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Aerial view of the campus at the Free University in Amsterdam, The Netherlands. Arrow indicates the Energy Center. Page 10.

General Report Thema IV, Part 1

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DISTRICT HEATING NETWORKS AND DISTRIBUTION CENTRES

This report, because of its length, will be divided into two parts: the first half is printed in this issue; and the second part will be included in our July-August-September issue. Copies of Themes I, II and III from previous issues may be obtained from IDHA Headquarters.

The reports, which are summaries of papers presented at the Third International District Heating Conference held in Warsaw, Poland, April 1976, are verbatim transcripts prepared by Poland, the host country. IDHA Past President Ellwood A. Clymer, Jr., President during 1976, attended the Conference as the Association's representative.

Introduction

Twenty-six reports from eight European countries, namely: Bulgaria, Czechoslovakia, Finland, German Democratic Republic, Federal Republic of Germany, Italy, Soviet Union and Poland, have been sent for the Conference. The subjects tackled in these reports are fairly wide in scope and, virtually, they comprise all of the most important problems that are uppermost in the minds of scientists, technicians and economists working in the field of district heating. Such a wide scope of subjects could not be fully covered in this collective report, condensed by necessity. Thus, the report deals only with the aspects that have been selected from particular reports and which, according to their respective authors, are the most essential and provide a wide material for discussion, the results of which are of utmost importance - as it is just the case in every successful scientific or technical conference. Basically, all the reports comprise the thesis that the scientific field of district heating is highly important, and that its general and fairly rapid development in all the countries results from the necessity of both making economies on fuels and protecting the environment.

The Conference reports can be generally classified into eight subject groups, in the following way:

- 1. Heat carriers, heating factors, and their parameters
- 2. Configuration and systems of the district heating networks
- 3. Calculation and optimization of the district heating networks
- 4. Construction of the district heating networks
- 5. Regulation and automation in exploitation
- 6. Exploitation problems
- 7. Corrosion problems
- 8. Heating energy reckoning systems

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The abstracts of reports are given in the following part of this summary. They contain only the most essential ideas of particular reports, as well as the names and countries of their respective authors. The conception was to facilitate, in this way, the participants of the Conference, their getting in contact with problems of particular interest for them, as well as expressing their opinions both in the course of public discussion and direct talks with the authors; and finally, receiving authoritative answers for a number of doubts that usually harass any expert.

Below are the main theses advanced by the authors of reports.

Abstracts of Reports

1. Heat carriers, heating factors, and their parameters

a. "Transmission of High-Pressure Steam from a Heating Nuclear Plant and Use of Heat for the Production in Turbines of Electric Energy Required by Industry and Remote Heating Plant" by K. Kirvela and R. Seppala, Helsinki.

The mere production of electric energy and its transmission to consumers is characterized by a low level efficiency, amounting only to 30%. The authors advance the thesis - which is at variance with the principle not generally accepted, and consisting in remote heat transmission with use of hot water. They propose to make use of saturated high-pressure steam as a heat carrier, as a fairly advantageous method, especially in the case of nuclear power plants. According to the proposal of the authors, a nuclear plant does not consume all the steam produced in the reactor, its surplus being transmitted to the turbines in the satellite electric plants with parameters of 62 bars and 280 C. The diminished pressure steam, as well as that from the extraction of turbines. is applied in heat exchangers of the district heating network. It is necessary to apply a cooler that absorbs the surplus heat, for instance in the summertime. An optimization calculation for pressure drop, duct diameters and insulation thickness has been carried out with the use of computers.

Because of a considerable pressure drop, it has been determined that 50 km is a maximum transmission distance for satellite turbines.

The authors state that the energy loss in the case of transmission of high-pressure saturated steam, when local turbines that apply of the low level pressure is the same as in the case of heat transmission when using a hot water carrier 160/70 C.

According to the authors' opinion, when the transmission distance amounts to 5-40 km, the diameters are of 700-1200 mm and heat efficiency of 400-1600 MW, heat transmission to the supplied area by means of saturated high-pressure steam is the most advantageous when for heating use is made of the pressure drop in the local back-pressure turbines and of the outflow heat. As there are plans of implementing the method proposed by the authors, in practice we should await with interest the exploitation results which will decide on its usefulness.

b. "Optimum Parameters of Heating Factors for the Preparation in the Summertime of Hot Service Water in Urban District Heating Networks Fed from Power Plants" by Z. Piotrowski, Warsaw.

In the summertime, i.e. during some 4000 hours annually, when the heat supplied from district heating networks is used exclusively for service water heating, the temperature of the feedwater in the district heating network is usually permanently kept on the level of 70 C. No conditions make it necessary to keep the temperature on this level and it has been adopted arbitrally with no substantiation. The author took up the effort of carrying out a full optimization calculation for a model urban agglomeration. This calculation comprises all the elements that participate in production, transmission and reception of heat. Both the investment and exploitation costs have been taken into consideration, assuming that a typical district heating block

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with a BC-50-100 turbine is the source of heat, and analysing the change in the temperature of exhausted steam. It has been adopted that the temperature of heating water on the supply line will be 60, 70, 80 and 90 C, the return temperature being constantly on the level of 40 C. Costs of heat exchangers have been calculated for a selected model agglomeration. An analysis was carried out of the total costs of the production of electric power, as well as of the heat distributing centres in the function of the temperature of feedwater; and the results have been compiled both in tables and graphs as an effective curve of interdependence of profits and losses of the costs in the function of the temperature of feedwater in a district heating network.

The minimum of this curve, i.e. the optimum of the function, occurs when the temperature is of 80 C.

In his final remarks the author is right to stress that we shall have to do with a considerable overheating of rooms, i.e. with unnecessary fuel losses during transitory periods in the case of application of hydroelevators in heat distribution centres, for a qualitative regulation. Thus, an eventual increase in the temperature of feedwater can find its application for connecting indirect central heatings through the heat exchanger equipped with an automated regulation.

c. "Method of Increasing the Economies on Heat Industry by Use of Additional Cycles" by G. Angelino, P. De Marchi, P. Ferrari, G. Giglioli, E. Macchi, C. Piemonte, G. Scalvi; Milan.

Concentration of both heat and power production when it is necessary to transmit the low-temperature heat for large distances is not proper. The most advantageous is transmission of heating energy to the consumers when there is a significant difference in temperature between the feed and return, which however, provokes a drop in power production in the central source.

The authors think that a better solution consists in using only partially the enthalphy drop for power production in the central plant, and transmission of the remaining amount of heat having a temperature of 250 C on the supply line and 60 C on the return line to the remote intake places in which power production would take place. The parameters of heating factor sufficiently high would be, then, achieved through connection of the heat pump to the circuit. According to a technical-economical analysis that has been carried out, such a solution would give 20% of economies.

This is a fairly interesting elaboration bearing the character of a theoretical study with no confirmation of the solution of proposed systems by practical results. It would be difficult to give an opinion to what extent the proposed conception is realistic.

2. Configuration and systems of the district heating networks

a. "Centralized District Heating System of West Berlin with a Special Consideration of Network Pumping Stations" by K. Bublitz and J. Bock, West Berlin.

The report gives a compact description of the district heating network of West Berlin which is just under the process of extention of connection of the existing district heating systems into one common circuit.

The district heating network is fed by six thermalelectric power stations, equipped either with steam or gas turbines. The total heat production capacity amounts to more than 1500 Gcal/h and it feeds a network 220 km long. Power stations with gas turbines are to be the peak power stations. This is a three-duct network: a feed duct with the temperature changing depending on the outer changes in temperature, a duct with a constant temperature of 110 C the whole year round that heats the hot service water and, finally the back duct for both feed ducts. The maximum temperature of the duct for central heating is 110 C.

A number of underground network pumping stations have been envisaged in order to assure a proper work of the network. These pumping stations are equipped with pumps located on the by-passes of both feed ducts and

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of the back duct as well as with an additional fourth reserve pump for all the above mentioned ones. A proper location of the regulating stop gate valves and of the swing-type return ones makes it possible to change the position of working pumps easily. Projects are under preparation of a central system regulating control station which will assure a proper distribution of heat factor and of pressure systems. For the time being, this can be achieved by changing the rotations of pumps. In the future, it will be necessary to use additional, both cutting off and stuffing instruments on the network.

b. "Annual Networks of District Heating in Wroclaw" by W. Olak and G. Kiobut, Wroclaw.

Stress has been put in the report upon the superiority of annular configuration of district heating network as compared with the radial type, because of infallibility of circulation, which is obvious. In the further part, the report contains a description of the extention project for the district heating network in Wroclaw, including future plans of complete junction of all the branches into one annular network. A computer ODRA was used in the elaboration of the annular systems. Roughness coefficient of 0.5 mm was adopted in hydraulic calculation.

The system consisting in feeding a multi-annular network from several power plants situated in various parts of the town - preferably in the outskirts - would be the most proper for the future, instead of the present one which feeds the network from two heating power plants located in the close vicinity of each other.

c. "Technical Conditions of Cooperation Between the Basic and Peak Sources" by J. Clinka, Warsaw.

On the basis of many years experience in exploitation of district heating networks fed from several heat sources, the principle of cooperation between those sources and of connecting the district heating network into one system fed by those sources has been elaborated.

A cooperation between the heat sources gives considerable advantages, an increased infallibility of operation being the most important one, as particular sources constitute a reserve for the others in the case of a breakdown. The second advantage consists in the maximum use of highly efficient sources, limiting the use of those less efficient to the peak periods. In order to achieve the possibility of cooperation of several heat sources for a common network, it is necessary to build a main network either annular or multi-annular in its configuration. At the same time, pumping stations should be envisaged for such a system, the task of which would consist in maintenance of a proper distribution of pressure within the network. From the hydraulic point of view, such a system represents a complicated task insofar as calculation is concerned, as several variants of solution are possible in this respect. It is just for this reason that the unique possibility of a proper elaboration of the project of duct diameters and of all the pumping stations consists in making use of electronic computers in this respect. The optimal system can be obtained as a result of calculations for many systems.

In his further deliberations, the author analyses the task of both basic and peak sources as well as both temperature and hydraulic conditions in the network and moreover, the sources of heat arranged either in series or parallelly.

Remarks concerning the possibilities of feeding the network from several sources terminate the report, stress being put upon the importance of automation in heat distribution centres, as well as of telemetry and telecontrol for the whole system.

d. "District Heating as a Component of Technical Junction of Residential Settlements" by W. Rattay and J. Prokopowicz, Leipzig.

The authors underline the importance of the problem of equipping the residential settlements in all the sanitary, heat producing and connecting installations, which is of special importance in the period of modern construction, broad scale and mechanical in character. The underground installations and their use, taken as a whole, require a technical progress, as they lag behind the on-land construction. The proper organization of construction and use of the underground installations makes it necessary to apply modern methods and, first of all, industrialization. In the German Democratic Republic, construction of collecting ducts (some 130 km now in exploitation) is considered as a big step forward. This solution has undoubtable advantages. Because of their big cross-sections, the district heating pipelines occupy 35-45% of the whole lateral cross-section of collecting duct.

According to the experience acquired in the G.D.R., application of collecting ducts is a proper solution for residential settlements in which the number of apartments is more than 1000.

As concerns duct construction, preference is given by the authors to radial systems despite the fact that they are less infallible in heat supply.

A cooperation of urban planners, architects and plumbers makes it possible to give a configuration to the buildings in a given area, which would enable it for arrangement of collecting duct in the cellars of buildings; thus, limiting the necessity of building them underground.

Thus, the investment costs can be considerably diminished, and they always represent the highest expenditures in this respect. An interesting solution of the problem consists in building the collecting ducts only in the settlement area, and non-connected ones being built only for the main supply lines.

e. "Some Technical and Economic Aspects Concerning the Extention of District Heating Network in Sofia" by V. Stoev, Sofia.

The district heating network in Sofia develops fairly quickly. In 1980, some 90% of the population, i.e. 1,100,000 will be supplied from a centralized system. The length of district heating network amounts to 380 km and it is prolonged some 40 km annually. The network is fed from the three basic sources of heat, the diameters of the main supply lines being 500-1200 mm. It is envisaged that up to 1980 two others, and to the 1990 still two other heat distributing centres will be built.' Three heating power plants, four peak power plants, operating only in winter, will feed the district heating network.

The authors formulate the following conclusions:

- A centralization of heat supply is workable for a heat density of more than 35 $\rm MW/km^2$.
- District heating central station of high parameters is proper when the supplies for the population will have more than 450 MW_t of heat capacity.
- A heating power plant of a capacity below 90 MWt should not be applied.
- High-parameter heating plants are proper when heat requirement amounts to 140-150 $\rm MW_t$ and the annual demand is more than 4200 h.

Two-thirds of the urban installations providing heat to Sofia inhabitants are connected by means of hydroelevators, the other ones by means of exchangers. Hot service water is heated in the two-stage exchangers to the temperature up to 60 C.

Independently of the central qualitative regulation, a regulation in consumers' connections is planned: a two-position regulator with a heating programme and with a thermostatic proportional valve assuring a constant temperature of hot service water. Recently the group distribution centres of hot service water are applied (8, 16 and 32 Gcal/h), which eventually permits to increase the temperature of the network water up to 170-180 C. For a heat density below 80 MW_t/km^2 individual exchanger distribution centres are more workable than the group ones. In 1975, four heat accumulators have to be installed, each with a capacity of 350 m³, and a pressure of 20 kN/m^2 to equalize heat consumption in the 24-hour periods.

The envisaged group of accumulators will have a heat capacity of 850 $\rm MW_{t},$ i.e. 5% of maximum winter capacity and 80% in summertime, in relation to maximal capacity in 1980.

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3. <u>Calculation and optimization of the district heating</u> networks

a. "Optimization of District Heating Networks with Use of Computers" by N. Nikolov, Bulgaria.

In dimensioning the district heating networks, especially of those with large diameters, usually a calculation proper from the hydraulic point of view is not sufficient, and an optimization calculation should be obligatorily carried out. It is fairly difficult and time consuming in the case of complicated network systems of broad extention. For this reason, an electronic calculation technique should be used with an application of programmes properly planned, and taking into consideration all the values both physical and economic, which have an impact on the choice of maximal diameter of the pipe in every part of the network. The proper mathematical formulae are presented by the author for their application to the programmes of computers made in the Soviet Union. Such a programme has been elaborated for 265 sections of the district heating network in Sofia. The calculation has revealed that investment costs of this network could be diminished by 8-10%.

4. Construction of district heating networks and distribution centres

a. "Information on Ductless Arrangement of District Heating Pipelines in Plastic Coats" by Book Herved, Finland.

Some 300 km of district heating ducts were installed in Finland in 1975. Their diameters varied between 40, up to 200 mm. Out of them, 250 km were installed according to the new method, i.e. in plastic coats. The outer polyethylene jacket is fully waterproof. The 12-m sections are connected by muffs welded to the jacket with the use of a welding gas torch.

Two or four ducts are conducted in the jacket, their inner diameter being 10-35 mm wider than the external diameter of district heating pipelines. The space between the pipe ducts and the external jacket is filled with an insulating material of polyethylene, with closed cells. The conductivity coefficient of the insulation amounts to approximately 0.026 kcal/mh C.

The construction assures the free movement of pipes in casing, which makes easier to conduct the ducts and to fasten them in the fixed points. The lower pipe duct constitutes a draining system protecting against eventual penetration of water due to leaks. The ducts are conducted with a declivity to dewatering wells of concrete or, eventually, to cellars. It is since ten years that this method has been applied in Finland.

b. "Rapid Heating of Hot Service Water from Heating Networks" by J. Kremla, Praha.

Up until now the service hot water was heated in volumetric heat exchangers in Czechoslovakia. This method represents many disadvantages, such as considerable investment costs, difficulties in cleaning the containers, as well as difficulties in exchanging installations. An insufficient cooling of heat factor is an additional disadvantage from the point of view of heat output in heating power stations, and of the efficiency in sending heat through the network.

The method of rapid heating in counter-flow exchangers does not reveal the above mentioned disadvantages.

The authors have carried out calculation and tests of equipment in two large installations. The calculated diameters of ducts as well as heat exchangers used in peak demand, i.e. between 18.00 and 21.00 h, will meet the heat requirements in the out of peak periods.

On the basis of the theory of probability, the authors have determined the coefficient for simultaneous action. They assume that for 600 apartments, 27 bathtubs can be filled up in six minutes.

According to the author's opinion, when 200 apartments are fed with hot service water through counterflow heating, the intensity of the flow of network water does not differ much from the intensity when volumetric heaters are used. Optimization of the selected types of heat exchangers has been made with use of computers depending on the checked magnitudes, namely: flow density M₁ and M₂, flow speed w₁ and w₂, Reynold's figures, coefficient of heat intake \sim_e and \sim_i , as well as coefficients of heat penetration K_{tr}. On this basis, calculation has been made of heat capacity Q and pressure drops during the flow through the tested exchanger.

The tests concerning the exchangers connected in series, have been carried out as well. For a proper work of the equipment that heats the service water, a proper selection of control installation is necessary. After a long and detailed research and the proper constructional changes, a suitable regulator was selected and it has been working fairly satisfactorily since 1973; the deviations in the hot water temperature from the assumed one do not excede $\Delta t = 8$ C, and in the second installation with the regulator produced by Billman Company, the deviations do not exceed $\Delta t = 5$ C.

Because of positive results obtained in the two-year exploitation of both installations and no users' complaints in this period, the exchange of the installations with volumetric heaters for the one with backcurrent heaters should be taken in consideration insofar as Czechoslovakia is concerned.

c. "Development Tendencies Concerning the Hot Service Water Distribution Centres" by H. Scheel and Coworkers, G.D.R.

In the German Democratic Republic, 80-90% of dwelling houses are fed from the central heat sources, and a broad extension of district heating networks has been assumed.

For this reason, great importance should be given to the proper solution of the problem of distribution centres which are the connector between the outer heating network and the internal installations. Two types of hot water distribution centres are possible: direct and indirect with use of surface heat exchangers.

In the view of the authors of the report, the direct

distribution centres with pump-type mixing are preferable. Attention should be drawn to the proper system of pressures, depending on the height of buildings connected by a distribution centre and on the maximum supply temperature. Of essential importance are changes in the pressure system taking place either during starting or disconnecting of the installation, or a pump breakdown.

The appliances in a distribution centre should have a fully automated regulation and security fittings.

The authors of the report give an illustration of the tendencies concerning the development of hot water distribution centres, taking into consideration the impact of non-stationary conditions of the district heating network, as well as of automation applied more and more often on the side of consumers and, finally, the problems connected with an economical exploitation of the distribution centres of district heating water, arranged in group.

Stress has been put by the authors on the importance of standard type selection and prefabrication of district heating distribution centres. As a standard size of the room for a group-type distribution centre, they propose 12 x 12 m which permits to insert, either fully or partially, such a room within the cellars of one of the buildings.

d. "Impact of the Change in Both the Temperature and Quantity of Network Water on the Heat Output Capacity of the Exchanger of Central Heating and Deviations in Room Temperature" by J. Kwiatkowski and L. Cholewa, Lublin.

The authors determine in their report the minimum and maximum flow of network water through the installation of central heating, depending on the duration of minimal flow (the working time of the second-stage exchanger of central service water). Such flows do not result, in effect, in the temperature deviations inside the heated rooms. The deliberations and results concern the case of a quantitative regulation adapted to the requirements of the central heating installation,

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as well as that of the lowest temperature of network water amounting to 70 C. When installations of central heating and central service water are fed in parallel and a hot water accumulator is applied, the exchanger that heats the hot service water works only several hours during the 24-hour periods. During its out-ofoperation period, the flow through the central heating installation becomes increased, and the rate of increase depends on the disponible pressure and hydraulic resistance of the particular elements of a given heating distribution centre. The hydraulic resistance can be selected, within the framework of determined limits, during the elaboration of the project of distribution centre.

The digital data given in Table I enables it for a control or changes in the flows. Limiting the maximum flows through the distribution centre, they will provoke the no bigger deviations in the inner temperature of heated rooms than 0.5 C. The deliberations, taken as a whole, are based on the principle that: determination of the average differences of temperature as the arithmetical means is admissible; the effects of the changes in coefficients of heat penetration can be omitted. The changes are substantiated by a calculation for heat exchangers applied in Poland, and use should be made of a semi-empirical pattern 17 for the rate of deviations in the inside temperature.

5. Regulation and automation of district heating networks

a. "Regulation of Heat Intake from District Heating Networks in Helsinki" by V. Hokkanen, Helsinki.

The intake of heat from the district heating network in Helsinki, as well as in the whole of Finland, is indirect and takes place through the heat exchangers. The maximum temperature of network water amounts to 120 C on the supply line and to 65 C on the return line. Respectively, the temperature of water in the installations of central heating amounts to 90 and 60 C, the water that heats the hot service water up to the temperature 5-55 C has a temperature of 25 and 75 C. The air conditioning exchangers are heated with water 120-150 C hot.

Heating in a dwelling house is controlled centrally with a valve equipped with a servo-motor controlled from the impulses of two indicators placed outside the building and in the characteristic room. Because the quantity of water that flows through the inner installation is not constant, every consumer can select the temperature he wishes to have, by a proper manual setting of valves. The additional thermostats can be turned on in order to compensate the impact of insulation and wind, as well as to decrease the night temperature.

The temperature of the hot service water in two heaters connected in series and parallelly, is maintained at the permanent level of +55 C. The uniformity of temperature is assured by circulation pumps. The 400-800 liter accumulators are used when the quantity of heat supplied by the district heating network is not sufficient. These accumulators are made of stainless steel sheet, or of carbon steel sheet with copper lining. The heat intake for air conditioning is fully automated, and it has a complete anti-frost protection in the case when circulation pumps are blocked and have a suction fan of outside air.

The author gives a short analysis of the control systems, giving preference to both electric and electronic systems. The report is terminated by a mention about the rate of pressure drop in the valves, which is acceptable because of the cavitation danger, and he gives the systems for reckoning the customers for the heat energy.