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Planning guide for steam boiler systems

Bosch Industriekessel

Plan professionally and design efficiently

Buhar kazanı sistemleri için planlama kitabı

profesyonelce planla, verimli tasarla

- 150 yıldan fazla tecrübenin toplandığı
- Planlamadan, işletime tüm süreci kapsayan
- İnteraktif bir şekilde tasarlanmış

https://www.bosch-thermotechnology.com/global/media/country_pool/service/technical-guides/steamboiler.pdf

Planlama:
Kazan kapasitesinden yakıt seçimine varan kapsamlı tavsiyeler

Hata Önleme:
Su kalitesi, yakma yönetimi, tesisat ile ilgili detaylar

Teknoloji:
Buhar tipleri, kullanıldığı alanlar ve güncel bilgiler

Verim:
Yanma verimi, ekonomizör ve daha birçok verimlilik artırıcı önlemler

Ürünler:
Bosch Industriekessel buhar sistem çözümleri

Araçlar:
Birim dönüştürme, yakıt karakteristiği, blöf oranı gibi interaktif hesap tabloları

Buhar ile ilgili akla gelen tüm konular için…

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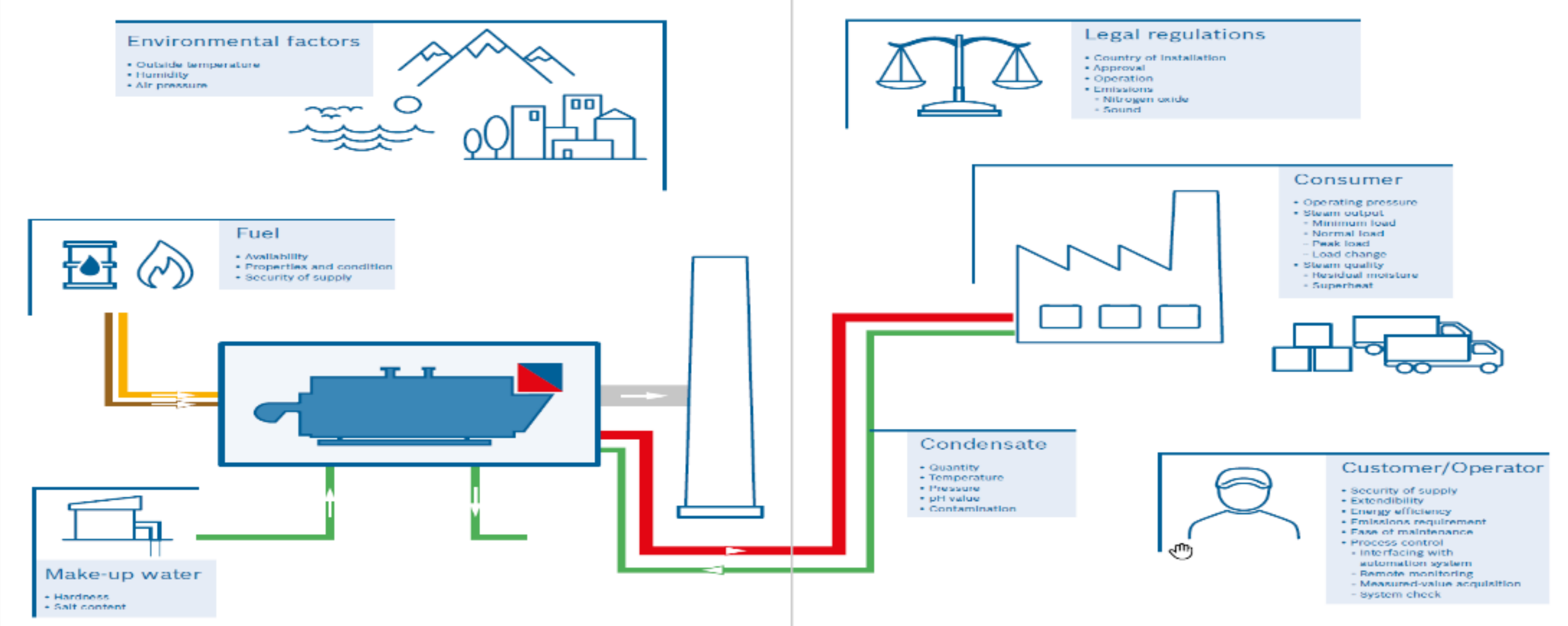


Environmental factors
- Outside temperature
- Humidity
- Air pressure

Legal regulations
- Country of installation
- Approval
- Operation
- Emissions
  - Nitrogen oxide
  - Sound

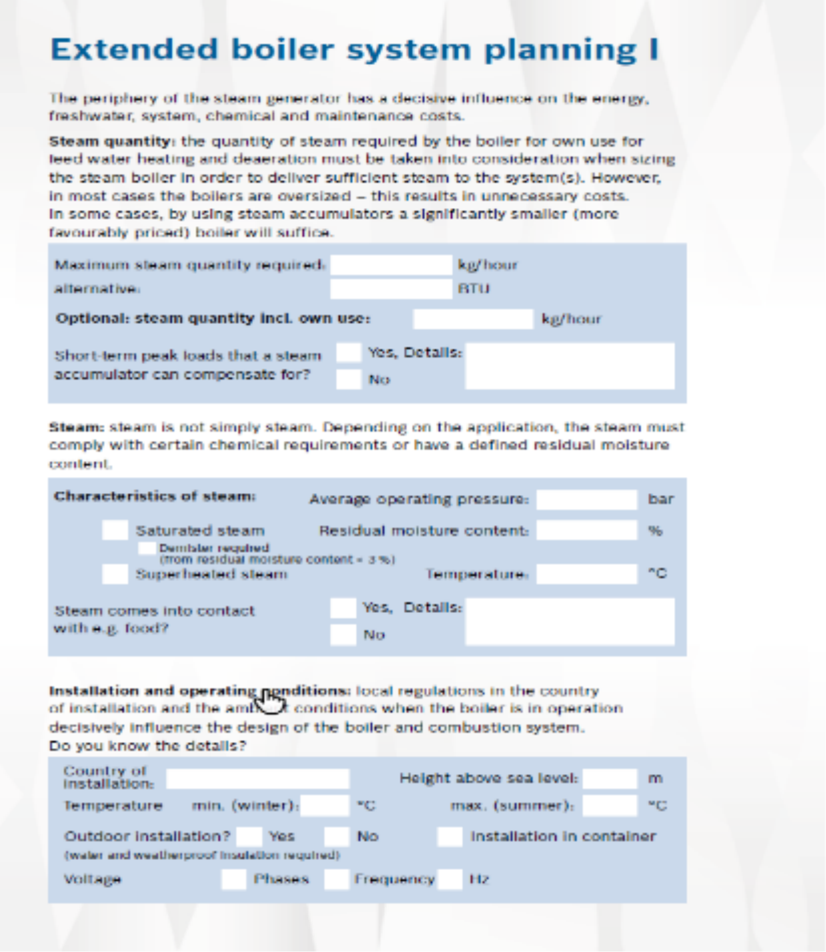
Fuel
- Availability
- Properties and condition
- Security of supply

Consumer
- Operating pressure
- Steam output
  - Minimum load
  - Normal load
  - Peak load
  - Load change
- Steam quality
  - Residual moisture
  - Superheat

Condensate
- Quantity
- Temperature
- Pressure
- pH value
- Contamination

Make-up water
- Hardness
- Salt content

Customer/Operator
- Security of supply
- Extendibility
- Energy efficiency
- Emissions requirement
- Ease of maintenance
- Process control
  - Interfacing with automation system
  - Remote monitoring
  - Measured-value acquisition
  - System check



Extended boiler system planning I

The periphery of the steam generator has a decisive influence on the energy, freshwater, system, chemical and maintenance costs.

Steam quantity: the quantity of steam required by the boiler for own use for feed water heating and deaeration must be taken into consideration when sizing the steam boiler in order to deliver sufficient steam to the system(s). However, in most cases the boilers are oversized – this results in unnecessary costs.
In some cases, by using steam accumulators a significantly smaller (more favourably priced) boiler will suffice.

Maximum steam quantity required: ☐ kg/hour
alternative: ☐ BTU
Optional: steam quantity incl. own use: ☐ kg/hour
Short-term peak loads that a steam accumulator can compensate for? ☐ Yes, Details: ☐ ☐ No

Steam: steam is not simply steam. Depending on the application, the steam must comply with certain chemical requirements or have a defined residual moisture content.

Characteristics of steam: Average operating pressure: ☐ bar
☐ Saturated steam Residual moisture content: ☐ %
☐ Demister required (from residual moisture content < 3 %)
☐ Superheated steam Temperature: ☐ °C
Steam comes into contact with e.g. food? ☐ Yes, Details: ☐ ☐ No

Installation and operating conditions: local regulations in the country of installation and the ambient conditions when the boiler is in operation decisively influence the design of the boiler and combustion system.
Do you know the details?

Country of installation: ☐ Height above sea level: ☐ m
Temperature min. (winter): ☐ °C max. (summer): ☐ °C
Outdoor installation? ☐ Yes ☐ No ☐ Installation in container
(water and weatherproof insulation required)
Voltage ☐ Phases ☐ Frequency ☐ Hz

2 Pressure

Excess pressure and absolute pressure

In steam boiler technology, it is customary for all pressures to be stated as excess pressure relative to an atmospheric pressure of 1 bar.

The unit [bar] or [barg] is used at these points.

The excess pressure is therefore converted to absolute pressure as follows:

$$p_{absolute} = p + 1.01325 \text{ bar}$$

F1. *Conversion from excess pressure to absolute pressure*

Normal temperature and pressure and standard temperature and pressure

Normal temperature and pressure (according to DIN 1343):
p_n = 101,325 Pa = 1.01325 bar = 1 atm
T_n = 273.15 K = 0 °C

Standard temperature and pressure (STP, IUPAC):
p° = 100,000 Pa = 1.0 bar
T° = 273.15 K = 0 °C

Standard ambient temperature and pressure (SATP, IUPAC):
p° = 100,000 Pa = 1.0 bar
T° = 298.15 K = 25 °C

F2. *Normal temperature and pressure and standard temperature and pressure*

2.1 Average operating pressure

The operating pressure of a boiler system is not a constant value, and instead fluctuates around the average operating pressure p_{avg}. The reason for this is that the operating pressure in the steam boiler is used as the input variable for the output regulation of the steam boiler system and therefore fluctuates in a range of roughly ±10 % of the average operating pressure used as the set value.

3 Steam output

The most important data is obtained from the performance data of the individual steam consumers. However, the internal consumption of the steam boiler system must also be taken into consideration, especially for heating up and deaerating the make-up water and condensate, surface blowdown and heat losses in the pipework.

When determining the necessary steam output of the boiler system, additional factors such as the simultaneity of the maximum outputs of the individual consumers, the maximum loading rate and purely technical aspects that can often only be measured with difficulty, such as security of supply or possible extensions, must also be considered.

The typical steam output distribution is shown below. The calculation of the precise project-specific consumption is described in the following chapter.

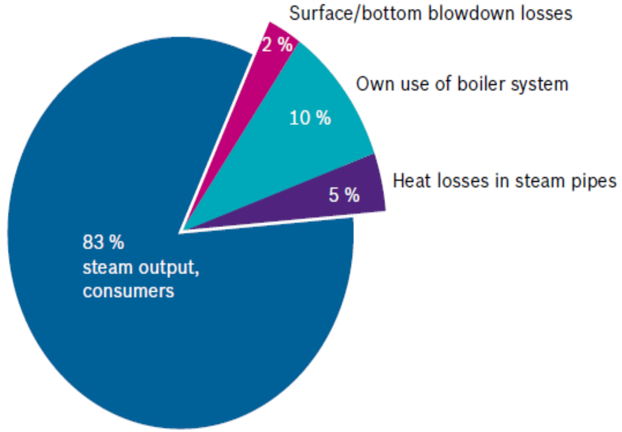


Fig. 7 *Illustration of the correlation between the nominal steam output of the boiler and the steam output at the consumers (values shown are examples)*

4 Fuel

The following fuels are used in the majority of steam boiler systems:

- Natural gas
- Fuel oil

The fuels are more or less available everywhere and, as they are to a large extent standardised, have a high quality.

However, other fuels can be used to generate steam:

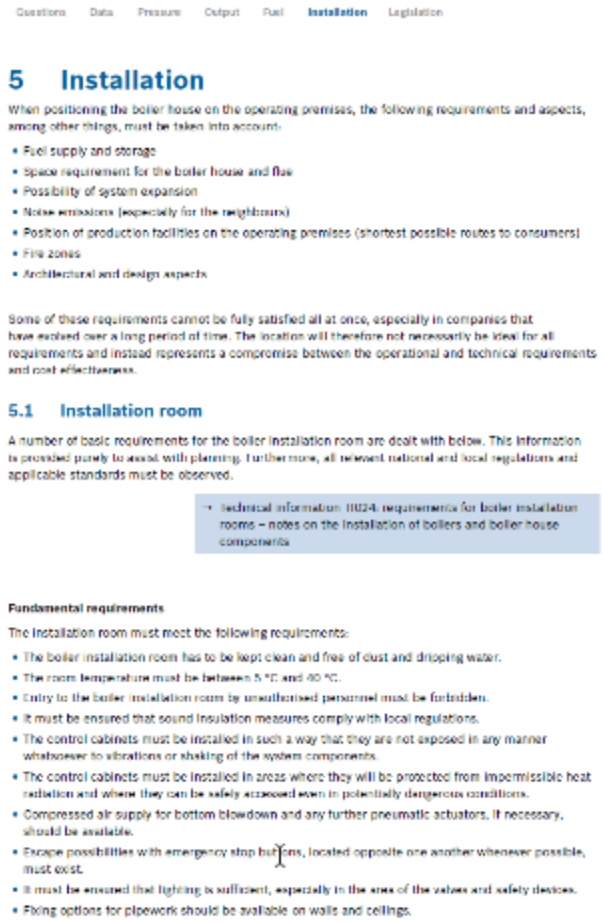
- Heavy oil or medium oil
- Other gases (e. g. hydrogen, LPG, LNG)
- Biofuels (e. g. lean gases, sewage gases and biogases)
- Contaminated by-products from the chemical industry (e. g. styrene, toluene)
- By-products from other industries (e. g. animal fat, fish oil)

The choice of fuel initially depends on the availability at the planned installation location. Oil is delivered via road tanker while for gas a station for gas transfer from the gas distribution system must be available.

If the requirements for security of supply are high, two fuels can also be used at the same boiler. Gas is then normally used as the main fuel and fuel oil as the substitute fuel.

Economy is another important factor in fuel selection. When comparing costs, it must be ensured that exact comparability is possible. When using gas as the fuel, the comparison price can be obtained directly from the gas bill or requested from the gas provider. The fuel oil supply prices are published in the Internet.

→ Planning – Chapter 4.3: Criteria for selection between fuel oil and natural gas, page 56



Questions Data Pressure Output Fuel **Installation** Legislation

5 Installation

When positioning the boiler house on the operating premises, the following requirements and aspects, among other things, must be taken into account:

- Fuel supply and storage
- Space requirement for the boiler house and flue
- Possibility of system expansion
- Noise emissions (especially for the neighbours)
- Position of production facilities on the operating premises (shortest possible routes to consumers)
- Fire zones
- Architectural and design aspects

Some of these requirements cannot be fully satisfied all at once, especially in companies that have evolved over a long period of time. The location will therefore not necessarily be ideal for all requirements and instead represents a compromise between the operational and technical requirements and cost effectiveness.

5.1 Installation room

A number of basic requirements for the boiler installation room are dealt with below. This information is provided purely to assist with planning. Furthermore, all relevant national and local regulations and applicable standards must be observed.

→ Technical information 11024: requirements for boiler installation rooms – notes on the installation of boilers and boiler house components

Fundamental requirements

The installation room must meet the following requirements:

- The boiler installation room has to be kept clean and free of dust and dripping water.
- The room temperature must be between 5 °C and 40 °C.
- Entry to the boiler installation room by unauthorised personnel must be forbidden.
- It must be ensured that sound insulation measures comply with local regulations.
- The control cabinets must be installed in such a way that they are not exposed in any manner whatsoever to vibrations or shaking of the system components.
- The control cabinets must be installed in areas where they will be protected from impermissible heat radiation and where they can be safely accessed even in potentially dangerous conditions.
- Compressed air supply for bottom blowdown and any further pneumatic actuators, if necessary, should be available.
- Escape possibilities with emergency stop buttons, located opposite one another whenever possible, must exist.
- It must be ensured that lighting is sufficient, especially in the area of the valves and safety devices.
- Fixing options for pipework should be available on walls and ceilings.

6 Legislation

Steam boiler systems are usually subject to compulsory monitoring and various legal framework conditions must be observed and complied with when manufacturing the components, during planning and construction and when operating the system. The following requirements are stipulated at all levels of the legislation (and monitoring):

- **European directives and ordinances**, such as the Pressure Equipment Directive, Machine Directive, Low Voltage Directive, Gas Appliances Directive, EMC Directive, Hazardous Substances Directive and Explosion Protection Directive
- **National laws and ordinances**, such as the German Health and Safety at Work regulation, Emission and Immission Control Act, Occupational Health and Safety Law, Hazardous Substances Ordinance, Water Resources Law
- **Regional and local regulations**, such as building regulations, water conservation, fire safety, additional emission requirements

The most important laws, directives, ordinances and standards governing the installation and operation of a steam boiler system are described below. These are arranged in the following groups:

- Manufacturing of boiler systems
- Emission and immission protection laws
- Approval regulations/operating permit
- Operation of boiler systems

In this case it must be observed that further EU directives or national laws and regulations apply.

Failure prevention

Fig. 16 *Impermissible merging of safety valve and expansion steam pipe*

Fig. 17 *If the internal diameter of expansion steam pipes is reduced, this can lead to an increase in pressure and rupturing of the vessel*

Fig. 20 *Holders of safety valve blow-off pipes missing*

Fig. 23 *Water-side deposits on the tube panel and tube plate of the boiler*

1.1.1 Saturated steam or dry saturated steam

Steam which is at the borderline between wet and superheated steam is referred to as saturated steam, also referred to as dry saturated steam, or also sometimes "dry steam" to distinguish it from wet steam. The values stated in steam tables refer to this specific state.

→Tools – Chapter 4.2: Water vapour table, page 388

The physical characteristics of saturated steam are almost always used when designing heat exchangers in practise, or when calculating the steam demand of thermal processes.

However, in reality saturated steam only occurs precisely at the phase boundary. Even if it is only very slightly cooled at the same pressure it turns into wet steam or, if very slightly heated, it turns into superheated steam. If, however, the steam states are close to the phase boundary, the physical characteristics of saturated steam can be used for calculation purposes when designing a steam system.

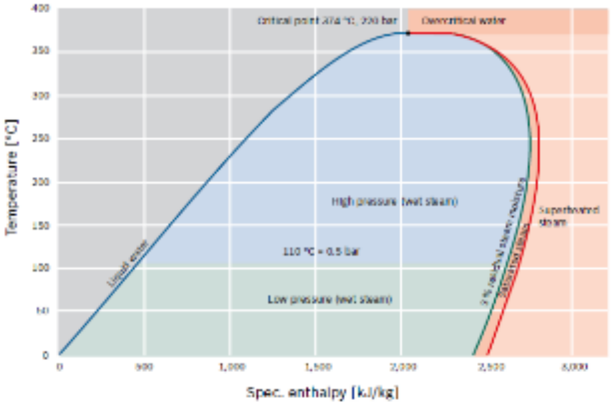


Fig. 35 *Diagram showing states of water or steam in temperature-enthalpy graph (T-h diagram) with the technical designations of the surfaces*

1.1.2 Wet steam

Wet steam is a mixture of the liquid and gaseous phase of water. Steam with a very low mass fraction of water up to approx. 3 % is also referred to in technical circles as saturated steam. This is the most common steam state which is used in industrial systems to heat products.

When steam flows out of the steam boiler, it carries along tiny droplets of water which means the steam has a residual moisture content, i.e. a liquid fraction (1 to 3 % of the total mass). This residual moisture content can be reduced to roughly 0.1 % of the steam quantity when exiting the boiler, by installing steam dryers for example.

$$x = \frac{h - h'}{h'' - h'} = \frac{h - h'}{r}$$

F18. *Equation for calculating the mass fraction of expansion steam*

x	Mass fraction of expansion steam [%]
h	Enthalpy [kJ/kg]
h'	Enthalpy of the boiling water [kJ/kg]
h''	Enthalpy of the saturated steam [kJ/kg]
r	Evaporation enthalpy [kJ/kg]

$$x = \frac{919\ [\text{kJ/kg}] - 782\ [\text{kJ/kg}]}{2{,}780\ [\text{kJ/kg}] - 782\ [\text{kJ/kg}]} = 6.9\%$$

B8. *Example calculation for determining the mass fraction of expansion steam*

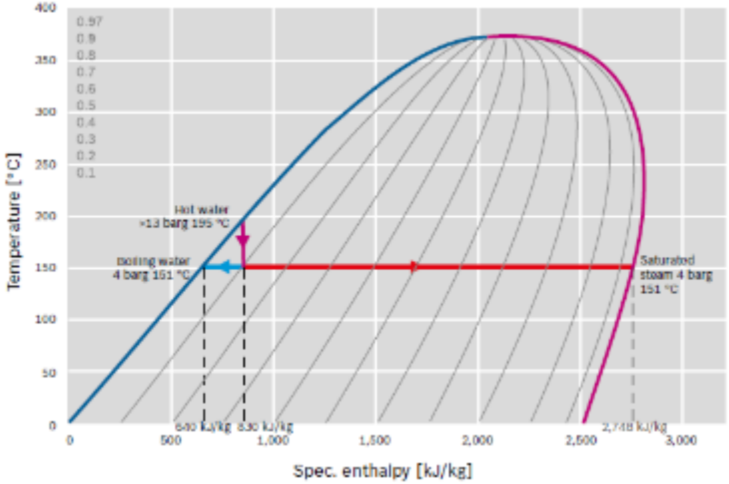


Fig. 38 *Re-evaporation shown in temperature-enthalpy graph (T-h diagram)*

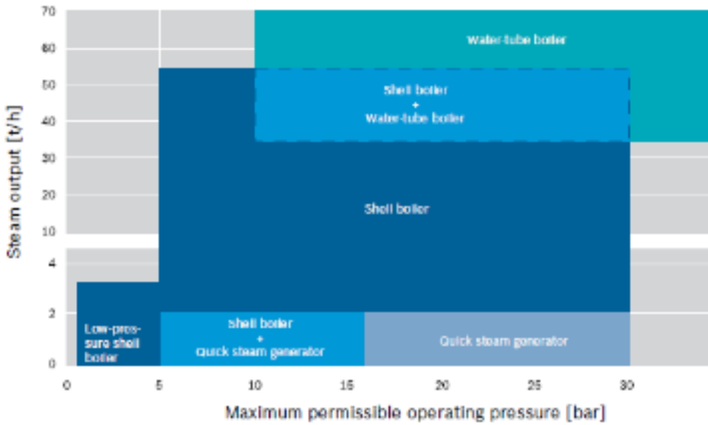


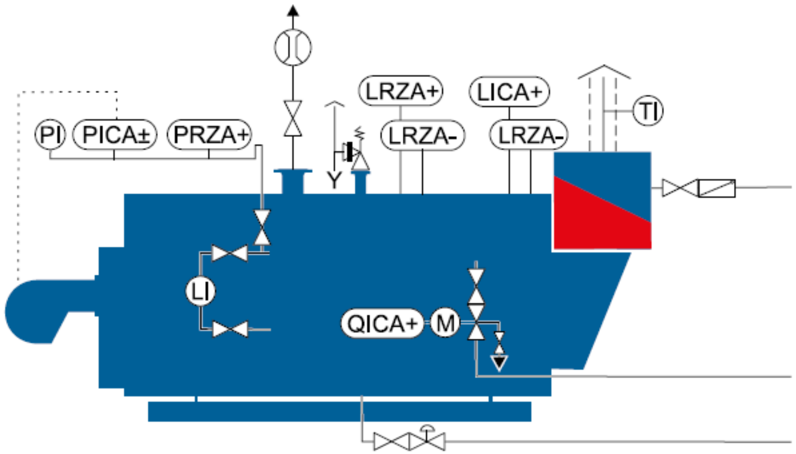
Fig. 39 *Standard areas of application of shell boiler, quick steam generator and water tube boiler types*

	Shell boilers	Quick steam generator
Water content	Large water content	Small water content
Heat-up duration	Longer	Cold start within several minutes
Response to load fluctuations	Damping of load fluctuations of consumers High short-term overload possible when using steam accumulators	High pressure fluctuations even with slight load variations at consumers
Steam moisture	Dry steam	Steam dryer required
Approval of installation and monitoring[1]	Normally subject to mandatory approval and monitoring	The installation and monitoring conditions have been partially eased in the very small output range
Procurement costs	Slightly higher	Lower
Operating personnel[2]	Qualified boiler attendant required[2]	Trained operating personnel required[1]
Maximum steam output	≤ 55,000 kg/h per boiler	≤ 2,000 kg/h per boiler
Efficiency	94 … 105 % therefore ideal for continuous operation	< 90 % therefore only suitable for short-term provision of steam at short notice
Annual degree of utilisation	≤ 95 %	Frequent < 75 %
Service costs	Lower	Higher
Service life	Robust, low wear, therefore durable	Low

Tab. 9 Comparison of quick steam generators with shell boilers

2.2 Equipment and control

The minimum requirements for operation and the safety equipment of steam boilers are set out in EN 12953-6. This includes the primary shut-off valves in the pipework, the safety equipment to safeguard against pressure exceedance and water shortage, heating equipment and all valves and measuring devices required for operation and control. All of this equipment requires an approval in accordance with the Pressure Equipment Directive.



3.1.2 Fan variants of combustion systems

Monoblock burner

Gas supply

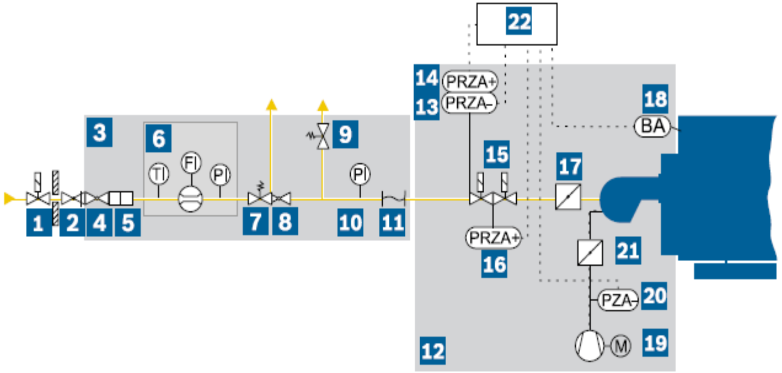


Fig. 59 *Example showing schematic representation of gas combustion (high-pressure supply)*

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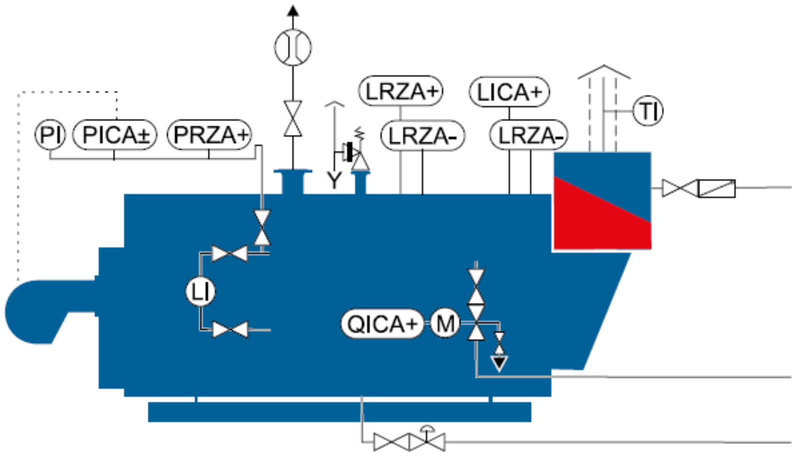

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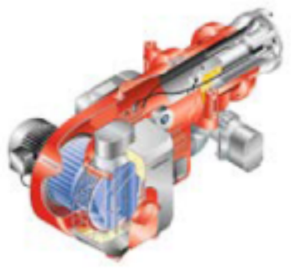


Gas supply

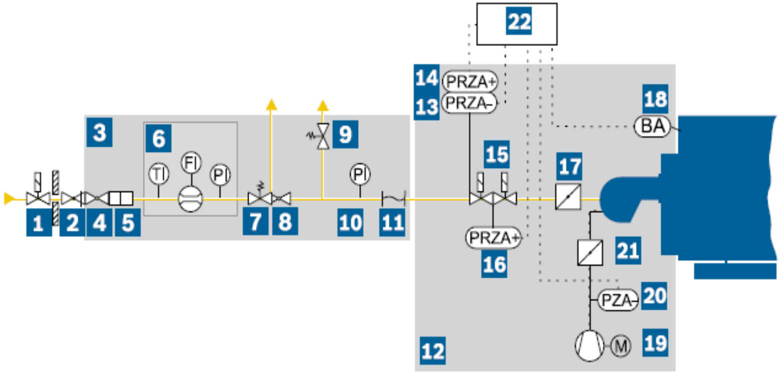
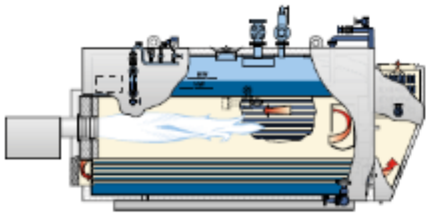


Fig. 59 *Example showing schematic representation of gas combustion (high-pressure supply)*

Integrated economiser

The fully integrated economiser which is directly mounted on the boiler offers benefits especially for new boiler systems. The specially developed heat exchanger bundle with variable size and highly efficient finned tubes is installed as an integral component of the boiler in the flue gas collection chamber, fully insulated and connected directly to the boiler on the water side. Integrated economisers are available for the U-MB, UL-S, ZFR and HRSB boiler series.

An integrated economiser has significant benefits compared to a conventional boiler with separate economiser.



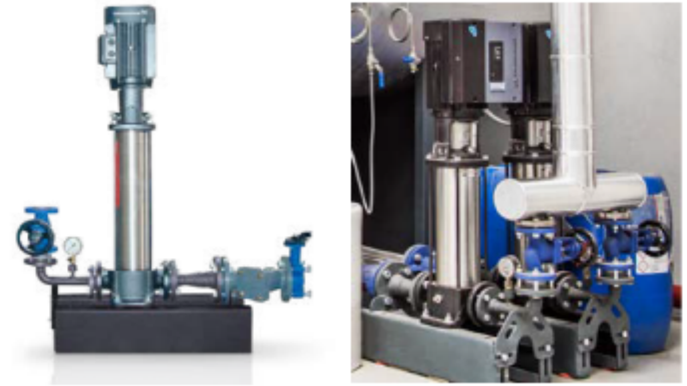


Fig. 70 *Pump module and double module*

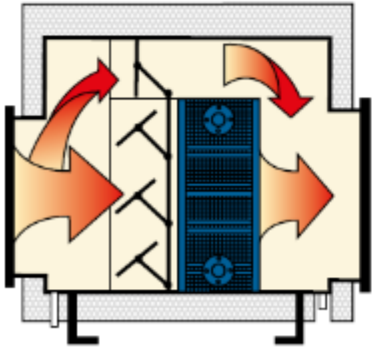
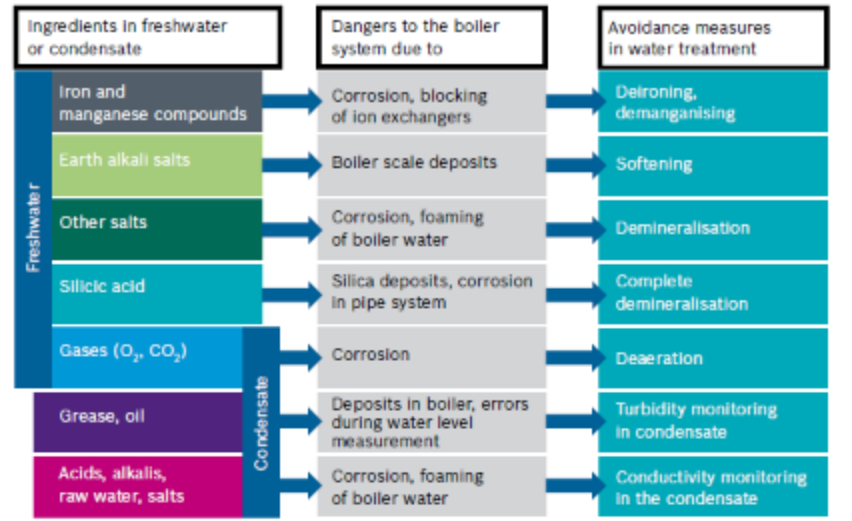


Fig. 68 *Condensing heat exchanger*

Fig. 73 *Double flame-tube boiler with mounted superheater on top*



Ingredients in freshwater or condensate	Dangers to the boiler system due to	Avoidance measures in water treatment
Iron and manganese compounds	Corrosion, blocking of ion exchangers	Deironing, demanganising
Earth alkali salts	Boiler scale deposits	Softening
Other salts	Corrosion, foaming of boiler water	Demineralisation
Silicic acid	Silica deposits, corrosion in pipe system	Complete demineralisation
Gases (O_2, CO_2)	Corrosion	Deaeration
Grease, oil	Deposits in boiler, errors during water level measurement	Turbidity monitoring in condensate
Acids, alkalis, raw water, salts	Corrosion, foaming of boiler water	Conductivity monitoring in the condensate

Fig. 89 *Ingredients of freshwater and condensate*

4.1.2 Softening

Among the substances dissolved in water, hardness is especially harmful to the operation of a boiler system. Hardness mainly comprises calcium and magnesium ions (Ca^{2+}; Mg^{2+}). If these so-called alkaline earth metals are present in the feed water, they can precipitate due to the heating in the boiler and form limescale which is deposited as a layer on the heating surfaces.

Fig. 90 *Layer formation in boiler with damage to flame tube*

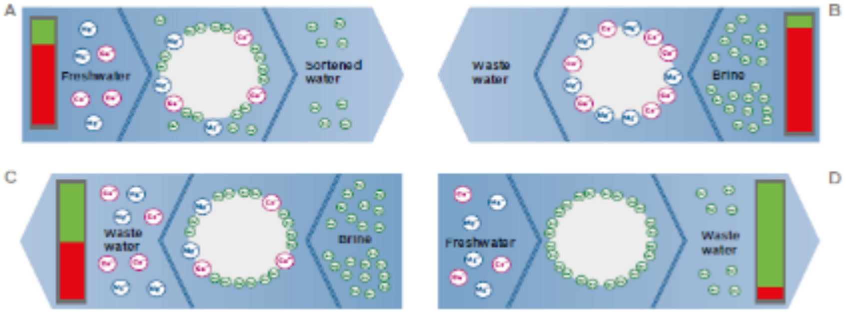


Fig. 91 *Principle of operation of an ion exchanger for water softening*

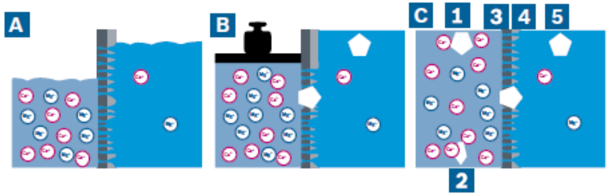
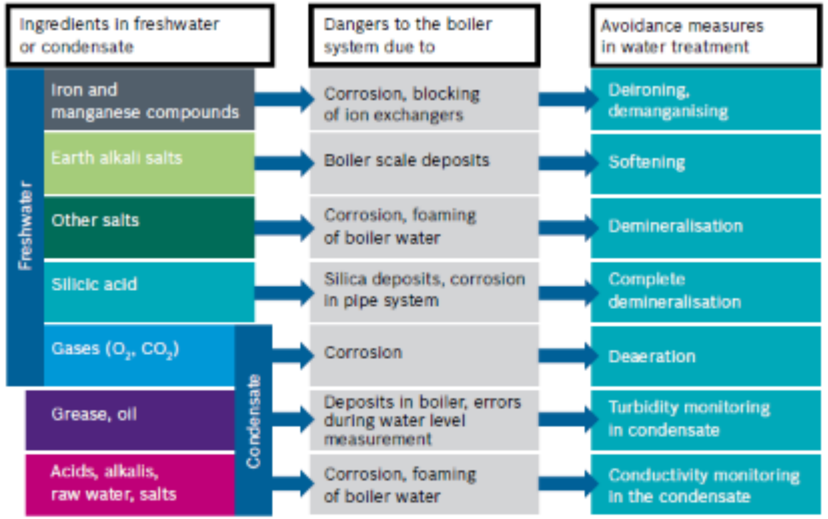


Fig. 93 *Visualisation of osmotic pressure (A), reverse osmosis by pressure charging on the concentrate side (B) and the continuous reverse osmosis process (C)*



Ingredients in freshwater or condensate	Dangers to the boiler system due to	Avoidance measures in water treatment
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Other salts	Corrosion, foaming of boiler water	Demineralisation
Silicic acid	Silica deposits, corrosion in pipe system	Complete demineralisation
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Grease, oil	Deposits in boiler, errors during water level measurement	Turbidity monitoring in condensate
Acids, alkalis, raw water, salts	Corrosion, foaming of boiler water	Conductivity monitoring in the condensate

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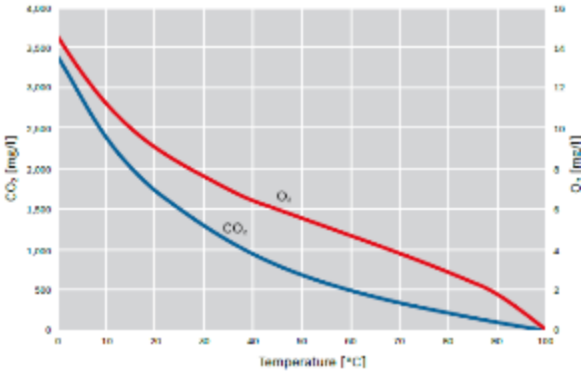

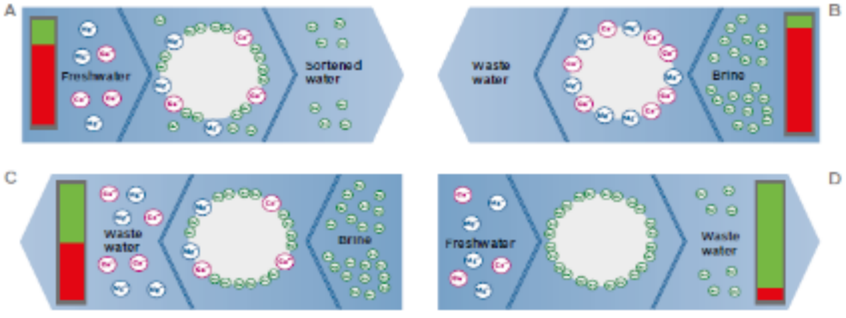

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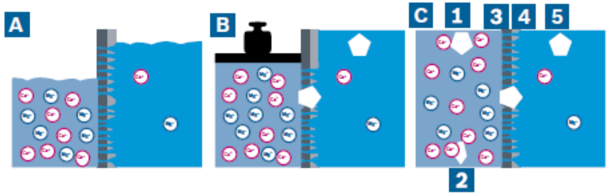


Fig. 93 *Visualisation of osmotic pressure (A), reverse osmosis by pressure charging on the concentrate side (B) and the continuous reverse osmosis process (C)*

Nominal diameter DN	External diameter d_1 [mm]	Nominal diameter DN	External diameter d_1 [mm]
6	10.2	250	273.0
8	13.5	300	323.9
10	17.2	350	355.6
15	21.3	400	406.4
20	26.9	450	457.0
25	33.7	500	508.0
32	42.4	600	610.0
40	48.3	700	711.0
50	60.3	800	813.0
65	76.1	900	914.0
80	88.9	1000	1016.0
100	114.3	1200	1219.0
125	139.7	1400	1422.0
150	168.3	1600	1626.0
200	219.1		

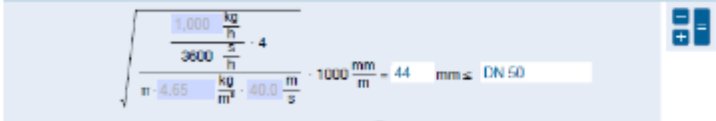
Tab. 18 *Pipe diameter (EN 10255:2004+A1:2007, EN 1092-1:2013-04, Table A.1)*

The necessary nominal diameter can then be calculated as follows:

$$DN \geq \sqrt{\frac{\dot{V} \cdot 4}{\pi \cdot u}} = \sqrt{\frac{\dot{m} \cdot 4}{\pi \cdot \rho \cdot u}}$$

F20. *Equation for calculation of required nominal diameter*

DN — Nominal pipe diameter [mm]
V — Flow rate [m³/s]
m — Mass flow rate [kg/h]
ρ — Density [kg/m³]
u — Recommended speed according to table [m/s]



$$\sqrt{\frac{\frac{1{,}000\,\frac{kg}{h}}{3600\,\frac{s}{h}} \cdot 4}{\pi \cdot 4.65\,\frac{kg}{m^3} \cdot 40.0\,\frac{m}{s}}} \cdot 1000\,\frac{mm}{m} = 44\ \text{mm} \leq \text{DN 50}$$

B9. *Example calculation for determining the required nominal diameter*

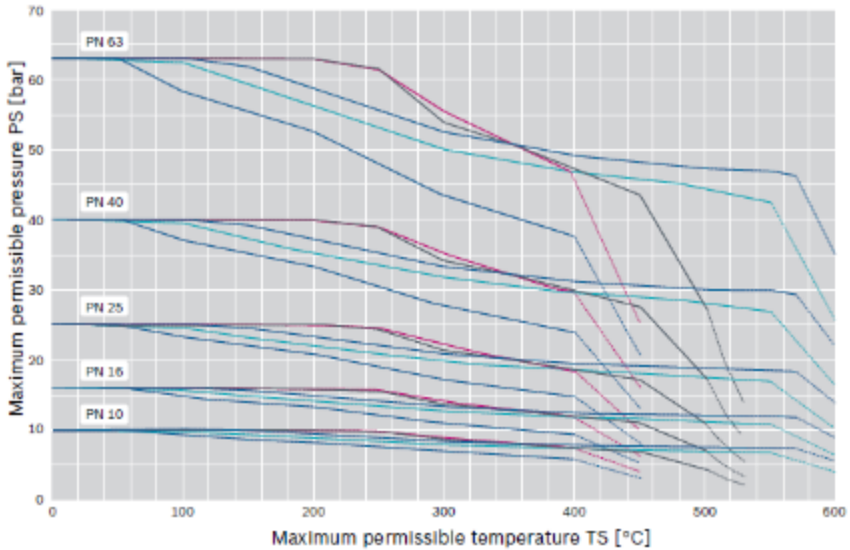


Fig. 119 *Pressure-temperature assignment for flanges according to EN 1092-1*

Application area	Pipework material
Steam pipes	Steel or stainless steel with inspection certificate
Feed water lines	Steel
Safety valve blow-off pipes	Steel
Ventilation and drain lines	Steel
Seat drainage (safety valve)	Copper or stainless steel
Softened water	Plastic (cold) or stainless steel (following heating)
Osmosis water	Stainless steel

Tab. 20 *Minimum requirement for material selection*

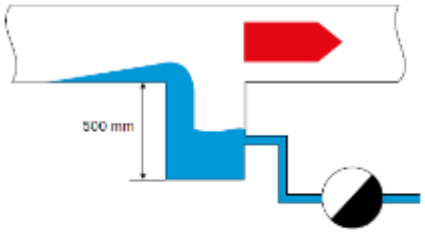
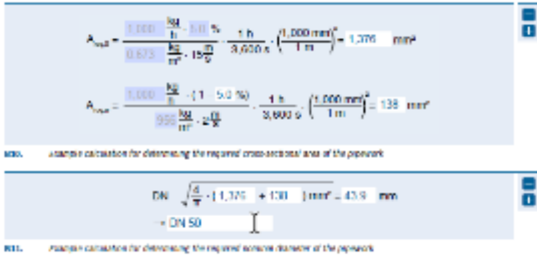


Fig. 121 *Drainage connections*



A [illegible] = 1,000 kg/h · 5.0 % / (0.673 kg/m³ · 15 m/s) · 1 h / 3,600 s · (1,000 mm / 1 m)² = 1,376 mm²

A [illegible] = 1,000 kg/h · (1 − 5.0 %) / (958 kg/m³ · 2 m/s) · 1 h / 3,600 s · (1,000 mm / 1 m)² = 138 mm²

B10. *Example calculation for determining the required cross-sectional area of the pipework*

DN √(4/π · (1,376 + 138) mm²) = 43.9 mm
→ DN 50

B11. *Example calculation for determining the required nominal diameter of the pipework*

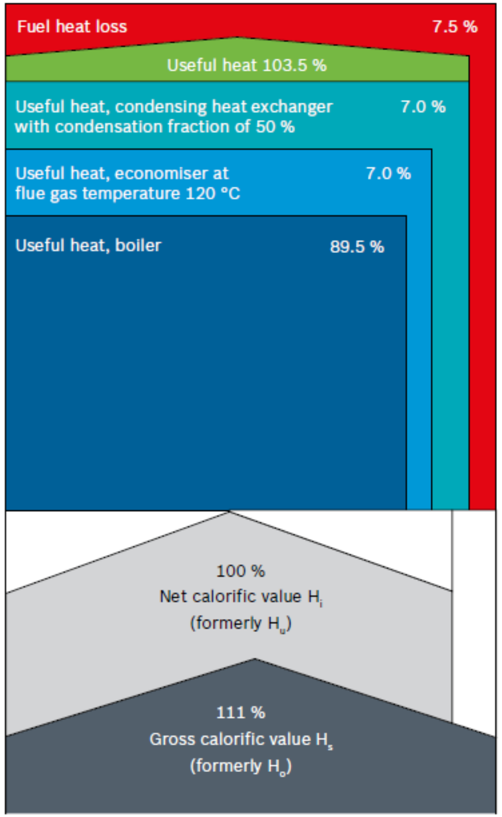
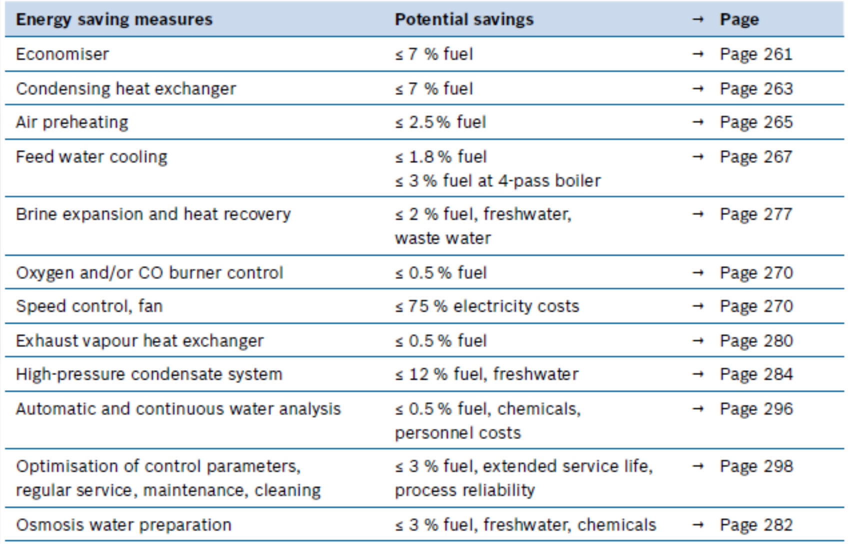


Fig. 134 *Heat balance of a steam generator featuring condensing technology and gas combustion (values are examples)*



Energy saving measures	Potential savings	→ Page
Economiser	≤ 7 % fuel	→ Page 261
Condensing heat exchanger	≤ 7 % fuel	→ Page 263
Air preheating	≤ 2.5 % fuel	→ Page 265
Feed water cooling	≤ 1.8 % fuel ≤ 3 % fuel at 4-pass boiler	→ Page 267
Brine expansion and heat recovery	≤ 2 % fuel, freshwater, waste water	→ Page 277
Oxygen and/or CO burner control	≤ 0.5 % fuel	→ Page 270
Speed control, fan	≤ 75 % electricity costs	→ Page 270
Exhaust vapour heat exchanger	≤ 0.5 % fuel	→ Page 280
High-pressure condensate system	≤ 12 % fuel, freshwater	→ Page 284
Automatic and continuous water analysis	≤ 0.5 % fuel, chemicals, personnel costs	→ Page 296
Optimisation of control parameters, regular service, maintenance, cleaning	≤ 3 % fuel, extended service life, process reliability	→ Page 298
Osmosis water preparation	≤ 3 % fuel, freshwater, chemicals	→ Page 282

Tab. 25 *Energy saving measures and the resulting savings potential*

1.4 Combustion efficiency

The combustion efficiency η_f describes the sensible heat yield during combustion of a fuel. It is determined by calculating the thermal losses q_A in the flue gas with reference to the ambient temperature level. Unburnt components of the fuel are not taken into account for oil and gas combustion since in practice they must not occur on a relevant scale.

→ Efficiency – Chapter 1.1: Net calorific value, gross calorific value and condensation heat, page 243

The combustion efficiency is based on the net calorific value of a fuel and is calculated by deducting the flue gas losses from the maximum achievable 100 %.

$$\eta_f = 100\,\% - q_A$$

F27. *Formula for calculating the combustion efficiency*

$$q_A = \frac{f}{CO_{2,max}} \cdot \frac{21\%}{21\% - O_2} \cdot (t_{FG} - t_L)$$

F28. *Formula for calculating the flue gas loss*

$$O_{2,f} = 21\% \cdot \left(1 - \frac{CO_2}{CO_{2,max}}\right)$$

F29. *Formula for calculating the residual oxygen content from the CO_2 value*

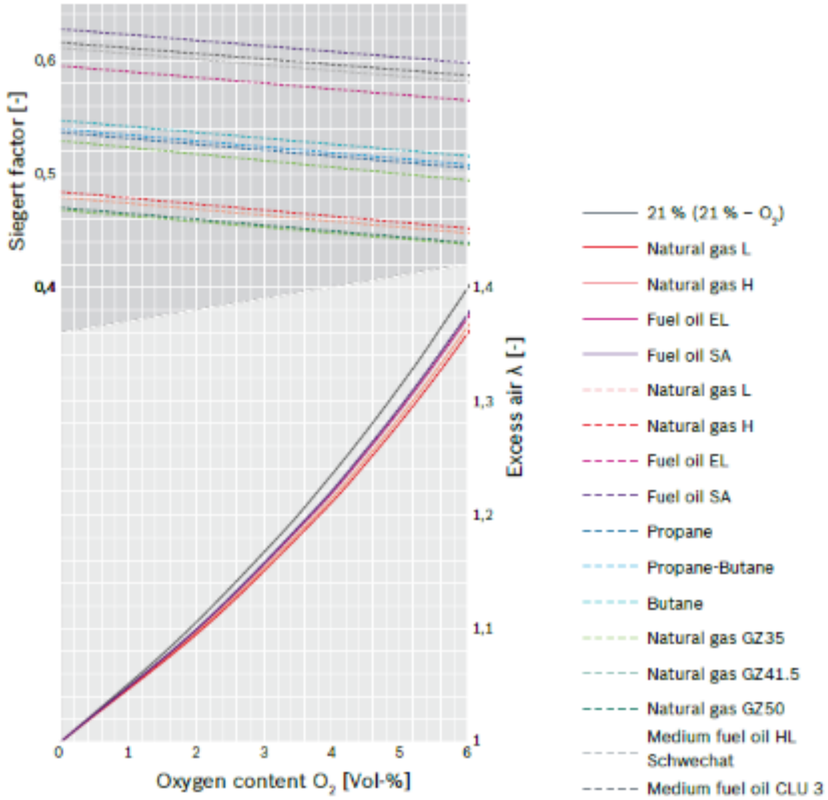


Fig. 135 *Correlation between oxygen content in dry flue gas, excess air and Siegert factor*

1.5 Boiler efficiency

The boiler efficiency η_{boi} is the same as the combustion efficiency minus the heat losses on the surface of the boiler to the environment at the installation room during the burner runtime. It can be calculated as follows:

$$\eta_{boi} = 100\,\% - q_A - \frac{\dot{Q}_{l,boi}}{\dot{Q}_{bu}}$$

oder

$$\eta_{boi} = \frac{(\dot{Q}_{bu} - q_A) \cdot (\dot{Q}_{bu} - \dot{Q}_{l,boi})}{\dot{Q}_{bu}}$$

F30. *Formula for calculating the boiler efficiency*

η_{boi}	Boiler efficiency
q_A	Flue gas loss with reference to the combustion output and the lower net calorific value [%]
$\dot{Q}_{l,boi}$	Heat loss performance of the boiler type [kW]
$\dot{Q}_{bu}$	Current combustion output of the boiler [kW]

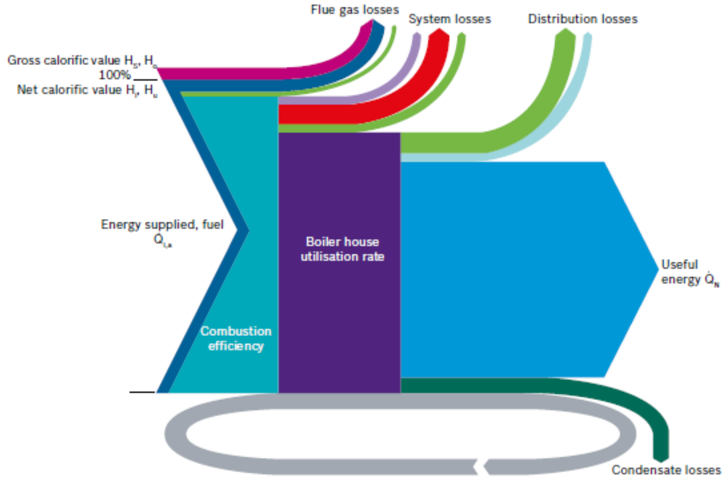


Fig. 138 *Sankey diagram (energy flow diagram) of a steam boiler system*

🟪	Latent heat of the flue gas
🟦	Sensible heat of the flue gas
🟩	Radiation and conduction (including downtime losses)
🟪	Pre-ventilation losses
🟥	Surface blowdown and bottom blowdown, exhaust vapours
🟦	Leaks (at the condensate drains, pipework)
🟩	Missing condensate recirculation and exhaust vapours
⬜	Recirculated condensate

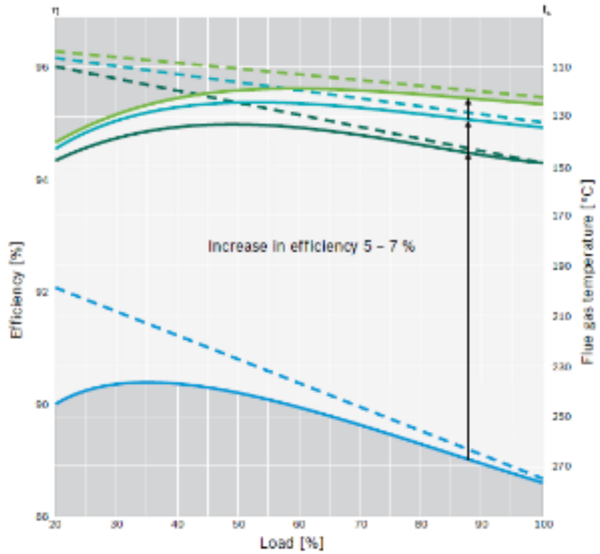


Fig. 143 Efficiency gain for various sizes of economiser (increasing from I to III)

η			tₐ	
	🟩	ECO III	– –	ECO III
	▬	ECO II	– –	ECO II
	▬	ECO I	– –	ECO I
	▬	without	– –	without

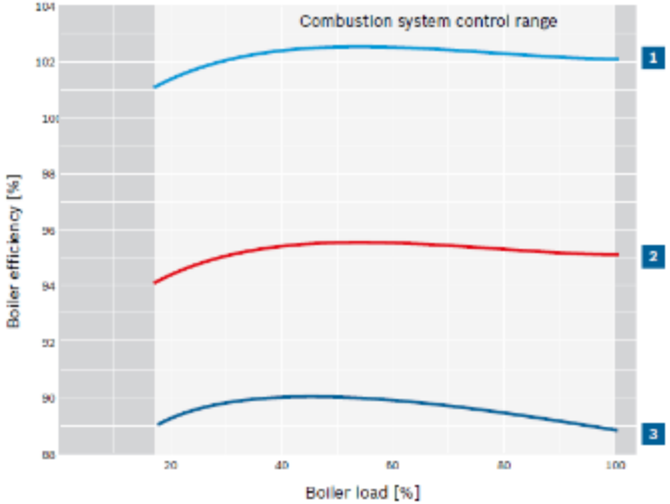


Fig. 144 Efficiency curve as a function of the boiler load of a boiler without economiser, boiler with economiser and boiler with economiser and additional condensing heat exchanger

- **1** Steam boiler with economiser and upstream condensing heat exchanger
- **2** Steam boiler with economiser
- **3** Steam boiler without economiser

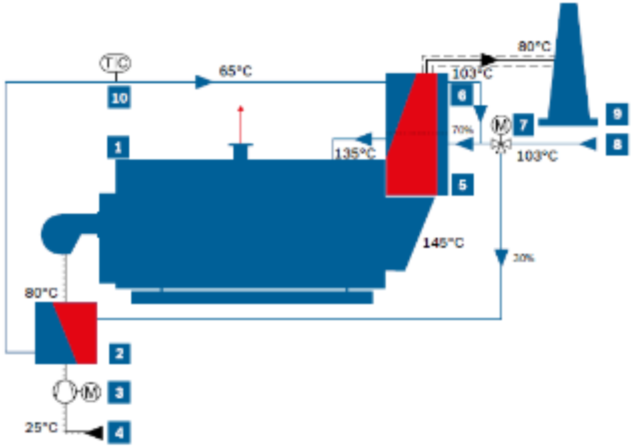


Fig. 147 Combustion air preheating at steam boiler according to Bosch patent

BOSCH

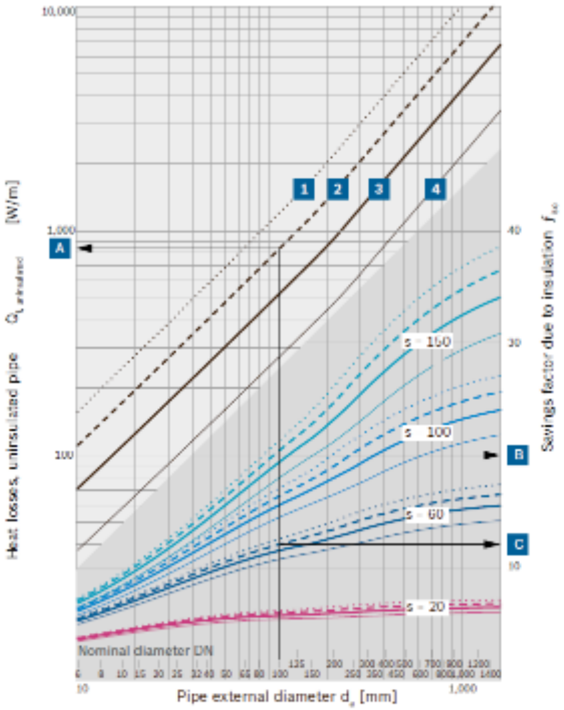


Fig. 154 Savings factor due to insulation and heat losses in pipework

1	Medium temperature: 250 °C (⋯⋯)	🟦	Insulation thickness s = 150 mm
2	Medium temperature: 200 °C (- - - -)	🟦	Insulation thickness s = 100 mm
3	Medium temperature: 150 °C (——)	🟦	Insulation thickness s = 60 mm
4	Medium temperature: 100 °C (——)	🟪	Insulation thickness s = 20 mm

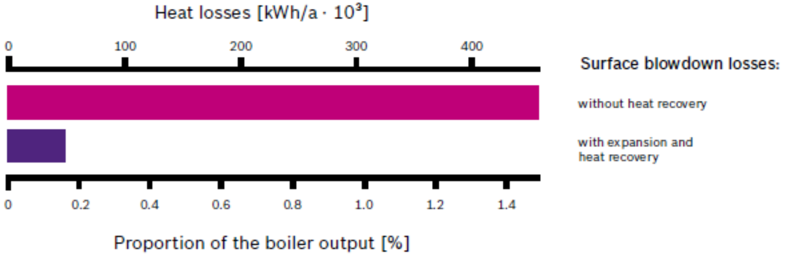


Fig. 155 *Potential savings of expansion and heat recovery (EHM or EHB)*

4.1.4 Insulated valves

Valves are located at many points in steam boiler systems and are required for operation and maintenance. For installation or cost reasons, or owing to various supply limits, the insulation of valves or adaptor flanges in new systems is still frequently omitted. Likewise, uninsulated valves can also often be found in existing systems.

A great deal of energy is however lost via these uninsulated areas. The following table can be used to estimate the energy lost via an uninsulated valve.

Pipe nominal diameter		DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
Length according to EN 558 series 1	[mm]	230	290	310	350	400	480	600	730
Heat loss, uninsulated	[W]	224	343	419	586	795	1,119	1,800	2,728
Heat loss, insulated	[W]	21	27	29	33	43	58	88	127
Savings	[W]	202	316	390	553	752	1,061	1,712	2,601
Heat loss at 8,000 Bh/a	[kWh/a]	1,619	2,527	3,117	4,425	6,018	8,489	13,693	20,810
Savings with 4.5 Ct/kWh	[€/a]	73	114	140	199	270	382	616	936

Tab. 30 *Heat losses and operating costs of uninsulated valves (medium temperature 200 °C)*

Steam boilers

	U-ND	U-HD	U-MB	UL-S(X)	ZFR(X)
Output t/h	0.2–3.2	0.2–3.2	0.2–2	1.2–28	18–55
Max. temperature °C	110	204	204	300	300
Max. pressure in bar	0.5	16	16	30	30

Tab. 32 *Steam boilers*

Heat recovery

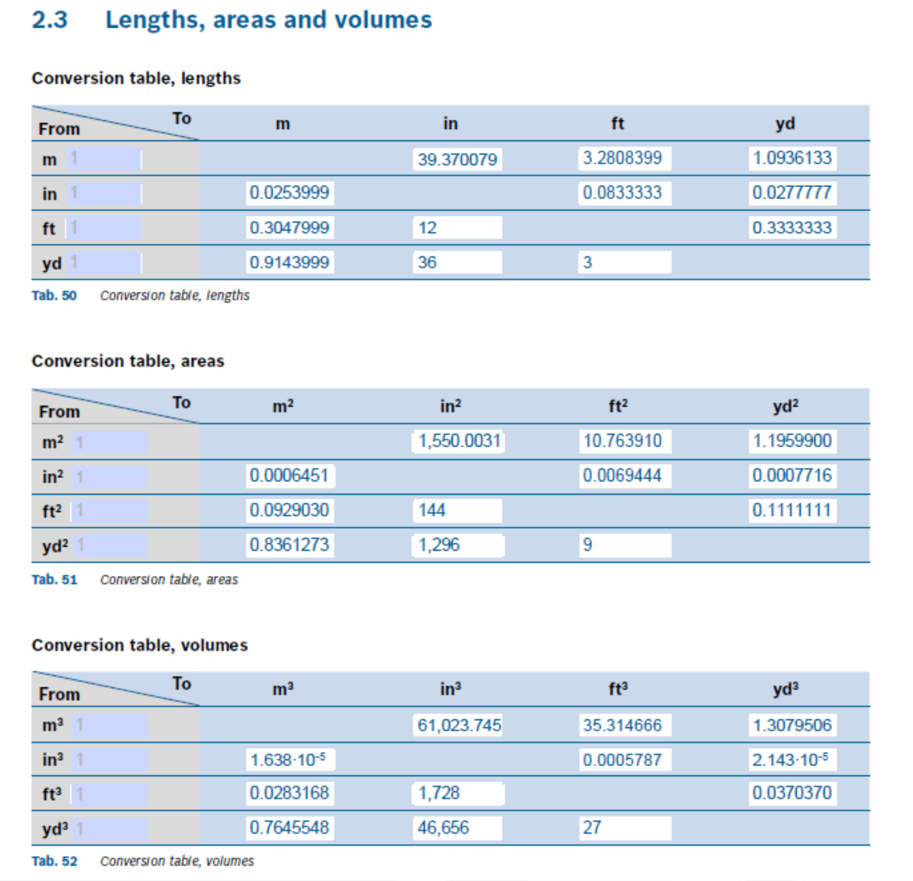
Heat recovery boiler HRSB	4-pass boiler with burner	3-pass boiler without burner	Recovery and use
Heat recovery steam boiler	Heat recovery boiler, steam/hot water		Waste heat

Tab. 33 *Heat recovery*

Components

Boiler/ system control	Water	Steam/condensate	Fuel supply
Controls	Modules	Modules	Combustion system

Tab. 34 *Components*



2.3 Lengths, areas and volumes

Conversion table, lengths

From \ To	m	in	ft	yd
m 1		39.370079	3.2808399	1.0936133
in 1	0.0253999		0.0833333	0.0277777
ft 1	0.3047999	12		0.3333333
yd 1	0.9143999	36	3	

Tab. 50 *Conversion table, lengths*

Conversion table, areas

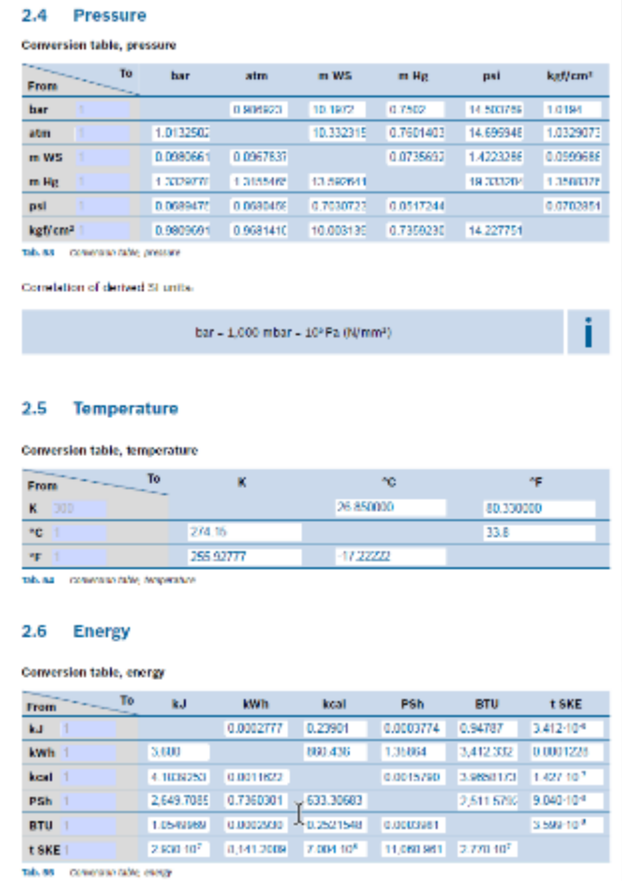
From \ To	m^2	in^2	ft^2	yd^2
m^2 1		1,550.0031	10.763910	1.1959900
in^2 1	0.0006451		0.0069444	0.0007716
ft^2 1	0.0929030	144		0.1111111
yd^2 1	0.8361273	1,296	9	

Tab. 51 *Conversion table, areas*

Conversion table, volumes

From \ To	m^3	in^3	ft^3	yd^3
m^3 1		61,023.745	35.314666	1.3079506
in^3 1	$1.638\cdot10^{-5}$		0.0005787	$2.143\cdot10^{-5}$
ft^3 1	0.0283168	1,728		0.0370370
yd^3 1	0.7645548	46,656	27	

Tab. 52 *Conversion table, volumes*



2.4 Pressure

Conversion table, pressure

From \ To	bar	atm	m WS	m Hg	psi	kgf/cm^2
bar 1		0.986923	10.1972	0.7502	14.503773	1.0197
atm 1	1.0132502		10.332315	0.7601403	14.695948	1.0329073
m WS 1	0.0980661	0.0967837		0.0735692	1.4223288	0.0999688
m Hg 1	1.3332237	1.3155462	13.595611		19.333204	1.3595378
psi 1	0.0689475	0.0680460	0.7030723	0.0517244		0.0702851
kgf/cm^2 1	0.9809691	0.9681410	10.003135	0.7356230	14.227751	

Tab. 53 *Conversion table, pressure*

Correlation of derived SI units:

bar = 1,000 mbar = 10^5 Pa (N/mm^2) ℹ

2.5 Temperature

Conversion table, temperature

From \ To	K	°C	°F
K 300		26.850000	80.330000
°C 1	274.15		33.8
°F 1	255.92777	-17.22222	

Tab. 54 *Conversion table, temperature*

2.6 Energy

Conversion table, energy

From \ To	kJ	kWh	kcal	PSh	BTU	t SKE
kJ 1		0.0002777	0.23901	0.0003774	0.94787	$3.412\cdot10^{-8}$
kWh 1	3,600		860.436	1.35964	3,412.332	0.0001228
kcal 1	4.1868250	0.0011622		0.0015790	3.9681170	$1.427\cdot10^{-7}$
PSh 1	2,649.7085	0.7360301	633.30683		2,511.5790	$9.040\cdot10^{-5}$
BTU 1	1.0549989	0.0002930	0.2521540	0.0003981		$3.599\cdot10^{-8}$
t SKE 1	$2.930\cdot10^{7}$	8,141.2009	$7.004\cdot10^{6}$	11,060.961	$2.770\cdot10^{7}$	

Tab. 55 *Conversion table, energy*

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