body/competent person. Related tests and inspections upon such repair shall be agreed with the approved inspection body/competent person.

Changes in component type or mode of operation by which plant safety is affected require a permission to §13 BetrSichV.

5 Periodic inspections on steam boiler plants and related components

The periodic inspection of a shell boiler plant consists of a plant inspection and an inspection of the plant parts/components

5.1 Plant inspection

The shell boiler plant shall be subjected to a plant inspection within the limits fixed by the employer/user in his risk assessment/safety evaluation. The plant inspection consists of an inspection of good order and a technical inspection.

5.1.1 Inspection of good order

During the inspection of good order (cf. TRBS 1201 and TRBS 1201-2) it shall be checked whether the mode of operation (e.g. pressure and temperature) corresponds to the intended mode of operation laid down in the risk assessment/safety evaluation and the requirements of the permission. In this case, the orderly documentation of maintenance work shall be checked as to which extent the safety of pressure-retaining walls of the pressurized plant or the plant component has been influenced.

During the inspection of good order within periodic inspections, the documentation shall be examined for availability and conclusiveness with special emphasis to be placed on former inspections. In the case of periodic inspections of good order it shall especially ascertained whether

(1) the type or the mode of operation has been changed since the last inspection according to statements made by the employer/user (not only safety relevant changes)
(2) maintenance work has been performed according to statements made by the employer/user, which may impair plant safety

(3) the prescriptions, if any, laid down by the authorities in the licence or permission have been satisfied
(4) the required documents (e.g. documentation on former inspections, such as inspection prior to putting into service*, periodic inspections, inspections as ordered, and specific inspections under the responsibility of the manufacturer) are available
(5) the requirements as to type, extent and periods of inspection have been defined and satisfied.

Where changes were made on the plant, the respective documentation for the changed plant component shall be submitted.

During the inspection of good order the documents submitted for the inspection prior to first putting into service*, upon an essential change or change of equipment and facilities need only be examined to the extent required for performing the technical inspection.

During the inspection of good order the operational records shall be checked for observance of the prescriptions, e.g. laid down in operating instructions.

5.1.2 Technical inspection

Besides the visual inspection for detecting anomalous or dangerous plant conditions, the technical inspection also covers the examination for functional capability of common safety-relevant items of equipment, e.g. PLT protective devices or the ascertainment that protective and safety distances have been observed.

5.2 External inspection of plant parts

During the periodic external inspection random checks will suffice if the accredited inspection body/competent person is able to evaluate the safe condition of the plant components on the basis of the inspection results and the available documentation on plant condition.

5.2.1 Visual inspection

The following steps shall be followed during visual inspection:

(1) Visual inspection of boiler components and hot water expansion vessels accessible during operation, of the furnace via observation ports, of the boiler steel structure, the supports and boiler cradle support, heat insulation, covers, access openings, inspection openings and for the detection of leakage, condensation water, discolouration, and vibrations
(2) Visual inspection of the firing system and of the fuel supply systems, fuel feed, storage and preparation facilities, air lines, air pre-heaters, flue gas ducts, ash handling plants and control for inadmissible deposits of coal, dust and wood dust, and of explosion flaps, if any.
(3) Visual inspection of the feed water, steam, hot water, discharge and drain lines as well as of the silencers of the safeguards against excessive pressure
(4) Visual inspection of corrosion, freeze and fire protection systems
(5) Visual inspection of boiler room condition

5.2.2 Inspections of items of equipment having safety functions and of related I&C systems

The inspection of items of equipment having safety functions and of related I&C systems covers:

- inspections of safety-relevant components
- testing of protective logic (lock-off function) of safety-relevant components

Items of equipment on the water and steam side which are to be provided according to the fabrication requirements and are safety-relevant:

(1) devices for limiting water level, pressure, temperature, furnace temperature, and flow rate as regards their functioning; controllers only if they have safety functions
(2) feed pumps: readiness for change-over in case of electric drive with possibility to change over to second net, where required; readiness for operation of standby pumps

(3) circulating pumps: response of alarm system if minimum flow rate is less than required; readiness for change-over in case of electric drive with possibility to change over to second net, where required
(4) safeguards against excessive pressure: set pressure; functioning; safeguarding against unintentional adjustment
(5) pressurization devices for hot water boiler plants with external pressure generation; ascertainment of trip set points and check of change-over function, where required
(6) check valves, isolation and drain devices; safeguarding of valve bodies against excessive pressure in the case of gate valves with pressure sealed covers.

Items of equipment of the firing system, which are to be provided according to the fabrication requirements and are safety-relevant, as regards their functioning:

(1) items of equipment of fuel tanks
(2) safety devices of fuel oil heaters
(3) fuel lines and devices including valves for easily flammable and all pulverized, liquid and gaseous fuels
(4) safety shut-off devices, where required also leak tightness check, as well as leak tightness control devices
(5) fuel feeding devices and burner; shut-off and regulating devices for combustion air; air-failsafe devices; ignition devices; flame monitoring devices; fuel-air ratio controls; safety devices initiating shut-off in consideration of the possible mode of operation; safety, waiting, purge and ignition periods
(6) furnace observation ports, burner linings and flame pattern
(7) induced and forced-draught fans.

The electrical safety circuit of the steam boiler plant shall be checked for possible defects that cannot be detected during functional testing of the equipment parts. To this end, the following may be required:

(1) a check whether the output contacts are correctly fused,
(2) a check of the correct wiring of monitors and limiters,
(3) a visual examination of proper installation of lines and wiring
(4) a check whether the operating conditions correspond to the design assumptions.
(5) a control of the total of checks performed in the case of safety-relevant electronic components

5.3 Internal inspection of plant components

5.3.1 Shell boilers

The periodic internal inspection shall cover shell boilers, economisers located in the flue gas path, superheaters and, where required, further plant components within the plant boundary laid down in the risk assessment.

The internal inspection shall be performed on the shut down plant. It shall be performed by visual inspection to be supplemented, where required, by using suitable auxiliary means such as inspection devices or by additional simple inspection measures such as wall thickness measurements or surface crack detection.

Random inspections will suffice if the accredited inspection body/competent person are able to evaluate the safe condition of the plant components on the basis of the inspection results and the available documentation on plant condition.

The internal inspection shall generally be performed as follows:

(1) water and steam side walls such as boiler shell and end plates, furnace tubes, reversal chambers, and the like shall be inspected where accessible in due consideration of the type of connections (e.g. welded joints), of knuckles, anchoring (gusset stays, tie rods and the like), of nozzles, tube connections, and access and inspection openings. Deposits shall be evaluated.

(2) flue-gas and fire-side walls and external walls shall be inspected, where accessible, especially furnace tubes, knuckles, inspection openings. Deposits shall be evaluated.
(3) headers shall be inspected internally and externally, where possible. Special consideration shall be given to bolted covers, nozzles, welded joints, knuckles, tube fields and rows as well as hangers, supports, lugs, and expansion possibilities.
(4) tube bundles, connecting lines and piping shall be subject to random external inspection in which case tube bends, bifurcations, the location of tube bundles and their external tube coils, hangers, lugs and expansion possibilities are to be considered.
(5) fittings and valves shall be inspected externally in which case especially the welded joints, extruded outlets, hangers and supports shall be considered. Bodies of water level controllers and limiters and related feed lines, and in addition blowdown valves with ≥ DN 50 shall also be inspected internally.
(6) feed water heaters shall be inspected on the flue gas side; on the water side only if detachable connections are provided. Consideration shall be given to corrosion and especially subdew point temperatures.
(7) pressure expansion vessels shall be inspected on the water and steam side. In the case of membrane-type expansion vessels the internal inspection may be replaced by visual inspection, representative ultrasonic wall thickness measurements and check of the membrane by observing the pressure gauge during vessel draining of the water side compartment
(8) in the case of furnace tubes with temperature measuring points, the tight fit, connection, cabling and cable penetration of the thermocouples shall be checked.

Where damage is suspected on account of the inspection documents established up to that point in time, knowledge gained from visual inspection or other experience made, with the damage not being detectable with the aforementioned procedural steps, supplementary inspection measures exceeding the normal extent of test and inspection will become necessary. Supplementary tests and inspections are, e.g. hydrostatic tests or non-destructive tests making statements on the safe condition of the plant possible. When selecting such test and inspection measures it shall be considered whether the boiler can be inspected internally and the areas to be inspected are accessible.

Where damage is detected, the test and inspection measures to be taken in consideration of boiler capacity, dimensions and type of construction shall be considered in proportion to the components and/or welded joints found to be damaged during visual inspection, and appropriate test and inspection methods/techniques shall apply.

5.3.2 Other pressure equipment

Pressure equipment of the steam boiler plant not covered by 5.3.1, e.g. steam accumulators and related items of equipment, if any, may e.g. be inspected on the basis of VGB Standard S-506.

5.4 Strength testing of plant components

In accordance with TRBS 1201-2, the test pressure shall generally not be higher that during the first strength testing unless a recalculation of the allowable test pressure is made on account of the risk assessment/safety evaluation in consideration of the actual plant condition.

The test pressure (P_P) shall be determined on the basis of the allowable working pressure (P_B) of the plant components and the test pressure factor (F_P):

$P_P = F_P \bullet P_B$

Where higher test pressures than those indicated hereafter are to be applied, care shall be taken to ensure that the loading occurring on pressure-retaining walls is within the allowable range (< 95 % yield strength at room temperature).

Note: It shall be taken into account that the most highly loaded location or the most highly loaded component is the basis for such calculation.

As a rule, the periodic strength test will be performed as hydrostatic test.

5.4.1 Boiler test pressure

According to TRBS 1201-2 cl. 3.4.2.3.3 item c) the following applies:

“The strength tests shall be performed with a test pressure such that the allowable stress under internal pressure is not exceeded in any component or the external pressure is reached at least on one component by approximation.

The allowable stress under internal pressure is 95% of the yield strength at ambient temperature. As a rule, supplementary non-destructive tests on the highly loaded locations are required at a test pressure less than $P_P = 1,85 \bullet P_B$.“ (see explanations in 5.5)

Where the test pressure is to be increased to be higher than the test pressure approved up to that date, an additional design review by the accredited inspection body/competent person will be necessary. The boiler manufacturer should also be consulted when determining the new test pressure. The corrosion and wear allowances need not be deducted when determining the test pressure if no large surface area corrosion is present.

5.4.2 Test pressure of other shell boiler plant components:

For isolatable feed water heaters and isolatable superheaters and related components consisting only of seamless or welded headers and tubes, the test pressure P_P shall be as follows:

$P_P = 1,3 \bullet P_B$

The following possibilities exist regarding the test pressure P_P for non-isolatable feed water heaters and non-isolatable superheaters and related components if they consist only of seamless or welded headers and tubes:

(1) a common strength test of boiler and feed water heater and / or superheater in which case the test pressure of the feed water heater and/or superheater shall be equal to that of the boiler. This procedure is optionally applicable to isolatable feed water heaters and / or superheaters.

(2) separate strength test of boiler analogously to 5.4.1 and feed water and /or superheater analogously to 5.4.2

Other steam boiler plant components may e.g. be inspected on the basis of VGB Standard S-506.

5.4.3 Performance of strength testing

Boiler insulations need not be removed for this hydrostatic test.

Boiler shutdown for hydrostatic testing shall be performed according to the operating instructions. Filling the boiler with test water shall not cause damage on the pressure-retaining walls.

The water used for filling the boiler shall not contain coarse impurities. Taking the operating conditions into account, the water shall not contain any constituents attacking or polluting the walls. The filling water temperature shall not exceed 50 °C during strength testing and inspection.

The test pressure should be applied in the presence of the accredited inspection body/competent person at two subsequent loadings with a nearly complete depressurization between the two load stages. If the manufacturer does not prescribe other values, the rate of pressure change shall not exceed 10 bar per minute to reach up to approx. 75% of the test pressure, and above that value shall be approx. 1 to 2 bar per minute. The test pressure shall be applied for at least 30 minutes before reducing it to a residual pressure (nearly 0 gauge bar) and be maintained at this level for at least 10 minutes. Then the second load application shall follow for at least 30 minutes before the approved inspection body/competent person begins with the inspection. At this stage, the test pressure should be slightly less (not more than 0,5%) than the test pressure of the first load application. Depressurization during the last third stage of pressure reduction shall be performed slowly.

Components set under pressure shall be inspected for the presence of cracks, inadmissible deformation or leakage.

Random inspections are only permitted if the accredited inspection body/competent person is able, by the inspection results obtained, to assess the safe condition of the plant. In case of well founded suspicion of damage, heat insulations shall be removed to an admissible extent.

During the subsequent internal inspection the respective welded joints shall be inspected. Should the required minimum pressure not be reached, supplementary non-destructive tests to clause 5.5 shall be performed.

5.5 Supplementary tests and inspections on shell boilers within internal inspection

Prior to each internal inspection a strength test to clause 5.4.2 and 5.4.3 is recommended to better recognize damage, if any, on the boiler. This also includes the detection of damage, if any, caused by load cycling. Otherwise, highly loaded locations shall be subject to non-destructive testing to 5.5.2 and 5.5.3 during the internal inspection.

Upon repair work on pressure-retaining components the following supplementary tests shall be performed:

- a pressure test at the pressure indicated in 5.4.1 and
- additional non-destructive tests at the locations of repair. Where testability of such locations is required for visual examination and non-destructive tests, these areas shall be ground.

	Test supplementing the internal inspection to §15BetrSichV	**Hydrostatic test to §15 BetrSichV**
Placing on the market prior to May 2001	Hydrostatic test with max. test pressure or Surface crack detection	Hydrostatic test with max. test pressure and if $P_P < 1.85 \bullet P_B$, than additional MT
Placing on the market as of May 2001	Hydrostatic test with max. test pressure and if $P_P < 1.85 \bullet P_B$, than additional MT, and UT on inaccessible locations	Hydrostatic test with max. test pressure and if $P_P < 1.85 \bullet P_B$, than additional MT, and UT on inaccessible locations

Table 1: Dependence of tests and inspections on the type of inspection to BetrSichV and on the point in time of placing the boiler on the market

5.5.1 Hydrostatic test

The hydrostatic test shall be performed in acc. with 5.4.1 und 5.4.3.

5.5.2 Surface crack detection

Steam boilers first placed on the market as of May 2001 where the ratio of test pressure to working pressure is less than 1.85, shall be subjected to magnetic particle testing for surface crack detection at the highly loaded locations in addition to the supplementary hydrostatic test. Where the steam boiler is accessible to a limited extent only, ultrasonic tests shall be performed at the highly loaded locations.

In lieu of the supplementary hydrostatic test, a magnetic particle test for surface crack detection at the highly loaded locations may be performed on request by the employer/user on steam boilers placed on the market before May 2001.

Upon agreement with the accredited inspection body/competent person the employer/user may agree on other equivalent tests/inspections to be performed.

5.5.3. Ultrasonic tests

The areas to be examined shall be testes ultrasonically at least every three years in accordance with clause 5.5.4.

For steam boilers made to the agreement VDK 003, these tests may be waived upon request by the employer/user if the boilers have been tested in acc. with clause 5.5.1 or 5.5.2. This also applies to boilers placed on the market prior to 2012, and which meet the requirements of the agreement on steam boilers 2003/1. Where required, the fulfilment of the requirements of these agreements on steam boilers made between the respective associations shall be ascertained by the accredited inspection body/competent person.

5.5.4 Areas to be examined by the tests and inspections to clauses 5.5.2 and 5.5.3

5.5.4.1 Welded joints between set-in unflanged flat end plate and boiler shell

The welds between set-in unflanged flat end plate and boiler shell shall be inspected in the areas of largest unstayed surfaces, at the location of smallest distance between furnace tube and boiler shell as well as in the area of influence of the ends of gusset stays.

5.5.4.2 Welded joints between set-on unflanged flat end plate and boiler shell

The welds between set-on unflanged flat end plate and boiler shell shall be inspected over their full length.

5.5.4.3 Welded joints on gusset stays

Welded joints on gusset stays shall be completely inspected.

5.5.4.4 Furnace tube-to-end plate joints

Furnace tube-to-end plate joints shall be inspected at the location of smallest distance to the boiler shell and in the case of twin-furnace boilers additionally at the location of smallest distance between the two furnace tubes as well as in the area of influence of the ends of gusset stays.

5.5.4.5 Welded joints on other main load-bearing stayings

These are e.g. welded joints of gusset stays and stay tubes to mutually anchor boiler end plate and reversal chamber. These welds shall be inspected over their full length.

5.5.4.6 Longitudinal welds of boiler shell

Boiler shell longitudinal welds shall be inspected if $P_P < 1{,}25 \cdot R_{p0,2/TR} / R_{p0,2/TS} \cdot P_B$

5.5.4.7 Other highly loaded areas

These cover the areas of influence *of* ends of gusset stays, peaking, end plate ring stiffeners.

6 Inspection periods

The inspection period for the external inspection shall be one year at maximum, in the case of operation without permanent supervision exceeding 24 hours it shall be 6 months at maximum.

Independently of the design and the operating conditions, the inspection period for internal inspections including the supplementary inspection measures described in this agreement shall be 3 years at maximum and for the strength test shall be 9 years at maximum in consideration of clause 5.5.1.

The inspection periods shall be determined by the employer/user on the basis of the risk assessment/safety evaluation in consideration of the operating instructions and shall be supervised by the accredited inspection body. Where the requirements of the agreement on steam boilers VDK 003 have been met, or in case of boilers placed on the market by the end of 2011, the requirements of the agreements 1994/1 and 2003/1 have been met, an inspection period of 3 years shall apply. Where the requirements of the agreement on steam boilers VDK 003 are not met, an extension of the inspection period for the internal inspection by more than one year can be approved only if permitted by the risk assessment/safety evaluation.

In dependence of the results of the external and internal inspections and the strength test as well as in case of special operational influences (e.g. safety-relevant boiler scale, oil contained in boiler water, large cohesive corroded surfaces in the areas of welds to be inspected), other inspection periods may become necessary.

In accordance with BetrSichV §15 (17) the competent authority may, in individual cases, extend the inspection periods prescribed by BetrSichV §15(5) and indicated hereafter if safety is ensured by other means. Where required to protect employees or third persons, the competent authority may, in individual cases, also shorten the inspection periods as provided by BetrSichV §15(17).

7 Documentation of tests and inspections and of damage

The tests and inspections shall be documented in acc. with TRBS 1201 clause. 4.2.

In case of damage, additional damage reports shall be established by the approved inspection body/competent person, which shall contain the following:

a) boiler description, type of construction, heating surface, nominal capacity, allowable working pressure, allowable operating temperature, year built, type of heating system etc. ;
b) operating conditions of the steam boiler plant (mode of operation, feed water treatment, firing system control, operating times);
c) information on boiler condition ascertained (boiler scale, chemical cleaning, corrosion, etc.);
d) detailed description of damage (e.g. in case of cracks: location of crack initiation, depth and length, propagation and location).

For the purpose of documenting damage, pictures (e.g. photographs, sketches) should be added to the documents.

Notes on the determination of cause of damage, removal and preventive measures are shown in the Annex.

The results of the periodic strength test or supplementary inspections within the internal inspection on shell boilers performed by the accredited inspection body/competent person will be recorded centrally and evaluated by VdTÜV. A neutral statistics derived from this evaluation will be submitted to the associations having taken part in the establishment of this agreement.

8 Literature

DIN EN ISO 10628: 2000	Flow diagrams for process plants - General rules
DIN EN 50156-1 VDE 0116-1:2005-03	Electrical equipment for furnaces and ancillary equipment. Part 1: Requirements for application design and installation

Directive 97/23/EC of the European Parliament and the European Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment , transposed into German Law by the 14th Ordinance on Product Safety – Pressure Equipment Ordinance

Technical Rules for Operational Safety TRBS 1201:	Inspection of work equipment and plants liable to supervision
Technical Rules for Operational Safety TRBS 1201 Part 2:	Inspections in case of hazards arising from steam or pressure
Technical Rules for Operational Safety TRBS 1203:	Competent persons

Ordinance on industrial safety and health when providing work equipment and on its utilization during work, on safety during operation of plants liable to supervision, and on the organisation of industrial safety (Ordinance on Industrial Safety and Health – BetrSichV)

Agreement Steam Boiler 1994/1:	Guideline for the assessment of shell boiler designs (July 1994)
Agreement Steam Boiler 2000/1:	Guideline for supplementary tests and inspection within the periodic internal inspections on shell boilers or similar boiler types
Agreement Steam Boiler 2003/1:	Guideline for the assessment of shell boiler designs
Agreement Steam Boiler 003: 2011-01	Guideline for the assessment of shell boiler designs (January 2011)
VGB S-506-R-00;2012-03-EN	Condition monitoring and inspection of components of steam boiler plants, pressure vessel installations and high-pressure water and steam pipes

9 Former agreements and effective date

This agreement shall replace the agreement 2000/1.

This agreement shall apply to all steam boilers as of its date of publication.

Bundesindustrieverband Deutschland Haus-, Energie- und Umwelttechnik e. V.

Cologne, 30th August 2013

Signed Lücke

VGB PowerTech e.V.

Essen, 12th August 2013

Signed: Christensen

VdTÜV Verband der Technischen Überwachungs-Vereine e.V.

Berlin, 18th September 2013

Signed: Dr. Brüggemann

FDBR e. V. Fachverband Anlagenbau

Düsseldorf, 10th September 2013

Signed: Dr. Maaß

Annex

Determination of cause of damage, removal and protective measures

The operational factors of influence shall be considered in more detail as they may be the cause of damage. In this case, information on operational parameters such as load cycling and rate of load changes of the steam boilers, and the control and operational behaviour of the firing systems during start-up and duty operation will be clear indications of causes of damage.

In addition, thermally induced precipitations, hardness scales and deposits on account of insufficient boiler and feed water qualities and/or lacking maintenance and care of operational equipment will be identified as causes of damage, such as boiler scale on wall areas subject to high thermal loadings, ingress of foreign matter (grease, alkaline solutions, oil) as well as corrective chemicals on the water side with similar characteristics, which may damage steam boiler components or cause safety equipment failure.

Operational and plant engineering conditions may especially be considered cause of damage, such as:

(1) insufficient flow rates in hot-water boilers;
(2) too great temperature differentials;
(3) start-up from cold condition with too high temperature gradients or too high burner output;
(4) insufficient shutdown heating;
(5) frequent burner on-off operations;
(6) heating surface deposits, especially silica, oil, grease, milk, or boiler scale;
(7) insufficient chemical treatment of water,
(8) unsuited follow-up control and circuitry arrangement in multi-boiler plants.

Prior to repair work the manufacturer should be consulted for proposals as to repair work in order to take advantage of his experience. If proposals are made by the manufacturer, they shall be taken into account.

Depending on the cause of damage, measures for preventing damage shall be agreed upon between the employer/user, accredited inspection body/competent person and manufacturer.