The first international conference on district heating will be held from June 19 to 21 at The Homestead Hot Springs, Virginia, U.S.A.
General Report
Thema IV, Part 2

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DISTRICT HEATING NETWORKS AND DISTRIBUTION CENTRES

The first part of this fourth report on papers presented at the Third International District Heating Conference in Warsaw, Poland in April 1976, was published in our April-May-June 1977 issue.

This second part concludes the series of paper summaries which have been published in five consecutive issues, beginning with July-August-September 1976. Copies of all summaries may be obtained from the IDHA Office.

5. Regulation and automation of district heating networks (continued)


The necessity of creating automated management systems for heat supply (ASU) is considered by the author as an essential problem in our days. Such a system would have the following tasks:

- Optimization of conditions for heat supply at various stages of its control.
- Optimization of work of the system as a component of power supply system.
- Prognosis and central detection of breakdown.
- Organization of heat supply under the condition of breakdown.
- Optimization of the processes of technical exploitation of the district heating system.

The essential ASU element consists in the automated system of information on supply and distribution of heat among particular consumers.

Creation of mathematical models and algorithms permitting to implement partially the management functions with ETO help is a condition for elaboration and introduction of ASU.

Because of the complexity of the system, it is not possible, in the author's view, to give a detailed formal description of the whole district heating system. It is only possible to talk about a certain complex of mathematical models mutually connected as concerns the information exchange.

Application of ETO increases considerably the possibilities of central control concerning the reactions to the changes in hydraulic conditions of the network and, moreover, when the district heating distribution centres are equipped with regulating systems, it gives significant possibilities for optimization of both hydraulic and heating conditions of the network.
At present, research has been undertaken in the Soviet Union aiming at creation of mathematical models, algorithms and calculation programmes for their practical introduction of ASU.

Infallibility of the work of regulating apparatuses which are located in rooms with disadvantageous humidity and transport conditions is a specific requirement in exploitation of district heating systems.

For this reason it is necessary, in addition to the elaboration of basic control patterns, to elaborate the construction of the elements of automated regulation (control).

The research has permitted to state that hydraulic systems are the most proper and infallible. The set of elements of such a system has been elaborated in the Soviet Union owing to which a stabilization of the following factors is possible:

- Pressure both before and after regulator
- Pressure drop
- Water level
- Water temperature (central water)
- Air temperature in ventilating installation

Patterns illustrating the use of hydraulic elements of the direct pressure stabilising action in the net and in back-water pumping station are quoted in the report. On the basis of information given in the report, it can be assumed that in the Soviet Union the system based on a contactless electronic transmitter is applied for the regulation of the output capacity of the central heating installation in particular buildings.

This transmitter decides on the quantity of water supplied by the network, depending on the actual outer temperature, or on the temperature in the selected rooms that are heated. Eventually it depends on these both quantities.

The experiments with the application of heating regulators have confirmed their efficiency; however, they have not found a mass-scale popularization, so far.

The author analyses in his report the hydraulic problems related to the mutual impact exerted by the following control function:

- Central, in the source of heat
- Indirect, transmission stations
- Individual, directly concerning the heat absorber in the case when the whole quantity of water sent from the source passes through the heat receiver.

It is true that in the case when shunts are applied in particular receivers, a stability of hydraulic conditions is obtained in the district heating system; however, the exploitation costs of it are much higher, especially in the case of centralized management, and it is for this reason that such a regulation system should not be applied for big systems due to its economic disadvantages.

The central change of the temperature of network water as well as quantitative regulation in transmission stations or, eventually, directly at the receivers is the basis for deliberations.

From the three possibilities for flow regulation in the source, namely:

- Through stabilization of pressure differences.
- Through stabilization of the last consumer's disposable pressure.
- Through stabilization of intermediary customers' disposable pressure, preference is given by the author to the last one, because this possibility consists in the maintenance of a constant hydraulic characteristic of the network. The last statation should be considered as fairly disputable one in the case of quantitative regulation in transmission stations.

In the case of application of individual regulators of indirect function for the heaters, the author postu-
lates that regulation of the temperature of feedwater (flowing out of the exchangers) should be applied when the installation is connected by means of exchangers. In the case of hydroelevating district heating distribution centres and of pump based mixing, the author proposes to stabilize the pressure disponible in the inner installation or to regulate the temperature of feedwater (depending on the characteristic of the distribution centre).

When the pump is inserted into the mixing duct, application of regulation in the connecting distribution centre is not indispensible.

If the district heating distribution centre of the building is the last stage of the central heating installation, the author proposes to regulate only the temperature of water that feeds the central heating installation, if we have to do with connecting exchangers.

At the distribution centres with pump mixing, the regulator of the temperature of feedwater of the central heating is, in the author's view, the basic regulation system. Only in exceptional cases it should be completed by a regulator of the permanent differences of pressure between the feed line and the return duct of the central heating installation.

For a hydroelevating distribution centre two alternative solutions are proposed in order to enable it for the regulation of the capacity of inner installation within the determined limits:

- Shunting of hydroelevators, i.e. partial supply of network water to the inner installation, by-passing the hydroelevator.

- To control the change in the cross-section of the hydroelevator nozzle by means of the outside temperature.

The second solution is fairly troublesome from the constructional point of view, but it gives better exploitation effects, because the drop in the quantity of water supplied from the network is accompanied by an increase of the mixing coefficient.

The first solution is more simple from the constructional point of view, but it requires a high disponible pressure that will assure the mixing coefficient to be sufficiently high for the flow through the hydroelevator, of network water quantities that would be below the nominal ones, which occurs in such a case.

According to this solution - in the case of a high temperature outside - the system is unable to limit the heat supply in concordance with requirements, because the feed temperature is never below 70°C (Table I).

The author terminates his report by drawing attention to the effects of the changes in the hydraulic conditions of the network equipped with automated heat distribution centres as well as to the necessity of analysing those phenomena when design of the district heating distribution centre is made.


First the authors state that in the qualitative regulation applied centrally, the connecting distribution centres should be automated in the first stage, the heating output capacity of particular heaters being automated during the second stage. The experiments carried out in three buildings have shown that application of an automated regulation in the distributing centre decreases heat consumption in central heating by 15-25%.

The selected control system is based on an electronic transmitter controlled by the outer temperature. It gives the possibility of implementing the selected relation between the outer temperature and the average temperature of heaters. Such a solution has been recognized as the more proper than placing of temperature gauge in several selected rooms. Bulgaria is a producer of electronic transmitters. Tests have been made with heat regulators of Bulgarian production. It appeared that their use diminishes the heat consumption by 20-30%.

Attention has been drawn by the authors on the impact of automation on hydraulic network system. They have quoted the results of calculation that illustrate
the effects of automation in one of the residential settlements of the city of Sofia for the hydraulic system of the district heating network, taken as a whole. The calculation mentioned above and the evaluation of effects were made before application of automation in this settlement.


The district heating network in the town of Koszyce has the heat output capacity of 262 MW which is supplied to the customers mainly under the form of water with nominal temperatures 180/80 °C in winter and 80/40 °C in the summertime. Control of heat supply during winter is qualitative. The heat is used for both central heating and hot water preparation. The internal installations of central heating 92.5/67.7 °C are connected by means of exchangers in a closed cycle with pressure stabilization through connecting them with return pipe of the district heating network. The hot water is heated, during the heating period, with water returning from the installation of central heating being mixed, if needed, with water from the heat network. The hot service water distribution centres which have no permanent operation staff are equipped with the following control-signalizing system.

Protecting (four systems) within the framework of which the following functions take place:
- Disconnection of the central heating exchanger in the system is leaky - the isolating valves are controlled by the room temperature and index of water level in the room.
- Disconnection of the central heating installation when the temperature of feedwater amounts to more than 110 °C.
- Disconnection of the exchanger supply of district heating network when the temperature of hot water amounts to more than 70 °C - with simultaneous opening of the flow through the shunt for the return water of central heating.
- Disconnection of the supply of network water to the distribution centre when there is either a lack of electric power supply or an excessive temperature of water in the central heating installation. (The system concerning the excessive temperatures is the reserve one.) The cutting off valves of this system are closed by the network pressure.

In the field of exploitation:
- The pressure stabilizing system (filling) of the central heating installation for water supply from the return pipe of the district heating network.
- The system putting the reserve pumps into motion (in central heating and heating water network).

Economical:
- The system regulating the temperature of water that feeds the internal installation of central heating - in the function of outer temperature.
- The system maintaining the temperature of hot water at the level of 55 °C - which in the case of shortage in the heating output capacity cuts off the supply of hot service water.
- The system stabilizing the pressure differences in both supply and return pipes (now not in use because of lack of work stability in the applied solution).

Signalizing. About the occurrence of disturbances with no interruption of heat supply, they comprise:
- Defects in the central heating pumps.
- Damage of a pump, of the service water network, or of both of them.
- The pressure increase in the central heating installation.

About a breakdown, namely:
- Damage of both circulation pumps of the central heating.
- Disconnection of exchangers resulting from the excess of temperature in the room when the distribution centre is located or from either priming or an interval in the supply of electric power.
- Interval in the heat supply of the central heating installation (with the exception of remote disconnection).
- Interval in the supply of service water (with the exception of its remote disconnection).
- Pressure drop in the central heating installation.
- Unproper work of remote control.

In the central control station, summarized signals are obtained which inform on normal work of the distribution centre, occurrence of disturbances or of a breakdown.

Remote control system:
- Turning the service water supply on or off.
- Turning the central heating installation on or off.
- Switching the transmitter of the central heating regulator from day to night position.
- Decreasing the characteristic of the transmitter of the central heating regulator if there is a lack of heat output capacity in the source.

Measurement:
Every exchanger is equipped with a heat counter. Moreover, the indications of all the basic parameters, characterizing its work are placed in the distribution centres. In the future, the indications in question will be transmitted to the dispatch office (for 50 distribution centres, approximately).

The particular dispatch offices (with a permanent servicing) have a telephone connection with the central dispatch office which will manage the exploitation of the sources in the future.

Data from the indicators that measure the basic parameters in the distribution centres of the network are gradually sent to the central dispatch office.

The rented telephone cables as well as the owned ones, installed on the network route are used for information transmission. As concerns the remote control, the general network of remote control located in the town for other purposes and transmitting the signals of a frequency of 1050 Kh through electric power cables is used for remote control.

In the author's view, even in the case when the investment costs of automation exceed its effect obtained so far, lack of manpower substantiate a full automation of heat supply.

f. "Tasks, Operation System and Calculation of Modern Valves of Constant Pressure for District Heating Networks" by W. Peters, Frankfurt.

The report illustrates the necessity of applying the valves that maintain a constant pressure in the point of heat intake. In the district heating networks we have usually to do with a pressure of 10-18 Ba, while in the inner installations with cast-iron steel sheet heaters the pressure cannot overpass 4-6 Ba. Thus, there is the need of obtaining a pressure drop infallibly. In order of achieving it, the automated valve of constant pressure must be of special construction, assuring a protection against any pressure increase above the admissible one, even when the membrane is damaged. Such valves work directly with no use of additional energy from the outside. A noiseless work of automated throttles is important, especially as concerns the valves installed in the heating distribution centres in residential houses. The diameter of the throttle should be selected with taking into consideration the dynamics of the network.


In 1970-73, big scale connection by means of controlled hydroelevators was applied in two residential districts of the city of Prague. It provoked a strong lack of regulation in inner installations: the upper stories became overheated, the low level ones, insufficiently heated. The reverse water cycle was revealed in some low level heaters. This results from the totalized pressure difference produced by the hydroelevator with gravitation pressure.

Regulation in the cycles separated by an intermediary heat exchanger is much more simple than in the case of a direct connection through by means of the hy-
droelevator. In the first case, we have to do with a constant mass-flow of the water, and in the second, with a changing flow. In the case of a faulty hydroelevator, we have not to do with one curve: the characteristic curve Q-H is as in the case of pump, and not with the unlimited number of curves. The author presents the diagram of the bunches of characteristic curves of a jet pump for an arbitrary value of the rise of control needle in relation to the maximum rise h/hmax. The network characteristic Gs = f (p) is unchangeable. When the flow through the jet pump is strongly throttled, the pump does not act anymore as a pump, and the hot water passes through the mixing chamber to the return network (short circuit). In the author's view, the principle of regulation consists in fixing the flow through the hydroelevator depending on the temperature of influx into the internal network, but on the impulse of the average temperature between the supply and return t3 + t2, the level of this average temperature being determined depending on the outer temperature.

This system requires: a precise regulation close to the heaters, a proper limitation of the movement of control needle in the hydroelevator nozzle, and a proper maintenance of the pressure system. At the end of his paper, the author gives the conditions which should be fulfilled in order to avoid a defective functioning of the jet pump and, even, a return in the direction of the flow. On the basis of what the author says, it can be assumed that he considers application of jet pumps with controlled flow as a fairly troublesome and that, in certain cases, it can provoke a failure.


The report deals with the effects of cutting off one of the cycle of a multi-branch district heating network as concerns its hydraulic characteristic. Against the background of these deliberations changes in piezometric diagrams have been analysed, in the presence of:

- Stabilization of the pressure difference in the source of heat.

Stabilization or the difference of pressures at the last consumer, both in the case when all the service water distribution centres are equipped with automated regulators, and in the case of lack of such installations. On the basis of analyses that have been carried out, the author recognizes the stabilization of the pressure difference at the last consumer as the most proper one, because it gives the greatest drop in pumping costs. In order to avoid the necessity of making the remote measurements, he proposes to adopt the linear relation between the pressure difference in the source and the quantity of flowing water.

Attention is drawn by the author to the necessity of taking into consideration the fact of changes in pressure and flow when project of district heating networks and distribution centres is in the stage of elaboration.

6. Exploitation problems


Because of the enormous increase in demand for both thermal and electric energy connected with the scope of both housing and industrial construction, the principle has been accepted in the German Democratic Republic of making use of combined management as the most proper form from technical and economic point of view. Against this background, the conception has been crystallized of supplying East Berlin - for the time being from two, and in the future, from several sources of heat that feeds a common hot service water network. The heat output capacity now available amounts in both the power plant to 850 Gcal/h. In 1976, a waste burning plant is to be connected as the additional source of heat. In Berlin, in most cases the heating networks are directly connected to the central heating networks by means of hydroelevators. The average pressure determined on the basis of a definite dynamics of the network and most suitable for a given network system is maintained in the whole network. An accumulator of network water is
able to take over the changes in water quantity with no need of its removal or completion has been planned for the whole network. Installation of motor pumps with changeable quantity of rotations in the central station gives advantageous effects as well.

In Berlin, where the conditions for it, permitted the onground networks on brackets, eventually on pillars was built being located in the settlement areas, in the non-connected ducts.

The most essential problems which require a solution are the following: Maintenance of proper pressures in the network, proper dimensioning of pipelines according to the hydraulic analysis and proper information between the power plants and the organs distributing both the electric and heat energy.

The aim is to obtain economic advantages, infallible supplies and proper use of fuels.


The hot service water network was put into operation in Helsinki in 1950, covering in 1974 almost one-half of the surface of the city. Heat demand for the system of outer temperatures similar to that in Poland is a little greater, because the minimum calculation temperature amounts to -27°C. The district heating network works all the year round, supplying the inhabitants in hot service water as well.

The production of power in Helsinki is assured by three different sources: 30 MW from hydroelectric power plants, 390 MW from steam generating power plants, 128 MW from power plants with gas turbines. The heating network with the capacity of 1500 MW is partially supplied from electric-thermal power plants, and partially from heating plant with both steam and water boilers.

A network 220 km long is partially conducted through the ducts, and partially (90 km) through the cellars. The diameters of main lines oscillate within the limits of 250-700 mm.

In order to assure a proper supply of heat from six heat sources, a central dispatch station has been set up with the main task of a proper distribution and regulation of heat supply from particular sources depending on a given heat demand.

The dispatching station operates on the basis of a programme with use of a computer. The temperature of feedwater is changing within the limits 120-75°C, depending on the changes in outer temperature.

The pressure is regulated, for the whole network, within the limits 5-515 Ba. Only in the most modern thermal–electric plant Hanasaari, it is regulated by means of an automated pressure regulator with determined impulse from the back supply conduit. The average pressure obtained in this way is independent of the number of working pumps and of the height of their rising. The pressure equalizing containers appeared to have an insufficient capacity and they will be enlarged, in the nearest future up to 500 m³.

The measurement apparatuses (selfwriting) register the heat output, flow intensity and temperature of both feed and return in every central station separately, as well as their value for the whole network, and also the pressure and differences in pressure in the characteristic points of the network. The alarm signal system starts to work when the critical stages are overpassed. The temperatures of outer air, wind strength and isolation are registered as well. In order to facilitate localization of leakage gate valves with electric drive controlled from dispatching station have been mounted. They make it possible to rapidly close 3-4 stretches of the network. Owing to this, the repairs and connection of new branches can be executed with no stop in the network work.

Regulation of heat output capacity is completely automated in the central Hanasaari B most recently built.

The determination of feed temperature on the network controls the turbine gate valves automatically. The circulating pumps on return network have motor rotations automatically regulated.

The peak heating central stations are put into operation depending on the need. The shift mechanic determined the number of pump rotations and selected the temperature for the heat factor on which depends the mixing of feed and return water in proper proportions.

The automated regulation maintains the influx of fuel oil and lighting air proper for maintenance of constant temperature of 120°C in the boiler. The temperature of water flowing into the boiler cannot drop below 80°C. Peak central stations work partially in winter, when the
heat requirement overpasses 60% of the annual average, as well as during night periods and weekends when the current demand is at minimum level.

7. Problems of corrosion


The author analyses in his report the problems of network construction, as well as of protection against the stray currents in the working networks. On the basis of experiences achieved in the Warsaw heating network, it can be assumed that ductless constructions are most exposed to effects of stray currents that provoke the electro-chemical corrosion. Moistening of insulation, both in suspended duct constructions and in ductless ones, has an essential impact on accelerated corrosive action. The author proposes, as the basic condition of protection against the stray currents, to insulate the networks on either fixed or shoe supports by means of insulating separators. Such a passive protection aims at preventing the penetration of currents into the heating network. It is necessary to apply an active, so-called cathodic protection in the heating networks with no passive protection. Polarized drainage is the most effective measure in this respect. Its task is to take the stray currents, passing through the district heating pipelines, off to their source, i.e. to the return cable of the network of electric traction. The experiences carried out on the Warsaw heating network show that this is an effective protection against the corrosion provoked by stray currents.


We have to do with other phenomena, similar to those occurring in the district heating networks, in the installations of hot water in buildings. The results of the analysis of those phenomena were presented in the report by Mr. Juchniewicz. The tests have shown that the phenomena of coating fractures occurs in zinc coated steel pipes. This results in a corrosion process which cannot be stopped by a protective measure. In some cases, for instance, in the case of water from the Warsaw supply system, we have to do with the phenomenon of excessive polarity of zinc coating and of the alloy film in relation to steel. The tests show, moreover, that hampering of corrosion and electro-chemical protection of steel in these installations can be assured only by preventing the excess of polarity or return of polarity after the occurrence of an excessive polarity. The electro-chemical protection depends on the maintenance of a proper potential in relation to the chlorine-silver electrode. The corrosion process can be hampered by adding mainly aluminum ions to the water. The maintenance of steel potential below the value of 0.80 V in relation to Ag/AgCl guaranties, in the author's view, the brake of corrosion process.

8. Reckoning means and economy of work of the district heating network

a. "Experiences from Various Methods of Heat Consumption Reckoning" by E. Mattersdorff, Hamburg.

Many systems of reckoning the consumers for the used heat are applied in Hamburg. The oldest system consists in applying sealed heat counters in every apartment. These are fairly costly installations. By means of example: for an apartment of medium size installation of counters and their use increase the heating costs by 10-15%. These costs are indispensable in buildings of public utility, for instance shops, restaurants, schools, workshops and the like.

Another reckoning system consists in installing a heat counter at every heater under the form of a tank with liquid evaporating, depending on the heater temperature. This is a simple and cheap method which gives a certain possibility of regulating the use by the consumer, but it is not precise and requires to carry out often the sealage and checking of the counters.

In the author's view, the most proper method consists in reckoning the charge for heat supply, depending on the utilized apartment surface in meters. This is the most convenient and cheapest method (only the collection cost). Though it should be assumed that when this method is applied heat consumption increases, however, this increase is negligible. Water counters are proper for reckoning for not service water consumption. They are placed either on the influx of cold water which is to be heated in every individual apartment, or centrally for the whole building. Water heating up to 45 C is assumed.

Water consumption in Hamburg, when central water heat-
ing and quantity measurements were carried out, amounted to some 40 m$^3$/person annually, and in the case of individual measurement in every apartment, to 30 m$^3$/person.

**Thesis for Discussion**

A number of subjects approached in different ways by the authors representing various countries and positions emerges from reports concerning the networks of district heating, that have been sent for the Third District Heating Conference, and which have been enumerated and shortly presented. This is a very valuable aspect for any conference, giving a field for a broad discussion, many questions and information from the part of the authors defending their respective theses, as well as for exchange of experience.

As concerns controversial problems of great interest, they include the ideas analysed in the reports and related to transmission of heat under the high-pressure steam at big distances and with use making of both electric and thermal energy for its production in the thermal power plants having the heat output capacity properly diminished and scattered in the area in places grouping the consumers. The second problem that several reports have dealt with consists in changes in network parameters in the so-called grouping centres, the size of these distribution centres and scopes of the networks with diminished parameters, as well as the work system of the distribution centres when the parameters are changed as the distribution centres, direct or indirect and using the surface exchangers, is a matter for discussion. Fairly interesting can be the thesis on application of various parameters varying in size is a fairly essential theme from both technical and economic points of view of infallibility in functioning. This is a matter for discussion for many configurations and size of agglomerations, and it should not be approached in a too dogmatic way. Of interest is, as well, determination of optimum scope of district heating networks. The problem of connecting direct consumers by means of cheap hydroelevators simple in use and, eventually, their general replacement by means of indirect connecting with use of surface exchangers is absorbing many experts, being an important aspect that should be discussed multilaterally at the Conference. Of interest is the opinion of some authors as concerns regulated hydroelevators. Worth of discussion is also the problem where and what sort of automation should be imperatively applied, and where is only desirable; crystallization of opinion in this respect may be of decisive importance. The next problem requiring an exchange of views and experiences by the Conference members concerns the reckoning systems for supplied heat energy which finds various solutions in particular countries.

As concerns the field of district heating constructions, of interest is the problem of highly costly, but most infallible, solutions of collective tunnels and use of building cellars in new residential settlements for a partial conducting of various heat supplying networks. Unfortunately, the reports do not deal with new methods of network construction. It should be expected that the discussion will fill up this gap. Moreover, the systems of ductless conducting of pipelines and the usefulness of these methods are dealt with in the reports in a relatively marginal way. Placing of pipelines in plastic coat which is more and more often applied should, as well, provoke an exchange of views. Of great importance is fairly broad field of insulation and its resistance to high temperatures. Moreover, it seems necessary to broadly discuss the problems of pipeline corrosion and of the methods for combatting it in district heating, mainly as concerns the supply of hot service water and the proper method of making water adaptable, connected with the problem of corrosion. Mention has been made here only about some from among many problems tackled upon in reports. They are worth a special discussion within the framework of such a broad scientific field as district heating. There are many other problems. The organisers of the Conference express the conviction that due to such a broad participation of experts in district heating from many countries who are fairly experienced technically and who represent a great knowledge of problems dealt with, a broad discussion will give, in effect, the elucidation of many doubts and will show the development guidelines contributing to the continuous improvement of this scientific field that deals with meeting of district heating requirements which are of such importance for human well-being.