(FOUO 1/79)

2 JANUARY 1979

1 OF 1

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USSR

TRANSLATIONS ON USSR INDUSTRIAL AFFAIRS
(FOUO 1/79)

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TRANSLATIONS ON USSR INDUSTRIAL AFFAIRS

(FOUO 1/79)

CONTENTS PAGE

AUTOMOTIVE AND TRACTOR INDUSTRY

USSR REPORTEDLY SEEKING WESTERN AID IN PRODUCING NEW CAR

London THE FINANCIAL TIMES in English 4 Dec 78 p 1 LD

[Dispatch by motor industry correspondent Kenneth Gooding: "Russia in Talks on New Car"]

[Text] Moscow, 3 Dec--The Soviet Union wants to put a family saloon of Cortina size on the road as quickly as possible, and has had initial discussions with a handful of Western European manufacturers about the project.

Ford, General Motors--which makes Opel and Vauxhall cars in Europe--Renault and Citroen have been involved in the talks. The Russians insist that though the project is in its very early stages, some Western car-makers are seriously interested.

Negotiations will be complex, but the Soviet Ministry of Automobile Transport hopes they will be completed in time for the start of the next five-year plan in 1981.

The idea would be for one of the two plants near Moscow now making the outdated Moskvich cars to switch production to the family saloon, which would be identical with a model produced in the West. Up to 200,000 a year would be produced.

At present the Soviet Union wants the Western manufacturers to pay for the reequipment programme and then take cars produced at the Moscow plant in payment.

About 30 percent of the output would be exported and any of the companies named could easily absorb the 60,000 to 70,000 cars a year involved in their European sales networks.

Production costs are much lower in Russia than in the West and the scheme could be highly profitable for the Western manufacturer concerned.

But tremendous obstacles have to be cleared away for the project to come to fruition, not the least of them the political problems facing U.S.-owned concerns like Ford and General Motors in a deal of this sort.

CSO: 1827

CONSTRUCTION, CONSTRUCTION MACHINERY, AND BUILDING MATERIALS

SITING AND LAYOUT OF HEATING-SYSTEM BOILERHOUSES DESCRIBED

Moscow KOTEL'NYYE USTANOVKI in Russian 1977 pp 398-410

[Chapter 10 from the book, "Kotel'nyye Ustanovki" [Boilerhouse Installations], by K. F. Roddatis, Energiya; passages between slantlines printed in fine type]

[Excerpt] 10-1. The Siting of Heat-Supply Sources

When siting a boilerhouse that will serve as the heat-supply source for an enterprise and a housing district, an effort is made to place it close to the center of the heating load, giving consideration to the direction of the prevailing winds (or wind rose), the location of the housing tracts, planted greenery, the local terrain, the ground-water level, water-supply sources, the potential for establishing cinder heaps, and a number of other circumstances that are governed by the appropriate construction and other norms and regulations, as well as the potential for further expansion during the estimated period of development of the district in question. In so doing, the possibility is created of combining existing or planned boilerhouses and heating grids of other districts with the boilerhouse being designed.

The land on which the boilerhouse or heat-supply source is to be located should have reliable ground that can serve as a natural foundation for the building and structures. Earthmoving and other leveling work should be minimal.

The boilerhouse building, the facility for receiving and discharging solid and liquid fuel, and the railroad tracks should, as a rule, be situated parallel to the contour of the natural relief. The terrain should also be considered when siting facilities for removing clinker and ash from the boilerhouse. Where the clinker and ash cannot be used for construction or other specific purposes, the dumps for them should be placed on land sections that are closest to the boilerhouse and are unsuitable or less suitable for other purposes, or outside the boilerhouse grounds, preferably in gullies or at marshy places. Cinder-heap dimensions are chosen on the basis of a boilerhouse's operation for 10-25 years.

The discharge of water from the grounds and from the boilerhouse building should be executed and coordinated with the network of industrial, storm, and household sewer systems for the whole area of the erterprise or the land that has been set aside for construction of the boilerhouse. Effluent from the chemical water-treatment, mazut and lubricant activities, from washing the external heating surfaces of boiler units, and from acid-flushing and other flushing of equipment should be neutralized and purified of solid-particle, petroleum-product and other pollutants, and cooled to a temperature below 40 degrees Celsius, and only after this released into the sewer system.

In designing boilerhouses for industrial enterprises, roads, structures and buildings for like purposes should be amalgamated. The grounds of a boiler house, if it is located outside the industrial enterprise and has an open area with the equipment, warehouses, transport installations and communications located on them, should be furnished with all the conveniences, a protective zone planted to greenery, and surrounded by a 2.4-meter chain-link fence. The distances (gaps) that correspond to the construction norms and regulations and roads that will enable transport and fire-department operations to be performed should be stipulated between buildings, structures and the fuel storage and other installations. The main access route to the grounds and the ring road around the boilerhouse will be built from the nonextensible end of the boilerhouse building. Joining the boilerhouse grounds to the common-carrier railroad is planned in coordination with the appropriate railroad administration. Premises, buildings and structures that present fire hazards should be made of noncombustible materials. The categories of the various parts of the boilerhouse building and auxiliary structures and premises and the characteristics of the materials that are required for them are fixed. In choosing the materials and structure for structural members of boilerhouse buildings, the requirements of the Principles [L. [Bibliography, not reproduced] 1, 2 and 18] and other appropriate SNiP's [Construction Norms and Regulations] and Principles, including electrical-engineering specifications, should be considered.

10-2. Boilerhouse Buildings

It is customary to classify boilerhouses as enclosed, semiopen and open: at enclosed boilerhouses all the equipment is placed inside the building; in semiopen boilerhouses, auxiliary equipment—deaerators, tanks, ash traps, flue-gas pumps and fans—is installed outside the building; and at open boilerhouses shelter is provided for regular servicing of the basic equipment—the boiler units—but only the control panels and pumps and filters for the chemical water purifiers are placed inside buildings.

The basic equipment for open-type boiler houses should be specially adapted to operation at below-freezing ambient temperatures.

Boilerhouses situated at inhabited places should, as a rule, be of the enclosed type, but on the grounds of industrial enterprises they can be of any type, if climatic conditions and the equipment permit.

Boilerhouse buildings can be built to be freestanding or contiguous to other buildings—interlocked.

Boilerhouse premises are interlocked with production departments at some enterprises, at municipal and domestic-amenities buildings (except for the bathhouse) and at the services buildings of therapeutic institutions. The boilerhouse is separated from other premises by a special substantial fireproof wall; no premises of any kind are placed above the boiler units. Sometimes boilerhouses are placed inside production, social or housing buildings, part of the premises being allocated for them; such boilerrooms are said to be built-in.

The installation of boiler units of all types and shapes inside production premises is accomplished by the forming of a boilerroom premise with a height of at least 2 meters, with noncombustible partitions, floor and ceiling.

Waste-heat recovery boilers and power-engineering units can be isolated from the operating premise together with the technological units. Free-standing buildings are most widely used for boilerhouses.

Modern boilerhouse buildings are erected, as a rule, with one-story frameworks with single-alignment spans of equal width and height. When the equipment must be placed in several stories, pavilion-type buildings with built-in etageres are used. The dimensions of the spans of buildings are to be 12, 18, 24 and 30 meters; for small boilerhouses, spans of 6 and 9 meters are permitted. Aside from columns, outer walls with pilasters can be load-bearing building members where the spans are small (6, 9 and 12 meters), the height is small (up to 7.2 meters) and no load-lifting mechanisms rest on the walls. Where the span is 12 meters or more, only columns with spacing of 6 or 12 meters are used. For the multistory portion of a boilerhouse building, it is proper, for example, to use column grids of 6x7 or 6x9 meters at the nonextensible end. The height of boilerhouse buildings depends upon the size of the span and is established in size multiples of 0.6 to 1.8 meters.

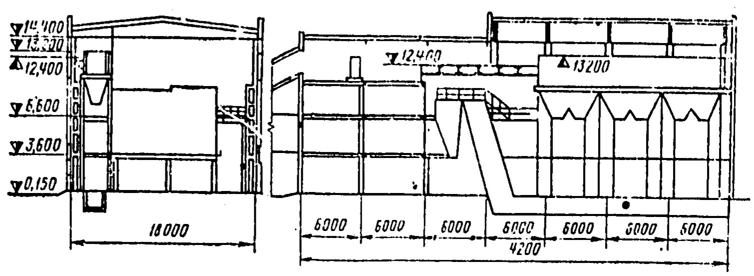
If part of the building is to be multistory, then the grade levels of the stories should be 3.6, 4.2 and 6 meters, except for the first floor, which can have a height of 7.2 meters. Where the building's height is less than 7.2 meters, its load-bearing outer walls can be made of brick or of other masonry units. A boilerhouse building can have an ash story with the floor level at the grade level of the grounds only where a special scheme for clinker and ash removal is used or where there is a high ground-water level: an ash story should not be specially separated.

If equipment that imparts dynamic loadings on footings—crushers, mills, flue-gas pumps, fans, and so on—is installed in a boilerhouse, the footings erected for it are not joined to the floor and walls of the building. The outer walls, socle, and inner walls of buildings with load-bearing columns are made of hung panels made of lightweight concrete or keramzit concrete, or of masonry pieces; partitions are made of gypsum-concrete panels or other panels. Apertures for doors and windows and holes for the passage of gas and air lines and pipelines and for the installation of modularized equipment are made in walls and partitions. Structure for the wall at the extensible end of a boilerhouse building should allow for the execution of construction and installing operations. Interstory ceiling floors are made of concrete slabs, which are laid on crossbars that rest on column projections. The roofs of boilerhouse buildings consist of reinforced-concrete plates, with a thermal insulating layer made of foam or aerated concrete, which are protected by bituminous or rolled material, glued to the smoothed surface by a cement coupling. Reinforced foam-concrete slabs of 1.5x6 meters that combine planking and insulation are being used more widely. A waterproof carpet with a protective layer of mastic and gravel applied to it is placed on top of the roof; the use of skylights is limited. Floors should be strong, resistant to heat and moisture, noncombustible, and not susceptible to destruction by the temporary effects of oil, acids and alkalies. Conduits are laid in boilerhouse floors for the removal of clinker and ash, for feed lines for air to firebox installations, for electrical and other cable, and for pipelines for water and sewage; openings are sometimes left in the floor for the footings under the equipment. The floor can be one-piece of several layers or made of slabs. The windows more often than not are made in the form of separate openings or long strips; large apertures are divided into parts by posts and beams; the window casements are attached to the posts and beams, which transmit the casement load and the wind load to the load-bearing parts of the building. The window sills are made at an angle of 50 degrees, and the height of the aperture is in multiples of 0.6 to 4.8 meters. Doors are to be 1.0, 1.5 or 2.0 meters wide and 2.4 meters high; they are manufactured from steel or metal framework or are made of wood with felt lining impregnated with clay and with steel-sheet lining. Exit doors from the boilerroom premises should open outward and not have locks; other doors open inward and are locked. There should be at least two exits from the boilerhouse with fire escape on opposite sides (if outside, in a storm porch or stairway enclosure). Gates from the boiler-unit premises are made of two halves that open wide outward for the passage of transport, have a height of 2-4 meters and a width of 2.4-4.2 meters and incorporates a wicket gate for pedestrians.

If clinker and ash are removed and fuel is brought in through the gates, then in areas where the average air temperature for the year's coldest 5-day period is below -5 degrees Celsius, a storm porch or a heated screen is installed. Conveyors and the bunker for solid fuel should be separated from the boilerroom premises by noncombustible partitions. If the bunker and the charging components are installed in a common premise, the conveyor mechanism should not contaminate the premise with fuel and fuel dust. The solid-fuel bunker is made of reinforced concrete or of steel with a volume that will enable at least 1.5-3 hours of operation of the boiler unit at full load and full descent of fuel by gravity feed.

The steel bunkers are covered on the outside by thermal insulation to prevent condensation of steam on their walls. Fuel bunkers rest on columns or crossbars or are hung from them. The span between the column axes of the bunker gallery or the columns that are built into the premises are to be 3.0 and 6.0 meters. Above the bunker, the width of the galleries for fuel feed depends upon the number and sizes of the fuel-transport mechanisms: they adjoin the boilerhouse at the nonextensible end of the building, not resting upon the load-bearing walls or the building's framework.

An example of executing such a boilerhouse building, for 35 MW (30 Gcal/hr) and made of prefabricated reinforced concrete, is shown in figure 10-1. The load-bearing structure has been executed in the form of a framework with columns, concrete-slab ceiling floors, reinforced-concrete girders and a plate roof with thermoinsulating layer and water insulation and a covering of rolled material.



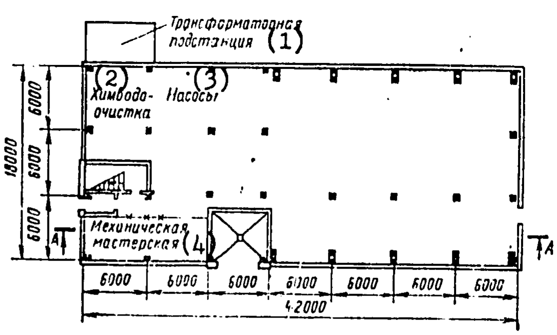


Figure 10-1. Dimensions and Scheme of a Boilerhouse Building Based on 35 MW (30 Gcal/hr) with Boiler Units That Burn Solid Fuel in a Bed (Design by Latgiproprom [Latvian State Regional Institute for the Design of Industrial Equipment]).

Key:
1. Transformer station.
2. Chemical water purifier.
3. Pumps.
4. Machine shop.

Solid fuel is fed by belt conveyors that are located in an inclined gallery and over the bunkers. Clinker and ash removal has been mechanized. All the basic and auxiliary equipment has been placed in one pavilion-type premise, which is separated from the machine shop, services and amenities premises by partitions; the transformer substation has been placed outside the building.

A still simpler boilerhouse building at which gas and mazut are burned is shown in figure 10-2, where the built-in etagere and services and amenities premises that are situated at the nonextensible end of the building are seen in elevation.

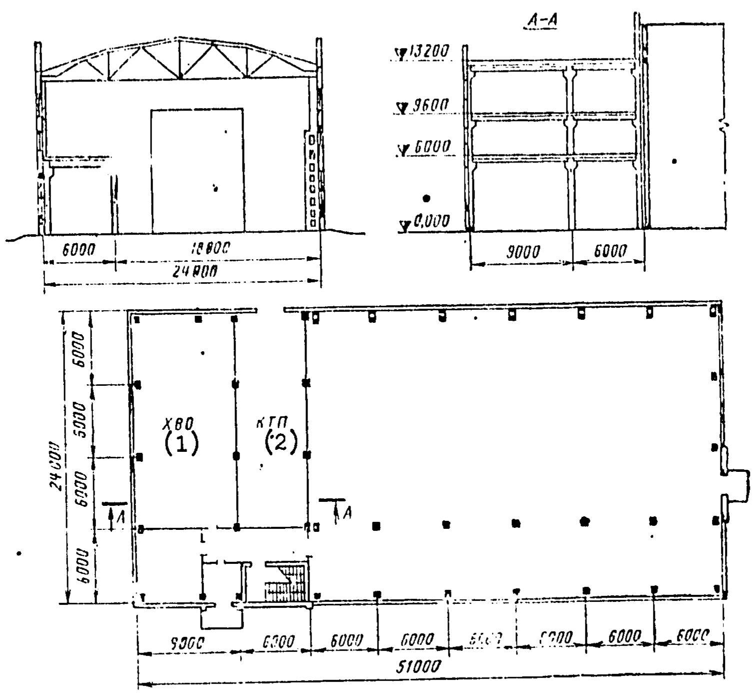


Figure 10-2. Dimensions and Scheme for Boilerhouse Building Based on 105 MW (90 Gcal/hr) with Steel Hot-Water Boilers for Gas and Mazut (Design by Latgiproprom [Latvian State Regional Institute for the Design of Industrial Equipment]).

Key:
1. KhVO [management].
2. KTP [technical monitoring point].

The choice of dimensions for the building is determined by the factory-stated clearances of the equipment and by the size of the passages between the equipment and curtain-wall structure, which is governed by the Principles and by construction norms.

In order to provide for mechanization of the installation and repair of equipment in the boilerhouse premises, beams and adapters for attaching load-lifting devices should be stipulated, if the weight of the parts removed is more than 100 kg. For the heaviest parts, provisions should be made for bringing up a truck crane or other similar mechanisms.

10-3. Equipment Layout.

Inside the building the boilerhouse equipment should be placed in accordance with the layout developed by the plant that manufactures the boiler units or in accordance with a standard design. Other layouts are allowed only during rebuilding. The boiler units are placed within the premise in one row with the servicing front facing window openings, and it is desirable that the heat-recovery surfaces—the water economizer and water preheater—and the auxiliary equipment (mills, forced-draft fans, arrangements for scrubbing flue gases and flue-gas pumps) be placed before and after each separate boiler unit individually. The only exception to this are cast-iron boilers that are modularized in two units, their side walls joining.

The general boilerhouse equipment that serves to prepare the water, and also the heat exchangers and pumps, are located in the boilerhouse at the nonextensible end of the building. Above the water-preparation equipment, where the layout is enclosed, the deaerator is installed in such fashion that the distance therefrom to the pumps that feed the water into the boiler unit will be small. The place for water preparation usually is isolated by a wall, and in it are placed integrated transformer substations, workshops for the repair of boilerroom equipment, monitoring and measuring instruments, and other services and premises for the amenities.

Figure 10-3 shows an enclosed layout for a boilerhouse with four cast-iron Energiya-6 hot-water boilers that operate on solid fuel (AS [anthracite seed], PZh [boiler and forge coal] and brown coal), with a total thermal productivity of 2.3-3.5 MW (2-3 Gcal/hr).

/The boilerhouse is designed for heat supply under an enclosed system and for supplying hot water in accordance with a circulating system with accumulator tanks.

A four-pipe system has been adopted for districts where the lowest outside air temperature $t_{out.air}$ is -40 degrees C. A fuel warehouse of the enclosed type is selected and it is placed at the part of the boilerhouse where the expansion thereof is anticipated, in a boilerhouse compartment of 6x12 meters; fuel is fed from the warehouse to the boilerhouse by means of electrical hoist and narrow-gage car, and into the warehouse by automotive transport. Clinker and ash are removed by means of a scraper into a bunker in the boilerhouse building. The clinker and ash are brought out from the bunker by automotive transport.

Gases move along underground horizontal flues to the steel flue from the NIIOGAZ [State Scientific-Research Institute for Industrial and Sanitary Gas Scrubbing] cyclones by flue-gas pumps.

Water is prepared under a scheme for single-stage treatment with a sodium cationite with wet storage of salt and with vacuum deaeration; the water is supplied from water mains; production and amenities sewage systems have been made separate.

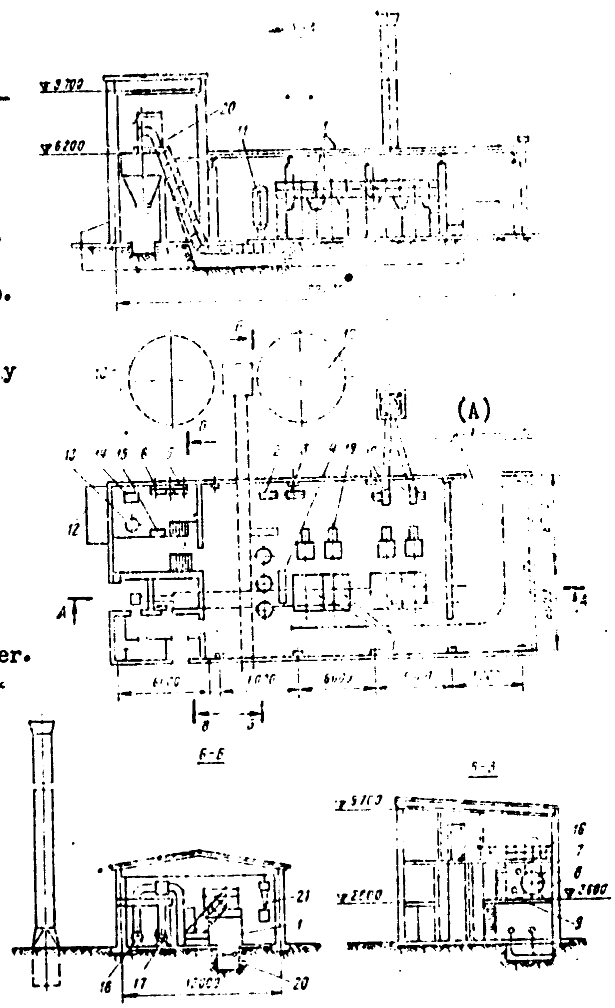


Figure 10-3. Enclosed Layout of Equipment for a Boilerhouse with Cast-Iron Hot-Water Boilers, Developed by Santekhproyekt [State Design Institute for Industrial Sanitary-Engineering Design of USSR Gosstroy].

Key:
1. Energiya-6 type boiler.
2. Pumps for network water (winter and summer).
3. Raw-material water pump.
4. Raw-material water preheater.
5. Preheater for chemically purified water.
6. Pump for deaerated water.
7. Deaerator.
8. Intermediate tank.
9. Pump for feeding water from the deaerator to the suction-pump ejectors.
10. Accumulator tanks.
11. Sodium cationite filter.
12. Tank for storing salt.
13. Measuring tank.
14. Water-level tank.
15. Ejector or pump for salt-solution feed.
16. Ejector for feeding water into the intermediate tank.
17. Forced-draft fan.
18. Flue-gas pump.
19. Ash trap.
20. Slag and ash remover.
21. Electrical hoist.

A. Fuel storage.

Electricity is supplied from a 380- or 220-volt grid to a panel for in-house needs. Accumulator tanks are installed behind the boilerhouse building, which is made with a load-bearing reinforced-concrete framework. The annual number of hours of use of the boilerhouse is set at 4,300.

The unit-by-unit principle was not adhered to in laying out the flue-gas pumps and other pumps./

Aside from heating and hot-water supply, customers often require low-pressure steam. For food, light, and meat industry enterprises, municipal and household customers, and agriculture, there are designs for boilerhouses with cast-iron or steel boilers for hot water and steam.

Examples of such boilerhouses are given in [L. 22].

Steam boiler units of low productivity are laid out in pavilion-type buildings with arrangements on the premise for etageres.

An example of a layout of a heating and production boilerhouse with an enclosed heat-supply system with DKVR-10-13 boiler units, to operate on gas and mazut, is shown in figure 10-4.

/Steam is sent to production with a pressure of 0.7 MPa (7 kg-force/cm^2) after reduction; losses of condensate to production are 50 percent. Water for heat-supply needs is heated by steam at 0.7 MPa (7 kg-force/cm^2) in steam-water heat exchangers almost without loss of condensate. The water is processed in sodium-cationite exchange filters under a two-stage scheme, it receives an addition of sodium nitrate, and it is deaerated in an atmospheric-type thermal deaerator installed outside the boilerhouse building. Also outside the building are tanks (or bunker) and a pump for wet storage and pumping of saline solution (12 and 15). All the pipes to the equipment inside the boilerhouse building have been laid in a sunken heated conduit. Next to the boilerhouse building is an open transformer substation, not far from which a well has been built for heating lines and for water from scavenging.

The boilerhouse building is made of prefabricated reinforced concrete, and the posts, crossbars and window casements are steel; the doors are of wood and the footings under the equipment are made of monolithic reinforced concrete.

Telephone service, radio communications and clock service are called for.

Electric power comes from the grid through a distribution substation at a voltage of 6 or 10 kv.

All the boilerhouse equipment has been laid out in unit-by-unit fashion. The steam line has been made single-strand, the feed line two-strand; feed pumps with electric and steam drive are to be installed. Flue gases from the flue-gas pumps are sent along the underground horizontal flues to the brick or concrete flue—one for the four boiler units.

Auxiliary equipment for the whole boilerhouse is situated at the unextensible end of the building; the boilerhouse compartment is 6x18 meters in size.

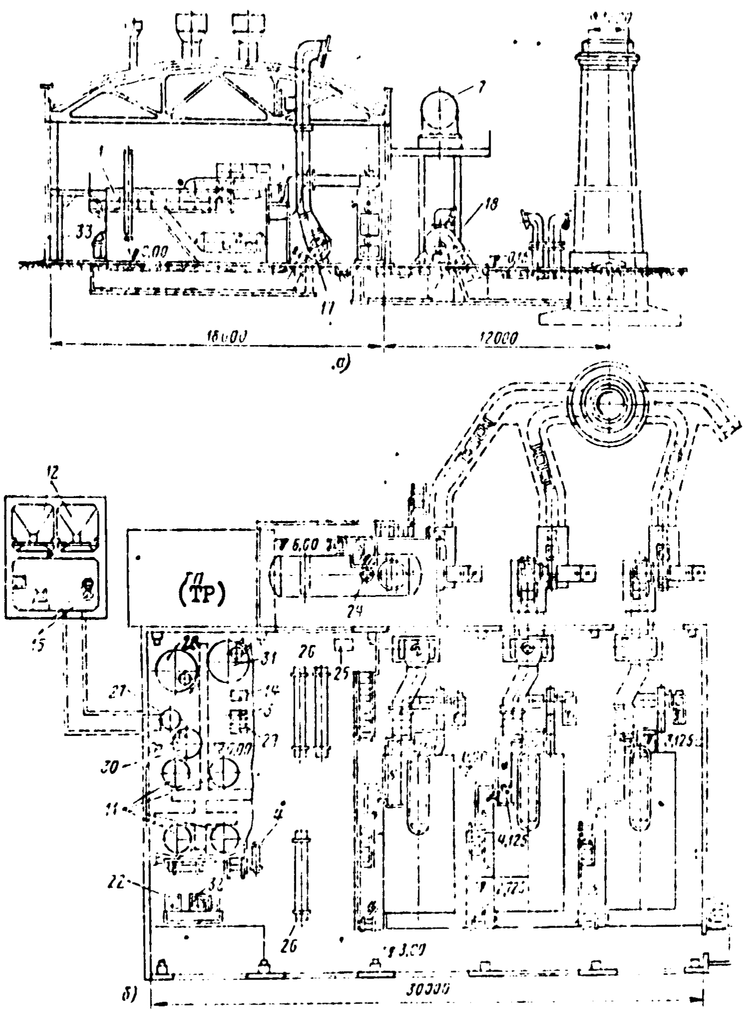


Figure 10-4. Semiopen Layout for a Boilerhouse with DKVR-10-13 Steam Boilers, Developed by Santekhproyekt [State Design Institute for Industrial Sanitary-Engineering Design of USSR Gosstroy].

Key:
a. Elevation.
b. Plan.

For legend, see figure 10-3, except for:

[Key continued on next page]

22. Continuous scavenging separator.
23. Reduction-cooling installation (above the chemical water purifier).
24. Cooler for steam.
25. Feed pump.
26. Network water preheater.
27. Salt solution filter.
28. Tank for transferring cationites.
29. Dispenser pump.
30. Tank for strong salt solution.
31. Tank for flushing water.
32. Pump for flushing water.
33. Panel for monitoring and measuring instruments and automated equipment.

TP. Transformer substation.

These are standard designs for the layout of boilerhouses that have been developed for cases of heat supply by one heat carrier—steam or hot water. Their deficiencies include crowded placement of water-preparation equipment and pumps, which complicates repair work, and the use of open installation of transformers./

Latgiproprom [Latvian State Regional Institute for the Design of Industrial Enterprises] has developed layouts also for larger steam boiler units [L. 22]. Layouts have been developed with hot-water boilers (steel) for various fuels for KV-GM and KV-TS boilers, for 4.76 to 58 MW (from 4 to 50 Gcal/hr). An example of a layout for a boilerhouse with large KV-GM-50 hot-water boilers is shown in figure 10-5.

/KV-GM-50 boilers and the other equipment are placed in pavilion-type buildings. The heat load of the boiler-house involves the expenditure of 80 percent of the heat on heating and ventilation and 20 percent on hot-water supply with the operation of covered heating networks with a water temperature of 150-70 degrees Celsius.

In this boilerhouse layout, network and recirculation pumps have been installed in front of the boilers, and panels with monitoring and measuring instruments are installed above them on an etagere. The inextensible end is occupied by a transformer substation, repair shops and amenities premises.

Equipment for water preparation, including deaeration, has been placed in the first boilerhouse compartments. The positions indicated previously have been preserved in the constructional sphere and, in order to reduce vibration, fans and flue-gas pumps have been installed on monolithic footings not joined to the floor. The placement of the rest of the equipment is apparent from figure 10-5.

Boilerhouses that operate on solid fuel that is burned in headers have the largest dimensions. Figure 10-6 shows a covered layout for KV-TK-30 steel hot-water boilers in a boilerhouse for an enclosed heat-supply system.

Figure 10-5. Enclosed Layout for a Boiler-house with KV-GM-50 Steel Hot-Water Boilers, Developed by Latgiproprom [Latvian State Regional Institute for the Design of Industrial Equipment].

Key:

For legend, see figures 10-3 and 10-4, except for:

34. Recirculating pump.

A. Plan at the 0.00 grade level.

B. Plan at the 600 grade level.

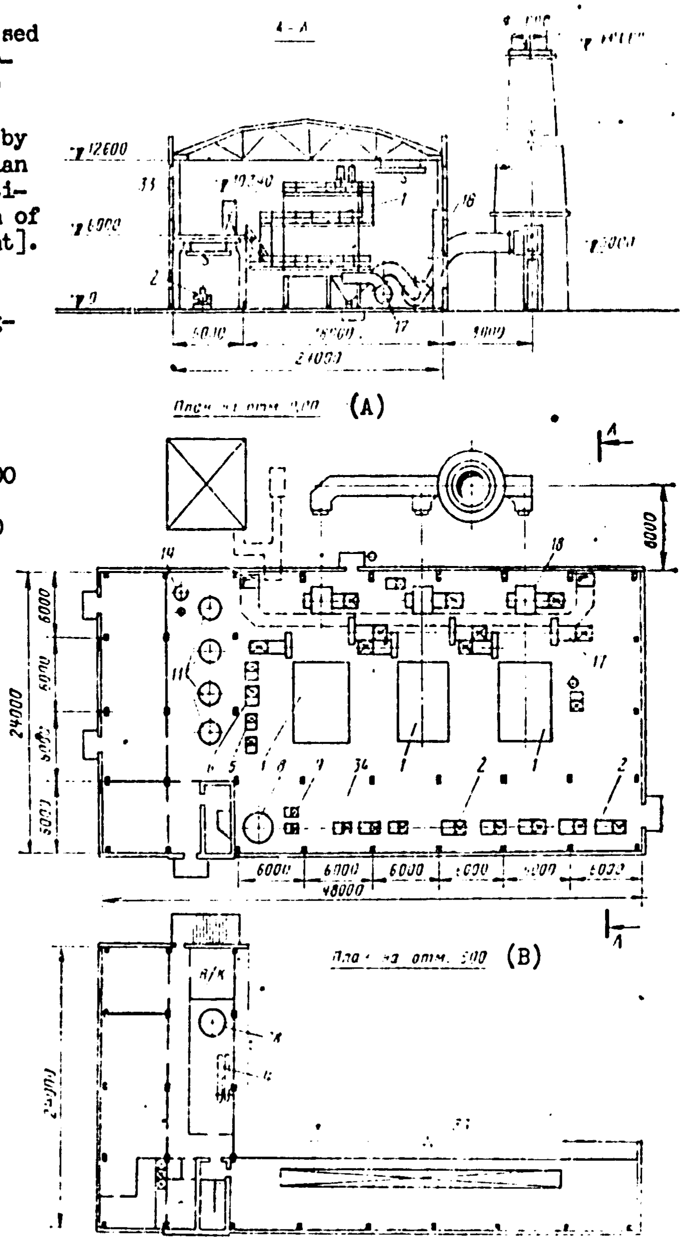
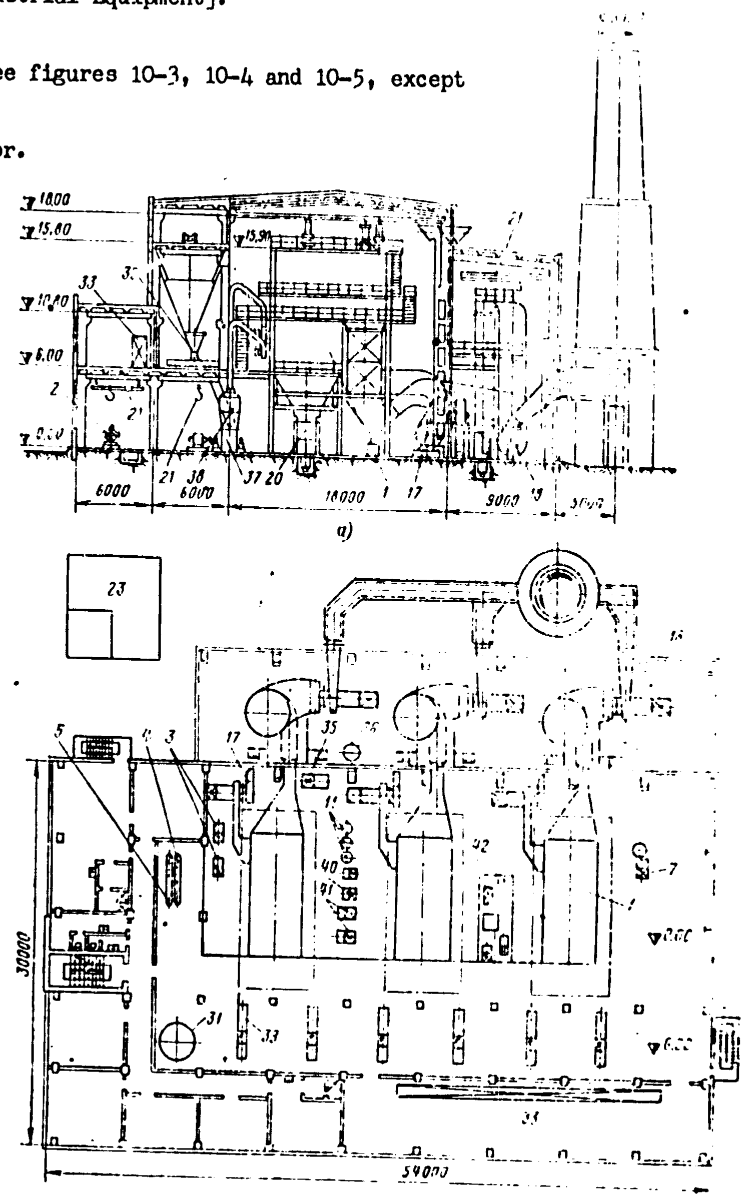


Figure 10-6. Covered Layout for a Boilerhouse with KV-TK-30 Steel Hot-Water Boilers, Developed by Latgiproprom [Latvian State Regional Institute for the Design of Industrial Equipment].

Key:

For legend, see figures 10-3, 10-4 and 10-5, except for:

35. Compressor.
36. Air collector.
37. Hammer mill.
38. Mill separator.
39. Scraper feeder.
40. Pump for sprinkling the ash trap.
41. Flushing pump.
42. Ash-sluicing pump.



This same equipment layout can be retained also for the installation of ash traps and flue-gas pumps outside the building. In front of the boilers is the bunker gallery, atop which are the fuel conveyors; the raw-fuel feeders are under the bunkers, and the pulverization equipment is at grade level.

The placement of the other equipment is the same as in the preceding layout, but ash traps of the wet type have been installed in front of the flue-gas pumps. Hydraulic removal of clinker and ash, the scheme for which is shown in figure 7-32 [not reproduced], that required the installation of additional pumps and tanks and a change in the sewerage system, has been used in the boilerhouse.

The constructional phase has been executed in a fashion similar to the layout that has been examined.

Somewhat different from the examined layouts are those for use of the heat of secondary energy sources, for example, waste-heat recovery boilers, and the heat of waste gases from open-hearth furnaces; one of these has been shown, where the waste-heat recovery boiler is located in the enclosed premise, in figure 10-7.

The boiler unit 1 of the type depicted in figure 6-31 [not reproduced] has compound forced-circulation of water from drum 2 through coils, using pump 3. Flue gases from an open-hearth furnace pass through boiler 1, which involves convective heating surfaces, and are removed by flue-gas pump 4 into the flue 5. Since the gases from the open-hearth furnace are polluted by carry-off from the charge, with a dust content of up to 10 grams per m^3, the boiler heating surface is to be cleaned by shot (see figures 5-60 and 5-61 [not reproduced] that arrive from bunker 6 and distributor 7, and is to be washed with water that comes from special pipes 8. The shot or sludge is collected during the washing with water in bunker 9, and then the shot is returned by worm conveyor 10 along a pipeline into bunker 6, and the water and sludge are pumped out by pump 11. The waste-heat recovery boiler for servicing the purification installations is laid out with a substantial depth for the bunkers 9.

Where deepening is dispensed with and the waste-heat recovery boiler installation is enclosed, the height of the building is almost doubled.

Boilers that serve for the heating or evaporation of high-boiling organic heat-transfer agents are placed as closely as possible to the technological apparatus, and their layout is distinguished from the layout of the DKVR boilers previously examined mainly by the absence of arrangements for water preparation and deaeration, and in some cases also of an air preheater.

The examples of boilerhouse equipment layout that were examined do not cover boilers with pressure charging, the development of the structure and layout of which has not been completed yet. Preliminary Santekhp. . .k.

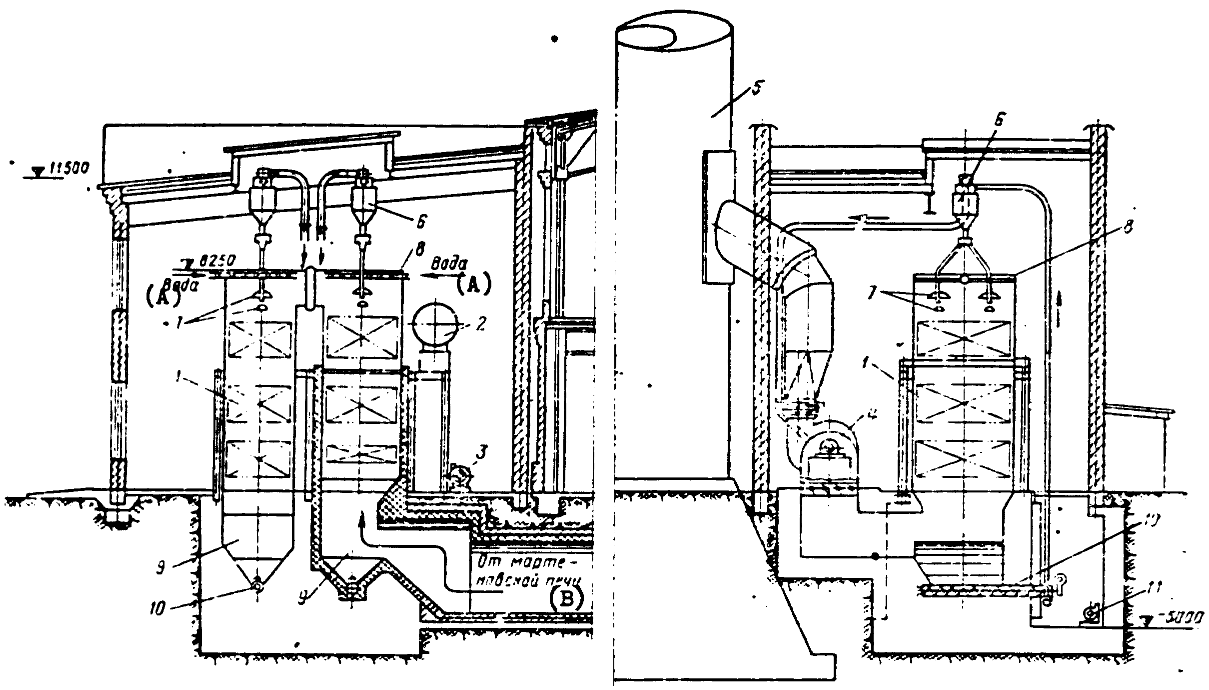


Figure 10-7. Layout for Waste-Heat Recovery Boiler with Open-Hearth Furnace.

Key:

1.	Boiler heating surfaces.	5.	Flue.	9.	Lower bunker.
2.	Drum.	6.	Bunker for shot.	10.	Worm conveyor.
3.	Circulation pump.	7.	Shot distributor.	11.	Sludge pump.
4.	Flue-gas pump.	8.	Pipes for washing heating surfaces with water.	A.	Water.
				B.	From the open-hearth surface.

[State Design Institute for Industrial Sanitary-Engineering Design of USSR Gosstroy] data for boiler-unit layouts of 1.1-7 kg-force/seconds (4-25 tons per hour) have shown that the construction volume of the building changes but little in comparison with the layout shown in figure 10-4.

The main changes in equipment layout are the transfer of the fan to the front of the boiler unit and dispensing with the installation of flue-gas pumps. It is assumed that the cost of boilerhouse equipment for units with pressure charging and the annual operating expenses will not be changed considerably.

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METALWORKING EQUIPMENT

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RELIABILITY OF MACHINE TOOLS WITH DIGITAL PROGRAM CONTROL IN OPERATION

Moscow STANKI I INSTRUMENT in Russian No 10, 1978 pp 8-9

[Article by A. S. Lapidus, V. T. Portman, L. G. Megavoryan]

[Text] At the present time industry is using a procedure developed by the ENIMS Institute to study machine tools with digital program control in operation. The basic principles of the procedure are discussed below.

The system for gathering data on the reliability of machine tools with digital program control must insure that reliable, comparable and objective data will be obtained and also the possibility for generalization of them. When gathering the information, the causes of failures, their type and means of eliminating them, the time for returning the machine tool to operation and the run time of the machine tool between failures are recorded.

In order to obtain information about reliability, it is recommended that machine tools be selected which operate under standard conditions for the given model of machine tools not subject to capital and medium repair. When classifying the operating conditions as standard it is necessary to consider the nomenclature, overall dimensions, the requirements on accuracy and the material of the machined products altogether, the types of operations performed, the machining conditions, external conditions (dust, vibration level, temperature in the facility), the qualifications of the service personnel (including repair personnel), and the quality of technical servicing. The observations must be performed at the plants with well organized production facilities where the machine tools are loaded for two or three shifts.

The information is gathered by the service personnel under the direction and with the participation of the machine tool manufacturers. The size of the sample of machine tools and the observation time depend on what accuracy and reliability of the reliability indexes are required and also the proposed distribution law of the observed random events. It is recommended that from 5 to 20 machine tools be selected for observation (depending on the series nature of their output, the territorial arrangement, the operating conditions, and so on). Considering the actual

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distribution laws of the random events, it is necessary to select the number of machine tools and the duration of the observations so that the observed number of random events (failures, repairs and so on) will be no less than 55. This insures reliability of evaluating the reliability index of 0.9 with a relative error of 0.2.

The following components necessary to evaluating reliability enter into the rated stock of operating time of the machine tools with digital program control: the run time and the repair time.

The run time by which we mean the total time from beginning to end of operation of the machine tool with respect to each control program is determined by means of instruments which automatically record the operation of the machine tool by the program from the time the start button is switched on to the "end of program," or by recording the time for machining a given part with respect to the control program and the number of machined parts.

If a reject is detected for reasons which do not depend on the fitness of the machine tool, then the time spent on manufacturing the rejected parts is included in the run time. If the causes of rejects depend on the fitness of the machine tool, then the time expended on manufacturing the rejected products is excluded from the run time in the final rejects; for a correctable reject, the time for redoing the product is excluded; the reject is considered only in the case where the run time varies by more than 2 to 3%.

The repair time for a machine tool with digital program control is the time spent on detection of the failure, determination of the cause of its appearance and elimination of the consequences of the failure, including the time for a test start. This includes the time for elimination of tool failures if they are not a consequence of failure of the machine tool but also the repair expectation time.

A classification of the repair time of the machine tools with digital program control with respect to groups of components has been adopted: the digital program control unit, mechanical components, electrical equipment (the main propulsion and feed electric drive), the electroautomation, measuring devices (feedback sensors with converters), the feed network of the machine tool with digital program control; the hydraulic equipment; the lubrication and cooling systems. The time for elimination of failures, the cause of which has not been established is put in a separate group.

During the process of gathering information on the reliability of machine tools with digital program control in operation all types of failures are recorded, including mistakes (self-eliminating failures). With respect to the established actual causes of failures, the latter are separated into independent failures of the elements of the machine tool and dependent ones. Further analysis and evaluation of the reliability (including the determination of the number of failures taken into account when calculating the reliability indexes) is carried out with respect to the independent failures of the elements. Here the time for elimination of the dependent failures of the elements is included in the time for repair for the corresponding independent failures (that is, the repair time completely pertains to independent failures).

The appearance of dependent failures and damage requiring a great deal of time to eliminate indicates the vulnerability of the structural design, which is taken into account when analyzing the reliability. The operating failures are isolated in a separate group, in each case substantiating the classification of the failure among the operating failures. For determining the reliability indexes, the operating failures are not taken into account, for they usually are not caused by defects of the machine tool with digital program control. In particular, the response of the protection for causes connected with violation of the operating rules of the machine tool is not considered a failure.

If the given operating failure is systematically repeated on a number of machine tools, then it must be considered as the structural or production failure and taken into account when determining the reliability indexes; this is recorded when analyzing the reliability.

The partial failure (limiting the technological possibilities or output capacity of the machine tool but permitting continuation of work) eliminated during the periods of technical servicing or planned repair belongs to the insignificant damage. It is not recorded as a failure and correspondingly is not taken into account when determining the reliability indexes. The formula includes the number of failures or the repair time.

When analyzing the reliability, the systematically repeating failures are discovered which reflect the peculiarities of the structural design, the manufacturing defect and the operating conditions and the failure is connected with danger to life and health of people. The information about the dangerous failure must be transmitted directly to the main designer of the manufacturing plant and the chief mechanic of the user plant.

During the failures leading to rejection of the products, it is necessary to analyze the cause of the reject for the reason of their dependence on the fitness of the machine tool. If the reject does not depend on the fitness of the machine tool (it appears as a result of defects or noncorrespondence of the material of the machined product, failures of the tools, errors in programming, and so on), then the failure is not recorded.

The rejection for causes which depend on the fitness of the machine tool is considered to be a failure. If several of the products manufactured in a row turn out to be rejected (for example, as a result of the existing monitoring system or with respect to incomplete examination on the part of the machine tool operator), then this is considered as one failure.

The tool failures, as a rule, are not taken into account, and when necessary they are recorded separately.

The reliability indexes of the machine tools operating under the standard operating conditions for the given models during the period before the first capital repair are random variables and they are characterized by parameters (the average value, dispersion) estimated statistically with indication of the fiducial intervals.

By the ENIMS Institute procedure for machine tools with digital program control, the following reliability indexes are recommended.

1. The run time per failure (the fail-safeness index)

$$T = (1/m) \sum_{i=1}^{N} t_i,$$

where t_i is the total run time of the i-th machine tool for the observation period, hours; N is the number of machine tools under observation; m is the total number of failures (including mistakes) of the N machine tools (only the independent failures are taken into account, and the operating failures and tool failures are not considered).

2. The average repair time (the repairability index) $T_B = (1/m) \sum_{j=1}^{m} t_{Bj}$,

where t_{Bj} is the time spent on detection, finding the cause and eliminating the consequences of the j-th machine tool failure, hours (the waiting time for repairs is not included).

3. The specific repair time is the time spent on detection, finding the causes of failures and elimination of the consequences of the failures per unit time of fail-safe operation (the complex reliability index)

$$B = \sum_{j=1}^{m} t_{Bj} \Big/ \sum_{i=1}^{N} t_i = T_B \Big/ T$$

The value of B is conveniently expressed in hours of the repair time (the idle time of the machine tool and the unplanned repair) per 100 hours of operation of the machine tool with respect to the control programs.

The specific repair time is related functionally to the availability factor K_Γ -- the probability that the machine tool will turn out to be set at an arbitrary point in time (except the planned periods, during which the use of the machine tool for its purpose is not provided for, and the idle time with respect to organizational causes); $B=(1-K_\Gamma)/K_\Gamma$.

The fail-safeness indexes T and the repairability indexes T_B are determined only in cases where the observation conditions guarantee consideration of all of the failures without exception, including the mistakes. The complex reliability index B is defined under the conditions guaranteeing consideration of all the failures and in cases where some part of the failures (in particular, the mistakes) not causing significant idle time could not be recorded. The recovery time spent on unrecorded failures must be (and usually turns out to be) small by comparison with the repair time for actually considered failures.

As the use index of the machine tool with digital program control, the use coefficient of the stock of operating time with respect to the operating time of the machine tool by the control programs is used, which is in the form of the ratio of the run time of the machine tools to the rated stock of operating time: $K_t = \sum_{i=1}^{N} t_i \Big/ \sum_{i=1}^{N} t_{Fi}$, where t_{Fi} is the rated stock of operating time of the i-th machine tool with digital program control, hours.

The use index of the machine tools with digital program control complexly characterizes the level of organization of production at the user plants, the reliability of these machine tools and tools and also the nature of the operations performed on the machine tools.

The operational studies performed by the discussed procedure by the ENIMS Institute and the manufacturing plants of the machine tools with the participation of the manufacturers of the digital program control unit have made it possible to obtain initial data on the actual level of the reliability and use indexes of the machine tools with digital program control. In particular, it has been established that the values of $B \leq 0.05$ to 0.10 are acceptable (that is, 5 to 10 hours of idle time of the machine tool in unplanned repair per 100 hours of operation with respect to the control programs).

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METHOD OF ESTIMATING THE PROCESS RELIABILITY OF MACHINE TOOLS WITH DIGITAL PROGRAM CONTROL

Moscow STANKI I INSTRUMENT in Russian No 10, 1978 pp 9-11

[Article by V. S. Starodubov, M. S. Ukolov]

[Text] By the technological process reliability we mean the property of machine tools to perform the technological process operations arising from its purpose while maintaining machining precision in time and achieving quality of the machined surfaces within the given limit.[1]

The precision and reliability of the machine tools with digital program control depend on the operating quality of the entire set of electronic, mechanical and hydraulic components, the mechanisms and modules of the digital program control units (the information readout and input unit; the modules for storing information, reproducing and conversion of it; the elements of the automated control system for the feed drive), the drive motors of the servoelements of the machine tool, the mechanisms for automatic tool changing, the feedback sensor and so on.

In the machine tools with digital program control, many processes (for example, wear awnd thermal deformations) are occurring more intensely than in ordinary machine tools. This is explained by the high energy capacity (they have an increased number of control coordinates with independent drive and, as a rule, they are converted to hydraulic operations), and also the more intense operation (two or three shifts); the proportion of the machine time as a result of the high degree of automation is 80 to 85%. The machining on the machine tools with digital program control is realized by the previously written program, and therefore the operator has limited possibilities for active intervention in the process in order to decrease or eliminate the effect of the thermal deformations on the machining precision.

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[1] A. S. Pronikov, editor, TEKHNOLOGICHESKAYA NADEZHNOST' STANKOV [Technological Process Reliability of Machine Tools], Moscow, Mashinostroyeniye, 1971.

For determination of the actual level of technological reliability it is necessary to determine its indexes by testing the machine tools with digital program control. When testing it is necessary to take into account the specific nature of the interaction of the machine tools and the digital program control system consisting in the following: the machine tools and control systems (frequently in the form of the small computer) are considered as a single organically interrelated complex technological system; the degree or effect of the machine tool errors and the control system errors on the technological reliability is determined separately and in combination; a variety of operating conditions are taken into account (the frequent changing of the tool and the large nomenclature of machined parts) along with the complexity of the machining cycles (the multicoordinate control with multitool machining of the part); the increased intensity of occurrence of various processes in the machine tool and the control system is taken into account; there are devices which compensate for the effect of the individual errors in the machine tool, attachment, tool and part system and accelerating the search for the causes of a change in machining precision, and so on. In addition, a larger number of tests are required than for ordinary machine tools, including new types (for example, testing the positioning precision, the precision of the automatic tool changing, the operating quality of the drives and the control system) and also a large volume of tests considering a set of factors influencing the precision.

The statistical methods of observation immediately of a large number of machine tools with digital program control are expediently used as a result of increased complexity and cost. It is more expedient to test a specific machine tool and draw general conclusions on the basis of the information obtained during the analytical calculations and experimental studies (ordinary and accelerated tests) and also for the statistical observations of the reliability of individual components and elements of the machine tools with digital program control. Accordingly, it is possible to perform the tests in two areas: testing the machine tool combined with the control system; testing the components and mechanisms of the machine tool separately and also the feed drives, the digital program control unit, the feedback sensors, and so on.

It is possible to represent the estimation of the technological process reliability o f the machine tools with digital program control in the general case in the form of successive steps: 1) analysis of the specific nature of the machine tool and the control system selected for investigation; 2) selection of the indexes for estimating the technological process reliability; 3) development of the structural diagram for analysis of the technological process reliability and selection of the parameters for investigation; 4) development of the model of the variation of the machining and precision; 5) generation of the analytical functions which relate the indexes of technological process reliability to the precision parameters of the machine tool and the machined parts; 6) theoretical and experimental investigation of the component errors and factors influencing the machining precision; 7) calculation of the indexes and estimation of the level of technological process reliability of the machine tool.

The fourth step is the most important for the calculations and mathematical expectation of the processes of loss of precision by the machine tool. In order to create a model of the variation in machining precision it is necessary to investigate the formation of the errors in time by the selected parameters considering the specific nature of the machine tools with digital program control.

The analysis of the process of machining parts on machine tools with digital program control will permit isolation of the following basic types of errors lowering the precision and reflecting their specific nature of machine tools with digital program control: the programming error Δ_{pr} (it arises in the phase of preparing the programs to control the machine tool with digital program control); the error in adjusting the machine tool with digital program control Δ_H; the positioning error Δ_{pos} (the error when the controlled servoelement exits to the given coordinate); the error in automated tool changing Δ_{tc} (characteristic of the multitool machining on machine tools with digital program control); the error Δ_g [geometric error from nonrectilinearity, nonparallelness and nonperpendicularity of the movement of the servoelements of the machine tool (when machining it can appear as an error in size and shape of the part)]; the error Δ_{rigid} from elastic deformations (as a result of the insufficient rigidity of the SPID [machine tool, attachment, tool, part] system); the error Δ_b from the fast-occurring processes (it arises as a result of vibrations of redistribution of the frictional forces, change in processes, and so on); the error Δ_c from the processes occurring with a mean rate (from thermal deformations of the machine tool, tool, part, wear of the tool, and so on); the error Δ_M from the slowly occurring processes (from wear of the tool, warping, and so on). It is necessary to consider that the indicated errors can be by their nature random variables (or random processes), vary in time and have vector properties.

The most characteristic for machine tools with digital program control is the positioning error which noticeably reduces the control program operating precision. This error is caused by the error in the interpolation connected with nonuniformity of the pulse repetition, the error in the drive motors, the kinematic errors in the feed drive and feedback system, the dynamic drive errors, the geometric errors in the machine tool, the elastic deformations of the feed drives and other factors.

Thus, the total error Δ_{ct} of the machining on machine tools with digital program control is a function of many variables; $\Delta_{ct}=f(\Delta_{\pi p};\ \Delta_H;\ \Delta_{pos};\ \Delta_{t.c.};\ \Delta_g;\ \Delta_r;\ \Delta_b;\ \Delta_c;\ \Delta_M)$.

The analysis of the process of the error formation and the use of the model of variation of the machining precision on the machine tool proposed in general form in the mentioned paper made it possible to develop a model of the variation in machining precision on machine tools with digital program

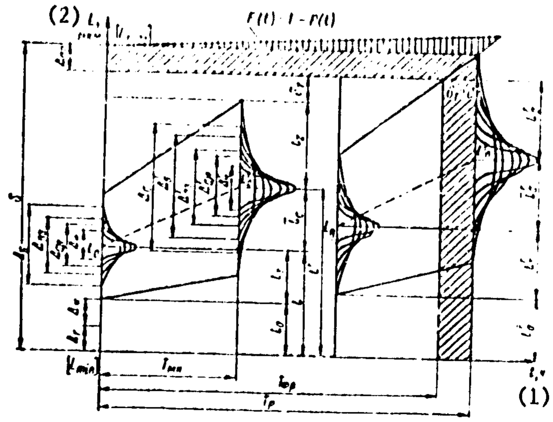

Figure 1. Model of the variation of the machining precision on a machine tool with digital program control:
L_0 and L'_C -- value of the control parameter at the beginning and end of the interadjustment period; L_n and L'_n -- current value of the controlled parameter in the operating process;
F(t) -- probability of failure with respect to the controlled parameter

Key:

1. t, hours
2. L, microns

control considering their specific nature. Using the model obtained it is possible to determine the analytical relations which relate the technological reliability indexes to the precision parameters of the machine tool and the machined parts (see Fig 1).

The specific nature of machining the parts on the machine tools with digital program control consists in the fact that part of the tolerance field δ is consumed before machining in the programming phase. Accordingly, the actual reserve δ_{actual} of the machine tool with digital program control with respect to the machine precision is less than that given by the amount $\Delta_{\pi p}$, that is, $\delta_\phi=(L_{max}-L_{min})-\Delta_{\pi p}=\delta-\Delta_{\pi p}$, where L_{min} and L_{max} are the minimum and maximum values- of the controlled machining precision parameter respectively. The programming errors are caused by approximation of the curvilinear outline and rounding of the dimensions to the value which is a multiple of the discreteness of the machine tool with digital program control.

Since the programming errors are unavoidable, the precision of the parts machined on the machine tool with digital program control goes outside the tolerance limits faster than the reserve δ_T with respect to the precision of the machine tool itself will be consumed. This must be considered when investigating the technological process reliability (in the indexes, in the analytical relations, when determining the reserves, and so on).

Before machining the part the machine tool is adjusted to the dimension L_0 which differs from L_{min} by the amount $\ell_0=\Delta_g+\Delta_r$ (in the general case, and the value of ℓ_1 which is the dispersion zone of the dimensions of the machined parts as a result of the error Δ_H, Δ_p, Δ_b and Δ_{tc}.

Considering the probrbility of the addition method

$$l_1 = \sqrt{(\Delta_H/2)^2+(\Delta_{c.H}/2)^2+(\Delta_{\text{пз}}/2)^2+(\Delta_б/2)^2}.$$
(1) (2)

Key:
1. tc
2. p

When operating the machine tool under the effect of different processes, the center of the dispersion zone of the dimension L_0 is shifted in the interadjustment period T_{MH} to the point L'_0 by the amount ℓ_c which must be considered as a random time function with the dispersionzone Δ_c and the mean value $\bar{\Delta}_c$. The shift of the center of the dispersionzone takes place, as a rule, as a result of the thermal deformations of the machine tool and the dimensional wear of the tool. As a result of the effect of these factors and also the fast-occurring processes, the errors during the interadjustment period vary ($\Delta_H \to \Delta'_H$; $\Delta_{tc} \to \Delta'_{tc}$; $\Delta_p \to \Delta'_p$; $\Delta_b \to \Delta'_b$). The scattering zone of the indicated errors with respect to L'_0 increases, and by the end of the interadjustment period it becomes equal to $2\ell_2$;

$$l_2 = \sqrt{(\Delta'_H/2)^2+(\Delta'_{\text{пз}}/2)^2+(\Delta'_{c.H}/2)^2+(\Delta'_б/2)^2+(\Delta'/2)^2}.$$

If it is assumed that ℓ_0, ℓ_1, $\bar{\ell}_c$ and ℓ_2 are interdependent, with a normal law of their distribution, the error in the machine tool with digital program control for the interadjustment period $\Delta_{ct}=\ell_0+\ell_1+\bar{\ell}_c+\ell_2$.

By the end of the interadjustment period, the machine tool reserve with digital program control with respect to machining precision remains unconsumed:

$$\delta_T = \delta_ф - \Delta_{CT} = (\delta - \Delta_{\text{пр}}) - \Delta_{CT}. \qquad (1)$$

The variation and the precision parameters of the machine tool in time is determined by long-term operating tests. However, the estimation of the level of technological reliability of the machine tool with digital program control can be given, using the reserve δ_T of the machine tool with respect to the machining precision and the precision reserve coefficient $K_T=(\delta/\Delta_{ct})\geq 1$ as the reserve. The value of K_T can be determined by the results of testing the machine tool with digital program control in the interadjustable period:

$$K_T = \delta_\phi/(\delta_\phi - \delta_T) = [(\delta - \Delta_{\pi p})/(l_0 + l_1 + \bar{l}_c + l_2)] \geq 1. \qquad (2)$$

The values of δ_T and K_T can be obtained as a result of short-time tests, since for their determination it is not necessary to estimate the rate of the slowly occurring process.

For the dispersion field $2\ell_2=6\sigma$ (here σ is the mean square deviation of the L at the end of the interadjustment period) and considering the fact that $\delta-\ell'=\delta_g+\ell_2$, the probability P(t) of fail-safe operation of the machine tool with digital program control can be defined as the probability that the mentioned L will get into the tolerance field $(\delta-\Delta_{\pi p})$ during machining of the part:

$$P(t) = 0{,}5 + \Phi_0 \left[\frac{(\delta - \Delta_{\pi p}) - (l_0 + l_1 + \bar{l}_c)}{l_2/3} \right], \qquad (3)$$

where ϕ_0 is the normalized Laplace function $(0 \leq \phi_0 \leq 0.5)$.

It is necessary to consider that in order to estimate the technological reliability it is insufficient to consider only the probability P(t) of fail-safe operation as its index, for with respect to the value of P(t) it is impossible to determine the value of δ_T and, consequently, the actual reliability level.

The machining error on the machine tool reaches the limit for maximum admissible values of the component errors of the machine tool, that is, when $\delta_T=0$ for the given value of P(t). The operating time of the machine tool with digital program control to this time determines the reserve T_p with respect to machining precision. Since when machining parts on machine tools with digital program control, part of the tolerance δ is spent before the beginning of machining, in the programming step (in Fig 1 the horizontal crosshatched zone), actually the machine tool error goes beyond the allowance field faster depending on the value of $\Delta_{\pi p}$ (the vertical crosshatched zone in Fig 1) and the actual reserve $T_{\phi,p}$ of the machine tool with digital program control with respect to machining precision is less than T_p.

The reserve of the investigated machine tool with digital program control with respect to machining precision and the safety factory K_T determined in the interadjustment period serve as the initial data for predicting the reserve T_p of the machine tool and the probability P(t) of fail-safe operation with respect to the machining precision.

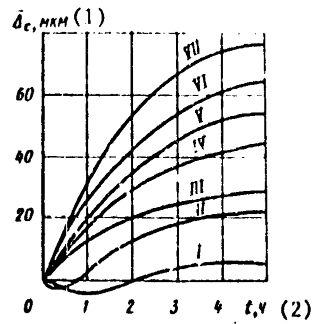

Figure 2. Graph of the shift of the spindle as a result of thermal deformations with rpm of n=100, 200, 400. 650, 800, 1000 and 1250 (the curves I-VII respectively)

Key:
1. microns
2. hours

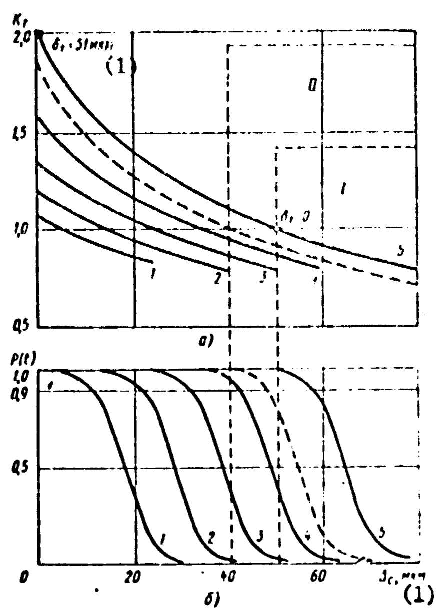

Figure 3. Graphs of the variation of the indexes of technological process reliability K_T (a) and P(t) (b) as a result of thermal deformations for Δ_g (in microns) equal to 50 (curve 1), 40 (curve 2), 30 (curve 3), 20 (curve 4) and 4 (curve 5); $K_T=f(\Delta_c; \Delta_g)$; $P(t)=f(\Delta_c);\ _g)$; I and II -- areas of occurrence of technological process failures respectively for $\Delta_{\pi p}=0$ and 10 microns

Key:
1. microns

[redacted]

In order to determine the numerical values of the indexes and to estimate the level of technological process reliability, studies were made of the errors Δ_g; Δ_r; Δ_p; Δ_{tc}; Δ_H; Δ_b; Δ_c and $\bar{\Delta}_c$, forming these indexes with respect to the "dimension precision with respect to the Y-coordinate" parameter, on the model 6520F3 vertical milling machine with digital program control. The studies demonstrated that the error in the control system is manifested in the form of scattering of the angles of rotation of the shaft of the stepping motor when the control pulses are developed by it. The magnitude of the dispersion for the stepping motor disconnected from the mechanical part of the master control unit of the machine tool is $\pm 0.15°$. During operation of the stepping motor together with the master control unit the amount of scattering of the angle increases to $\pm 0.6°$. This error influences Δ_p of the investigated machine tool.

The basic proportion in the overall balance, as the studies have demonstrated, is the errors as a result of the thermal deformations which vary in time and fluctuate within broad limits depending on the spindle rpm (see Fig 2). In order to study the effect of the thermal deformations on the technological process reliability of the machine tool according to formulas (1), (2) and (3) the indexes δ_T, P(t) and K_T were calculated for the following values of the errors (in microns): Δ_g=4; Δ_r=20; Δ_H=10; Δ_p=22; Δ_b=2; Δ_{tc}=0 for the case of the single tool machining); Δ_c=12 and $\bar{\Delta}_c$=0 to 80.

As is obvious from the graph (see Fig 3), the level of technological process reliability at the beginning of the interadjustment period (for $\bar{\Delta}_c$=0) is quite high: δ_T=51 microns, K_T=2.04 and P(t)$\approx$1. With an increase in $\bar{\Delta}_c$, δ_T and K_T decrease sharply (see Fig 3, a). For $\bar{\Delta}_c$=50 microns the reserve δ_T=0, and K_T=1 (without considering the programming error, that is, for $\Delta_{\pi p}$=0). With a further increase in $\bar{\Delta}_c$, the index P(t) decreases (see Fig 3, b). For example, for $\bar{\Delta}_c$=57 microns, P(t)=0.9, and for $\bar{\Delta}_c$=64 microns P(t)=0.5. Thus, if the level of thermal deformations is higher than 57 microns, then the probability P(t) of fail-safe operations decreases sharply. Therefore the region to the right of the point $\bar{\Delta}_c$=50 microns can be considered the region of occurrence of the technological process failures (the failures with respect to the machining precision). Considering the programming errors the failures can be exhibited still earlier. For example, if $\Delta_{\pi p}$=10 microns the failures are already exhibited for $\bar{\Delta}_c \geq 40$ microns.

Consequently, knowing the variation of the indexes δ_T, P(t) and K_T of the technological reliability it is possible to determine the limiting values of the individual component errors in the machine tools, for which the process failures do not occur. For example, for the given probability P(t)=0.9 of fail-safe operations (see Fig 3) the error as a result of the thermal deformations must not exceed 57 microns.

If the initial values of the technological process reliability indexes and the error components are known, then, experimentally (or analytically) determining the variations of these errors in the operating process, it is possible to calculate the indexes δ_T, P(t) and K_T and thus to estimate the level of technological process reliability and its variation in time. By varying the errors, it is also possible to determine their effect on the technological reliability and find effective means of improving it.

Thus, in the presented example Δ_g will increase as a result of wear of the guides (as a result of nonrectilinearity of the displacement of the bench the initial value Δ_g=4 microns). After determining (by calculation, experimentally or under operating conditions) the wear rate, it is possible to establish the variation of the errors Δ_g and also the time of occurrence of the technological process failures. From Fig 3 it is obvious that for wear by 46 microns (that is, for Δ_g=50 microns) the safety margin is close to one (K_T=1.06) already for $\bar{\Delta}_c$=0. Fifteen to 30 minutes after inclusion of the machine tool (see Fig 2), δ_T=0, and K_T=1, and the failure occurs with respect to precision.

The investigated method of estimating the process reliability of the machine tools with digital program control will permit discovery of the most characteristic precision parameters for the specific machine tool, determining its technological process reliability; establishment of the errors forming these parameters; factors which influence their variation to the highest degree and thus to find effective means of improving the technological process reliability of the machine tool with digital program control.

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METALWORKING EQUIPMENT

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HUNGARIAN-SOVIET COOPERATION IN MACHINE TOOL BUILDING

Moscow STANKI I INSTRUMENT in Russian No 10, 1978 pp 43-44

[Article by T. Gamori]

[Text] The Tekhnoimpeks Hungarian Foreign Trade Enterprise has close relations with the socialist countries; the volume of its foreign trade with dealings with respect to import and export of machine tools based on long-range agreements is increasing from year to year.

The Tekhnoimpeks and the Soviet foreign trade association Stankoimport have in the last 20 years developed an active, useful cooperation for machine tool building in both countries. In the opinion of the Hungarian specialists, the machine tools imported from the Soviet Union have a favorable influence on the production results of Hungarian plants. The import volume of the Soviet machine tools in rubles in the past years has increased significantly. Thus, from 1950 to 1977 it increased by approximately 32 times.

The demand of the Hungarian enterprises for Soviet machine tools is increasing from year to year. Therefore, every year several delegates, representatives of Tekhnoimpeks and specialists of Hungarian industry come to the Soviet Union to study the possibilities for export and import of machine tools. They not only visit Stankoimport, but also other machine tool building plants in the Soviet Union.

At the large Hungarian plants (for example, at the GANTS-MAVAG, TUNGSRAM, RABA plants) there are a significant number of Soviet-produced machine tools in operation. Tekhnoimpeks imports universal machine tools in large volume and also vertical drilling machines, surface grinding machines and other special machines (see Figures 1 to 3).

Stankoimport has already started deliveries of machine tools with digital program control to Hungary. The demand for these machine tools is growing, and beginning with the results of the talks held recently it is possible to state that more and more Soviet machine tools with digital program control will be operating at Hungarian plants.

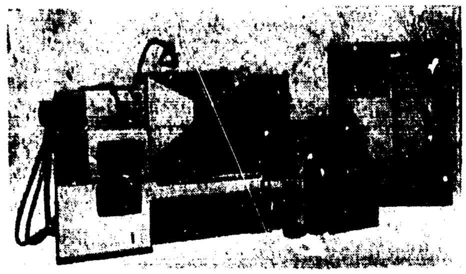

Figure 1. The ERI-250 lathes with digital program control

Figure 2. EV-630 lathe with digital program control

Figure 3. Drilling machine with digital program control

At the present time Tekhnoimpeks is exporting various machine tools to the Soviet Union, from ordinary to modern machine tools with digital program control. The export nomenclature of Tekhnoimpeks includes precision lathes, standless hammers, radial drilling machines. One of the new items of the Hungarian export nomenclature is the crimping machine. The Hungarian machine building combine and the Chepel'skiy Machine Building Plant have good traditions on the Soviet market, supplying machine tools to the Soviet Union.

In addition to the direct commercial items, the specialists of the Soviet Union and Hungary are jointly dealing with the problems of scientific and technical development, cooperation and specialization of production. The first example of cooperation in the field of machine tool production with digital program control in the socialist countries was the joint creation and production of the SOVIMAG 630 machine tool at the Lents Electrotechnical Plant and the Hungarian machine tool building combine. The Hungarian foreign trade enterprise Tekhnoimpeks has also participated in two expositions in the Soviet Union; in addition, it has organized five special lectures on Hungarian machine tool building and a showing of movies on achievements in this field by Hungarian industry. Hungarian specialists frequently visit the Soviet exposition. Stankoimport shows new equipment annually at the expositions in Budapest and organizes lectures by specialists there. It participates regularly in the Budapest Spring Fair where contracts for large sums were signed this year.

Both countries want to expand cooperation in the field of machine tool production further and increase the foreign trade turnover.

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END