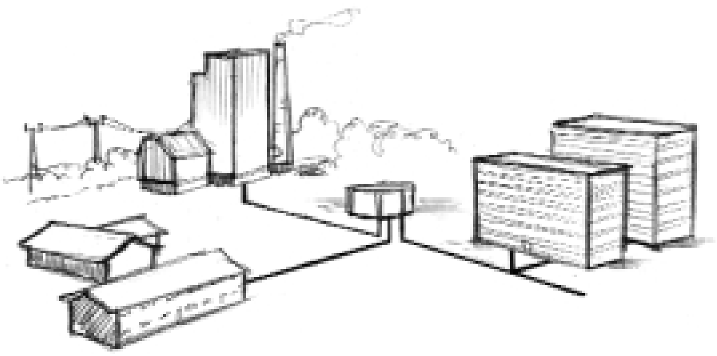
Instructions for designing district heating systems.

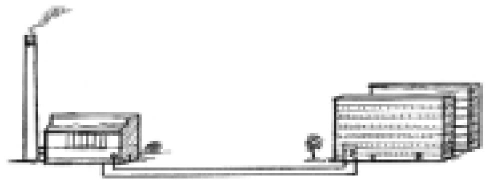


The methods and systems chosen at new systems and restoration of existing systems should be subject to a long-term planning. At the same time, we have to consider future development. The solutions listed below are those which seem to be the most suitable for this purpose during the next few years.

District heating is considered the long-term solution, but it has to be made more efficient. Small production plants are hard to manage from an environmental- and an efficiency point of view. Smaller systems should be removed, the load should be connected to larger production plants. When the local district heating networks have reached a sufficient number, they should be connected to a combined heating and power plant. Distances of 14-15 km or more between district heating networks creates no problem with the modern preinsulated pipes. The combined heating and power plants produces electricity and heat all year round. The local heating plant are on "Stand-by". They are started when the combined heating and power plants cannot meet the total heat requirement.

Large plants in operation day and night. They are required to achieve the most efficient combustion with the smallest possible discharges. When all the local district heating networks share the same operation conditions, it will, in the long run, be possible to connect them to a large combined heating and power plant.

The primary system/ the district heating can be divided into:
• production, central boiler plant
• distribution, preinsulated pipes
• consumption, sub-station



Production Distribution Consumption.
Fig. 5:1

Environment.

Most of what we are doing in our ordinary lives affects the environment in one way or the other. Some things are clear to the naked eye: the smoke and the soot when we are lighting a fire, for instance. Other things can be more difficult to detect: as how much more smoke and soot that is formed if we do not efficiently utilize the heat we are producing. Or: a unit in a central boiler plant must be exchanged after five years instead of 20 years, due to inefficient operation.

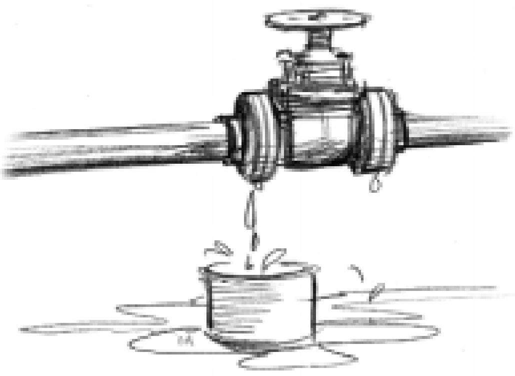
The consumption of coal has negative effects on the environment in the central boiler plant and its closest surroundings, but the area from where the coal is collected is also indirectly affected. The transport to and from the central boiler plant also has negative effects on the environment through its consumption of energy. The most efficient way of reducing the negative effects on the environment is to reduce the consumption of coal through a more effective use.

Efficient systems reduce the negativ effects on the enviroment.
Fig. 5:2

1. Durability.

There are two reasons for exchanging components in a district heating system:
• the component is worn out, for example a bearing in a pump
• a new product provides a better efficiency

Components with no moving parts do not wear out, and their technical life is calculated to 50 years. Boilers of a good quality can last for about 30 years with a proper maintainance.



Worn out components should be exchanged.
Fig. 5:3

2. Production.

In the production plant the temperatures are high and the wear is extreme. An efficient operation process, a reduced consumption of fuel, a large reduction of discharges and an increased durability of the components are measures that have to be considered. Small central boiler plants, up to 30 MW, should be replaced by connection to district heating networks, with larger boilers combusting more efficiently with fluidised beds.

3. Fuel.

The fuel in the district heating Main Power Stations will in general during a foreseeable future be coal and gas (only within certain areas). Irrespective of fuel type, impurities in the fuel has to be kept as low as possible. International standards apply.

A decrease of the ash content in coal causes an immediate increase of the efficiency and reduces the discharges radically. This decrease can be accomplished by washing the coal, and this should be made without delay, even for existing boilers.

Crushing and washing of coal should not be made at the district heating Power Station but rather in connection with the mining process.

By choosing coal containing small quantities of sulphur, the discharge of sulphur decreases in the combustion process. Internationally there is only coal with less than 1% sulphur for sale.

The use of better coal in all the boilers results immediately in smaller discharges and ought to be used as soon as possible. Coal of high quality should, in the long run, be used in the local heating plants, while coal with a lower quality is to be used in the combined heating and power plants where an efficient purification of the flue gases takes place.

	Particles mg/m^3	SO_x mg/m^3	NO_x mg/m^3
EC	50-100	400 - 2.000	650 - 1.300
Mininmum	40	160 - 270	80 - 540

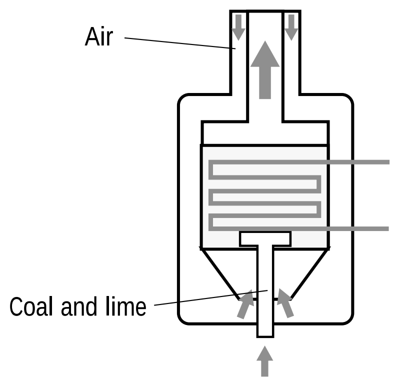
Allowed discharges according to IEA Coal Research air pollutant emission standards for coal-fired plants database, 1991.
The values regard new plants. The first value is for large plants and the second value for small ones.

4. Combustion.

The combustion has to be efficient, as it reduces the impurities in the flue gases and utilizes the heat contents of the coal.

Combustion of coal, based upon pulverised coal and burned with a fluidised bed, has proved to be the best combustion technique at present. The impurity content in the flue gases is already low without the purification. This combustion technique should be used in new plant and when replacing old boilers, both local and in combined heating and power plants. Combustion that is efficient and durable for a long time, requires automatic operation and sound operating conditions.

Boilers with fluidised bed combustion are very effective even from the environmental point of view.



Boiler with fluidised bed combustion.
Fig. 5:4

5. Flue gas purification.

All the discharges coming from the flue gases should be reduced to the lowest possible level.

No distinction is made between small and large plants, regarding discharge of particles. The best result in 1998 is, up till now, 40 mg/m^3. The local heating plants, with effects of more than 40 MW, should be equipped with bag filters. Electric filters may be more efficient when it comes to combined heating and power plants.

The discharges of SO_x and NO_x should be reduced to international levels, in the CHP plant 1998 =25 mg/MJ, but it is not possible to introduce such an efficient reduction of SO_x and NO_x into the local heating plants for economic reasons as they are only allowed to be used at peak load. Boilers with a fluidised bed emits small quantities of SO_x and NO_x. Local heating plants do not, for that reason, have to be equipped with further purification of the flue gases, as they are only in operation for a short time, after having been connected to combined heating and power plants.

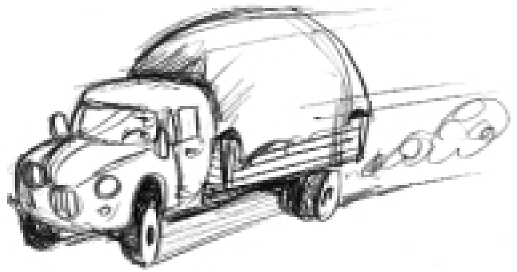
The combined heating and power plants should be equipped with purification of SO_x and NO_x.

6. Handling of ashes.

The ash quantity is dependent on the quality of the coal. The washing of coal reduces the ash contents and the better washing the less ashes.

The handling of ashes is important regarding the environment and should be carried in closed vehicles. The large volume of ash also involves consideration for it's long term use.

The transport of ashes should be made in tight vehicles or containers so that the surrounding environment is not affected.



Transport of coal and ashes can effect the environment in more than one way.
Fig. 5:5

7. Handling of coal.

Coal which is stored or moved openly should be handled in a way that the wind cannot carry away dust. Spraying with water or chemicals are tested methods.

Unloading, tipping, crushing or grinding of coal should be made in such a way that the surroundings are not disturbed by noise, or dust.

8. Water quality.

The water in the primary system should be of such a quality that there is no risk of corrosion or coatings. All the water brought to the system should be within the following requirements:

Conductivity	max 10 µS/cm
pH-value	9-10
Hardness	0,1 tH°
Appearance	clear and sediment free
O_2	0,02 mg/litre

Leakage is not acceptable. The material and the construction of shaft- and spindle inlets should be made so there can be no leakage.

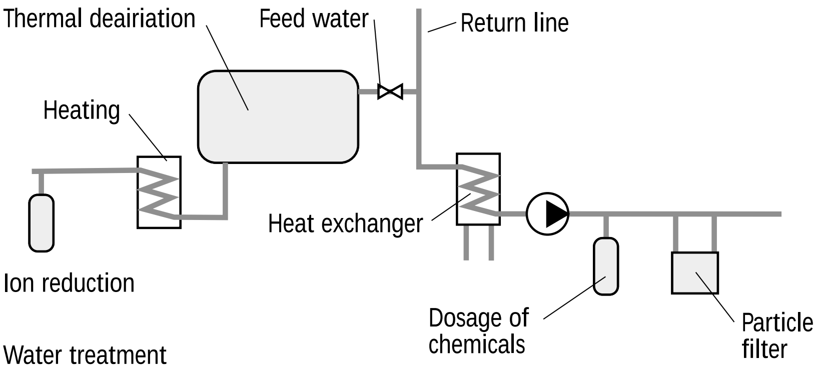
The water for refilling should be treated in the same way.

The systems should not be emptied of water, even though they are not in operation.

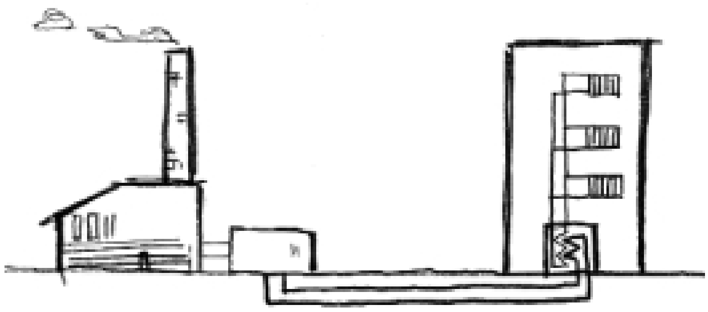
Flushing of the systems.

During the whole installation process of a production plant, all impurities, such as scales, sand, gravel etc., should be removed from the system, and the connections should be flushed before the system is finally filled.

The requirements for flushing and water quality applies to the production- as well as to the distribution unit.



Water treatment
Fig. 5:6



Local district heating system.

1. Effect ranges.

Local district heating systems should lie within the range of 40-60 MW. The effect refers to the actual heat requirement in the buildings.

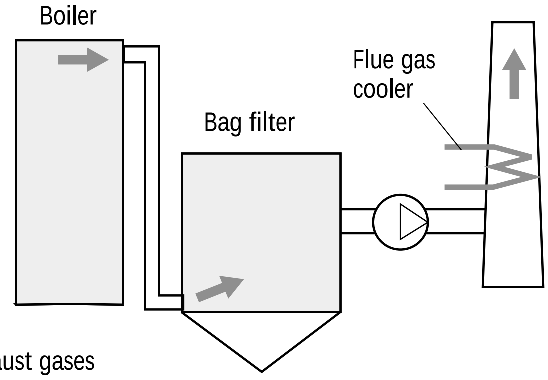
The combined heating and power plant should deliver about 60% of the total connected heat requirement, at optimum distribution between electricity (40%) and heat production (60%). Minimum output, electricity and heat, is to be 200 MW.

The local heating plants should be connection to a combined heating and power plant only be used at peak loads and at operational break down and maintainance the combined heating and power plant.

2. Existing boilers.

Existing boilers, of 40-60 MW, in good condition that do not need to be exchanged within a reasonable time, should use coal with a low content of ashes, the combustion should be made with a high efficiency. Flue gas coolers should be installed to raise the effictively and then the condensate, SO_x must be taken care of effectivly. The boilers should be in operation night and day and turned off only for cleaning.

A simple but effective purification of the exhaust gases can be done with bag filters and cooling the gases will raise the effeciency



Purification of the exhaust gases
Fig. 5:7

Flue gas purification with bag filter should be installed, and as maintenance work is required, other measures should be taken for a change-over to the supply from a combined heating and power plant.

In principle, the same procedure applies on both smaller and larger boilers, but the smaller ones should be removed as soon as possible, and their system is to be connected to larger plants with flue gas purification.

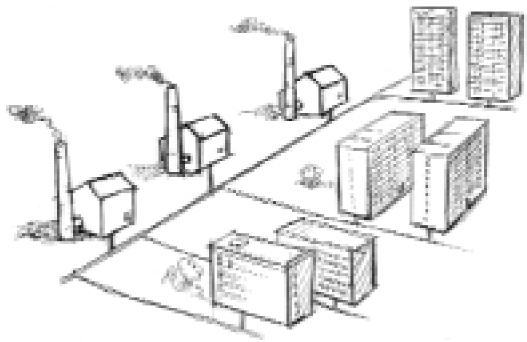
3. New boilers.

When new boilers are installed, either in new or existing district heating networks, the out put should be of about 40-60 MW, the combustion should be made with a fluidised bed.

The coal quality has to be good, i.e. low contents of sulphur and ashes, and the combustion should be done continuously as long as there is any need of it.

Two or more local heating plants of this size can at an early stage be connected to preinsulated pipes. It is better to have one heating plant with a capacity of 100% in operation, than to have three with a capacity of 33% each.

The discharges of SO_x and NO_x stays at an acceptable level with this combustion technique, even without purification. When the local heating plants are later connected to the combined heating and power plant, the operation times will be reduced to perhaps 15-20% per year, the SO_x -and NO_x levels are then acceptable. The discharges of particles must be limited. This is done by using bag filters.



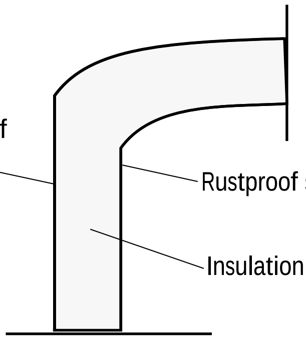
Connecting two or more district heating networks will rise the efficiency and the reliability.
Fig.5:8

Heat losses in the production units.

There are many surfaces with high temperatures emitting a lot of heat in the production units.

All warm surfaces should be well insulated in order to increase the efficiency of the plant.

A high room temperature which is a result of a bad insulation or none, is shortening the life of the devices required in an advanced plant of this type, not to mention the electronic equipment. Furthermore, people have to be able to work efficiently within the plant.



An accumulator must be protected from corrosion both on the outside as well as on the inside and also be well insulated.
Fig. 5:9

4. Accumulator.

The accumulator has two purposes:
• to level off the differences between production and consumption
• to be an expansion system for the distribution unit

The accumulator should have volume enough to manage a heat requirement of 12 hours.

The accumulator is made of steel with the same pressure class as the rest of the distribution network. It is anti-corrosively treated on the outside as well as on the inside and is equipped with outside insulation, for example extruded polyurethane, and a tight surface layer.

In order to be able to pick up the water volume change, the required expansion volume plus 20 % is added to the volume of the system. The expansion volume is filled with nitrogen gas and the pressure is raised to the required level.

Safety valves with the required capacity, opening at a maximum working pressure, should be installed. They have to be easily accessible for service and testing.

Heat exchangers.

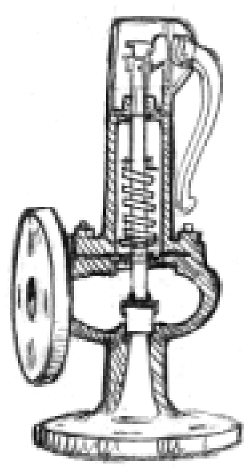
Heat exchangers for transfer of heat from the local boiler as well as from combined heating and power plant are connected to the accumulator. The exchangers are installed outside the accumulator, a charging pump, transfers the heat into the accumulator. An additional pump or valve system is required, to allow the stored heat in the accumulator to be used in the district heating on demand.

The local boilers are detached from the distribution network with a heat exchanger before installing the accumulator. The boiler circuit can be run with the optimum conditions for the fuel consumption, temperatures and pressures.

5. Expansion systems.

Closed expansion systems should be used. It is easier to adjust them to possible changes in systems or in operating conditions. It is also easy to increase the static pressure, should, for example, a cavitation arise.

Closed expansion vessel with inert gas for the keeping pressure.
Closed expansion vessels are exposed to the same pressure as the rest of the system and must therefore be constructed as pressure vessels.
Closed systems must be equipped with safety valves, opening and letting excessive pressure out if boiling should occur. The opening pressure is equal to the maximum working pressure of the plant. The safety valves require a permanent control.



Safety valve.
Fig. 5:10

Expansion systems for the boiler circuit.

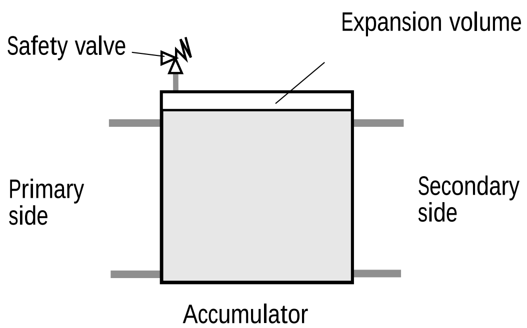
A pressure vessel with a volume corresponding to the expansion of the system plus approximately 10%, as a margin, is installed in a suitable location in the production plant.

The expansion circuit of the boiler is connected at the bottom of the vessel. The pressure is maintained by assistance of a compressor or with nitrogen straight from gas bottles. A gas pillow lies above the water surface at a constant pressure. Nitrogen is used because it prevents corrosion.

Expansion systems for the distribution unit.

Before installing the accumulator, the same type of closed vessel is used as for the boiler circuit.

The accumulator is sized for an extra volume (for the gas), which is 20% larger than the expansion volume required for the distribution unit. The pressure maintenance is effected in the same way as for the closed expansion vessels.



Expansion volume in the accumulator.
Fig. 5:11

6. Circulation pumps.

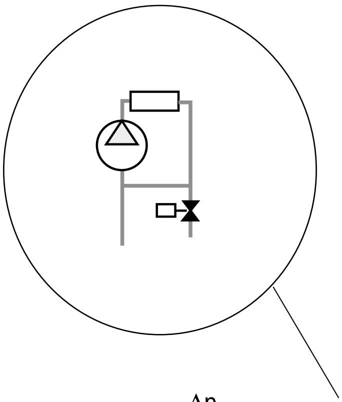
When considering the required static pressure, the circulation pumps should be placed in the flow.

The pumps in the boiler circuit and the charging pumps for the accumulator should be sized to be able to manage the resistance in the current circuits, including heat exchanger and control valves, if there should be any.

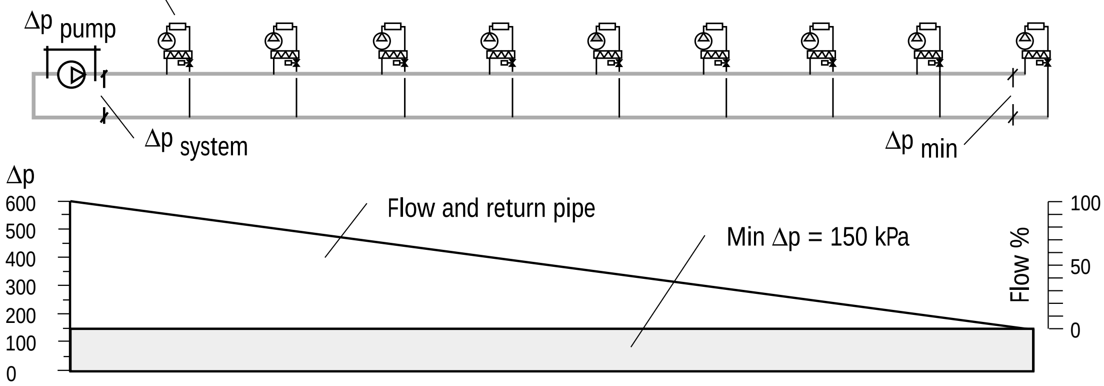
Dynamic pressure.

With regard to the local distribution systems, the lowest obtainable differential pressure of 150 kPa has to be available in all the sub-stations, and the stated maximum water rates should be strived for in the pre-insulated piping network.

The same conditions also apply to the central distribution network.



The minimum Δp, 150 kPa, should always be available in all sub-stations.



Dynamic pressure
Fig. 5:12

Flow.

The flow is determined on the basis of heat requirements and temperature drop. The theoretically calculated heat requirements are usually higher than the real ones, and therefore an exact calculation of the flow is not necessary.

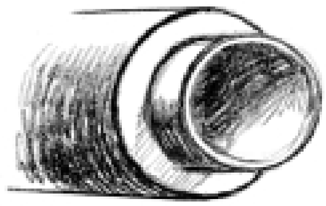
When the system has been commerioned, a measurement of the real values is important, in order to run the plant in the best way possible.

The specific heat amount of water is based on 1 kg at 15°C. Calculations for heating systems are normally made with 1 kg water equal to 1 litre and that is not physically correct because the volume and the specific heat will change with the temperature. This deviation is still small compared to the differences between calculated and real requirements.

7. Pre-insulated pipes.

Pre-insulated pipes with a high-quality insulation and a safe waterproof protective cover should be used for all the heating distribution systems. They should be constructed and installed in such a way as they last as long as possible.

Stated maximum water rates should be strived for which will give a smaller external diameter and therefore a smaller heat emitting surface. The standard insulating thickness should be used.



Pre-insulated pipe.
Fig. 5:13

Material.

Pre-insulated pipes consist of an internal steel pipe. On the outside there is foam insulation and the waterproof external layer consists of a polyethylene pipe. The insulation is foam with the steel pipe as an internal and the polyethylene pipe as an external mould. The construction function as one unit from an expansion point of view. There are preinsulated pipes in dimensions from the smallest to the largest, d_{out} 27 – 1.220 mm.

Linear expansion due to variations in temperature.

The mounting of pre-insulated pipes is made at temperatures far below the normal operating temperature. The pipes therefore expand operating, 0,12 mm/m pipe and a temperature raise of 10°C. The pre-insulated pipes are functioning as one unit, i.e. the forces arising when the steel pipe is expanding are transferred to the external plastic pipe through the insulation. The plastic pipe, in turn, is held in position by the friction against the poured sand. A linear expansion does not occur, but the wall of the steel pipe picks up the expansion.

The mounting and the re-filling are done without any special measures taken for an expansion pick-up. Once the pipes have been welded and the joint has been tested, the caps for the external mantle are mounted and the cavity filled with foam. After that there is a re-filling of sand around the joint. Open pipe ends should be covered to avoid sand and other impurities from entering the pipes. The system should be flushed before use.

Open pipe ends should be covered.
Fig. 5:14

Sizing of pipes.

A high water rate in pre-insulated pipes is important from several aspects. It results in smaller pipes which have the advantage of being cheaper and causes smaller heat losses. The temperature drop across a certain distance becomes twice as large at the same temperatures if the flow is halved. At the same time, the resistance in the circuit is reduced to a quarter, and the operational cost of the pump will only be an eighth.

8. Heat exchangers.

A sub-station is situated in each building, maybe several in long, high-rise buildings. It is cheaper to distribute heat in a primary distribution system than to construct up a secondary one.

Coil units or plate heat exchangers can be used for hot water as well as for domestic water systems. Both these types contain very small water quantities, and therefore an increased consumption requires that the whole primary system reacts quickly.

The water flow rate in heat exchangers ought to be high, so that the deposits do not remain in them.

The flow resistance across an exchanger is usually 20-50 kPa.

Operating conditions.

1. Temperature levels.

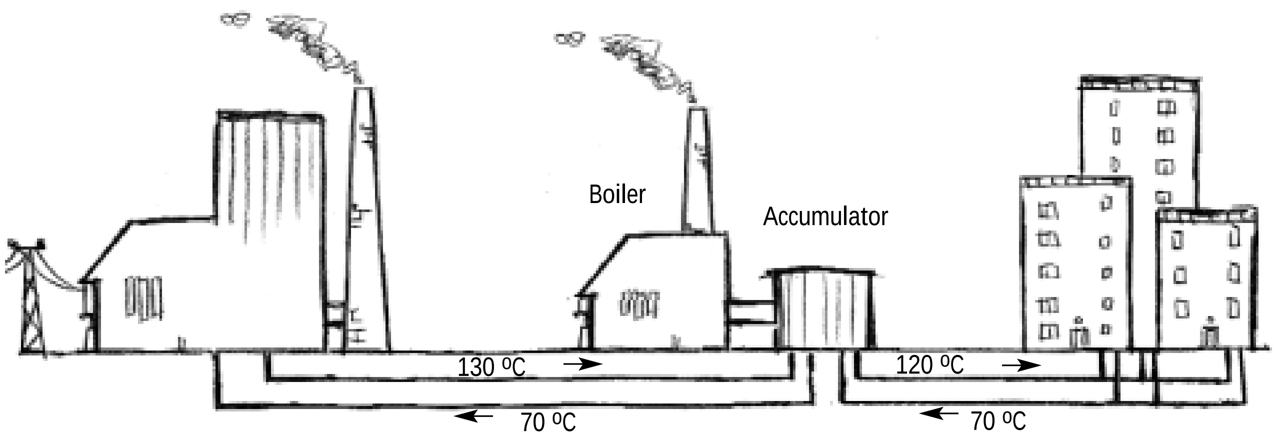
The boilers in the combined heating and power plant with an electrical production will work with steam, but a temperature of 130 °C ought to be chosen for the distribution out to the local district heating networks. The same temperature should also be applied to the boilers in the local district heating systems.

Maximum temperature in the local distribution unit is 120 °C.

2. Return temperatures.

Low return temperatures should be strived for, partly because the flue gas coolers, if any, require it, partly because a low return temperature means a large temperature drop, i.e. the flow pumped around in the district heating network is low.

The return temperature should be around 70 °C.



Temperatures in a local district heating system.
Fig. 5:1

3. Temperature drop in the distribution network.

Proper functioning requires the same flow temperature at all the sub-stations. Good insulation and a relatively high water rate through the pipes are required to achieve this. Heat losses of up to 30% may occur in a distribution network with low consumer energy density. In energy dense areas with pre-insulated pipes the losses are 3% or less.

The stated maximum water rates should be strived for, see graph in chapter 8.

4. Static pressure.

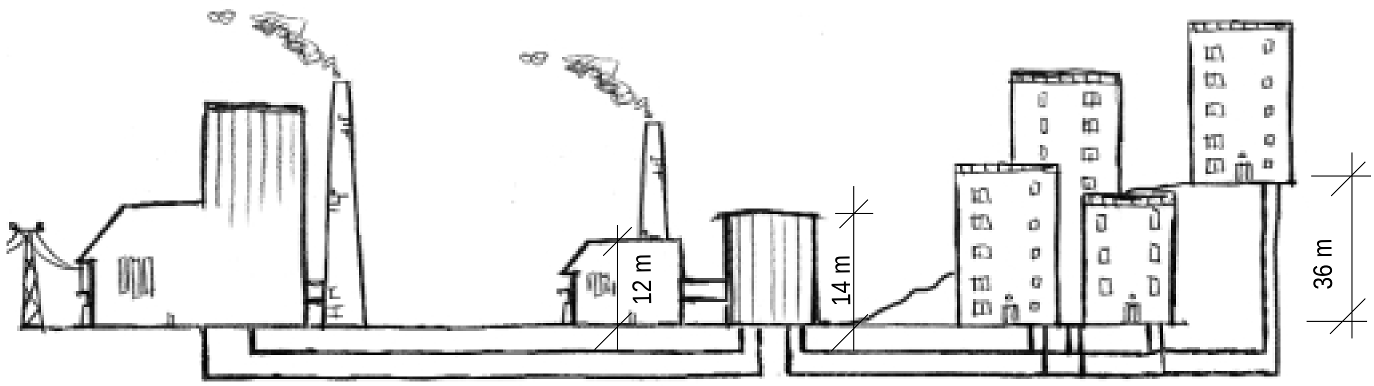
The local distribution unit will be working with a static pressure, which is the sum of the steam pressure (100 kPa at 120 °C) and the difference in height between the pressure gauge in the production unit and the highest located sub-station. The pump should be placed in the flow.

The static pressure of the local boilers depends on their maximum working temperature. The steam pressure is 200 kPa at 130 °C and that pressure is to be added to the height of the boiler converted into kPa.

If the circulation pump is placed in the flow pipe, it is enough with an addition of 10-20 kPa (as a safety margin) to the static pressure to get all the parts of the system water filled at operation.

The static pressure is determined by the maximum water temperature and the height of the highest part of of the system. To avoid boiling, a pressure that is higher than the steam pressure at the temperature in question is required at the highest point of the system.

Water temperature °C	Steam pressure kPa/bar (gauge pressure)
110	47/0,5
120	99/1
130	193/2
140	262/2,6
160	518/5,2



Static pressure, boiler 130 °C.
Steam pressure = 200 kPa
Level pressure = 120 kPa
Total = 320 kPa

Static pressure, district heating network 120 °C.
Steam pressure = 100 kPa
Level pressure = 360 kPa
Total = 360 kPa

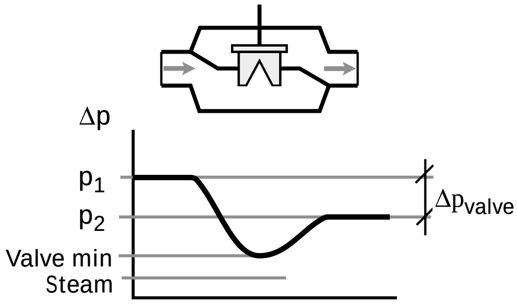
Static pressure in a local district heating system.
Fig. 5:16

Under certain operating condition, the pressure in the control valves could become so low that cavitation occurs. Cavitation means that steam bubbles are formed (through boiling), and when these steam bubbles are pressed together, imploding, large forces arise damaging the valve cone and the valve seat. Cavitation ceases if the static pressure is raised.

All the components included must be officially approved for the current working pressure.

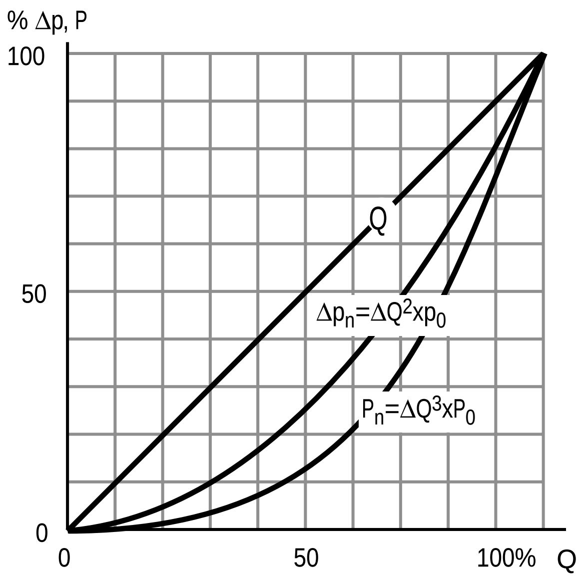
5. Available differential pressure.

The available differential pressure in the primary distribution system will vary with the flow in the system. The pump keep the differential pressure in the last sub-station constant at 150 kPa, at all flows. The differential pressure will vary for the rest of the connected sub-stations, from the maximum at 100% flow to approximately 150 kPa at a minimum flow. The control valves should be sized for the lowest possible available differential pressure, 150 kPa, minus the resistance in the heat exchanger in question.

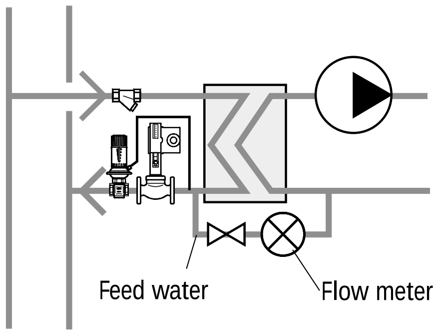


When water passes through a valve the speed will increase over the seat and cone and then decrease. The increase in speed will use up some pressure. The result is $\Delta p_{valve\ min}$.some of that pressure returns when the speed decreases and the result is p_2.
If the $\Delta p_{valve\ min}$ becomes lower than the steam pressure, cavitation occurs and the water will boil and bubbles of steam will form. When the speed decreases, the pressure will rise and the bubbles implode. This causes a loud noise and the large forces could damage surfaces of the valve.

Fig. 5:17



The resistance changes by the square of the flow change and the effect for the pump by the cube.
Fig. 5:18



A flow meter register the amount of water feeded.
Fig. 5:19

6. Water quality.

The water quality is very important as regards to the durability of all the components included in the primary system. A plant can provide the production as well as the distribution units with water. The plant for water treatment should be designed so that it can also manage the refilling of the secondary systems. Refilling pipes to the various systems should be equipped with meters to obtain control over the refilled volumes. With regard to systems with mixed new and old constructions, a water change of 0,5 times per year is taken into account. The new pre-insulated pipes are only refilled when considering new systems and sub-stations and a possible filling of the secondary systems.

The following values apply of the water after purification.

Conductivity	max 10μS/cm
pH-value	9-10
Hardness	0,1 tH°
Appearance	clear and sediment free
O_2	0,02 mg/l

7. Pressure testing.

Before a system or parts of it are commissioned it has to be pressure tested. The system in question is filled with treated water and all the air is purged. After that, the pressure is increased, with a pump, to at least 1,3 times the maximum working pressure. The pressure should be constant for at least 60 minutes, without dropping. Joints, connections and components should be visually checked during the pressure testing, to make sure that there is no leakage. The supervisor in charge should keep records of the pressure tests. The records should contain information on time, place, scope, current pressures at the beginning and the end of the test, and also leakages attended to. The records are then to be signed by the supervisor in charge.

Pressure testing of pre-insulated pipes.
Fig. 5:20

8. Operating times.

The local central boiler plants must be in operation until they are connected to an accumulator, another district heating network or a combined heating and power plant. If domestic hot water is to be produced as well, this applies all year round.

When several local central boiler plants have been connected, just as many boilers are used as necessary to obtain the required effect. After being connected to a combined heating and power plant, they only respond to the peak loads.

Combined heating and power plants producing electricity are to be in operation all year round. During the non-heating seasons, the combined heating and power plants should use the requirement of domestic hot water in the buildings for cooling, as far as possible. If there is requirement for air conditioning the heat can be used to run a cooling process.

Local control and supervision.

All the information required to operate a local district heating system efficiently can be gathered and processed only by computers. The concerns information about everything from the air temperature supplied to the combustion chamber in the boiler to the temperature in an apartment. The gathering of information is important to improve the operating process. The gathering comes out as statistics, and these statistics will at the same time serve as a control function for the operation.

There is today, in 1998, computer software for this purpose which is well tried and able to co-operate with weather compensators, control motors and other equipment. Temperatures and pressures can be adjusted from the centrally placed computer if and when there is a need for it.

A computer network control center can control the system and record and analyse large amounts of information.
Fig. 5:21

1. The control of boilers.

There are a lot of operations to be automated and supervised will regard to local boilers to making the plant effective and less pollutive.

On the whole, the supply of fuel should correspond to the requirement of heat. The introduction of an accumulator to which the boiler is connected, has made the task easier. A shortage or an excess of fuel during a short time is evened out by the accumulator.

The operating temperature as well as the return temperature of the boiler must be controlled the whole time. The filter and the flue gas temperature are important from an environmental and an efficiency point of view and must be checked regularly.

Flue gas fans and circulation pumps should be controlled according to the current requirement.

2. Control of the accumulator.

The accumulator is a buffer between the boiler and the load. By containing water with a high temperature in the accumulator during periods with a smaller consumption, the boiler can work with a more even load, which gives better combustion and a smaller amount of impurities. Heat is avilable continuously.

At low outdoor temperatures, the accumulator is completely charged, while it is only partly charged during spring and autumn.

The heat transfer from the heat exchanger to the accumulator is controlled by a variable-speed circulation pump.

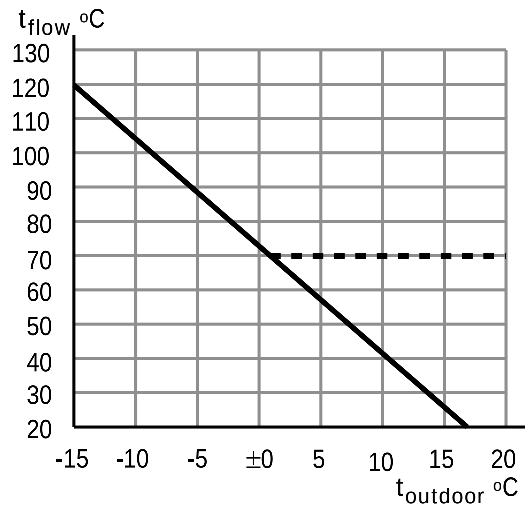
The temperature of the water to the accumulator should correspond to the current charging temperature, and it can vary with the outdoor temperature or the expected outdoor temperature. Weather forecasts, expected temperature and wind force are all parts of the decision records at the operation and the control of a district heating network with an accumulator.

3. Control of the outgoing temperature in the district heating network.

The maximum outgoing temperature is 120°C and the return temperature is 60°C. The outgoing temperature should be adjusted according to requirement, i.e. the outdoor temperature, down to the temperature required for the production of domestic hot water, 65-70°C. The advantage of this is that the losses from the pre-insulated piping network decreases, and the flow down to this temperature is relatively constant. When the heating system requires lower temperatures, large variations in the flow are obtained. The same temperature is required for the operation of cooling processes during the summer as for the production of domestic hot water.

The outgoing temperature can be lowered further according to the outdoor temperature in systems where domestic hot water is not produced.

The outgoing temperature must never be so low that the required heat volume is not available at each sub-station or that the return temperature becomes too high. The control valves should at all times have good heat authority.



The flow temperature will be controlled by the weather compensator according to the outdoor temperature. The dotted line represents the lowest temperature for domestic hot water production.
Fig. 5:22

4. Flow limitation.

In cases where there is a rapidly increasing heat requirement, or when the production unit hasn´t got enough energy, the solution would be to limit the flow to each heat exchanger. Flow limitation means that an exchanger does not receive a higher flow than it is set for. One exchanger cannot steal heat from the others.

The most simple flow limitation consists of a control valve and a differential pressure control. The differential pressure control keeps the differential pressure across the control valve constant. The current differential pressure is the one required in order to assure a fully open control valve to provide the maximum required flow.

With such equipment at each heat exchanger there will only be a maximum flow at each exchanger, even if the heat amount is not sufficient. When the flow temperature then increases, all the exchangers are receiving the same heat, until sufficient heat volume is available and the control valves begin to close up.

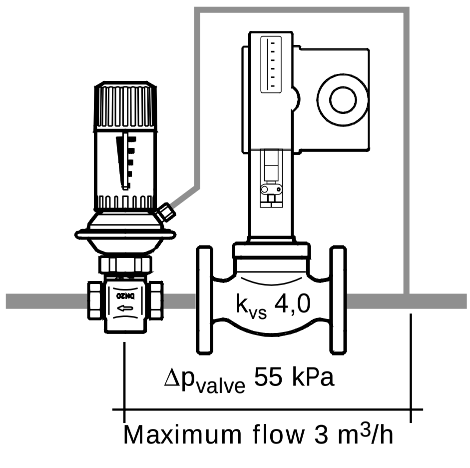
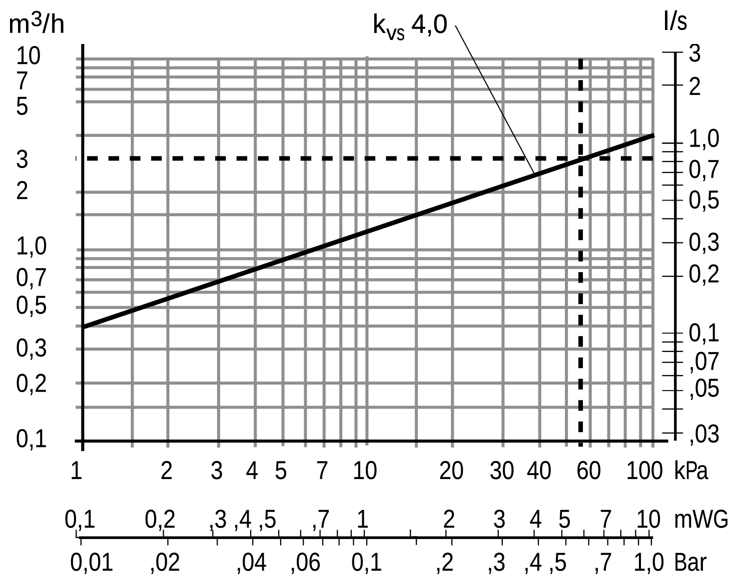


Fig. 5:23



Constant Δp, across a fully open valve, creates limitation.

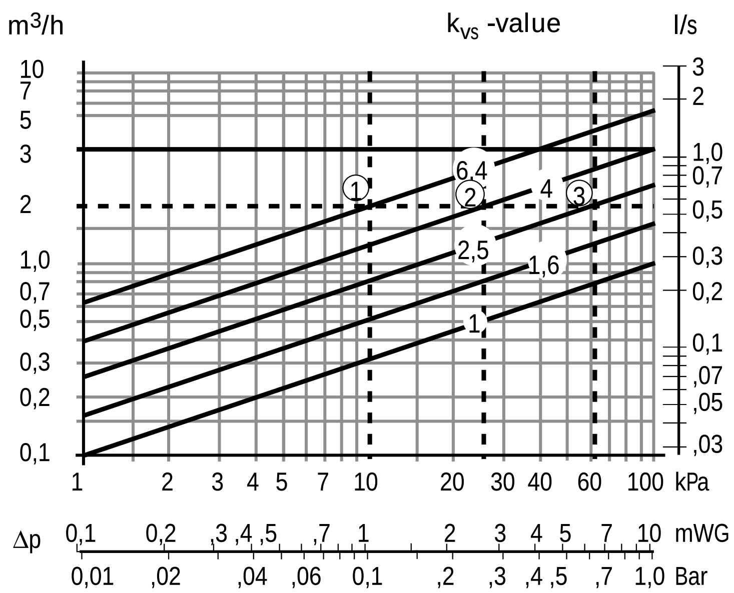
Fig. 5:24

5. Differential pressure control.

In systems with a varying flow, large variations arise in the available differential pressure for the control valves. A differential pressure control should be used if the difference between the calculated and the highest differential pressure is more than 50 % of the calculated one.

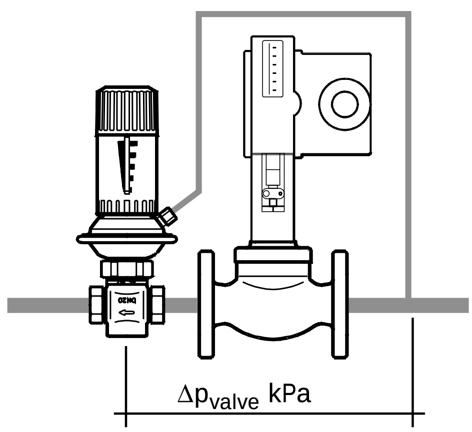
If a differential pressure control is installed in the flow direction after the control valve, with one impulse tube connected before and one after the control valve, the differential pressure across the control valve will be constant. Possible variations in the available differential pressure, even very large ones, will not affect the control valve.

If a control valve appears to be too large, a reduction of the differential pressure can adjust the control valve to the real requirement, with the help of the differential pressure control. This also applies in the opposite case.



By changing Δp, across the valve you can make it correspond exactly to the requirement.

Fig. 5:25



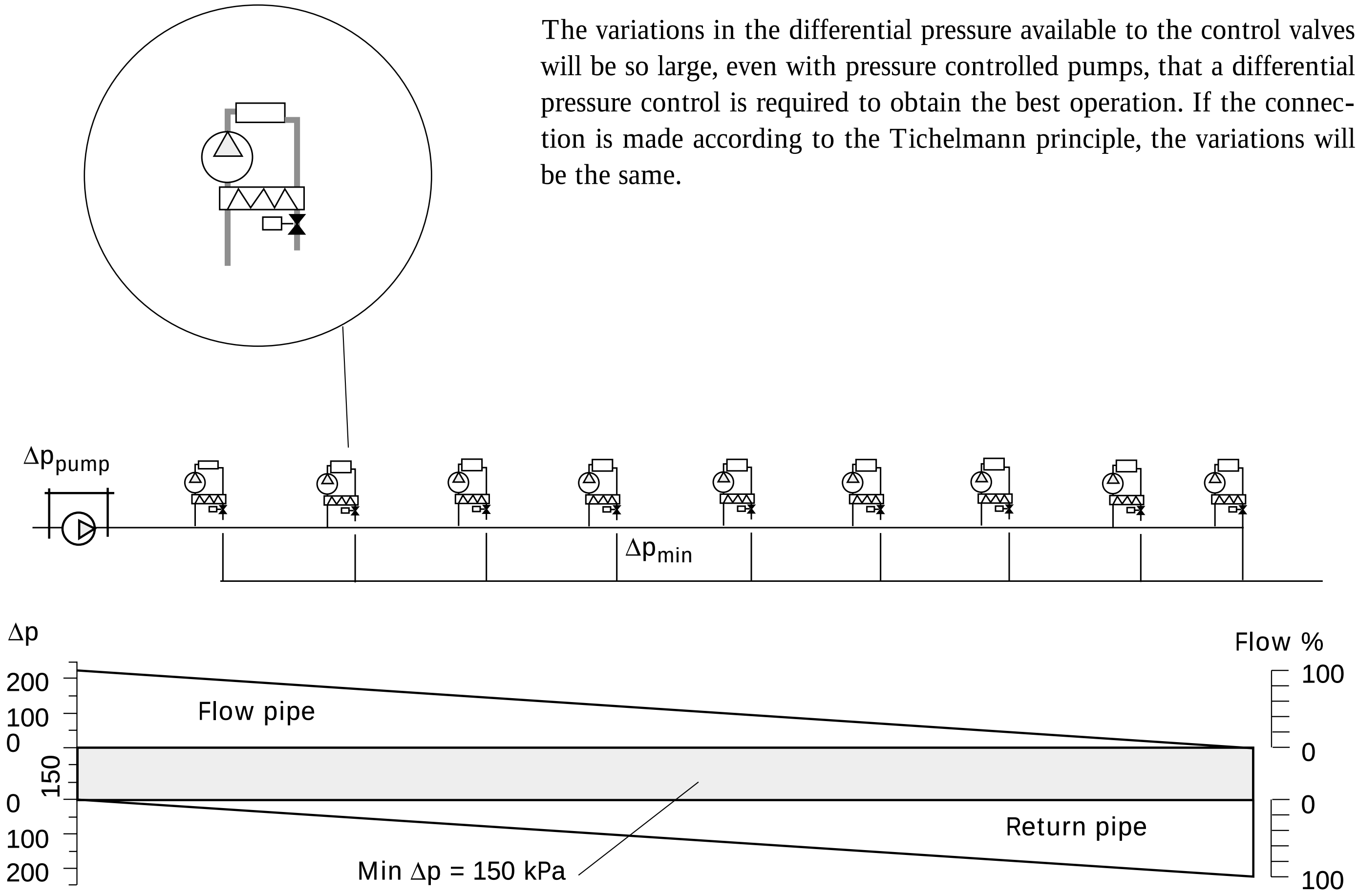
	k_{vs}	Δp_{valve} kPa	Flow m³/h
①	6,4	10	2,0
②	4,0	25	2,0
③	2,5	61	2,0

Fig. 5:26

6. Pressure control of pumps.

The pumps should be pressure or temperature controlled in all circuits with a varying flow. Temperature control applies to the charging pumps to the accumulator. Pressure control applies in all the systems where the control valves are adjusting the flow according to requirement, the local pre-insulated piping network with sub-stations for example.

The variations in the differential pressure available to the control valves will be so large, even with pressure controlled pumps, that a differential pressure control is required to obtain the best operation. If the connection is made according to the Tichelmann principle, the variations will be the same.



With a Tichelmann laying of the distribution pipes the same Δp is always available in all sub-stations. The differences in Δp depending on various flows will however be the same as with conventional two-pipe laying.

Fig. 5:27

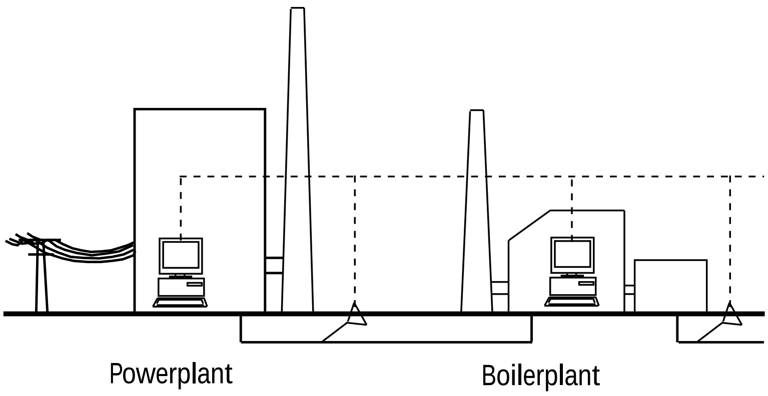
7. Heat metering.

The only way of establishing what has been produced and what has been delivered is by metering the heat volume. The metering also makes it possible to estimate the efficiency of different units. The deliveries constitute a basis for invoicing.

The modern heat meters based upon ultrasound are very efficient and safe in operation and they are available in all required sizes.

A heat meter is used to register the outgoing heat from the combined heating and power plant. The obtained heat volume and the outgoing delivery to the sub-stations is registered at each local production unit. The production in the local boiler should be registered as well. Finally, the heat volumen obtained in each sub-station should be registered.

The records made with values from these meters can reveal possible defects in pre-insulated pipe construction or in the control of certain units.



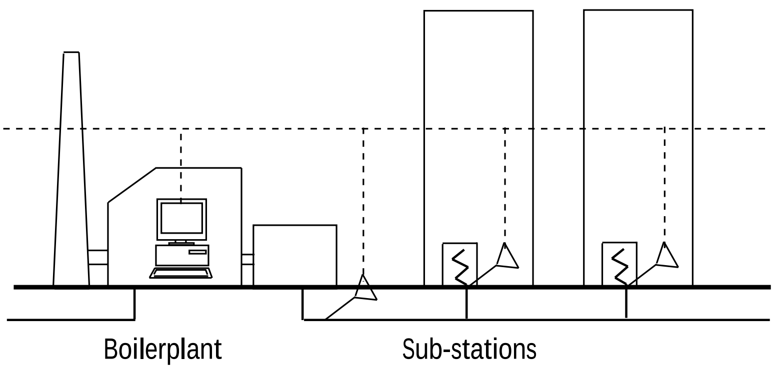
Heat metering is the basis for invoicing.
Fig. 5:28

8. Central control and supervision.

The question of control and supervision becomes even more important in combined heating and power plants that also produce electricity. For one thing, there are more items to take into consideration when the production of electricity items is effected. Secondly, the local district heating systems, in any case the operation of the accumulator, should be controlled from the combined heating and power plant. It is essential that centrally you have the knowledge of how much cooling that can be obtained from the local district heating systems.

When a local boiler is to be connected to assist the existing ones, you have to be able to control the operating process from a central point.

The local computers should be connected to the computer in the combined heating and power plant.



The operations and maintenance are assisted and made more efficient via central data control and supervision.
Fig. 5:29