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INDUSTRIAL PLANTS

Chapter twenty-seven:

Piping – Fluid distribution plants –Water distribution plants

DOUBLE DEGREE MASTER IN

“PRODUCTION ENGINEERING AND MANAGEMENT”

SEAT OF PORDENONE

UNIVERSITY OF TRIESTE

Water distribution plants

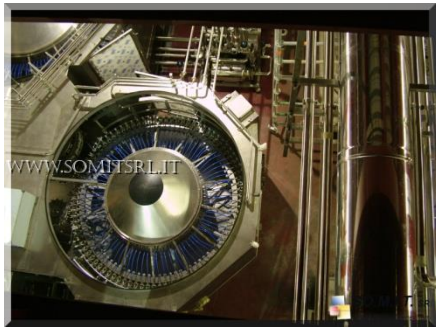
In an industrial plant, the water can be used for industrial uses, drinking water and fire-fighting.

While the network of drinking water can also be used to feed the utilities of industrial water, may not be the reverse, less than subjecting the industrial water to get a quote treatment of the drinking water.

In the case of small plants and productions to constitute a low fire danger, the water fire-fighting can be supplied by drinking water network and industrial, provided they are assured the continuity of pressure and power required by the exigencies of fire-fighting system.

Water distribution plants

Industrial water



Within an industrial plant, the industrial water is used as:

- cooling medium in certain plant and processes;
- raw material in processes that require;
- flushing medium and solvent;
- mechanical agent in plants, equipment or machinery of the hydraulic type;
- production of steam and heat transport;
- preparation of baths;
- transport of raw materials or scrap;
- cooling ambient air;
- cleaning of dust and gas.

For low power consumption and if it does not compromise the quality of drinking water, industrial users can be supplied with drinking water supply (maximum value for the two consumption 20 m^3/h).

Water distribution plants

Industrial water

The main sources of supply of water industry are:

- sea, lakes, rivers and canals;
- groundwater.

The water taken and purified can be pumped into the network.

If consumption are variable or the supply of water undergoes substantial changes during the day, it is appropriate to resort to storage tanks.

Among the storage systems, first there are the elevated tanks, which ensure availability of water for every eventuality (tips, interruption of the primary supply, fire-fighting etc.).

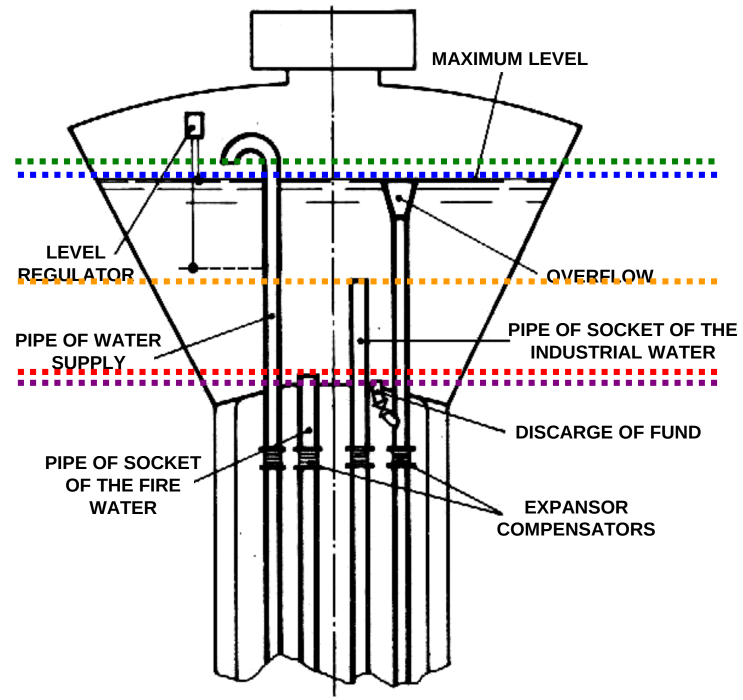
The tanks are constructed of steel or concrete and may have various shapes (spherical, cylindrical, mushroom etc.).

The height from the ground of the raised tank must be chosen so that the water reaches to the users to the required pressure, taking into account the load losses of the distribution network.

Industrial water

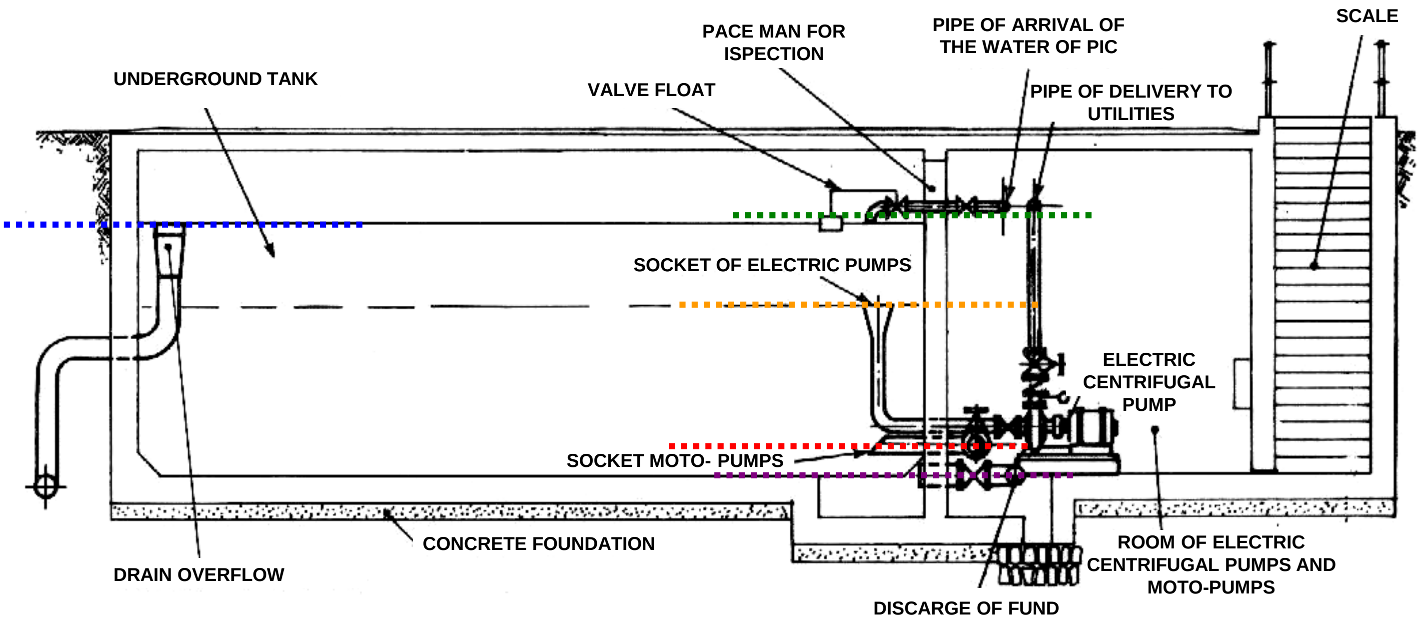
If the tank is also used to cope with any fire-fighting, which may occur in the plant, the height from the ground of the bottom of the tank should not be less than 30 - 35 m, so as to ensure a sufficient pressure for it to function.

The supply pipe always arrives at the top, while the conduct of the water uptake industrial part from a height such as to leave always available in the tank a volume of water varying between 1/3 and 3/4 of the total capacity. This stored water is constantly available to the fire prevention system. Must be provided for a pipe, connected with the drain, for the discharge of overflow. Finally, there is the total drain on the bottom connected to the overflow and intercepted by a shutter.



Industrial water

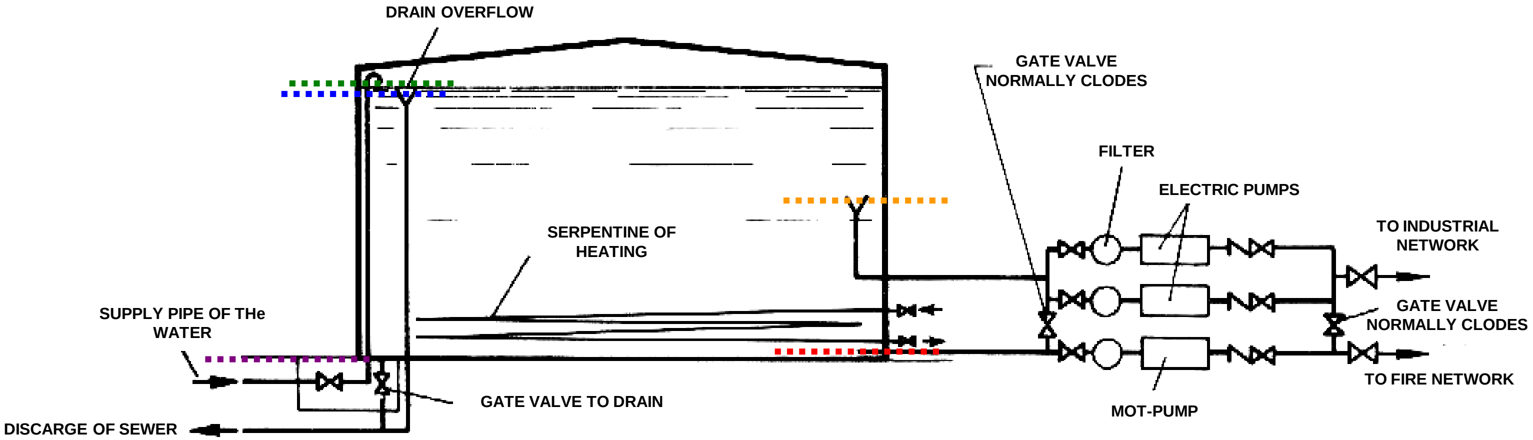
There is the possibility of accumulation of water by the construction of reinforced concrete tanks buried or semi-Buried, from which the water is then pumped to the users of the plant.



Water distribution plants

Industrial water

It uses, in addition, metal tanks above ground, that have the advantage, compared to tank in air, a lower cost, although in cold regions require winter heating water for the danger of frost.



Water distribution plants

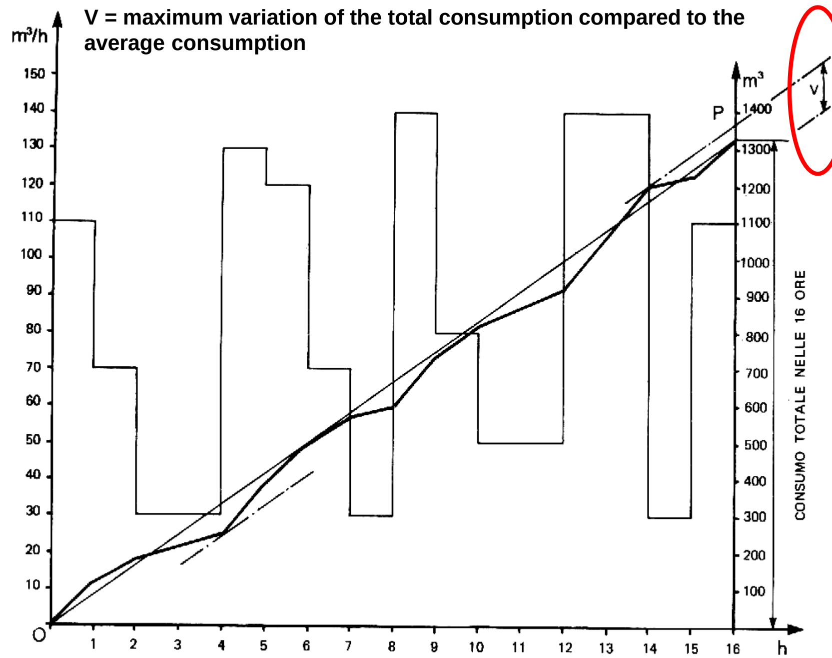
Industrial water

In the case of tanks above ground and underground tanks or basement, a part of the water can be reserved for needs fire-fighting. It must therefore also predict its pumping and ensure the safety of supply (to accompany one or more electric motor pumps and/or by connecting to a group generator).
The capacity of the storage tanks must be such as to ensure sufficient water during peak periods (while the pumping system which feeds the tank continues to pour in the same an average flow rate constant with reference to the daily consumption), or to feed the utilities for a preset time even with no power supply to the tank.
The evaluation of the capacity of an industrial water tank is not difficult if you know the trend, even approximately, of the consumption of the plant during working hours.

Industrial water

Assuming known the trend in consumption, one can determine the scope of the request to pumps of supply, integrating graphically the diagram of consumption and dividend the daily consumption by the number of working hours.

It then joins the origin point of the curve with the point P and draw the parallel to this segment to the farthest points of the integral curve: the vertical segment intercepted between two parallel lines more distant from each other provides the minimum capacity of the tank.



Determination of the minimum capacity of a storage tank of water for industrial use

Water distribution plants

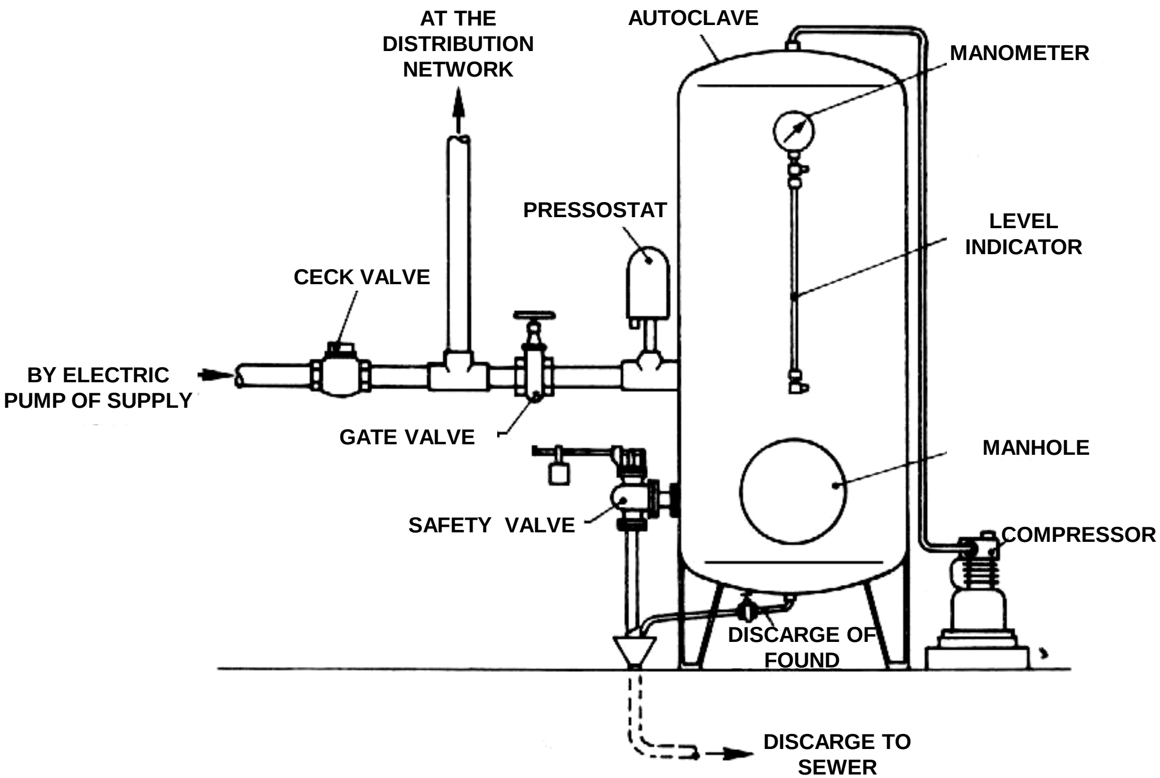
Industrial water

For security, this capacity is increased for adequately take into account possible, even if temporary, requests for industrial water not provided in the diagram of consumption (plant expansion) or an interruption in the feeding of tank.

Water distribution plants

Industrial water

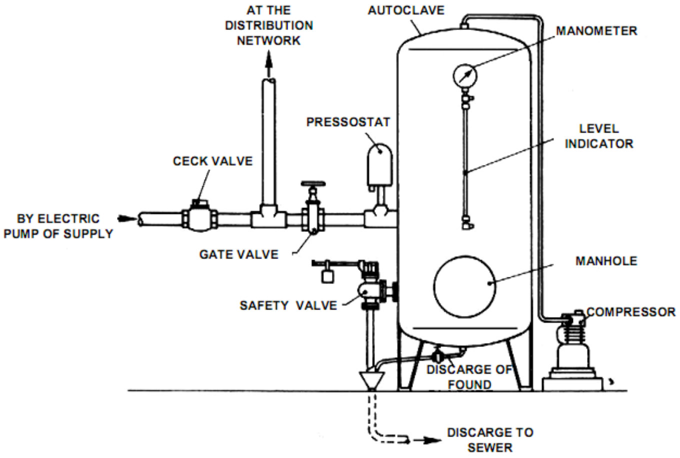
When not is used a raised tank and is want to have a nearly constant pressure in the network, we use the autoclaves.



Water distribution plants

Industrial water

Is a reservoir connected to the mains water supply by means of a pump; reservoir is connected to a compressor coupled to a level indicator and having the function of maintaining an "air cushion" in the upper part of the same. When the internal pressure, as a result of water withdrawals, drops below a certain lower limit, the pump is operated by a pressure and brings the pressure in the tank to the upper limit, when is reached the pump stops.



Water distribution plants

Industrial water

When not is adopt the autoclave and the pit or the reservoir above ground are directly connected to the water distribution network, it is convenient installation, downstream of the pumps, a servocontrolled valve for regulating the flow rate or pressure: in this way, it is maintains uniform pressure on the network and retrieves the surplus water not used.

On the other hand, is wasted energy expenditure for the lifting of the flow returned.

Tubes used for the construction of water distribution networks inside the plant are of steel, smooth, welded or seamless, or for diameters less than 4" of the type series natural gas, threaded or not, with sleeve.

The underground pipes are made of steel pipes inside bituminous and coated outside.

As for the airline network as for the underground pipes, are also used pipes in PVC.

Water distribution plants

Industrial water

The joints between the tubes are made of steel with bolted flanges or with oxyacetylene welding, and the gas pipes and PVC pipes are joined with sleeve joints.

Bends and fittings are malleable cast iron non galvanized, of uniform dimensions as the tubes.

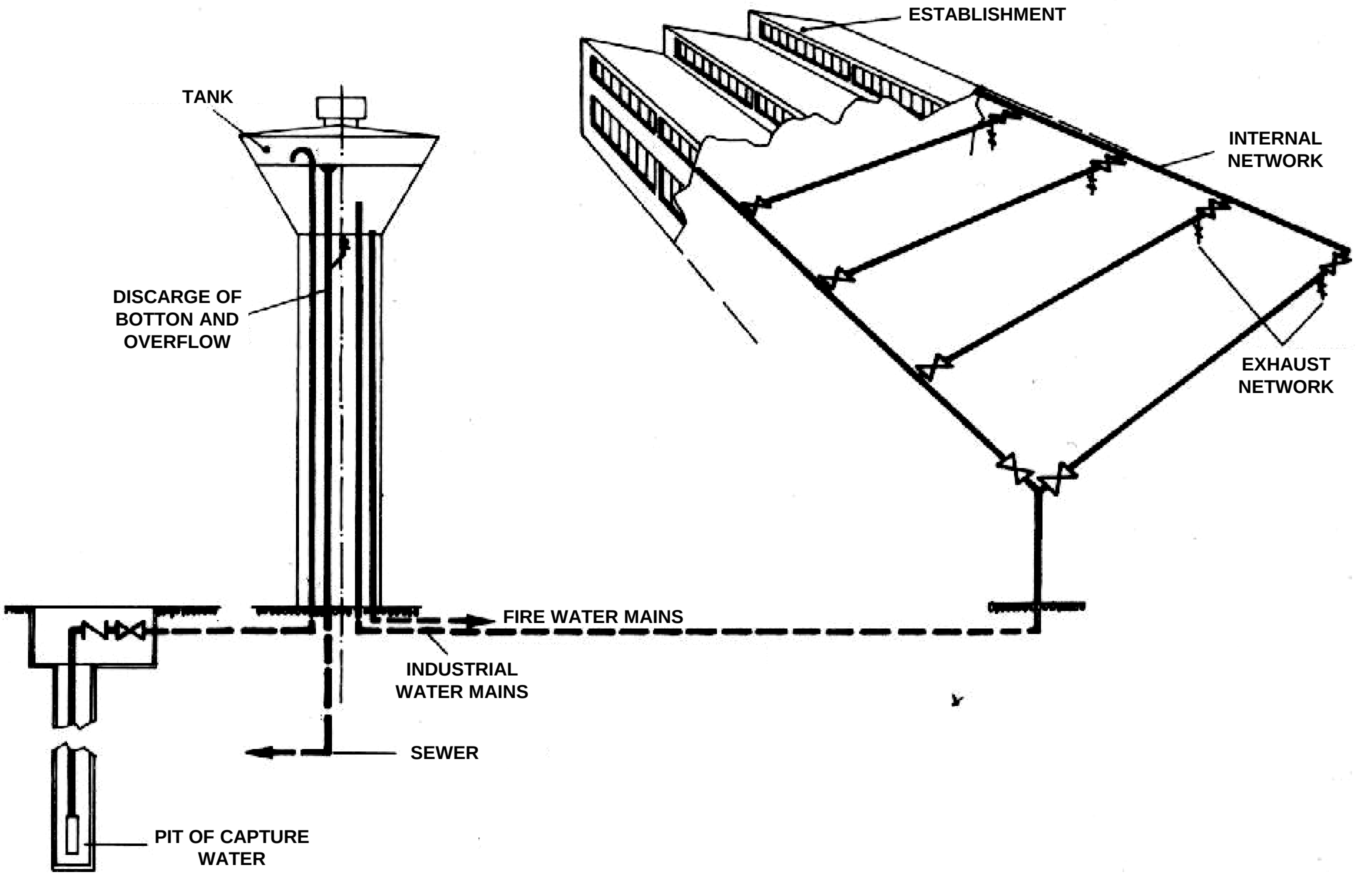
The valves and gate valves can be steel, cast iron or, for small diameters, bronze.

Is presented below a network of industrial water in the event of water collected from a well, stored in a tank raised and distributed in the plant for fall in a system at mesh with cross connections provided with gate valves at the two ends.

To allow emptying of the network, the pipes are installed with a slope of 0,2-0.4% converging special drains into sewer or in the pipeline supply at recovery or that of purification.

Water distribution plants

Industrial water



Water distribution plants

Drinking water

The sanitation plants of establishments must be supplied with potable water (showers, sinks, drinking fountains etc.).

The minimum requirements are 50 dm^3 per person per day, excluding any restaurant that provides a consumption of 20-25 dm^3/person in the case of a service of 200 persons/shift to 10-12 dm^3/person if you have a service to 1000 persons/shift.

The minimum requirement of water, usually of industrial water, toilet, turkish vessels etc., so we consider a consumption of 70-80 dm^3 per capita daily.

For the sizing of distribution networks is not enough to have the minimum daily requirements per person, but one must know the food brought by the individual services: showers 0.10 dm^3/s, fountains = 0.25 dm^3/s, washbasins normal 0.10 dm^3/s to multiple sinks taps 0.07 dm^3/s per beak, while for the water industry will have to turkish toilet or pot = 0.5 dm^3/s, urinals washing or operated intermittently between 0.10 to 0.20 dm^3/s.

Water distribution plants

Drinking water

The unitary consumption presented is refer only to the periods of use of the water and form of the tips, for which must is dimensioned the network.

To avoid at the source by food very high flow rates of water at certain times and very low in others, it is advisable to build up of the underground tanks or planes. The average consumption is taken only for the design of the extension or collection of water and its connection to the storage tank. From here the water is sent to the users for fall.

Assuming that the tank serves for the storage of drinking water intended for sanitation, its volume can be calculated by imposing that the stored water satisfies the tips of the consumption.

For example, if you have 25 washbasins and 5 showers if you believe that the peak period is 20 minutes, the tank capacity must be equal to:

$$(25 + 5) \times 0{,}10 \times 20 \times 60 = 3600 \text{ dm}^3$$

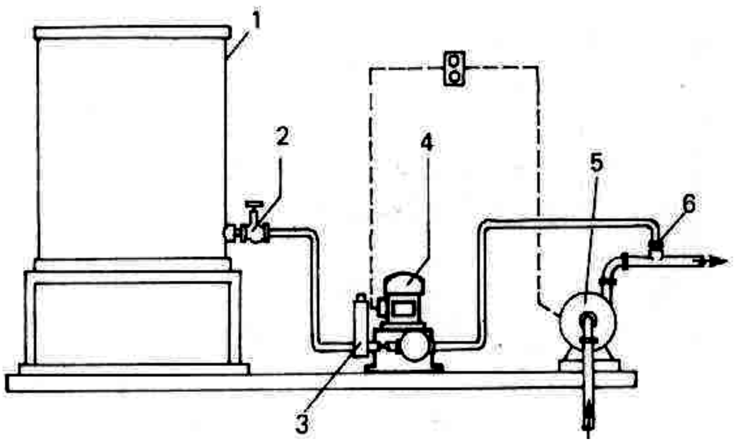
Water distribution plants

Drinking water

When it is not expected storage tank, also for the network connection to the aqueduct or the source of uptake, it must be sized to meet the maximum consumption of the utilities.

If you do not withdraw water from public water supply, you should request the Office of the Provincial Hygiene performing chemical and bacteriological analyzes to check the potability of the same.

If the water is not drinking, you will have to provide of the purification plants, which are generally of the type to chlorination (distilled water and sodium hypochlorite) or ozone.



1. Tank of preparation of the solution – 2. Tap of closing – 3. Apparatus for abdjusting the dosage – 4. Dispenser – 5. Lifting pump – 6. Diffuser

Water distribution plants

Drinking water

To avoid compromising the quality of drinking water distribution network in the establishment, this is realized in galvanized pipes unified or non-toxic PVC.

For buried pipes, are used steel pipes bituminous coated internally and externally or PVC.

The joints between the tubes are made using oxyacetylene welding or flanging, while if the tubes are threaded or plastic, by means of sleeves.

The curves and fittings for the networks are unified and constructed in galvanized malleable cast iron, while the valves are made of bronze and have the same diameters of the tubes unified.

The distribution networks can be a mesh (slope of the pipes 0,2-0.4% and discharges of the network located at the points of lesser height) and comb (the location of the loads and consumption are well defined).

Water distribution plants

Fire-figthing water

It provides a network external to the plant fire fighting (underground) and internal (air), these networks are usually at ring with cross connections in the case of internal networks.

Networks, both internal that underground, are made with the same types of pipes, valves and fittings of industrial water networks.

Water distribution plants

Design of distribution networks

The design of water distribution networks and industrial drinking water in industrial plants is to determine the diameters of the pipes, being generally known to their lengths, pressures and flow rates of water required by users.

The lengths are known as it is established initially the geometry of the network, depending on plant layout, to the characteristics of the building, to the needs of the service, etc.

The flow of water by food to utilities are another problem together because of the pressure required of the user.

An evaluation of large maximum of the diameter of the pipes is already known for a certain flow conveyed as it can take the average values of fluid velocity ranging between 1 and 2 m/s.

Water distribution plants

Design of distribution networks

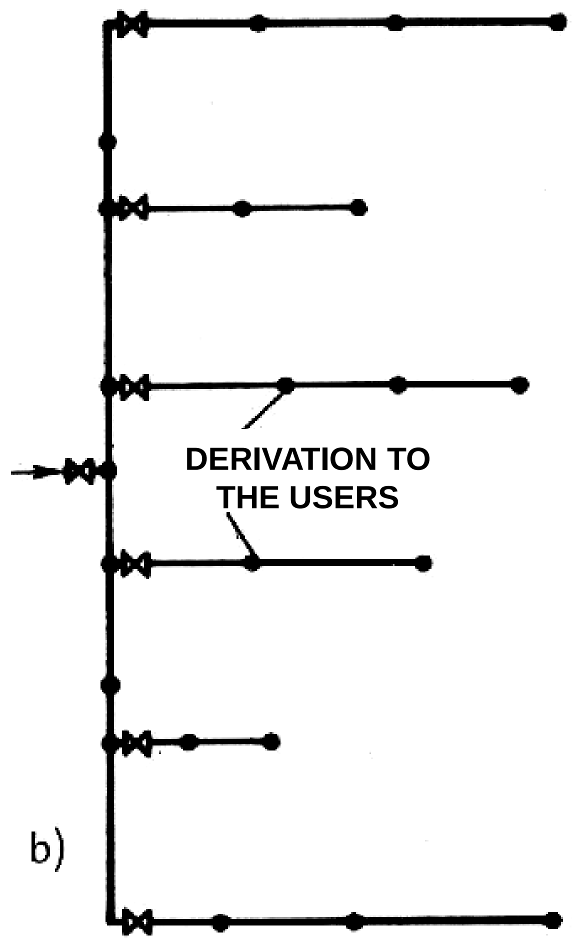
The network of fire-fighting water, since it is used occasionally and for limited times, it is not determined by the criterion of minimum cost, so that network is dimensioned assuming values of the velocity of the water varying between 2 and 3 m/s.

There are two types of network used for water distribution:

- networks to comb;
- networks to mesh.

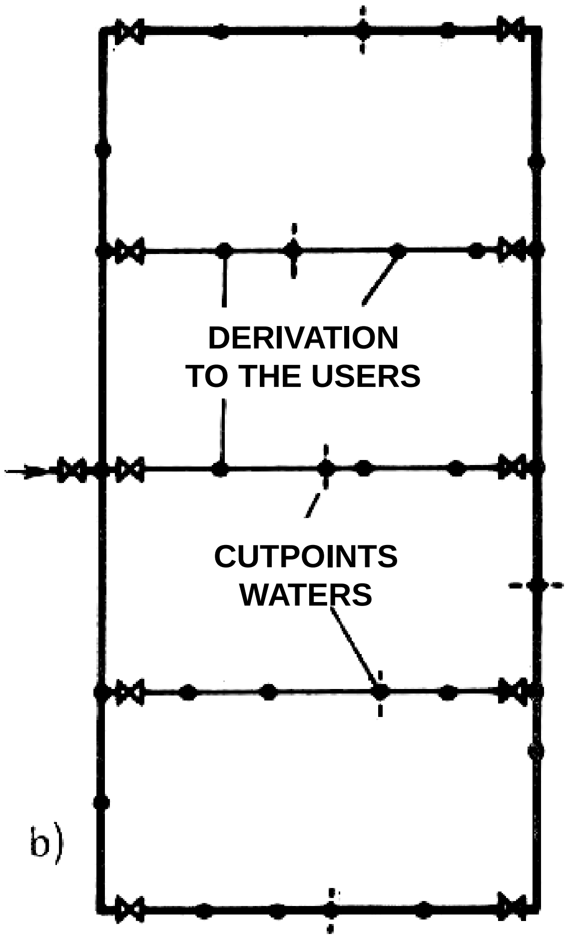
Water distribution plants

Design of distribution networks – networks to comb



Water distribution plants

Design of distribution networks – networks to mesh



Design of distribution networks – networks to comb

Method diameter economic

Is the most suitable for the sizing of pipelines with service ends, which conveys water from a power source to a point of use, despite lends itself for the dimensioning of the networks of internal distribution of industrial establishments. Method is applied to the two main manifolds; dimensioned the diameter of these manifolds are evaluated piezometric height at the points of junction of the secondary branches.

In some cases are known the hight piezometric in some points (users) of the secondary branches, so that it is possible to determine the diameter of each branch by applying one of the formulas monomials usual for the determination of the load losses h in a trunk length of the diameter D (in the case of the Darcy formula: with β function of roughness and n = 5 (if β depend on D) on n = 0.33 (if it does not depend on D):

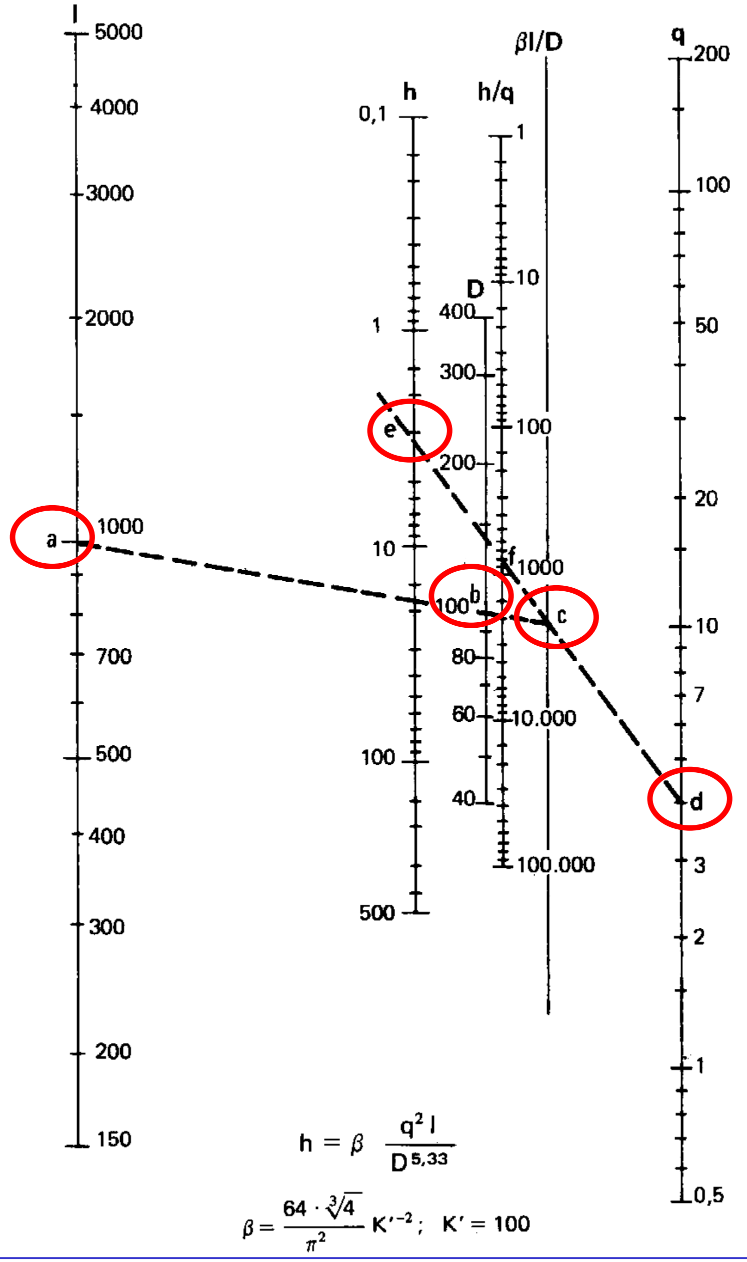
$$h = \beta \cdot \frac{q^2 \cdot l}{D^n}$$

Water distribution plants

Design of distribution networks – networks to comb

Method diameter economic

There is a nomogram that determines the pressure drop in a steel pipe

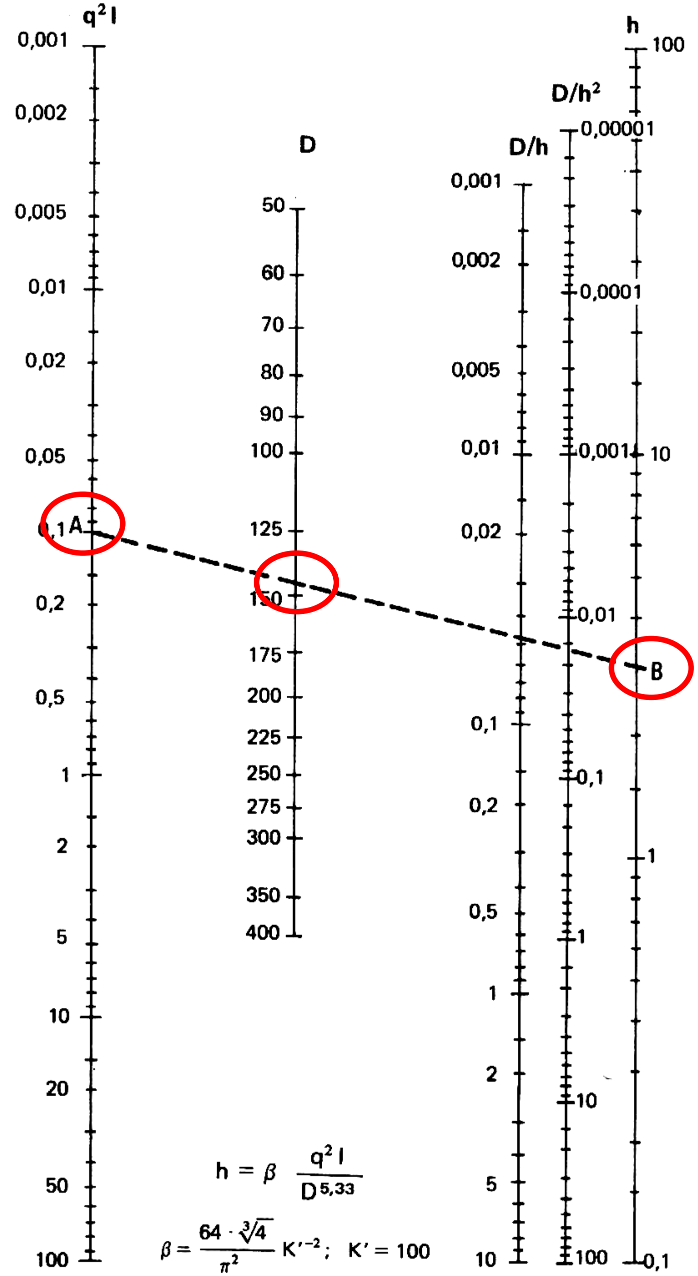


Water distribution plants

Design of distribution networks – networks to comb

<u>Method diameter economic</u>

There is a nomogram that allows to determine the diameter in a steel pipe.



Design of distribution networks – networks to comb

Method diameter economic

In case you have to do the summation of all the pressure drops in order to consider all derivations with a specific flow rate for each branch.

The cost of a water distribution network is constituted by:

- cost of depreciation of the expense of network plants;
- cost of depreciation of the expense of installation of the pumping system;
- cost of operation of the pumping system;
- cost of maintenance of the pumps and network.

Combining maintenance costs with those of depreciation, the total annual cost C (€/year) for pumping a water flow rate Q (m^3/s) in a pipe long L (M) is equal to:

$$C = C_1 + C_2 + C_3$$

where: C_1= annual cost of depreciation and maintenance of the pipeline

C_2 = cost of depreciation and maintenance of the pumping system

C_3 = annual cost for electricity consumption for pumping

Design of distribution networks – networks to comb

Method diameter economic

A decrease in the diameter of the network leads to a decrease in the cost of the pipe C_1 and an increase in costs resulting from the acquisition by the C_2 and C_3 management of the pumping system and vice versa.

Ultimately, it comes to sizing the pipes and to choose the pumping system so that the total annual cost is minimum.

The total cost of the pipe can be expressed by the relation:

$$C_1 = r_1 \cdot A \cdot D^m \cdot L$$

where:

r_1 = factor that combines the unitary term depreciation of the network and the coefficient used to evaluate the cost of maintenance;

A = coefficient taking into account the type of pipe used;

m = coefficient, which reflects prices for the supply and laying of pipe;

L = length of pipe.

Design of distribution networks – networks to comb

<u>*Method diameter economic*</u>

The total cost of the pumping system, complete with the engine and electrical device, can be expressed by the relation:

$$C_2 = r_2 \cdot B \cdot \left(\frac{1000}{102 \cdot \eta} \right)^p \cdot \left(Q \cdot H + \beta \cdot \frac{Q^3}{D^n} \cdot L \right)^p$$

where:

r_2 = factor, which sums up the unitary term of depreciation of the pumping system and the coefficient adopted to evaluate its cost of maintenance;

B, p = coefficients, which take into account the type of pumps used;

η = product of the efficiency of the pump and motor coupled thereto;

Q = water flow;

H = prevalence, including the conduct of the geodetic and the piezometric requested from the outlet;

β, n = coefficient and exponent in the Darcy formula for calculating the pressure loss in pipes;

D = inner diameter of the tube;

L = length of pipe.

Design of distribution networks – networks to comb

Method diameter economic

The total cost due to the operation of the pumping system can be expressed by the relation:

$$C_3 = c_w \cdot N \cdot \frac{1000}{102 \cdot \eta} \cdot \left(Q \cdot H + \beta \cdot \frac{Q^3}{D^n} \cdot L \right)$$

where:

c_w = unit cost of energy electricity;

N = number of hours of operation;

η = product of the efficiency of the pump and motor coupled thereto;

Q = water flow;

H = prevalence including the hight difference geodetic piezometric tube and the outlet required by outlet;

β, n = coefficient and exponent in the Darcy formula for calculating the pressure loss in pipes;

D = inner diameter of the tube;

L = length of pipe.

Design of distribution networks – networks to comb

Method diameter economic

Since the diameter of the pipe is more economical than that for which the first derivative of C with respect to D is canceled, highlighting L/D^{n+1}, we have that the condition of minimum cost is the one for which

$$m \cdot r_1 \cdot A \cdot D^{m+n} = n \cdot r_2 \cdot B \cdot p \cdot \beta \cdot Q^3 \cdot \left(\frac{9{,}8}{\eta} \right)^p \cdot$$

$$\cdot \left(Q \cdot H + \frac{Q^3}{D^n} \cdot L \right)^{p+1} + n \cdot c_w \cdot N \cdot \frac{9{,}8}{\eta} \cdot \beta \cdot Q^3$$

Introducing the flow of water to be pumped and the diameters of the tubes unified, this equation is solved.
If you fall between two commercial values, select diameter for which dC/dD has absolute value less.

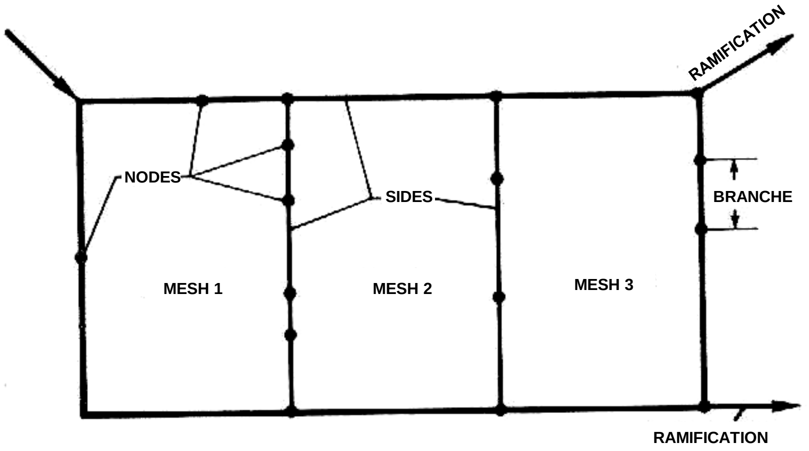
Design of distribution networks – networks to comb

Method of maximum economy

The method of sizing is based on the assumption that the simplified cost is proportional to the diameter of the pipes.

The networks consist of mesh and branches. Each link is made up of 3 or more sides, on which are identified branches and nodes. The **branches** are drawn with a constant section of pipe between two consecutive nodes.

The **nodes** are points of a pipe to which is received by the branches of which flows out a water flow rate note, or point of a pipe characterized in that the flow rate a point that comes in part from the two ends of the pipe (point of separation of water).



Design of distribution networks – networks to comb

Method of maximum economy

Note the construction characteristics of the mesh, the following conditions must be met:

a) *equation of continuity of flow rates applied to the node of the network*:

$$\Sigma_N (\pm q_i) \pm Q_N = 0$$

where $-q_i$ are the flow rates that cover the branches converge at node N_i, $+q_i$ the flow rates in branches that diverge, $+Q_N$ flow rates that flow from outside the node N (supply of the network) and $-Q_N$ the flow rates that depart from the same node (utilities). In the final, the q_i affecting the branches of the mesh, while the Q_N the branches.

Design of distribution networks – networks to comb

Method of maximum economy

Note the construction characteristics of the mesh, the following conditions must be met:

b) *principle of continuity and equations of motion of loads applied to each mesh of the network*:

$$\Sigma_N (\pm h_i) = 0$$

where we assume the pressure drop h_i with a + or - depending on whether the current along the sides of the mesh, it makes sense concordant or discordant with that of circulation taken as positive.

The determination of the diameters and piezometric shares may be made with the *equation of maximum economy*:

$$\sum_N \left(\pm \frac{D_i \cdot l_i}{h_i} \right) = 0$$

Design of distribution networks – networks to comb

Method of maximum economy

b) *principle of continuity and equations of motion of loads applied to each mesh of the network*:

This condition that expresses, for each node of the network N, the sum of the ratios $D_i \cdot l_i / h_i$ relative to the branches that convey water in the node (sign +) must be equal to the sum of the same relationships relative to the branches from that node N is branch (sign -).

Assuming to consider a branch that converges towards a node from which branch off two branches, suppositories notes the prevalence in the nodes 1, 2 and 3, the lengths of the three branches and the flow rates q_i, we can write, applying the Darcy's law the following relations:

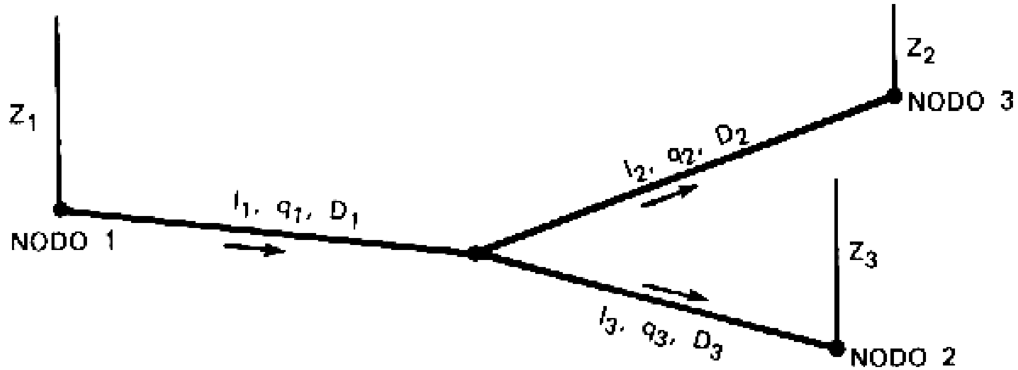
$$Z_1 - Z = \beta \cdot \frac{q_1^2 \cdot l_1}{D_1^n} \qquad Z - Z_2 = \beta \cdot \frac{q_2^2 \cdot l_2}{D_2^n} \qquad Z - Z_3 = \beta \cdot \frac{q_3^2 \cdot l_3}{D_3^n}$$

for which:

Design of distribution networks – networks to mesh

<u>*Method of maximum economy*</u>

b) *principle of continuity and equations of motion of loads applied to each mesh of the network*:



$$D_1 = \left(\frac{\beta \cdot q_1^2 \cdot l_1}{Z_1 - Z} \right)^{1/n} \qquad D_2 = \left(\frac{\beta \cdot q_2^2 \cdot l_2}{Z - Z_2} \right)^{1/n} \qquad D_3 = \left(\frac{\beta \cdot q_3^2 \cdot l_3}{Z - Z_3} \right)^{1/n}$$

Design of distribution networks – networks to mesh

<u>*Method of maximum economy*</u>

b) *principle of continuity and equations of motion of loads applied to each mesh of the network*:

Assumed that the cost is proportional to the diameter of the piping, the cost of the 3 branches is expressible in the report:

$$C = R \cdot (D_1 \cdot l_1 + D_2 \cdot l_2 + D_3 \cdot l_3)$$

from which we must search for the minimum cost, with the first derivative with respect to Z of the total cost:

$$dC/dZ = 0$$

For the application of the method, is identifies the points of division of the water in each transverse side of the network, that fall in correspondence of withdrawals from the pipes or of nodes. We determine the flow rates in individual branches, and, taking into account the shares piezometric notes, you specify the piezometric cutpoints previously identified.

Design of distribution networks – networks to mesh

Method of maximum economy

b) *principle of continuity and equations of motion of loads applied to each mesh of the network*:

At each point we assume piezometric values of attempt at various nodes the mesh, so the formula of Darcy or other, will determine the diameters of the pipes between node and node. We then apply the equations of maximum economy.

For subsequent iterations is reached at locate the most convenient theoretical diameter.

In practice, will be chosen the diameter tubes unified, limiting changes in diameter from one branch to another

Design of distribution networks – networks to mesh

Method of maximum economy

Note the construction characteristics of the mesh, the following conditions must be met:

c) *parametric method*

This method does not introduce more the hypothesis that the cost of the piping is directly proportional to the diameter.

The starting data are the knowledge of the geometry of the circuit, the flow rates to the users and the values of the minimum pressure to ensure at the same.

The process is iterative.

It begins with a preliminary dimensioning of the network, which corresponds to an evaluation of flow rates and pressures in the various branches and nodes.

You can then follow two alternatives:

Design of distribution networks – networks to mesh

Method of maximum economy

c) *parametric method*

Alternative 1

In one or more nodes, the resulting pressure to the preliminary dimensioning of the network is lower than the minimum request; it is must locate the node characterized by the greater pressure difference (compared to that of the project) and increases the diameter of one or more branches of network by adopting the DN immediately higher than that of the starting solution. The branch or branches on which it operates are those where the increase in diameter causes the maximum increase in pressure in the node in question with the minimum increase of cost.

Design of distribution networks – networks to mesh

<u>*Method of maximum economy*</u>

c) *parametric method*

Alternative 2

The pressures in the nodes are higher than those of the project (some of them may be the same); one should choose the node characterized by the minimum difference between the resulting pressure and the design pressure and is must try to decrease the diameter of one or more branches of the steep adopting the DN immediately below, always taking into account that the pressure in the second sub nodes not the design values (at most a tolerance established a priori). The branch or branches involved in this proceeding are those which cause the decrease in minimum pressure drop in the current node with the maximum decrease in cost.

Design of distribution networks – networks to mesh

Method of maximum economy

c) *parametric method*

At each interaction is calculated the annual cost due to depreciation and maintenance of the network and the pumping system, and the annual cost due to consumption of electromotive energy to operate the pumps, according to expressions previously considered.

This leads to find the solution corresponding to the minimum overall cost.

Design of distribution networks – networks to mesh

Method of maximum economy

Note the construction characteristics of the mesh, the following conditions must be met:

d) *method of Cross or of loads balancing*

This method seeks a solution that satisfies the equations of continuity of flow: $\Sigma_N (\pm q_i) \pm Q_N = 0$

This solution will be unbalanced compared to the loads it must therefore be corrected, in each mesh by circulating a flow rate sufficient to support load balancing.

Since the mesh sides have in common, the balancing, performed for a generic mesh, the meshs adjacent will unbalance that previously balanced.

It should follow a series of balances, repeating the operation several times, even though, in general, with 2 or 3 balancing results are obtained sufficiently approximated.

Design of distribution networks – networks to mesh

Method of maximum economy

d) *method of Cross or of loads balancing*

For a solution that satisfies the conditions of continuity of flow:

$$\Sigma_N (\pm q_i) \pm Q_N = 0$$

it has generally:

$$\Sigma_N (\pm r_i \cdot q_i^2) \neq 0 = \Delta h$$

being:

$$r_i = k \cdot l_i / D_i^n$$

so that the network is unbalanced with respect to the loads

To cancel Δh is considered a corrective to the extent and magnitude as to achieve the balance the mesh:

$$\Sigma_N [\pm r_i \cdot (qi + q_c)^2] = 0$$

where q_c represents the flow corrective, that does not unbalance the equation of continuity of flow rates because the same flow qc arrives and departs from the same node.

Design of distribution networks – networks to mesh

Method of maximum economy

d) *method of Cross or of loads balancing*

Neglecting the terms of the second degree and solving for q_c, we obtain:

$$q_c = -\frac{\sum\left(\pm r_i \cdot q_i^2\right)}{2 \cdot \sum\left(r_i \cdot q_i\right)}$$

Since the operation must be repeated for all links in the network, the flows are added algebraically to the corrective flow q_i that flowing along the sides of the common links.

This method can be developed with manual calculations for networks that are not too large. In addition to the dimensioning, the method is used to check if the existing network, to which have been made of variations (derivations, consumption etc.). Still fulfills the conditions of optimization riscontate initially

Water distribution plants

Pressure losses within pipes of various types

The literature provides some diagrams that allow to highlight the relationship between pressure drop, diameter, flow rate and velocity of the water in the case of straight tubes made of steel, plastic, etc.

For steel tubes new, bituminati internally, having diameters ranging from DN 40 to DN 400 and which convey water at 15°C using the formula of Scimemi-Veronese:

$$J = 6{,}81 \cdot 10^{8} \cdot \frac{Q^{1{,}82}}{D^{4{,}71}}$$

where:

J = pressure drop (m/km pipe);

Q = water flow (dm^3/s);

D = internal diameter effective of the tube (mm).

To take into account that, with time, the load losses in the pipes increases, it is advisable to multiply the values of J to a factor between 1.1 (water little hard, non-aggressive and having low acidity or to tubes having diameters more considered the high range) and 1.4.

Water distribution plants

Pressure losses within pipes of various types

For steel tubes new, bituminati internally, having diameters larger than DN 400 is using the formula of Colebrook:

$$J = 8{,}2624 \cdot 10^{10} \cdot \lambda \cdot \frac{Q^2}{D^5}$$

where:

J = pressure drop (m/km pipe);

Q = water flow (dm^3/s);

D = internal diameter effective of the tube (mm);

λ = coefficient which is a function of the roughness:

$$\lambda = \frac{1}{\left(2 \cdot \lg \frac{3{,}71 \cdot D}{\varepsilon}\right)^2} \cdot \left(1 + \frac{8 \cdot D}{\mathrm{Re} \cdot \varepsilon}\right)$$

with:

Re = number of Reynolds for water at 15°C = $v \cdot D \cdot 10^3 / 1{,}14$

v = velocity of the water in the tubes

ε = value of the roughness, equal to 0.03 mm for the tubes bituminati new and 0.1 mm for those used, and 0.05 mm for pipes rough new.

Pressure losses within pipes of various types

For the new galvanized steel tubes using the formula of Marchetti:

$$J = 12 \cdot 10^{8} \cdot \frac{Q^{1,83}}{D^{4,83}}$$

where:

J = pressure drop (m/km pipe);

Q = water flow (dm^3/s);

D = internal diameter effective of the tube (mm).

Since the galvanized tubes, the surface conditions remain unchanged over time, for which the values of J should not be increased for the tubes used.

Pressure losses within pipes of various types

For rigid pipes in non-plasticized PVC, for water under pressure and about 10°C temperature using the formula of Blasius:

$$J = \frac{\lambda \cdot v^2}{2 \cdot g \cdot D}$$

where:

J = pressure drop (m/km pipe);

v = kinematic velocity of the fluid (m^2/s – for water at 12°C = $1,24.10^{-6}$ m^2/s);

g = acceleration of gravity (m/s^2);

D = internal diameter effective of pipe (mm).

Finally, numerous tables and graphs provide the equivalent pipe length or the pressure drop due to valves, gate valves, elbows, T, variations in section etc. (is seen books and manuals).