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PROJECT OF PRE-INSULATED CENTRAL HEATING NETWORK FOR RESIDENTIAL SETTLEMENT "KOLEJARZ" AND OF BI-FUNCTIONAL HEATING CENTRE FOR ONE OF THE BUILDINGS

SIEĆ CIEPŁOWNICZA PREIZOLOWANA I JEJ PROJEKT DLA OSIEDLA MIESZKANIOWEGO „KOLEJARZ" ORAZ DWUFUNKCYJNEGO WĘZŁA CIEPLNEGO JEDNEGO Z BUDYNKÓW

***Summary**: The publication presents information on the principles of designing the heating network. It also pays attention to the conditions which should be met as well as the elements which should be considered when designing the above mentioned network. The paper contains also the description of the system of nets contained in the plan, the types of the nets according to distribution and, also, the way of conducting the pipelines. Besides it, the attention was paid to the type of material used in construction of the discussed network as it has the influence during its operation. Additionally, the routing of the network was discussed as well as the some respective solutions for heat-supplying network were submitted. It includes the problems of heat power balance, setting of the flows, compensation of elongation and determination of the line pressure and its calculation.*

***Keywords**: routing of network, heating substation, equipment, receiving pipelines, heat power balance.*

***Streszczenie**: Artykuł przedstawia informacje na temat zasad projektowych sieci ciepłowniczej, oraz przedstawia warunki jakie powinny odpowiadać przy projektowaniu sieci i na co należy zwrócić uwagę przy projektowaniu sieci. W pracy została również opisany układ sieci w planie, rodzaj sieci ze względu na dystrybucję, a także rodzaj sieci prowadzenia przewodów. Zwrócono również uwagę na rodzaj materiału z jakiego ma być zbudowana sieć bo to ma duże znaczenie przy eksploatacji. W pracy pojawiło się także kilka słów na temat trasowania sieci, a także przedstawiono stosowne rozwiązania dla sieci ciepłowniczej. Praca posiada metodę obliczeniową sieci ciepłowniczej, która dotyczy zagadnień: bilansu mocy cieplnej, ustalenie przepływów, kompensację wydłużeń, a także ciśnienie linii i jej ustalenie.*

***Słowa kluczowe**: trasowanie sieci, węzeł cieplny, sieć cieplna, urządzenia i przewody odbiorcze, bilans mocy cieplnej*

Introduction

The main source of heating of houses and generation of heat water in Poland is based upon the water as heat transfer medium. It is delivered by the pipeline system which, together with the appropriate fittings, composes the district heating network. The aim of the heating network is to take heat energy in the heat source and then, to transport it to its users.

The assembly of the equipment and receiving pipelines which take and distribute the delivered heat is called a heating substation. It is the site of connection of the heating network and the heating installation. It is found in a separate room, usually underground; it must be centrally situated in relation to heat receivers [1, 2].

The aim of the study was development of the problem of pre-insulated heating network for residential housing area of housing cooperative "Kolejarz" in Koszalin in accordance with the binding standards.

The principles of designing the heating network

When constructing the heating network, we always strive at obtaining the lowest heat losses. A correct transport of heating medium is required to be reliable and characterized by the smallest resistance in flow. In case of the user from industrial sector, water vapour (steam) may be also a heat medium [3].

General condition of designing the heating network is the supply of heat medium under the appropriate pressure to all planned points of receipt, maximum quantity of heat medium, being delivery in a continuous way and reaching of the low costs of construction and operation [2, 4].

Designing of the mentioned network includes designing of the paper project and routing of the network.

The project of the network system in plan

The application of the heating network is the first step considered in its designing. We may distinguish industrial, urban or mixed types of network. When working upon the urban network, we should always check whether it is planned for dwelling settlement which already exists, or for that one which is at the moment of constructing [5, 6, 7].

In the first case, the route of the network is referred to the already existing construction, with a complete infrastructure and also, to the communication road. In the second case of the network development, it should be conducted in parallel to the

plans for development of the streets and infrastructure of a given territory [5, 7].

The type of the network is related to the choice of the heat medium. We may distinguish the following types of the possible heating media: high-temperature water heating (the range above 115oC), low-temperature water heating (temperature of 115°C), high-temperature steam heating (steam pressure is above 0.07 MPa, low-temperature steam heating (the steam has the pressure equal to 0.07 MPa and mixed heating [8].

Types of network according to the way of construction

The network system in plan version consists always in the appropriate choice of the heat medium. We may distinguish the following network types:

- manifold (branched) in a form of truss (Fig. 1) – it is employed in the vase of a very high heat density of the region and for the systems of the streets, crossed at right angle (e.g. in New York); the mentioned solution enables joining of all users with the application of short connections; it is characterized by a high reliability because each of the users receives heat from at least two directions. The basic disadvantage of the branched network is its very high cost; hence, the mentioned solution is employed extremely seldom [9],
- the radial network – the heat is transferred only in a specified direction with the aim to supply big users, or those who are found at greater distance each other [7].

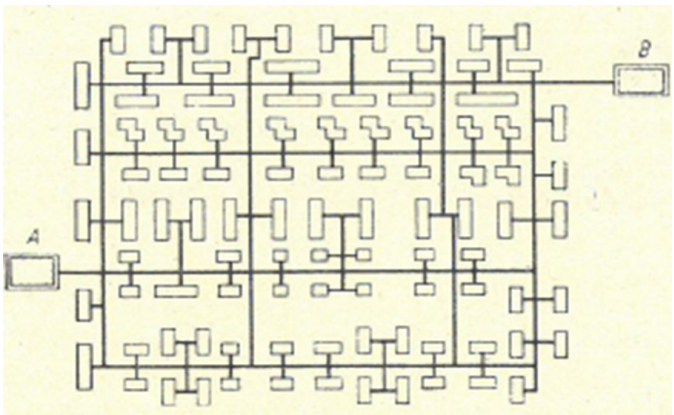


Fig. 1. The branched (manifold) network [12]]

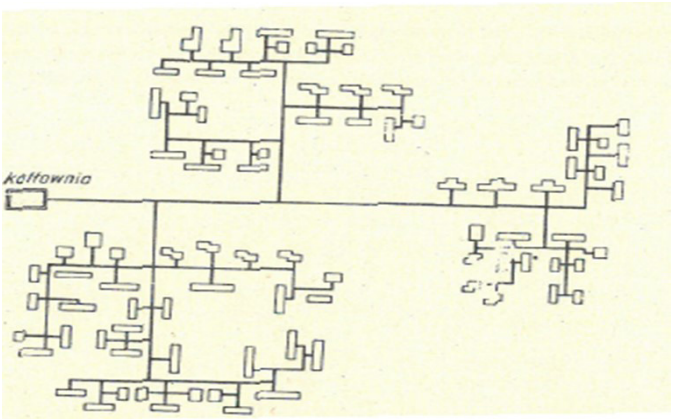


Fig. 2. The ring network [12]]

Types of networks according to the number of pipelines

- A single pipeline network where the cooled water does not return to the source. The return water has a lowered temperature and it is used directly for sanitary purposes via heat network of domestic hot water, i.e. the whole supplied water is directed to sewage system after having passed through heat exchangers what causes lowering of the mentioned above temperature [9, 10]
- Four-pipeline network which consists of two independent pipelines (feeding and returning) which serve only for heating purposes and two independent pipelines which serve for technological purposes [7, 9].

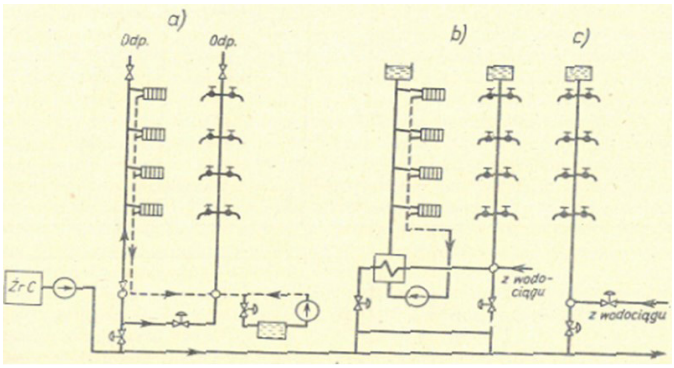


Fig. 3. A single pipeline network: a) connection of central heating and hot tap water installations by the hydro-elevator, b) indirect connection of central heating and hot tap water installations via hest exchanges, c) direct connection of hot water installation [12]]

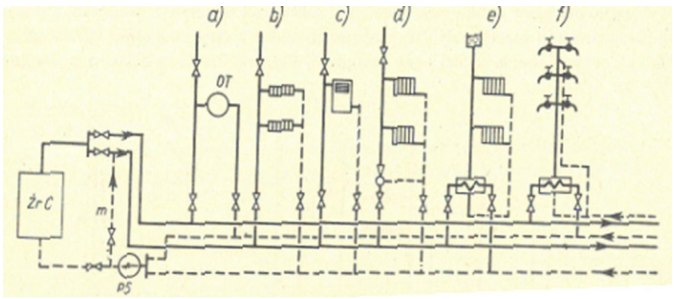


Fig.4. Four-pipeline network: a) direct connection of technological receivers, b) direct connection of central heating, c) direct connection of ventilation heaters, d) direct connection of central heating via hydro-elevator, e) indirect connection of central heating, f) indirect connection of hot tap water installation [12].]]

Types of network according to the way of laying the pipes

We should always choose the appropriate way of laying the pipelines. We can distinguish aboveground and underground networks of pipelines. The heating aboveground network may be employed in the exceptional cases, e.g. in the occurrence of a great number of crosses with railway trails, difference in the level of the area and in the case of wetland with a high level of groundwater [10].

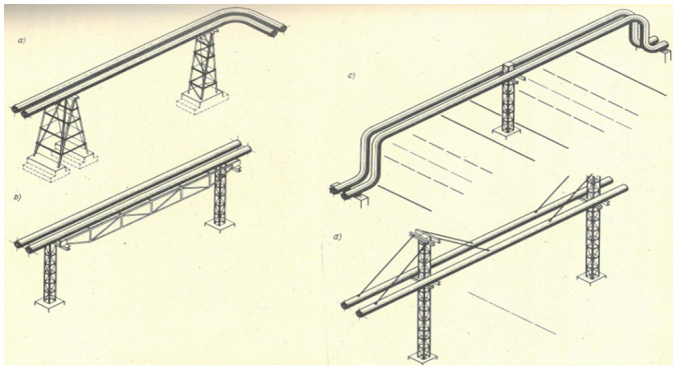


Fig. 5. Laying the pipelines: a) on high steel supports, b) in lattice girder, c) over the two-directional road, d) suspended [12]

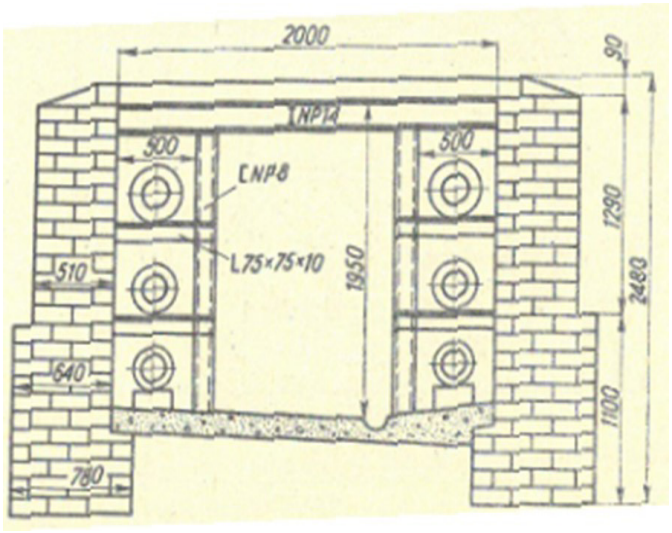


Fig. 6. Pipe network in the front channel [13]]

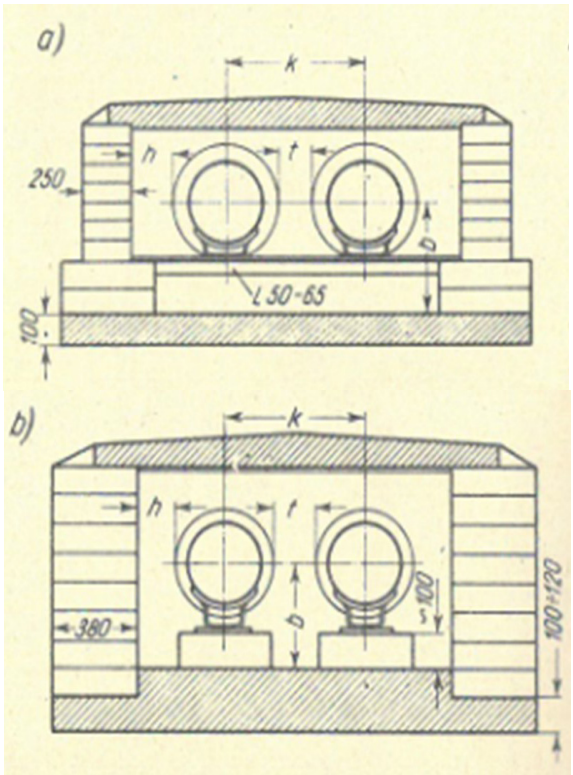


Fig. 7. Pipe network in intransitive channels [13]

The intransitive brick channel for: a) for ϕ 50–100 mm, b) for ϕ 150–600 mm.

Fig. 8. Non-ducted network [14]

Types of the heating pipelines according to the employed material

Choice of the appropriate material is an important aspect of designing the heating networks. We can distinguish the following types of networks:

- Networks made of black steel pipes;
- Networks made of galvanized steel pipes,
- Networks made of plastic pipes,
- Networks made of copper pipes.

Routing of the networks

The routing of the heating networks is connected with the choice of a short route. The mentioned route should have the possibly highest number of users. The arrangement of the network should be found on the developed area, under the pavements and lawns. The network crossing the road and railway rails should be laid in protective pipes. The conducted network of the pipelines should be laid in a distance from the forests and with the protection of the green areas. The mentioned operation should be performed as shallow as possible, with the preservation of the cover, assured by the producer of the pipes. The equipment in the channels should have the ensured ventilation by gravitation [5, 8]:

Significant solutions for heating system

Materials which constitute the heating networks include the pre-insulated pipes. They consist of the conductive insulating pipes and the protective pipelines. The conductive pipes are the most important element of the pipeline. The heating element may be made of black or galvanized steel and also, of copper or plastics (low-parameter pipelines) [4, 6, 7].

The task of the conductive pipe, covered with insulation made of polyurethane foam, is to limit the heat losses and to transfer the thermal elongations onto the protective (external) pipe. On the other hand, the protective pipe is made of polyethylene what prevents corrosion. There is a protective pipe made of galvanized steel band or of corrosion resistant steel. The discussed pipelines are additionally equipped in alarm system which inform about occurrence of humidity of thermal insulation or about a fault [6, 8, 9].

The traditional heating networks, being implemented as intransitive underground channel constructions, are made of prefabricated elements. In contrast to those mentioned above pipes, the pre-insulated pipes are laid on the ground what brings many advantages. The situation of non-ducted pipeline increases its stability, decreases the number of failures and limits the costs of operation. It causes reduction of heat losses, resulting during the transfer of heat medium. A simplified assembly of the pipeline enables its quick laying. We can distinguish the pre-insulated composite pipes and the pre-insulated sliding pipes [6, 7].

The pre-insulated composite pipe is a system of pipes where insulation connects the external protective pipe and internal conducting pipe. The assemblies of pre-insulated pipes have single layer insulation and it is made of polyurethane foam (PIR). The pre-insulated pipelines with the foam PUR are employed in transfer of heating medium, the operating temperature of which is 120–130°C. In the case of foam PIR, its temperature is equal to 160°C [8, 11]:

Fig. 9. The pre-insulated composite pipes

Fig. 10. Pre-insulated sliding pipe [13]

Insulation of pre-insulated sliding pipes consists usually of two layers. The internal insulation is made of mineral wool or fibreglass wool whereas the external layer is made of PUR or PIR foam and insulates from the direct effect of temperature of heating medium. The pre-insulated pipes, intended for construction of pipelines laid directly in the ground with protective polyethylene jacket and for aboveground pipelines with the protective pipe of "spiro" type consist of steel galvanized sheet or corrosion-resistant steel [6, 4].

The pre-insulated pipes and their production

In manufacture of pre-insulated pipes, the popular method of "pipe in pipe" is employed. The mentioned method consists in foam injection into the area between the conducting pipe and protective pipe. The thickness of insulation is determined by the size of diameter of protective pipe. In order to obtain any thickness of insulation, the technology of semi-continuous method is employed [3, 4]. The mentioned method consists in foaming of polyurethane foam in a steel profile which is put on the conducting pipe; when the mentioned form is taken off, the protective HDPE (high density polyethylene) jacket is wound on the insulation.

Conti technology consists in formation of insulation together with anti-diffusion barrier and also, injection of protective jacket into it. The mentioned barrier is found between the PUR foam insulation and the external insulation of the protective pipe. Owing to this fact, the pipes produced by the above discussed method, have slower ageing process during the operation [5, 6, 8]

The calculating methods, employed in relation to district heating network

Routing and designing the network is connected with the following issues:

— ***balance of heat power*** – each user should possess the developed power balance, necessary for designing of the network; it illustrates the demand on the heat power for the following purposes:
  - ventilation Q_w,
  - technology Q_T,
  - central heating Q_{co},
  - hot tap water Q_{cwu},

$$Q = Q_{co} + Q_{cwu} + Q_w + Q_T$$

— ***determination of flow***

Flow is the amount of water, flowing by a defined cross-section of the pipe during a time unit. In the project, the established route of the network should be marked in accordance with the position of the main pipes of the central heating main [6, 7].

— ***Choice of the pipe diameters***

The first step in the choice of the diameter of the pipes is to specify the type of a given pipe and establish the rate of flow of the heating medium [8, 9]. Depending on the above, water in the

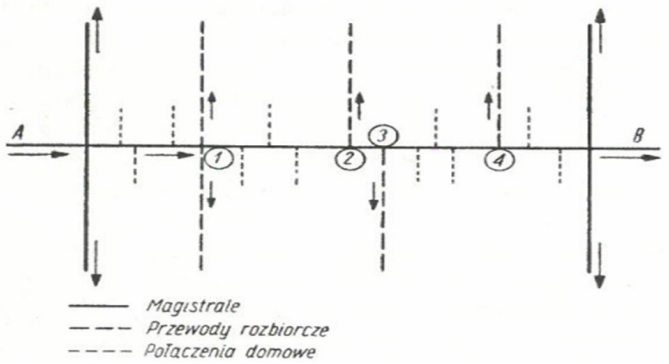


Fig. 11. Scheme of the flow [15]]

heating network may have the rate flow in accordance with its standard:

- 3.0 m/s – the main pipelines;
- 2.0 m/s – the branching from the main pipeline;
- 1.0 m/s – the connection to the buildings

The rate of flow through a given cross-sectional area of the pipe is expressed by the following formula:

$$A = G/V \ [m^3]$$

where:
G – flow rate from the calculations [m^3/s]
V – rate of the heat medium [m/s]

The diameter of the pipe is:

$$d = \sqrt{4 \cdot A/\Pi} \ [m]$$

— *Compensation of elongations*

The increase and lowering of temperature is subjected to phenomenon of thermal expansion. In case of obstruction, the thermal elongation is not possible and a fatigue crack may happen. Such situation happens when the material of the pipes exceeds a standard of mechanical strain. If we want to avoid a risk of destruction of a given part of the material, we have always to consider the possibility of elongation of the pipeline and compensate it [9, 10, 11].

The compensation of the pipelines includes as follows:

- natural compensation with utilization of compensation equipment (housing type compensator)
- application of compensating devices (elastic pre-insulated networks)
- compensation "on cold' (industrial pipes)

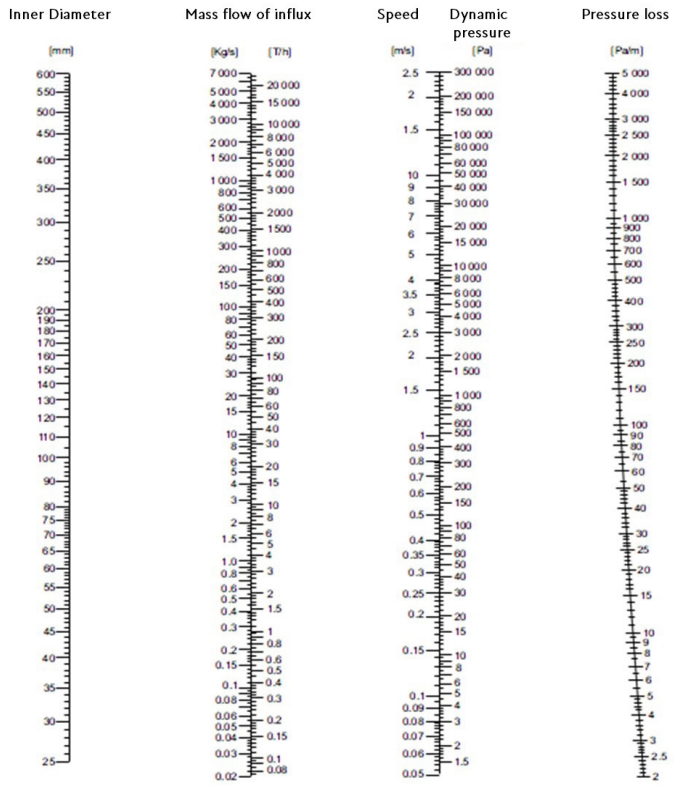
— *Pressure of the heating line and its establishment*

In order to determine the pressure of the heating line, we have to possess a special established nomogram which contains such parameters as pressure loss, dynamic pressure, flow rate, mass flow, flow intensity and dimensions of internal diameter [3, 4].

The determination of the line pressure is obtained by combination of two lower parameters and by prolongation of its segment what gives the readout of the remaining parameters [2].

Tab. 1. Example of choosing the appropriate diameter of the pipe [9]

Seamless service pipe			Casing pipe	Losing strength	Installation length
Dz	g	A	Dzp	F	Lmax
mm	mm	mm^2	Mm	N/m	m
26,9	2,9	219	75	1410	24
33,7	2,9	281	90	1410	31
42,4	2,9	360	110	1723	32
48,3	2,9	414	110	1723	38
60,3	3,2	574	125	1958	46
76,1	3,2	733	140	2193	53
88,9	3,6	965	160	2506	61
114,3	4,0	1386	200	3132	71
139,7	4,0	1705	225	3524	79
168,3	4,5	2316	250	3916	97
219,1	6,3	4212	315	4934	140
273,0	7,1	5931	400	6265	156
323,9	7,1	7066	450	7048	168
355,6	8,0	8736	500	7831	187
406,4	8,8	10992	560	8144	211
457,0	10,0	14043	630	8771	239
508,0	11,0	17175	710	9867	260



Tab. 12. Nomogram for determination of the pressure of heating lines [9]

Summing up

- The underground heating network should be constructed in technology of pre-insulated pipes which are laid directly in the ground. The assumed time of operation of the heating network is 30 years,
- The segments of the pipes should be supplied to the building site in pre-fabricated element of 6.0–12.0 m length. In the case of the pipes delivered in pipe coils, its length should be always given in the material specification,
- The performance of the elements of the pre-insulated pipes' system should be consistent with the standards PN-EN 253-2009 and their later amendments,
- The pipe assembly is a factory made element, consisting of conducting pipe, insulating material and protective sheath, satisfying the requirements of PN-EN 253,
- Heating pre-insulated networks should be so designed and assembled as to meet the requirements of self-compensation, considering the bending of installation in the route of the pipelines,
- It is allowed to lay the routes of heating networks in the territory under the demountable surface of the housing internal roads, driveways and escape routes,
- We should avoid laying the heating pipelines alongside under the road lanes which are charged with big car traffic, excluding the transverse passages on the run of the network; each pipe should be furnished with a warning tape,
- The passage of connections, made of pre-insulated pipes through the outer partitions should be performed in the way, ensuring its waterproofness.

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