Office Copy

The BULLETIN of the NATIONAL DISTRICT HEATING ASSOCIATION

ORGANIZED 1909

VOLUME XXXIV APRIL 1949 NUMBER 3

District Heating in Sweden

PER ALSEN*

District heat distribution on a small scale has been practiced a good deal in Sweden in recent years. Thus when new groups of dwelling houses are being built, these are often fitted with a joint hot water boiler plant. In certain cases such a plant has been prescribed for an entire quarter of a town.

Heat distribution with simultaneous production of electricity by back-pressure occurs in many industries. This category comprises also the plants at many hospitals, where it is of importance to have a local power reserve, in case of failure of the public electric supply. The industrial combined power-heat plants will not be dealt with in the following.

At our two Institutes of Technology—one in Stockholm and one in Gothenburg—power-heat plants are under erection. These are intended for experimental purposes, and it is planned, by means of these plants, to train suitable personnel for the operation of the big power-heat stations under design.

Previously no municipal power-heat stations were erected in Sweden; mainly due to the ample water-power supply in our country. Consequently it has not previously been necessary in Sweden, as is the case in Denmark, to substitute condensing generating electricity by back-pressure electricity from power-heat stations. Now, however, it is planned to erect power-heat stations also in Sweden for the purpose of heat distribution within large territories or towns. For Gothenburg as well as for Malmo (in number of inhabitants respectively the second and third towns in Sweden) thus fully completed projects for power-heat stations are to be found.

In the following I am going to state some examples of plants for district heat distribution.

PLANTS FOR DISTRIBUTION OF HEAT ONLY

In districts which have not previously been covered with buildings, it is now common to construct a group of dwelling houses at the same time and under joint supervision, either by a private contractor or by the municipality. In such cases a joint heat distribution central is often prescribed for the houses in question, which arrangement offers several essential advantages in comparison with the employment of a particular hot water boiler plant for each house. In a big joint central the heating surface of the boilers can be divided into an adequate number of fairly large boilers. The thermal efficiency will be high, partly because big boilers usually have a better thermal efficiency than small ones, and partly because it is possible, during the entire heating period to keep going just so many boilers that a suitable average load factor per boiler is obtained. Furthermore, it will be easier to furnish the big boilers with mechanical firing devices, such as stokers and oil burners.

The boilers are either section boilers, of cast iron, or forged boilers, usually meant for hot water circulation at a maximum temperature of 195 F. In the boiler room is moreover a joint calorifier for hot-water supply for kitchens and bath rooms.

The circulating water from the boilers is distributed to the dwelling houses connected with the boiler plant. The pipes are placed in the basements of the houses, and as usual they are heat insulated with glass wool mats or similar materials.

As mentioned above, joint heating centrals for entire districts have been arranged at some places. The most well-known of such district heated territories is the one for the Guldheds buildings at Gothenburg. This district comprises numerous residential houses situated at a high elevation on one of the many knolls which are characteristic of the city of Gothenburg. The residential houses comprise a total of about 550 flats and moreover offices, restaurants etc. In the heating plant is to be found 6 pcs. of forged

*Civil Engineer, Malmo, Sweden.

hot water boilers with a total heating surface of 5,100 sq ft and a steam boiler with a heating surface of 270 sq ft. The boilers are heated with coal, by stokers, or with oil. The consumption of coal per 24 hours amounts normally to about 19,000 lbs and at a maximum to 24,000 lbs.

The hot water is pumped to the different dwelling houses through pipes placed in cylindrical concrete conduits. The pipes are insulated with glass wool mats. The biggest pipes are 7 inches. In the houses return water from the radiators is mixed with hot water from the central. This takes place quite automatically by means of a so-called impulse regulator, consisting of an open air thermostat as impulse device, a motor driven mixing valve as executing device and a thermostat in the pipe to the radiators as a returning device.

In the dwelling houses hot water for kitchen and bathroom is prepared by means of calorifiers heated with circulating hot water from the central.

The radiators in these dwelling houses have been tested at a pressure of psi. Due to the very big differences in heights within the territory, the lowest situated radiators receive a pressure of 78 psi. Minor leakages of the radiators have occurred.

The distribution of the fuel costs on the various flats is done on the basis of small heat meters fitted on the exterior side of the radiators and close to the hot water taps.

Combustible waste is brought to the central and burned under the boilers. Two men with a lorry see to the transport of waste.

Next to the heating central a joint laundry, equipped among other things with washing-machines, centrifugal separators and heated calendars, is situated.

MINOR PLANTS FOR PRODUCTION OF POWER AS WELL AS HEAT

At our big hospitals it is usual to combine the heating plants with electric plant reserve, provided by steam-engines or steam turbines. Very often it has proved an economic advantage to work the electric plant reserve continously and utilize the exhaust steam for heating etc., thus providing a power-heat plant in miniature. An example of such a plant is the installation at one of the big new hospitals in Stockholm, named Sodersjukhuset, having beds for about 1,200 patients. The volume of the buildings is approximately 16,000,000 cu ft. The hospital has been erected in two blocks of buildings, one of which has 9 stories above ground level.

The steam plant of the hospital comprises three water-tube boilers, designed for a pressure of 355 psi and a steam temperature of 660 F. Each boiler has a maximum capacity of 26,500 lbs. The mechanical equipment consists of three back-pressure turbine generators, two of which have been made for 350 kva and the third one for 500 kva, at 6,000 v and 50 p/s. The turbines are driven with a back-pressure of 21 to 28 psi. The exhaust steam from the turbines is chiefly utilized in calorifiers for heating the circulating hot water up to a maximum of about 195 F as well as for heating the water of consumption. A minor part of the exhaust steam is utilized for sterilizing, disinfection as well, and in kitchen and laundry. The total maximum heat demand is calculated to be about 48 million Btu/hr. The calorifiers are placed in the steam plant, which also contains closed expansion tanks to compensate for the alterations in volume of the hot water system. In order to avoid too much static pressure on the lowest situated radiators, the heat distribution for the top flats in the main building has been separated from the remaining system and furnished with separate calorifiers, expansion tanks, etc.

By the method of operating at"Sodersjukhuset"the power demand of the hospital may, during the greater part of the year, be supplied by local back-pressure power. As the turbine generators are connected to the district system during operation, 100 per cent power reserve will always be at disposal.

As far as the systems at the Institutes of Technology in Gothenburg and Stockholm are concerned, the demand for mechanical plants for educational purposes has made the combined power-heat station the most favorable solution, as seen from many points of view. In designing the plants in question it has been the endeavour to install as many different machines and apparatuses as possible in contrast to what should be the case in a commercial plant.

The plant at the Institute of Technology in Stockholm comprises, in the first stage of erection, two water tube boilers, each with an ordinary steam supply of about 33,000 lbs/hr. One of the boilers is for a pressure of 570 psi and a steam temperature of 800 F and the other one for 1420 psi resp. 970 F. At a later stage of erection it is thought to install an extra steam boiler, for a pressure of 1,420 psi and a steam temperature according to the development at that time, presumably about 1,100 F. The machine plant will comprise a turbine generator operated by steam with a pressure of about 500 psi and furnished with a hot water condenser for heating the circulating hot water and of a topping turbine generator working between the pressure limits 1,200 and 500 psi.

Circulating hot water with a maximum temperature of about 240 F will be distributed to the various buildings within the territory of the Institute and to a series of similar public institutions in the neighborhood of the Institute. Later on, a few hospitals and other buildings will also be connected to the heating network. At the start the maximum heat demand is reckoned to reach about 45 million Btu/hr.

The power-heat plant at Chalmers Institute of Technology in Gothenburg will be furnished with two water-tube boilers, one of which will be a la Mont boiler, designed for a pressure of 570 psi and a steam temperature of 800 F. Each boiler must be of a capacity of 20,000 lbs/hr. The steam from the boilers will be utilized for power production, partly in a back-pressure turbine and partly in a condensing turbine. The circulating hot water is heated in this condenser. The steam from the back-pressure turbine is utilized for extra heating of the circulating water when the heat demand is particularly large. The maximum temperature of the circulating water has been calculated at 195 F. The maximum heat demand which must be supplied from the plant will be 32 million Btu/hr.

BIG PLANTS FOR PRODUCTION OF POWER AS WELL AS HEAT

As mentioned in the beginning of this article no plants of this kind have been executed in Sweden yet. In Gothenburg as well as in Malmo extensive investigations have been made to obtain a clear understanding as to the suppositions that would justify power-heat plants economically.

In both towns there are municipal condensing power generating plants serving as reserve stations for the direct current systems of the respective towns in case of interruption of the supply from water power.

The present steam power plants are now out of date, and new ones must, under any circumstances, be procured. In this connection it has been discussed whether it would not be more advantageous to erect power-heat stations instead of condensing stations. The discussions have shown that application of power-heat stations is economically justified.

The design of the Malmo system has been partly entrusted to me, for which reason I am most acquainted with it.

The present power reserve station in Malmo is fairly centrally situated, and is favorably situated in relation to a possible district heating distribution.

The plant contains devices for receipt and distribution of alternating current. Furthermore converters—motor converters as will as mercury vapour rectifiers—for conversion of alternating current into direct current and devices for distribution of direct current. For the direct current system a monentary reserve is required, in case the electricity from the water power supply should fail. The power reserve comprises a storage battery and a condensing steam turbine plant.

This steam turbine generator, and specially the boiler plant producing steam for the turbine, is out of date, and of too small capacity. A modernization and extension of the plant is therefore very urgently required.

The new plant should have a capacity of 14-MW. As mentioned above, estimates have been made for a condensing power plant as well as for a combined power-plant station. The former alternative is of no interest in the present connection. The power-heat station is in the first stage fitted with two water tube boilers of a capacity of approximately 145,000 lb/hr and a 14-MW steam turbine with a condenser for heating the circulating water. The pressure in the condenser is calculated at a minimum of 4.3 psia. For distribution of heat, hot water at a maximum temperature of 230 F is used. During the greater part of the year it is considered sufficient to keep the flow-water at a temperature of 150 F. It will not be advisable to keep lower temperatures when, as assumed, domestic water is to be produced, through indirect heating with the circulating water, in the calorifiers for hot water supply in the dwelling houses. In the turbine condenser the circulating water can be heated to a maximum of 195 F. Extra heating of the water at low exterior temperatures is done in heat exchangers, heated with exhaust steam from the turbine and with reduced live steam from the boilers.

At the end of the first stage of erection it is calculated that approximately 420 dwelling houses will be connected to the district heating network. The maximum demand of heat should thereby amount to about 260 million Btu/hr and the yearly heat demand to about 530 billion Btu per year. An entirely completed station should be able to supply nearly double as much heat, and the station at this stage will be equipped with 4 boilers and 3 turbines of the same size as those first installed.

The design of the conduits of the district heating network almost corresponds to the one employed in Denmark, i. e. with pipes placed in concrete conduits, more or less reinforced, and with the space between pipes and conduits filled with Cell-Concrete. The distribution mains are calculated to be extended to the districts of the town situated within about 2,000 yards of the plant. Six pairs of pipes leave the station, four of which are 18 inch pipes.

The pipes should mainly be placed in the streets. The work in this connection will most likely cause certain difficulties, as Malmo is an old town with rather narrow and winding streets. The free space at disposal for placing of the conduits is very small. On the other hand certain factors may facilitate matters and make the construction simpler than in many other places where district heating has already been introduced. Thus Malmo is located on practically level ground and, as a whole, the ground conditions are favorable.

The residential houses will be connected with the district heating network through branch ducts from the street to boiler rooms in the basements. The circulating hot water from the central will be used partly for heating of the domestic hot water in calorifiers for hot-water supply, and partly for room heating through radiators of the dwelling houses. Regulation of the temperature of the water for the radiators is effected by mixing return water with the hot water from the station. This regulation may be done manually or automatically.

A problem that has caused fairly extensive discussions is the way of measuring the consumption of heat in the individual houses. A complete system of heat-meters would, of course, afford the most reliable results, but such meters are very expensive to procure and to maintain. As far as Malmo is concerned it is intended to use ordinary water meters and determine the consumption of heat by measuring the quantity of water in the respective houses, and the difference in temperatures of flow-water and return-water at the central. It is supposed that for residential territories with similar types of heating devices, fairly trustworthy results will be obtained in this way.

The price obtainable for the sale of heat has been examined and it has been decided that heat ought to be paid for according to the following rate, according to the prevailing rates of exchange:

$$w = 0.70 + (K - 1.9) \times 0.14;$$

where w is the heat price in \$ per 10 million Btu and K is the coal price in \$ per 1,000 lb (with a net calorific value 11,700 Btu/lb) c.i.f. Malmo.

No connection fee has been assumed. All costs involved being taken into due regard, heating through the district heating network should, at the price above, be cheaper than firing in local boilers. Due to the many indirect advantages obtained by the house-owner through connection to the district heating network, connection is presumed even in cases where district heating might be somewhat more expensive than heating through local boilers.

SHARE OF POWER-HEAT PLANTS IN NATIONAL POWER-SUPPLY

At the end of February a district heating congress with representatives from the whole country, and also from Denmark and Norway, took place at Gothenburg. The congress had been invited on the intiative of the Electric Works of Gothenburg.

At the conference in question several lectures were given, some of which treated the possible importance of power-heat stations to future supply of electric power of the country. From these lectures could be concluded that out of Sweden's estimated developable water-power, which is at present calculated at 50 billion kwh/year, 15 billion kwh/year are now working. The greater part of the total electric demand of our country is covered by water-power, and only a minor part, about 5 per cent, by steam-power plants. The steam plants are utilized only in peak-load periods and constitute a power reserve in years with insufficient water in the rivers. It is reckoned that in case the present big raise in the electric consumption continues, the developable water power will be fully utilized within two or three decennia. A production of 50 billion kwh/year equals, for 5,000 hours working time, an effect of 10,000 MW. This value should be compared with the effect of the power-heat stations. It is calculated that in case of power-heat plants being erected in the 20 Swedish towns of more than 20,000 inhabitants, and about 60 per cent of the heat demand being covered by district heating, the corresponding power production would be 700 MW and 1.6 billion kwh/year. Consequently power-heat stations could cover only a minor part of the power demand of the country. Furthermore it was pointed out that these stations could not replace such condensing generating plants as are required as power reserves during periods with shortage of water. On the other hand power-heat stations might to a certain extent contribute to cover the peak-loads, as on the whole the periods of maximum production of the power-heat plants correspond to those of maximum power consumption.

KENDALL SQUARE STATION

Cambridge Electric Light Company

George K. Saurwein*

The Kendall Square Station of the Cambridge Electric Light Company is located in a highly industrialized area in East Cambridge overlooking the Charles River Basin. Its buff tile walls with terra cotta trim, make a fine appearance on the much travelled parkway. The corrugated aluminum housing of the coal handling equipment and crusher house, not visible in the picture, adds a good deal to the "new look" of the station.

This is a combination steam-electric station designed for 1500 psi and 910 F in which the turbines are bled at 200 psi for steam sendout.

This first section of the station contains 2—200,000 lb/hr steam generators and 1—18,750 kw turbine—generator. The ultimate plant will have 3 turbines and 5 or 6 boilers.

A 16 in. main leaves the station in a tunnel built for an additional 16 in. line and with its branches supplies steam to a number of industries in East Cambridge, some as far as 3,000 ft. from the plant. Included in the industries served is the Cambridge Gas Works, whose boilers have been supplying a limited number of steam customers. These will be taken over by the new plant when it goes into operation.

*Mechanical Engineer, New England Gas and Electric Association.