- Part 1 Physical basis of steam generation
- 1.1 Introduction
- 1.2 Units for measuring systems
- 1.2.1 International unit system
- 1.2.1.1 SI basic units (Système International d'Unités)
- 1.2.1.2 Derived SI units
- 1.2.1.3 International recognized prefixes for decimal parts and multiples of units
- 1.2.1.4 German legal recognized units in addition to the SI units
- 1.2.2 Overall view of the valid metric units compared with former units
- 1.2.2.1 Lenght, square measure, cubic or volume measure
- 1.2.2.1.1 Lenght
- 1.2.2.1.2 Square
- 1.2.2.1.3 Volume
- 1.2.2.2Time related units
- 1.2.2.3 Mass related units
- 1.2.2.4 Mechanical units
- 1.2.2.4.1 Power
- 1.2.2.4.2 Output, energy and heat capacity
- 1.2.2.4.3 Capacity
- 1.2.2.4.4 Pressure
- 1.2.2.5 Temperature and expansion
- 1.3 Heat
- 1.3.1 Specifically heat capacity
- 1.3.2 Heat exchange
- 1.3.2.1 Heat conduction
- 1.3.2.2 Heat flux
- 1.3.2.3 Heat radiation
- 1.4 Water vapour
- 1.5 Wet steam saturated steam superhetad steam
- Part 2 The fuels and their combustion
- 2.1 General
- 2.2 Fuels for steam generator
- 2.3 Origins and deposits of fuels
- 2.3.1 Natural fuels
- 2.3.2 Artificial fuels
- 2.3.2.1 Degasification of coal
- 2.3.2.2 Gasification of coal
- 2.3.2.3 Hydrogenation of coal
- 2.3.2.4 Blust furnace gas
- 2.3.2.5 Liquid gas
- 2.3.2.6 Refinery gas
- 2.3.2.7 Coke
- 2.3.2.8 Briquet
- 2.3.3 Waste fuels
- 2.3.4 Sludge
- 2.4 Composition of fuels
- 2.4.1 Salt coal
- 2.5 Classification of solid fuels
- 2.5.1 Volatiles of coals
- 2.5.2 Grindability

2.5.3 2.5.4 2.5.5 2.5.6 2.6 2.7 2.7.1 2.7.2 2.7.3 2.7.4 2.7.5	Ash melting behaviour Grain Bulk density Swelling index of hard coal Storage of coal Fuel oil Density Flash point Combustion point Viskosity
2.7.6 2.7.7	Pour point Sulfur content Coke residue
2.7.8	Vanadium content
2.7.9	Acid content
2.7.10	Content of asphaltenes
2.7.11	Salt content
2.7.12	Nitrogen content
2.7.13	Samplings
2.8	Storage of fuel oil
2.8.1	Fuel oil storage room
2.8.2	Fuel oil tank
2.8.3	Storage of fuel oil for ship steam generator
2.9	Classification and characteristics of gases
2.9.1	Classification
2.9.2	Characteristics
2.10	Storage of gases
2.11	The combustion
2.11.1	General
2.11.2	Process during the combustion
2.11.3	Ignition reaction
2.11.3.1	Ignition temperature
2.11.3.2	Ignition limits
2.11.3.3	Lighting-up rate
2.11.4	Combustion air
2.11.4.1	Theoretical combustion air quantity
2.11.4.2	excess air
2.11.5	Perfect combustion
2.11.6	Incomplete combustion
2.11.7	Chemical combustion reactions
2.11.8	Maximum CO ₂ -content
2.11.9	excess air coefficient
2.11.10	Combustion triangle from Bunte
2.11.11	False air / infiltration air
2.11.12	Combustion gases and their properties
2.11.12.1	Carbon dioxide
2.11.12.2	Carbon monoxide
2.11.12.3	Sulfure dioxide
2.11.12.4	Sulfure trioxide
2.11.12.5	Nitrogen gases
2.12	Heat losses during the combustion
2.12.1	Losses by flue gas
2.12.2	Losses by fuel gases

Losses by combustibles in the residues 2.12.3 2.12.4 Losses by radiation and conducting 2.12.5 Losses by perceptible heat in the slag Losses by buildup of tar and soot 2.12.6 General summery of losses 2.12.7 Boiler efficiency 2.13 Dew point and coat binding speed 2.14 2.15 Cause of draft Natural draft 2.15.1 2.15.2 Artificial draft 2.15.3 Chimney The important boiler designs Part 3 3.1 General The boiler, definition 3.1.1 3.1.1.1 Design of smoke tube boiler 3.1.1.2 Design of water tube boiler 3.1.2 Technical characteristics of boilers 3.2 Shell boiler 3.2.1 Fire tube boiler 3.2.2 Fire tube - smoke tube boiler 3.2.2.1 Steamblock 3.2.3 Water tube - smoke tube boiler Gravity-feed hopper type boiler 3.2.4 Water tube boiler 3.3 3.3.1 General 3.3.2 Natural circulation 3.3.2.1 Inclined tube boiler 3.3.2.2 Vertical tube boiler 3.3.2.3 Boiler with integral furnace 3.3.2.4 Corner tube boiler 3.3.2.5 Package- or compakt-boiler Marine boiler (radiant boiler) 3.3.2.6 3.3.3 Forced circulation boiler 3.3.3.1 La Mont-boiler Once-through boiler 3.3.4 3.3.4.1 Benson boiler 3.3.4.2 Sulzer boiler 3.4 Supplementary- and back end heating surfaces General 3.4.1 3.4.2 Superheater 3.4.3 Steam cooler 3.4.3.1 Spray attemperator Surface-type attemperator 3.4.3.2 3.4.4 Economiser (feed water preheater) Heat exchanger for liquid mediums 3.5 3.5.1 General 3.5.2 Feed water preheater 3.5.2.1 Low pressure preheater High pressure preheater 3.5.2.2 Heat exchanger for gaseous mediums 3.6 3.6.1 General 3.6.2 Heat exchanger

- 3.6.2.1 Regenerative heat exchanger
- 3.6.2.1.1 Regenerative heat exchanger based of the rotating principle
- 3.6.2.1.2 Regenerative heat exchanger based of the stationary principle
- 3.6.2.2 Recuperative heat exchanger
- 3.6.2.2.1 Gas-air- heat exchanger
- 3.6.2.2.2 Gas-gas- heat exchanger
- 3.6.2.2.3 Steam-gas- heat exchanger
- 3.7 Boiler designs large steam generator
- 3.7.1 General
- 3.7.2 Natural circulation boiler
- 3.7.3 Forced flow boiler
- 3.8 Refractory lining / boiler linings
- 3.8.1 Boiler with oil- or gas firings
- 3.8.2 Boiler with coal dust firings
- 3.8.2.1 Flue gas recirculation ducts
- 3.8.3 Boiler for waste and biomass firings
- 3.8.4 Fluidized bed combustion / recirculation cyclones
- 3.9 Boiler isolations
- Part 4 Boiler firing systems
- 4.1 General
- 4.2 Firing systems for solid fuels
- 4.2.1 Grate firing systems
- 4.2.1.1 Firing systems with immovable grates
- 4.2.1.2 Firing systems with movable grates
- 4.2.2 Coal dust firing systems
- 4.2.2.1 General
- 4.2.2.2 Firings with dry ash extraction
- 4.2.2.2.1 Hard coal / black coal firing
- 4.2.2.2.2 Brown coal / Lignite firing
- 4.2.2.3 Firings with wet ash extraction
- 4.2.2.3.1 Slag tap firing
- 4.2.2.3.2 Cyclon firing
- 4.2.3 Pulveriser systems for coal dust firings
- 4.2.3.1 Yoke mill / bowl mill
- 4.2.3.2 Tube ball mill
- 4.2.3.3 Lignite mills
- 4.2.3.4 Coal conveyor
- 4.2.3.5 Controls of coal dust firing systems
- 4.2.3.6 Burn out grate
- 4.2.4 Fluidized bed combustion
- 4.2.4.1 Historic development
- 4.2.4.2 General
- 4.2.4.3 Process description
- 4.2.4.4 Technologies
- 4.2.4.4.1 Atmospheric fluidized bed
- 4.2.4.4.2 Atmospheric circulating fluidized bed
- 4.2.4.4.3 Internaly circulating fluidized bed
- 4.2.4.4.4 Pressurized fluidized bed
- 4.2.5 Biomass incineration
- 4.2.5.1 General
- 4.2.5.2 Process description
- 4.2.5.3 Technologies

4.3	Waste incineration
4.3.1	Historic development
4.3.2	General
4.3.3	Concept of plant
4.3.4	Boiler designs
4.3.4.1	Furnace designs
4.3.4.2	Combustion air systems
4.3.4.2.1	Secondary air systems
4.3.4.3	Boiler constructions
4.3.5	Grate designs
4.3.5.1	Roller grate
4.3.5.2	Reverse-acting grate Vario, Company Martin
4.3.5.3	Horizontal grate, Company Martin
4.3.5.4	Moving grate Company Fisia Babcock
4.3.5.5	Moving grate Company Baumgarte
4.3.5.6	Moving grate Company AE&E Inova
4.3.5.7	Water cooled grates
4.3.5.7.1	System Company Martin
4.3.5.7.2	System Company Fisia Babcock
4.3.5.7.3	System Company Baumgarte
4.3.5.7.4	System Company AE&E Inova
4.3.6	Controls of waste combustion
4.4	
	Oil firing
4.4.1	Terms and implementation measures
4.4.2	Oil burner general
4.4.3	Burner with pressure atomizer
4.4.3.1	Fuel oil atomizer general
4.4.3.1.1	Fuel oil atomizer for smal capacity
4.4.3.1.2	Low pressure atomizer
4.4.3.1.3	Pressure air- or steam atomizer
4.4.3.1.4	Fuel oil atomizer for large capacity
4.4.3.1.5	Return flow oil atomizer
4.4.3.1.6	Oil pressure- / steam pressure atomizer
4.4.3.2	
	Burner casings, overal concept
4.4.4	Burner with rotation / swivelling atomizer
4.4.5	Accessories and function of a fuel oil firing plant
4.4.5.1	Fuel oil filter
4.4.5.2	Fuel oil pumps
4.4.5.3	Fuel oil heater
4.4.5.4	Trace heating
4.4.6	Control of fuel oil firing
4.4.6.1	On-Off-control
4.4.6.2	Step control
4.4.6.3	Continuous control
4.5	Gas firing
4.5.1	Terms and implementation measures
4.5.2	Gas burner general
4.5.2.1	Processing of mixture
4.5.3	Designs of gas burners
4.5.3.1	Low pressure burner
4.5.3.2	High pressure burner
4.5.3.2.1	Single lance gas circular burner
4.5.3.2.2	Multi lance gas circular burner

- 4.5.3.2.2.1 Combined burner for gas and oil
- 4.5.3.2.2.2 Combined burner for gas and oil with recirculation
- 4.5.3.2.3 Low NOx gas-/oil burner
- 4.5.3.3 Gas air fan burner (compact burners)
- 4.5.3.4 Gas air-suction burner
- 4.5.3.5 Liquid gas burner
- 4.5.4 Accessories and function of a gas firing plant
- 4.5.4.1 Gas-pressure control apparatuses
- 4.6 Hot gas generator
- 4.7 Accessories for firing plants
- 4.7.1 Ignition systems
- 4.7.1.1 High energy igniter
- 4.7.1.2 Ionisation monitoring
- 4.7.1.3 High voltage igniter
- 4.7.1.4 Gas-electrical igniter
- 4.7.1.5 Fuel oil igniter / dual fuel igniter
- 4.7.2 Flame monitor systems
- 4.7.2.1 IR-flame monitor
- 4.7.2.2 UV- flame monitor
- 4.7.3 Firing control units
- 4.7.4 Safety valves
- 4.7.4.1 Safety valves for fuel oil firing plants
- 4.7.4.2 Safety valves for gas firing plants
- Part 5 Flue gas cleaning
- 5.1 Introduction
- 5.1.1 Generallies about clean environment
- 5.1.2 Legal requirements for clean environment
- 5.1.3 Measures to avoid air pollutants
- 5.2 Separation and reduction mechanism
- 5.2.1 Combustion
- 5.2.2 Absorption
- 5.2.3 Adsorption
- 5.2.4 Catalytical flue gas cleaning
- 5.2.5 Biological flue gas cleaning
- 5.2.6 Condensation
- 5.3 Apparatuses and processes for separation of various components of pollutants
- 5.3.1 Dust and particle separation
- 5.3.1.1 Cyclon separetor
- 5.3.1.2 Fabric filters
- 5.3.1.3 Electrostatic prcipitators
- 5.3.1.4 Wet separator / scrubber
- 5.3.2 Sulphur compounds
- 5.3.2.1 Sulphure dioxid (SO₂)
- 5.3.2.1.1 Dry desulphurization processes
- 5.3.2.1.2 Semi dry desulphurization processes
- 5.3.2.1.3 Wet desulphurization processes
- 5.3.2.2 Sulphure trioxid (SO₃)
- 5.3.3 Halogen compounds
- 5.3.3.1 Dry processes
- 5.3.3.2 Semi dry processes
- 5.3.3.3 Wet processes

- 5.3.4 Nitrogen compounds
- 5.3.4.1 Primary measures
- 5.3.4.2 Secondary measures
- 5.3.4.2.1 SNCR-process
- 5.3.4.2.2 SCR-process
- 5.3.5 Heavy metal
- 5.3.6 Dioxine / Furan
- 5.3.7 Carbon dioxide
- 5.3.7.1 Basis
- 5.3.7.2 Post combustion
- 5.3.7.3 Pre combustion
- 5.3.7.4 Oxyfuel
- 5.4 Process selection
- 5.5 Circuit variations of the several flue gas cleaning stages
- 5.5.1 Power plants with fossil fuels
- 5.5.2 Power plants for waste incineration
- 5.5.3 Power plants for hazardous waste incineration
- 5.5.4 Power plants for biomass incineration
- Part 6 Valves, Apparatuses, Ancillary machines
- 6.1 Valves
- 6.1.1 Feed water valves
- 6.1.1.1 Non return valves
- 6.1.2 Isolation and drain components
- 6.1.2.1 Isolation components
- 6.1.2.1.1 Shut off valves
- 6.1.2.1.2 Gate valve
- 6.1.2.2 Drain valves
- 6.1.2.3 Pressure check valve
- 6.1.3 Control valves
- 6.1.3.1 Feed water control valves
- 6.1.3.1.1 Full load or main control valve
- 6.1.3.1.2 Start up or low load control valve
- 6.1.3.1.3 Minimum flow control valve
- 6.1.4 Steam transformer valves / Steam reducing valves
- 6.1.4.1 High pressure (HP) bypass valves
- 6.1.5 Safety valves
- 6.1.5.1 Dead weight safety valve
- 6.1.5.2 Spring loaded safety valve
- 6.1.5.3 Pilot operated safety valve
- 6.1.5.4 Safety valve with pilot operated auxiliary load
- 6.1.5.5 Feed water heater isolation system
- 6.1.6 Blow off silencer
- 6.2 Boiler feed pumps
- 6.2.1 Piston pump (Duplex-pump)
- 6.2.2 Centrifugal pump
- 6.2.3 Jet pump (steam, liquid or gas injector)
- 6.3 Monitoring and Test Instruments
- 6.3.1 Monitoring instruments
- 6.3.1.1 Water level measurements
- 6.3.1.1.1 Water level measurements with direct indicator
- 6.3.1.1.2 Water level measurements with remote indicator (indirect)
- 6.3.1.1.2.1 mechanical or hydrostatically water level measurements

- 6.3.1.1.2.2 Electrical remote indicator
- 6.3.1.1.2.2.1 Float remote indicator
- 6.3.1.1.2.2.2 Differential pressure level indicator
- 6.3.1.2 Pressure measurements
- 6.3.1.2.1 Draft measurement
- 6.3.1.3 Temperature measurements
- 6.3.1.3.1 Thermocouples
- 6.3.1.3.1.1 Wall temperature difference measurement
- 6.3.1.3.2 Resistance thermometer
- 6.3.1.4 Flow measurements for water, steam, gas and oil
- 6.3.1.4.1 Flow measurements for water, steam
- 6.3.1.4.2 Flow measurements for gases incl. air
- 6.3.1.5 Leakage detector
- 6.3.2 Flue gas analysis
- 6.3.2.1 Processes of analysis
- 6.3.2.1.1 Orsat apparatus
- 6.3.2.1.2 Cirkonoxid process
- 6.3.2.1.3 Chemilumineszenz process
- 6.3.2.1.4 Infrared (IR) spectroscopy
- 6.3.2.1.4.1 NDIR process (Non-Dispersive Infrared Detector)
- 6.3.2.1.4.2 FTIR process (Fourier-Transformations-IR-Spektroscopy)
- 6.3.2.1.5 FID process (Flame Ionisation Detector)
- 6.3.2.1.6 Process photometer
- 6.3.2.1.7 DOAS process (Differential Optically Absorptions Spectroscopy)
- 6.3.2.1.8 Laser process
- 6.3.2.1.9 Optically process / Opacity
- 6.3.2.2 Measurements of flue gas components
- 6.3.2.2.1 Oxigen
- 6.3.2.2.2 carbon monoxide
- 6.3.2.2.3 carbon dioxide
- 6.3.2.2.4 Nitrogen (NO, NO₂)
- 6.3.2.2.5 Sulphur dioxid
- 6.3.2.2.6 Chlorid compounds
- 6.3.2.2.7 Gaseous fluorine compounds
- 6.3.2.2.8 Dust
- 6.3.2.2.9 Total carbon
- 6.3.2.2.10 Mercury
- 6.3.2.3 Sampling handling
- 6.3.2.4 Continuous Emissions Monitoring (CEM)
- 6.3.2.4.1 Emission limit values
- 6.4 Open and closed loop control instruments
- 6.4.1 Three way temperature controler
- 6.4.2 Electrical temperature controler / limit switch
- 6.4.3 Level limitation
- 6.4.3.1 Float level switch
- 6.4.3.2 Level electrodes
- 6.4.4 Oil and turbidity monitoring
- 6.5 Separator for water and oil
- 6.5.1 Steam traps
- 6.5.1.1 Float Steam traps
- 6.5.1.2 Thermostatic steam traps
- 6.5.1.3 Thermodynamic steam traps
- 6.5.1.4 Rigid steam traps

- 6.5.1.4.1 Nozzle steam traps with thermo control
- 6.5.1.5 Use, maintenance and monitoring of steam traps
- 6.5.1.5.1 Condensate monitoring instruments
- 6.5.2 Steam and oil water separator
- 6.6 Drainage flash tank / Start up flash tank
- 6.7 Fans / Ventilators
- 6.7.1 Centrifugal fans
- 6.7.1.1 Control of centrifugal fans
- 6.7.2 Axial flow fans
- 6.7.2.1 Control of axial flow fans
- 6.7.3 Installation of fans
- 6.7.3.1 Installation of centrifugal fans
- 6.7.3.2 Installation of axial flow fans
- Part 7 Operation practice of a steam generator plant
- 7.1 Commissioning
- 7.2 Operation
- 7.3 Inspektion, Service and Maintenance
- 7.3.1 Inspektions
- 7.3.2 Service and Maintenance
- 7.4 Shut down operation
- 7.5 Fault shut down
- 7.5.1 Reaction of faults
- 7.5.2 Operational faults
- 7.5.2.1 Dust firing systems
- 7.5.2.2Waste incineration systems
- 7.5.2.3 Other grate firing systems
- 7.5.2.4 Fluidized bed firing systems
- 7.5.2.5 Oil firing systems
- 7.5.2.6 Gas firing systems
- 7.6 Losses during boiler operation
- 7.6.1 Boiler losses
- 7.6.2Heater losses
- 7.6.3 Economizer losses
- 7.6.4Deposits general
- 7.6.5Air heater losses
- 7.6.6Radiation losses
- 7.6.7Cooling losses
- 7.6.8 Losses based on leaks of refractory
- 7.6.9Losses based on non isolated pipes
- 7.6.10 Suitable isolation materials
- 7.6.11 Other losses of pipe systems
- 7.6.12Losses of to high excess air
- 7.6.13Losses of deficiency of air
- 7.7 Puffing / Flue gas explosion
- 7.8Boiler explosion
- 7.9Boiler cleaning
- 7.9.1 During the operation (On-load)
- 7.9.1.1 Soot blower
- 7.9.1.2 Rapping (knocker) divices
- 7.9.1.3 Sonic
- 7.9.1.4 Temporarily cleaning
- 7.9.1.4.1 Explosion and shock wave cleaning

- 7.9.1.4.1.1 Manual gas explosion cleaning
- 7.9.1.4.1.2 Automatic gas explosion cleaning
- 7.9.1.4.1.3 CO₂-explosion cleaning
- 7.9.2 During out of operation (Off-Load)
- 7.9.2.1 Outer cleaning
- 7.9.2.2 Inner cleaning
- 7.9.2.3 Cleaning and inspection of apparatuses and valves
- 7.10 Inner inspection of boiler and firing plants and tests
- 7.11 Conservation of steam generator
- 7.11.1 Wet conservation
- 7.11.1.1 Safety measures during wet conservation, draining of conservation water
- 7.11.2 Dry conservation
- 7.11.2.1 Drying of the plant
- 7.11.2.2 Conservation with nitrogen
- 7.11.2.3 Conservation with dry air
- 7.11.2.4 Conservation with hot air
- 7.12 Feed water and Boiler water
- 7.12.1 General
- 7.12.2 Sorts of water
- 7.12.3 Water terms (definitions)
- 7.12.4 Water values
- 7.12.5 Water treatment
- 7.12.5.1 Ion exchanger process
- 7.12.5.1.1 Sodium exchanger
- 7.12.5.1.2 Water softening and decarbonisation
- 7.12.5.1.3 Hydrogen exchanger
- 7.12.5.1.3.1 Part flow (dual flow) process
- 7.12.5.1.3.2 Single flow process
- 7.12.5.1.3.3 Sequence exchange and mixing regeneration process
- 7.12.5.1.4 Complete demineralisation
- 7.12.5.1.5 Cation exchange
- 7.12.5.1.6 Anion exchange
- 7.12.5.2 Precipitation processes
- 7.12.5.2.1 Softening process
- 7.12.5.2.1.1 Calcium-sodium process
- 7.12.5.2.1.2 Caustic soda process
- 7.12.5.2.1.3 Trisodium phosphate process
- 7.12.5.2.2 Hot precipitation process with silicia removal
- 7.12.5.3 Evaporation process
- 7.12.6 Operation possibilities
- 7.12.6.1 Alcaline operation
- 7.12.6.2 Neutral and combined operation
- 7.12.6.3 Helamin
- 7.12.6.4 Silicid acid
- 7.12.6.5 Electrical cunductivity
- 7.12.6.6 Organic substances
- 7.12.6.7 Oxigen
- 7.12.7 Analysis processes for important water values
- 7.12.7.1 pH-value
- 7.12.7.2 Conductivity
- 7.12.7.3 Density
- 7.12.7.4 Acid capacities

- 7.12.7.5 Sum erth alkalis (whole hardnes)
- 7.12.7.6 Phospaht
- 7.12.7.7 Hydrazin
- 7.12.7.8 Sulphite
- Part 8 Regulations for the construction and the operation of a plant
- 8.1 Safety regulations
- 8.1.1 General
- 8.1.2 Safety regulations for safety and health during handling with surveillance plants or equipment (German: Betriebssicherheitsverordnung, BetrSichV)
- 8.1.3 EN 12952, Water-tube boilers and auxiliary installations
- 8.1.4 Steam boiler regulation, (German: Dampfkesselverordnung, DampfkV)
- 8.1.5 Technical regulations for steam boilers (German: TRD)
- 8.1.6 Guideline for the construction and equipment of marine steam boiler plants on sea-going ships sailing under the German flag (Document B 8129)
- 8.1.7 Operation of a steam generator plant
- 8.1.7.1 General
- 8.1.7.2 Technical regulations for operation safety (German: TRBS)
- 8.1.7.3 Conditioning monitoring and test during operation
- 8.2 Regulations with environmental relevances
- 8.2.1 General
- 8.2.2 Technical guidance for keeping clean the air (German: TA Luft)
- 8.2.3 Regulation for plants requiring licenc (German: 4. BImSchV
- 8.2.4 Regulation for large firing and gas turbine plants (German: 13. BImSchV)
- 8.2.5 Regulations for waste incineration plants and other plants with additional waste firing (German: 17. BImSchV)
- Appendix 1 Technical calculation
- Appendix 2 Combustion calculation
- Appendix 3 Formularies flue gas cleaning
- Appendix 4 Emission limit values
- Appendix 5 Operation manual for an Orsat-Apparatus to measuring flue gas compounds
- Appendix 6 The Greece alphabet