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electric boilers for steam service

state statutes and steam measurement

steam condensate corrosion control

new members in 1978

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U.S.S.R. Trip Report

by **William Diskant,** Executive Vice-President
American Hydrotherm Corporation, New York City

INTRODUCTION

In accordance with the United States-U.S.S.R. Joint Committee on Cooperation in the Field of Housing and Other Construction, signed on March 20, 1976, in Washington, D.C., a U.S.A. delegation chaired by the Author paid a reciprocal visit to the U.S.S.R. from June 12-21, 1977. In addition to the Author, the U.S. delegation included:

- —Jerome H. Rothenberg, Manager Utility and Energy Systems Research, Office of Policy Development and Research, Department of Housing and Urban Development, Washington, D.C.
- —Leonard Korobkin, Principal, Gamze-Korobkin-Caloger Inc., Consulting Engineers, Chicago, Illinois.

The purpose of this visit was to participate in a familiarization tour of district heating and thermal power plants [thermal power plants are defined as central cogeneration plants which produce electric power, process steam (if required), and hot water for space and domestic use in new or satellite communities]; and to visit institutes and bureaus generally related to these and associated fields.

The discussion which follows presents highlights of the visit from a district heating standpoint.

MINISTRIES AND INSTITUTES VISITED

In Moscow and Kiev, the delegation met with personnel from a wide variety of U.S.S.R. ministries and institutes including:

- —Ministry of Power Engineering and Electrification
- —Ministry for Specialized Industrial Construction and Installation
- —Utilities Board of Moscow
- —Moscow Design Institute
- —Central Research and Design Institute for Engineering Systems of Buildings
- —Kiev Office, Research and Design Institute

Responsibilities of these various and interrelated organizations range from the planning to construction and operation of district power and heating systems in the U.S.S.R.

New towns or satellite communities are built peripherally around an existing main city, so that the ultimate size of the entire community falls within a radius of a two-hour round-trip by public transportation from the town center to the community's extreme periphery. This is a radius of about 100 km (60 miles).

The U.S.S.R. attempts to design new systems on a five-to-ten year load prediction basis, subdivided into phased construction steps. This is aided by standardization of planned communities, including allocation of basic industry with supporting secondary industries. The Russian representatives also told us that they usually found their industrial loads to be equal to their domestic (space plus domestic hot water heating) loads.

When predicting heat loads in the planning of new communities, a heat density of .5 gigacalories per hectare (18.43 Btu/sq ft) is used in design. In order to justify the construction of a thermal power station, a heat load base of 2000 to 3000 gigacal/hr (8 to 12 billion Btu/hr) must be available. In addition, the minimum electrical load must be 200 MW. It appears that electrical requirements dictate in the decision making of installing thermal power plants.

The thermal power plants in the above categories are all steam turbine plants. The use of diesel-driven Total Energy Plants is confined to isolated areas. By 1971 the U.S.S.R. had 2600 installed turbines, 65 per cent of which covered modifications of old turbines. The most widely used turbine size throughout the country has been 50 MW (based on 1970 data). It appears that the majority of modern turbines in the 200 to 250 MW range are manufactured in Sverdlovsk.

The 50-MW turbines are provided with either double bleed points ranging from 0.5 to 2.5 ata (7.35 to 37 psia) for space and domestic hot water heating, or multiple bleed points for process steam production ranging from 7 to 13 ata (103 to 191 psia).

The district heating water supply temperature in Moscow varies in accordance with ambient outdoor temperatures according in preset operating schedules shown in Fig. 1. Summer supply temperatures vary from 70 to 90 C (158 to 194 F); winter water supply temperatures go up to 150 C (302 F). Tap water temperatures (D.H.W.) are maintained at 60 C (140 F).

New towns in the vicinity of Moscow and in Southern U.S.S.R. are reported to employ absorption refrigeration utilizing hot water for summer air conditioning. No such systems were seen, however.

The Utilities Board maintains the heat supply system of Moscow. The system is illustrated graphically on

Fig. 1—Operating schedules of H.T.W. plants

(Grateful acknowledgment is made here to James P. Lagowski, Supervisor of Resources and Facilities Planning, The Detroit Edison Company, for editing this report for District Heating. *Editor)*

two wall-mounted panels which show the location of all district heating and thermal power plants and hot water piping network, including manhole locations and sectioning valves as of 1975, and its expected extent in 1980. There are currently 40 km (24 miles) of hot water pipes serving Moscow's heating system, with maximum hot water pipe diameters of 1400 mm (4.6 ft).

Moscow fires coal of No. 6 oil in the winter, and natural gas in the summer. Heating value of domestic coal varies from 6500 kcal/kg to 7000 kcal/kg (11,818 Btu/lb to 12,727 Btu/lb). The permissible coal sulfur content is less than three per cent under U.S.S.R. pollution standards.

During the winter months, when all the turbine steam is used to produce water for district heating, heat rates are 160 to 180 grams of fuel per kwhr (.35 to .39 lb/kwhr); or based on No. 6 fuel oil @ 18,125 Btu/lb H.V., these values are equivalent to 6395 Btu/kwhr to 7069 Btu/kwhr. These rates appear to be extremely low, and the delegation was not able to ascertain how they were arrived at and whether or not they included the fuel consumption component attributable to the generation of hot water for district heating. Average year-round fuel consumption for thermal power plants was reported to be 224 grams/kwhr (.49 lb/kwhr or 8881 Btu/kwhr).

Rural areas not suitable for thermal power plant installations obtain their electrical power from the main power grid, with auxiliary individual boiler houses providing district hot water heat to communities of 150,000 to 200,000 population, having plant capacities from 300 gigacal/hr (1.2 billion Btu/hr) up.

Nuclear thermal power plants are in the planning stage and will have an overall capacity of 2000 MW_e plus 1800 gigacal/hr. These plants will be standardized into 1000 MW_e and 900 gigacal of heat/hr (3.6 billion Btu/hr) modules. Each module will consist of two turbines, each capable of generating 500 MW_e and 450 x 10^9 cal/hr heating. It is ultimately projected that plants will consist of combined nuclear facilities with auxiliary boiler houses to meet peak loads as shown in Fig. 2.

On June 15, 1977 the delegation visited an exhibit in Kiev. Amongst many models showing future technology, was the planned apartment of the future for a family of four. It consisted of a kitchen, single bathroom, and three rooms having a total area of 54 square meters (581 sq ft).

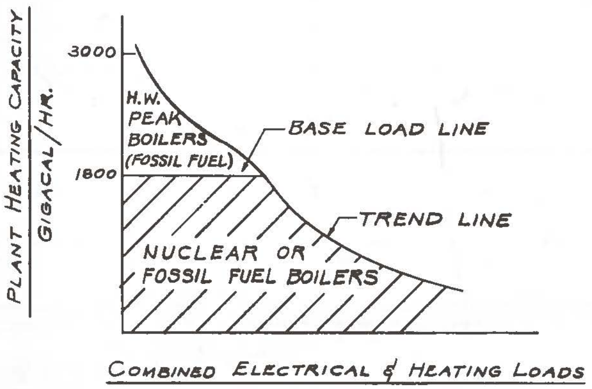

Fig. 2—Plant heat capacities for base and peak load thermal power (cogeneration) plants.

Fig. 3—Moscow: central heating plant serving housing project.

PLANT VISITS

Moscow Hot Water District Heating Plants

The district heating plant visited (Fig. 3) is one of three supplying heat to a new community in excess of 250,000 people in 500 buildings. Three-and-a-half million square meters (37.66 x 10^6 sq ft) of residential area, plus 20 per cent for service areas, is being added annually. (Assuming that the average future dwelling unit for a family of four will have 54 square meters (580 sq ft), as shown in the Kiev exhibit, this amounts to about 697,000 dwelling units annually.)

The plant had six gas-fired hot water boilers, each having a capacity of 50 gigacal (200 million Btu/hr), or a total installed capacity of 1.2 billion Btu/hr. Under peak load conditions, five boilers operate and one serves as standby. Winter hot water supply temperature is 150 C (302 F), and summer 70 C (158 F).

Each boiler was equipped with 12 gas burners and six forced-draft fans. No induced-draft fans were installed. The natural-draft effect of the metal stacks was relied upon to exhaust the flue gases into the atmosphere. The number of boilers fired depends upon ambient outdoor temperature. On the day of our visit, only two boilers were firing to satisfy domestic hot water demands.

Three hot water circulation pumps, each having a capacity of 1500 cubic meters/hr against a head of 110 meters driven by 500 kw electric motors (approximately 6600 gpm against 361 ft driven by 670 hp motors) serve the system (Fig. 4).

This type of plant is of standard design which can be built in one year, after allowing eight months to one year design time. District heating plants are normally intended for a life of six years, after which time the community has reached sufficient size to be disconnected from the heating plant and joined to a thermal power plant.

atmospheres to the district heating system 52,835 gpm at 162 psi). Each pump is driven by a 600 kw (800 hp) motor. Of the 14 circulating pumps installed, eight to nine are usually operating to meet heating demands. The length of the district heating distribution system is 10 km (six miles), and the main steel pipe diameter 1000 mm (about 3 ft 3 in).

Fig. 7—Leningrad: prefabricated concrete tunnel panels, five sections.

Of all the plants visited, Leningrad had the only "open loop" hot water circulating system. Instead of returning all the hot water to the heaters, of the 12,000 cubic meters/hr supplied, 5000 cubic meters/hr (22,000 gpm) is drawn directly from the supply lines for domestic hot water use. The reason for this unusual arrangement, which constantly requires 5000 cubic meters/hr of treated make-up water, is due to the corrosive nature of the soft Neva River water which supplies the plant.

The turbine condensers are cooled from a separate water supply, the Finnish Bay, 5 km (3 miles) from the plant.

As in the other plants visited, the turbines have one (or two) controlled steam bleed points for base load hot water generation ranging from 1.2 to 2.4 ata (18 to 35 psia), and one process steam bleed ranging from 8 to 13 ata (118 to 190 psia). In addition, the turbines have five uncontrolled steam bleeds. Process steam is supplied to local industry without condensate return at 400 C (750 F).

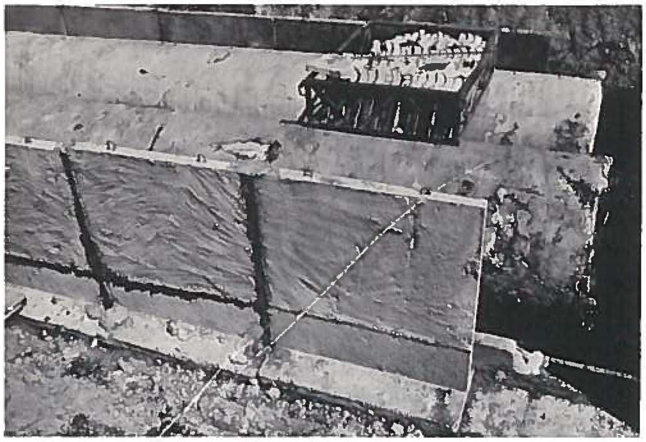

Fig. 8—Leningrad: expansion joints in tunnel.

Fig. 9—Leningrad: supply and return mains above ground, with expansion joint.

The district heating systems are started when the outdoor ambient temperature drops to 10 C (50 F). At One C (about 32 F) the peak hot water heaters go into operation.

Leningrad Heat-Power Station Construction Site

This standardized, modular thermal power station was being constructed for scheduled 1980 operation. Located on a 160-acre site, this new-type plant will initially consist of two standard turbo-generator modules, each producing 250 MW_e power and having a thermal capacity of 320 gigacal/hr (1.28 billion Btu/hr) per module. Each turbo-generator will be supplied with steam from a power boiler operating at 240 atmospheres at 545 C (3500 psi @ 1013 F). Two peak hot water heaters will serve each module. This type of standardized arrangement is the same as that used in the last expansion of the Kiev thermal power plant described earlier.

The field trip showed a good part of the hot water district heating system under construction (Figs. 7, 8, 9). Hot water supply and return piping, 5 km long in its initial stage (3 miles), is prefabricated, preinsulated, and partially installed in underground tunnels which are made up of prefabricated panels. Each pipe section is 11 meters (36 ft) long and is insulated with poured, porous, reinforced concrete having a density of 400 kg/cubic meter (25 lb/cu ft); and reported conductivity of 0.1 to 0.12 kgcal/hr-m^2-C/m (.0672 to .081 Btu/hr-ft^2-F/ft). Standard main pipe diameters for external (outside buildings) distribution in millimeters are: 300 to 1400 in 100 mm increments (approximately 12 in. to 4 ft 7 in.). Within building complex limits, pipe diameters are usually confined to 250 mm (about 10 in.). All main supply pipes are insulated; but the return pipes from 500 mm (20 in.) and larger in diameter, are just painted with anti-corrosive paint, asbestos cement filler, and double asphalt paper wrapping.

It was interesting to see sleeve-type expansion joints installed in 1400 mm (4 ft 7 in.) diameter supply and return lines at the plant. Upon questioning, our guides indicated that they have not experienced problems with sleeve joints in hot water service.

Regarding the practice of cathodic protection in underground piping installations, we were told that a separate institute determines their need and, if required, recommends the type to be applied. A statement was made that all underground piping is cathodically protected.

SUMMARY AND CONCLUSIONS

1. The centrally planned economy of the U.S.S.R. has enabled them to construct large-scale electric power, combined with hot water district and process steam heating plants (thermal power plants), on a very large scale. This is possible because location, size, and composition of a new community, including the integral planning of industrial settlements, is basically done by Government Institutes located in Moscow, with relatively limited design deviations allowed to the regional Institute offices to accommodate local conditions.
2. In mid-1977, 35 per cent of U.S.S.R. power plants were cogeneration plants; and future plants serving satellite communities will be standardized 250-MW cogeneration modules.
3. All generated power is fed into a common European Power Grid; and the existing cities and new communities draw their power from this grid, rather than from the individual plant serving a particular area.
4. In order to apply the U.S.S.R. technology to U.S.A. conditions, even on a much smaller or modified scale, sweeping institutional and legal changes would be required at the highest governmental levels.
5. Neither time nor visit program structure permitted the U.S. delegation to carry on technical discussions in any degree of depth. The tight schedule made this trip a *general survey*. Evaluation of the data given us by the various institute personnel was not possible during conferences, where essentially prepared statements were delivered. The data provided were accepted without analysis. ✺

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