

**Boiler Plants  
and  
Their Operation**

*by K.K. Dubas*

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U.S.S.R.  
THE MINISTRY OF THE MEAT AND MILK INDUSTRY  
OF THE ESTONIAN S.S.R.

B O I L E R P L A N T S A N D T H E I R O P E R A T I O N

A B S T R A C T S

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THE INTERNATIONAL SEMINAR  
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## I. INTRODUCTION

In the milk industry we use various kinds of boilers, furnace fittings for solid, liquid, and gas fuel, as well as auxiliary boilers of low capacity (from 0.3 up to 10 tons of steam per hour) and their automatic appliances. Steam engines and locomobiles are not used any more. During the post-war period the milk industry has begun to utilize electric power, all the more that every small area of Soviet Estonia has got its high-voltage power transmission lines. The milk industry has got also district boiler plants servicing their own areas. The main task now is to provide for more rapid and timely adoption of up-to-date machinery overcoming backwardness in mechanization of hard work, in surpassing technical and economic quotas of utilizing equipment, raw material, fuel, and electric power, in providing for proper fuel stocks, as well as in getting the enterprises ready in time for operation under any conditions.

Our industry has achieved certain success in overfulfilling the industrial plans, in innovating the enterprises and in improving production processing.

Economy of fuel and electric power has been achieved resulting from the enterprises' accomplishing measures in service organization and rationalization thermal power equipment.

Now the main task of energetics is to raise the efficiency of the steam boiler plants up to 65-80 per cent and equip them with modern techniques at an average of 90 per cent. To achieve the above-mentioned it is necessary for the plants to provide for the following measures:

- to mechanize the fuel delivery to furnaces and the removal of ash and slag (up to 67 per cent of ashes);
- to mount economizers at the steam boiler houses, the boilers generating up to 10 tons of steam per hour;
- to accomplish modernization of steam boilers at the boiler plants;
- to implant at the boiler plants new water purifying arrangements;
- to elaborate rational steam power standard schemes calculated for

maximum utilization of waste heat (condensate of hot water and combustion heat) and considering the peculiarities of embodying new technical schemes of continuous manufacture; to elaborate the techniques of determining specific quotas of electric power and fuel consumption for the basic kinds of products, to enlist the designing and fitting and scientific research institutions for this purpose.

In addition to this, it is necessary to elaborate standard projects for mechanizing the fuel discharge and stowage and its delivery to the boiler houses, as well as the expulsion of ash both for heat boilers of low capacity and for various kinds of fuel;

- to elaborate governing specifications for planning new heat boiler assemblies and mechanical furnaces applicably to the specification features of the enterprises (general profile of the condensed steam parameter, kinds of local fuel, furnace design, etc.);
- to elaborate standard schemes of automatic adjustment and control of thermal power processes for various branches of the industry;
- to elaborate standard instructions to carry out pre-planned preventive maintenance of the basic thermal power and electric equipment, to reinforce the instructors' body for mounting and fitting the control and measuring instruments at the plants;
- to elaborate service instructions for principal thermal power equipment and control instruments, in action or newly-mounted;
- to manufacture by machine works boiler assemblies equipped in full with required auxiliaries (furnace fittings, boiler accessories, garnitures, blower apparatus, as well as water pre-heaters and feed pumps, if required).

## II. FUEL, STORAGE ARRANGEMENT AND FUEL DELIVERY

A fuel store is the place to receive, keep, and deliver the fuel.

It is necessary to ensure that:

- a) every batch of fuel undergoes sampling for qualitative

analysis of coal, mazout, peat, firewood, and oil shale, with exchange coefficients being fixed;

b) the fuel discharge and stowage is mechanized to the maximum, employing loaders, scrapers, bulldozers, and portable transporters;

c) the fuel delivery to the boiler house is carried out, as a rule, with the help of machinery, such as telpher, winding skip, bucket elevator, belt loader (sloping and horizontal). All fuel delivered to the boiler house is to be weighed.

#### Fuel Burning

1. To develop the utilization of local kinds of fuel and to the utmost mechanize the burning process.

2. To use a clinker grate or a grate with rotating units, instead of a stationary one, for burning solid fuel.

#### Ash Handling

To consider obligatory for all boiler houses to remove the ash using trucks, scrapers, telfers, ash or clinker elevators, transporters, and in case of hydraulic expulsion of ash - to use best systems.

#### Boiler Assembly

To consider it obligatory for all steam boilers to comprise a blower apparatus (stationary unit, if the temperature is up to 700° C.).

#### Fuel Accounts, Checking, and Automation

1. To consider obligatory the installation of steam and water flow meters alongside with a weighing-machine at every boiler house in operation;

2. To furnish every boiler with heat meters, thermoelectric couples, thermometers, and the boilers of 60 t of steam per hour - with automatic gas analyzers;

3. To consider it expedient to automate the working and supply processes of the steam boilers equipped with mechanized furnace fittings and, first of all, of the boilers equipped with heaters.

## Feed-water Treatment

To equip the existing and newly built boiler houses with water softening plants , the kind of which is determined by the quality of the available feed-water.

To implant on a wider scale water purifiers with partial cationing of the treated water to provide a considerable softening (up to 0.15 - 0.20 degrees), utilization of waste heat, deaeration, and a limited amount of reagents. The treatment of water inside the boiler may be carried out with the boilers having pressure up to 12 atm., heating surface up to 250-300 sq. m, and spacious mud-traps or under drums. It may be carried out as well inside flue-tube boilers in case of favourable composition of initial water as to its hardness.

In order to raise technical standard of steam power assemblies and to raise their boiling capacity and economy - applying to those being in operation as well as newly-designed - should be recommended:

- to elaborate a technical plan of development and rationalization of the steam power enterprises, and replacement of worn-out equipment; to make use of the experience of modernizing out-of-date boilers of low capacity;
- to attain high performance of steam power equipment by means of exercising accounts of fuel, water, steam and electricity by keeping to the rules of operation and safety, as well as by accomplishing repairs, observing schedules, and by timely purchase of materials, units and spares.

### III. ELECTRIC EQUIPMENT AND NETWORKS

1. To introduce automatic control circuits on technological lines. To widely introduce methods of automatic control of processing operations that provide a rational consumption of electric power.

2. To elaborate operation instructions for achieving most economic conditions of working for all power-consuming units, such as compression coolers, blowers, etc.

3. Taking into consideration that improvement of production processes constitutes the best reserve of economy of electric energy; major importance should be attached to improving process schemes and to the economy of electric energy, at the same time not to neglect the maintenance of the electric equipment in service.

#### IV. NATURAL POWER RESOURCES

In order to obtain various kinds of energy (mechanical, electrical, thermal, and others) modern technology employs the following natural sources of energy called natural power resources: chemical energy of fuel, water or hydraulic energy, energy of wind, solar radiation energy, atomic or nuclear energy, tidal energy and energy of the entrails.

Of all the quoted natural power resources found in the U.S.S.R., and most other countries, chemical energy of fuel is the most important one, i.e., the energy accumulated in plants (firewood, peat, etc.), in solid mineral fuel (coal and oil shale), in crude oil and combustible gas. As to the reserves in the main natural fuels, the U.S.S.R. occupies a leading place in the world.

water power is second in utilization of natural power resources. There are in the U.S.S.R. powerful hydropower plants using up-to-date equipment, e.g. the Volga Hydropower Station, 2.3 million kW, the Volgograd Hydrostation (2.53 million kW), the Bratsk Hydropower Station on the Angarah river (4.5 million kW) and the Krasnoyarsk Hydropower Station (5.0 million kW).

In recent years special attention is paid to atomic reactor power stations, where electric power is obtained by utilizing the energy of nuclear transformations released during various nuclear reactions. Nuclear or atomic energy is produced by splitting the atomic nuclei of a fissionable element (uranium, thorium and plutonium), as well as by transforming hydrogen nuclei into helium nuclei. Atomic energy is peculiar for its extremely high concentration exceeding million times that of coal, crude oil, combustible gas and other kinds of fuel. Thus, to obtain one million kilowatt-hour of energy either 50 g of uranium or 140 t of high-grade coal is required; - the latter being 2.8 million times more in substance.

On June 27, 1954 in our country there was inaugurated the first atomic power plant in the world, under the Academy of Sciences of the U.S.S.R., with a useful capacity of 5.000 kW and is still continuously in operation at present. In 1958 the first stage of another atomic power plant was put into operation with a capacity of 100,000 kW. Its full capacity will be brought to 600,000 kW. Several other big atomic power plants are being built in the U.S.S.R. at present.

A high rate of utilization of natural power resources in the U.S.S.R. is required for accomplishing V.I. Lenin's ideas of complete electrification throughout the country and for fulfilling the historical mission of catching up and surpassing the most developed capitalist countries in the industrial output per capita.

## V. PRINCIPAL CHEMICAL REACTIONS IN BOILER PLANT PRACTICE

### Atmospheric Air

In order to burn fuel in the boiler plant the presence of air is essential. Air is a mixture of oxygen and nitrogen, comprising a negligible amount of water vapours, carbon dioxide and other gases.

### Water

Water is most widespread matter, it covers three fourths of the Earth's surface. Chemically pure water consists of 11 per cent hydrogen and 89 per cent oxygen.

The water fed to the boiler plant is never chemically pure. It always contains some quantity of dissolved and undissolved foreign substances that precipitate coating the faces of the boiler with fur and scale.

### Fuel Combustion

Fuel combustion is a chemical process of combining the combustible fuel elements (carbon, hydrogen, sulphur vapour) with oxygen of the air taking place with intense generation of heat and light.

## Design and Operation of Steam Boiler and Water-Heating Boiler Assemblies

A boiler plant is designed to supply consumers with steam at required pressure and temperature (or hot water of given temperature).

A boiler installation fed by liquid or gas fuel comprises the following units:

1. Boiler assemblies (working and auxiliary) - equipment for fuel burning and steam (hot water) producing.
2. Feed-water unit for water delivery to the boiler unit; comprises feeding accessories (piston or centrifugal pumps, injectors).
3. water pre-heating unit - for heating and softening of water.
4. Arrangement to keep and deliver fuel, and to prepare it for combustion.
5. Suction-blower unit - supplies air into the furnaces of boiler assemblies and expells combustion gases into the atmosphere.
6. Pipe lines - for steam (or hot water in water-heater boilers), feed-water, mazout, gas (when utilizing gas or mazout as fuel), drainage water, air, water used for fire-extinguishing and service purposes.
7. Instruments for thermal checking, automatic control of boilers and safety device.

### VI. MAIN COMPONENT PARTS OF STEAM BOILERS

Every steam boiler unit usually comprises the following main component parts:

1. Steam boiler - a device to obtain saturated steam at pressures exceeding atmospheric pressure, from feed-water being supplied to the boiler under the same pressure.
2. Screen - a tubing inside the boiler combustion chamber to protect its faces against the direct effect of the flame, and, besides, to effectively obtain steam from the water circulating through the screen tubes.
3. Superheater - an apparatus to heat up saturated steam to the temperature required.

4. Water economizer - an apparatus to pre-heat feed-water before it enters the boiler, at the expense of combustion gas heat.
5. Air heater - an apparatus to heat up the air at the expense of combustion gas heat until it enters the combustion chamber.
6. Boiler accessories and garniture (of water economizer, steam superheater, and air-heater boiler) - fittings that ensure safe operation of the boiler assembly.
7. Furnace unit - an apparatus for fuel burning in the combustion chamber and for transfer of some heat emitted during fuel combustion directly to the heating surface.
8. Boiler brickwork - faces of the furnace chamber and gas ducts separating and isolating hot elements of the boiler assembly and products of combustion from the outer space, and directing them along the heating surface of the boiler assembly.
9. Framework - metal constructions mounted on the boiler seating which connect and support the units of the boiler assembly.

Water-heating boiler assembly - consisting of a water-heating boiler, its accessories and fittings, furnace unit, brickwork, and framework.

Principal requirements with regard to boiler plants are:

- a. working reliability without breakdowns;
- b. high grade of economy.

## VII. TYPES OF STEAM BOILERS

As to their design steam boilers are divided into two groups: those with natural and those with forced circulation of water.

The first group comprises steam boilers of the following types: flue boilers, locomobile boilers, vertical cylinder boilers, horizontal water tube boilers, and vertical water-tube boilers.

The second group comprises direct flow boilers and special boilers, as well large-sized units.

Boiler Steam capacity (D) is the quantity of steam produced by the boiler assembly per hour. Boiler steam capacity is computed in kilograms of steam per hour (kg/h) or in tons of steam per hour (t/h).

water-tube boilers are characterized by their heat output

i.e. quantity of heat (Q) assimilated by the water-heating boiler assembly per unit of time (kcal/h or W, kW, and MW). (1 kcal/h = 1.163 W, 1,000 kcal/h = 1.163 kW, 1 million kcal/h = 1,163 MW.

Boiler heating surface is swept by hot flue gas on one side and water-touched on the other. It is measured in square metres ( $m^2$ ) and represented by the letter H. If we divide one steam capacity per h(D) of a boiler assembly by the value of its heating surface (H), we shall have the second characteristic of the water-heating boiler - heat liberation volume.

$$\frac{D}{H} = \text{kg}/m^2 \cdot h.$$

In case of water-heating boilers the heat output(Q) is divided by the heating surface (H) to obtain the second characteristic - heat liberation per unit heating surface:  $\frac{Q}{H} = \text{kcal}/m^2 \cdot h$

Heat liberation volume of steam boilers  
(kg of steam per hour and sq. m)

Boilers	$\frac{D}{H} = \text{kg}/m^2 \cdot h$
Flue boilers	20 - 25
Locomobile boilers	20 - 30
water-tube boilers, screenless	20 - 40
water-tube boilers, with screens	50 - 80
Direct flow boilers	100 - 200

The third parameter - boiler thermal efficiency - denotes the amount of heat efficiently consumed in the boiler to heat the water and transform it into steam in the steam boiler assembly or to heat water up in the water-heater boiler. The thermal efficiency of the boilers without economizers is 60-75 per cent and 80 - 93 per cent for the boilers of large dimensions.

## Boilers used in the Milk Industry of the Estonian S.S.R.

1. Flue Boilers comprise a steel riveted or welded boiler drum, inside of which, from one bottom to another, run one or two flue tubes of large diameter (0.8 - 0.9 m), the Cornish or Lancashire type

### 2. Steam boilers of the ДКБP type

Steam boilers of the ДКБP type are intended to supply small-scale power plants with steam and to provide for the processing needs of various industrial enterprises. The ДКБP type boilers are manufactured in 4 typical sizes with steam capacities of 2.5 - 4 - 6.5 and 10.0 t/h. The boilers are designed for burning fuel by layers in mechanically or manually operated furnaces. The boilers with a steam capacity of 2.5 t/h are manufactured without a superheater, the others - depending on the consumers' requirements. The ДКБP type boilers have been widely employed in industry and at heating boiler plants of average capacity. They are vertical flow water-tube double-drum boilers. The tube-and-drum system of the boiler comprises two longitudinal drums, two under-heaters, screens.

Its heat liberation volume is 30 kg/m<sup>2</sup>h, the temperature of gas at the outlet is 380°C, gas resistance of the boilers is 10 mm of water column.

The price of the ДКБP-2,5-13 boiler without a superheater is 19,800 roubles.

### Vertical Cylinder Boilers

Stand boilers of MM3 type, intended to produce saturated steam of 8 atm that is utilized for processing, heating, and other needs. The MM3 steam boiler comprises two cylindrical shells welded together with a spherical head at the top and a flat ring at the base. The inner shell that forms a boiler furnace comprises sloping beaded tubes 61 - 2.5 mm in diameter.

Main data	MM3-1,0/8	MM3 0,8/8	MM3 0,7/8	MM3 -0,4/8
Capacity, t/h	1.0	0.8	0.7	0.4
Pressure, kg/cm <sup>2</sup>	8	8	8	8
Heating surface, m <sup>2</sup>	28.5	25.0	22.0	15.8
Grate area, m <sup>2</sup>	1.32	0.91	0.91	0.60
Outer diameter of boiler, mm	1550	1400	1350	1100

### Vertical Type Steam Boilers

The BГД type boilers are intended to produce saturated steam of 8 atm. and the temperature of superheating up to 215°C. They are utilized for processing, heating, and service needs of industrial enterprises. The system has been named after N.G. Dobrinin.

The steam boiler comprises two welded cylindrical shells, outer and inner, interconnected by beaded flue tubes at the top, and by stamped carrier ring at the base.

At the top of the inner shell there is a bunch of boiler tubes  $\varnothing$  51 2.5 mm swept by gases. The outer body accommodates two man-holes providing access to the boiler tubes to remove fur off, and one elongated man-hole for surveying the bottom of the inner shell and the flue tubes.

The boiler is equipped with a manually-operated grate located at the lower part of the inner shell. The grate enables to differentiate between rough coal and anthracite.

In order to burn brown coal, firewood, peat, and other kinds of fuel the boiler must be fitted with a suitable extended furnace.

Boiler Steam capacity, kg/h	БГД 40/8 1 000	БГД 28/8 700 700	БГД 16/8 400
Pressure, kg/cm <sup>2</sup>	8	8 8	8
Heating surface, m <sup>2</sup>	40	28 28	16
External furnace	-	1 -	-
Internal furnace	-	- 1	-

## VIII. BOILER FEEDING ACCESSORIES

Feeding accessories delivering water to the boiler units are of great importance for the boiler plant. Correct and timely boiler feeding to compensate for the evaporated water is essential to provide normal and safe operation of the boiler plant as a whole.

1. Boiler feeding should be continuous, as any intermittent feeding diminishes steam pressure, causing damage to seams and beading of the tubes, and, besides, results in excess consumption of fuel.

2. Feeding devices should be used alternatively to ensure reliability.

3. When all the feeding devices are out of order, operation of the boiler plant must be stopped, and the case immediately reported to the person in charge of the boiler plant.

4. In case of leakage in the boiler it is necessary to stop boiler feeding and operation of the boiler assembly. Feeding of a leaky boiler may cause cracking of the boiler drum, violent evaporation of water and even explosion of the boiler assembly.

The following feeding accessories are employed at boiler installations.

1. Piston pumps mostly steam-power driven.

2. Centrifugal pumps driven by an electric motor or a turbine.

3. Injectors.

4. Hand pumps.

5. Special fittings to feed water into the boiler without pumps, i.e. pumpless feeding.

The boiler plant comprises at least two feeding fittings working independently, one of them is to be steam-operated.

For feeding steam boilers up to 0.5 t/h steam capacity, provided that excessive pressure does not exceed  $3 \text{ kg/cm}^2$ , it is allowed to use a pressure hand pump. The latter may be substituted by the water-line, if the water-line pressure at the boiler input exceeds the admissible operating pressure in the boiler at least by  $1.5 \text{ kg/cm}^2$ .

Centrifugal pumps of the 2,5 UB type are used for the boilers of 10 t/h steam capacity, for feeding boilers of low output, and for delivering water and other liquids at the rate of 5 to 34 m<sup>3</sup>/h, its head being from 53 to 224 mm water column, the liquid having a temperature of up to 105 °C and viscosity up to 5 °E.

The 2,5 UB type pumps are two-stage pumps with vortical impeller.

Specifications of the 2,5 UB type pump

Delivery, cub. m/h	5	9	12
Full head	200	127	72
R.p.m.		2900	
Shaft rating, kW	8.4	5.9	4.4
Electric motors, kW	14	14	14
Efficiency factor, per cent	33	49	44
Diameter of impeller,			
centrifugal		200 mm	
vortical		150 mm	
Price, roubles		2,410.-	

Three-phase asynchronous motors are widely used to drive centrifugal pumps. Such a motor is called asynchronous because it rotates slower than the magnetic field (i.e not synchronically with the field); when the torque increases the motor decreases its speed of rotation.

The electric motor comprises a stator and a rotor. The stator is immovable. It has three windings in star or delta connection. Each winding, to which the current is supplied, creates its alternating magnetic field of variable strength and direction, and displaced to one another by one third of the period.

Steam-operated Feed pump, the 46 FM type

Designed for steam boilers, it may be used likewise, for delivering fresh and salt water, and black oils at temperatures up to 100°C. The 46 FM type pump is a vertical direct, double piston, four-stroke pump. It is operated by dry saturated steam.

The pump comprises two main units: a steam cylinder unit and

a hydraulic cylinder unit connected together by two columns and a cast-iron bar.

#### Specifications

Capacity, m <sup>3</sup> /h	5.5 - 14,0
Head, kg/cm <sup>2</sup>	20
Number of double strokes per min	26 - 60
Height of vacuum suction at pumping water with a temperature of up to 30°C, water column, m.	6
Steam pressure at the inlet of the pump box	16. 17
Price, roubles	2,260.-

#### IX. FEED-WATER TREATMENT

The quality of water to feed boiler assemblies is of extreme importance for trouble-free and economic boiler plant operation. In case of unsatisfactory feed-water treatment deposit of fur (scale) coats the heating surface of steam boilers, water economizers, as well as of heat networks and water heaters; corrosion affects heating surfaces of the boiler assemblies, tubing and feed pumps. It causes superheating of the boiler faces and buckling honeycombs, through-burning of faces, breakdown of flue tubes, boiler and screen tubes and may result in explosion of the boiler.

Main properties of natural water are hardness, alkalinity, dry sediment, transparency and, admixture of oil in the water.

Hardness of water is characterized by containing fur-producing calcium and magnesium salts. The more salts water contains the harder it is.

One differentiates between temporary, permanent and general kinds of hardness of the water.

Temporary (or carbonate) hardness is caused by bicarbonates of calcium  $\text{Ca}(\text{HCO}_3)_2$  and magnesium  $\text{Mg}(\text{HCO}_3)_2$ . These salts dissociate to become semi-soluble salts - carbonate of calcium ( $\text{CaCO}_3$ ) and hydrate of magnesium  $\text{Mg}(\text{OH})_2$ , and will precipitate if the water is heated up, or boiled, in open vessels.

Depending on the degree of the total hardness, water is called:

very soft water	0-4° E
soft water	4 - 8°
average hard water	8 - 16°
hard water	16 - 25°
very hard water	exceeding 25°

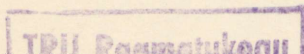
During boiler feeding and feed-water treatment, water is let through a filter charged with cationite (sulphurated carbon). The cationite stuff can extract ions of fur-producers (calcium and magnesium) from water and give away an equivalent amount of ions of sodium or hydrogen  $\text{H}^+$  contained in the cationite stuff.

The interchange process continues for 4 - 5 hours, thereafter the cationite agent gets exhausted and loses its property to soften water (0.02 - 0.04 g. equiv./m<sup>3</sup>). In order to regain the property of the exhausted sodium-cationite agent it is to undergo regeneration treatment with 5 - 10 per cent solution of sodium chloride (common salt). The sulphurated carbon - a phenol resin consists of black grains 0.3 - 1.2 mm in diameter.

#### X. SUPERVISION OF OPERATION AND AUTOMATIC CONTROL OF BOILER UNITS

Depending on the values to be measured boiler checking and controlling instruments are divided into six main groups:

1. Thermometers and steam meters - to measure the temperature.
2. Pressure gauges, vacuum gauges and draught meters - to measure pressure and vacuum.
3. Flow meters - to measure consumption of liquids, gases, and steam.
4. Level gauges - to measure level of liquids.



5. Gas analysers - to analyse gaseous combustion products.
6. Special-purpose instruments (hardness gauge, salt gauge, gas indicators, gas signaling apparatus, etc.)

As to their design and purpose, thermal checking and control instruments are divided into indicating, self-recording, signaling, and control devices.

Nearly every thermal control instrument comprises the following main parts: a sensing part (thermometers, etc) of the primary instrument (transmitter for remote transmission of data to the second-stage instruments), and the secondary instruments - indicating, recording or summarizing the data received from the primary instrument.

Widely-employed automatic control instruments (fuel combustion regulators, pressure and temperature governors, water-level regulators in boilers) keep up the pre-set value of pressure, steam temperature, and water level in the boiler drum. Depending on the way the data are transmitted to the remote point - there are pneumatic and electric transmission systems. All automatic control devices are divided into two main groups:

1. Direct-action regulators not needing external sources of energy (being not costly but reliable enough in operation, but of lower precision, therefore, they are used for small installations);
2. Indirect-action governors operated by external sources of energy (they are more complicated in design, more costly, but work with great accuracy and precision).

## XI. PRINCIPAL TECHNICAL AND ECONOMICAL CHARACTERISTICS OF BOILER INSTALLATION PERFORMANCE

These characteristics are the following:

1. Productivity of boiler assemblies and boiler plant as a whole, i.e. quantity of steam (or water for a water-heater plant) in kilograms or tons produced in every boiler assembly and the boiler plant as a whole.
2. Quality of the steam received, i.e. absolute pressure and temperature of superheated steam, or absolute pressure and degree of

dryness of the saturated steam or hot water.

3. Boiler efficiency of every single boiler assembly and efficiency of the boiler plant as a whole. If the boiler efficiency equals 75 per cent it means that of every 100 T.U. produced by fuel only 75 T.U. are utilized efficiently, and remaining 25 TU. constitute losses (or, say, of 100 decimetres only 75 decimetres are utilized and 25 decimetres are lost). Boiler efficiency is calculated in the following way:

1. To find the quantity of heat used to convert 1 kg of water into saturated or superheated steam (or hot water for water-heater - boilers) the heat content of the steam (or hot water) is subtracted from the amount of the heat absorbed by 1 kg of water.

2. To determine the quantity of heat per definite unit of time multiply the fuel consumption by its lowest value of combustion heat.

3. Efficiency of the boiler assembly or the boiler plant as a whole is calculated, dividing the quantity of heat that is efficiently absorbed by the water by the quantity of heat expended and the result is multiplied by 100.

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