Prof. Ing. Dario Pozzetto

Department of Engineering and Architecture – University of Trieste

Via Valerio, 10 –34127 Trieste – Tel: 040.558.3805 / 7982 Fax: 040.558.3812

E-mail: pozzetto@units.it

INDUSTRIAL PLANTS

Chapter twenty-nine:

Piping – Fluid distribution plants – Sewers and networks for the recovery of water

DOUBLE DEGREE MASTER IN

“PRODUCTION ENGINEERING AND MANAGEMENT”

SEAT OF PORDENONE

UNIVERSITY OF TRIESTE

Sewers and networks for the recovery of water

Pipes for drains and sewers

Networks evacuation of waste water are made up of separate ducts (rain, cloacal and technological) and for the industrial complexes that treat sewage and technology prior to discharge into surface waters are those which discharge into the public sewer.

The **pipes for the network of drains and sewers** have different characteristics from those of water distribution networks to users, either because they are subject to lower pressures, both because they resist the aggression of liquid discharges.

The materials constituents tubes are:

- ceramic stoneware;
- cement;
- resin;
- cast iron.

Pipes for drains and sewers

The tubes of **ceramic stoneware** are fabricated clay-ferruginous covered with a layer of material based on silicates, which becomes vitrified by cooking at high temperature.
These pipes are suitable especially for conveying of aggressive fluids. Their junction is of the type to glass with interposition of cement or tar tow and cement, or of prefabricated elastic joints with application of liquid polyurethane resin on the end of the glass. These junctions allow good seals and slight misalignments of the tubes.
In addition to the tubes, there are special pieces such as curves, junctions, reducers, inspection and siphons that allow the construction of networks.

Diameter (mm)	Tickness (mm)	Weight (kg/m)
120	20	26,3
150	20	30,1
......	.....	.....
700	35	250,0
800	36	294,2

Pipes for drains and sewers

The **cement** pipes are used only for the rainwater not polluted.

Diameter (mm)	Tickness (mm)	Weight (kg/m)
100	30	27
150	33	45
......	.....	.....
1000	88	650
1500	90	1060

For diameters greater than 1.5 m the pipes are made directly on site (economy and for avoid the breakage of the product).

There are ovoid section tubes, so as to follow the variations of the flow rate in that the lower part is semicircular and is interested by lean flows, while the upper part widens in accordance with the increase of the amount of water to bear. The union of the tubes is performed by sealing with cement.

Sewers and networks for the recovery of water

Pipes for drains and sewers

The **resin** tubes are installed in the drainage networks and sewerage and are made of PVC, high density polyethylene and polypropylene.
They require the use of special components such as bends, branches, reducers, traps and inspections.
The junctions are made by welding or bonding, threaded sleeve or cup with a rubber ring.
Tubes are suitable for conveying water polluted and technology appear to be very light, easy to handle and elastic.

Diameter (mm)	Tickness (mm)	Weight (kg/m)
32	1,8	0,24
40	1,8	0,30
......	.....	.....
160	3,2	2,22
200	4,0	3,45

For discharges of industrial buildings

Diameter (mm)	Tickness (mm)	Weight (kg/m)
110	3,2	1,55
125	3,2	1,78
......	.....	.....
500	12,2	27,20
630	15,4	43,60

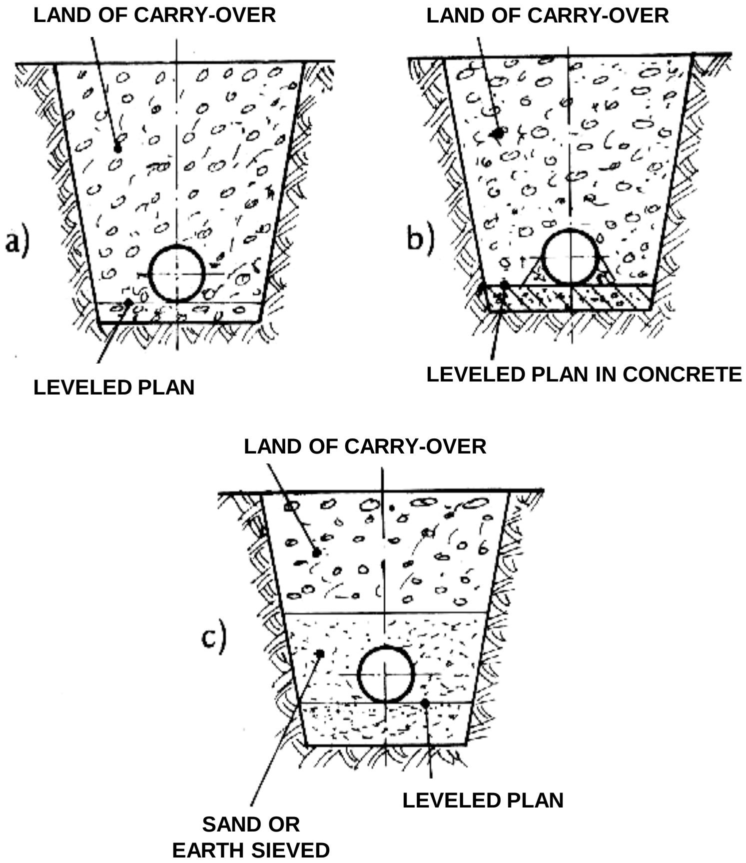
For discharges to underground pipelines and sewers

Sewers and networks for the recovery of water

Pipes for drains and sewers

The tubes of **cast iron** are of dimensions close to those of pipes of ceramic stoneware.

The laying of these tubes is such that, for land consisting, on the bottom of the excavation is provided a floor, with a predetermined slope, with the fill material or sand (in the junctions is should have a support in concrete). If the ground is not consistent, it must carry out a plan of laying on the bottom of the excavation with lean concrete (10 cm of thick). For the tubes in resin, on the bottom of the excavation starts a level plane (10 cm) and then the tube is covered with a layer ground or sieved sand (10 cm), and then you make the backfill.



Sewers and networks for the recovery of water

<u>General criteria for the design</u>

The criteria of design for all network for the recovery and drains of water are:

- the various collectors must be possible straights;
- within the building is try to install the pipes in places inspected (subplans, tunnels, galleries), while outside the pipes should be underground;
- the sewers containing the black waters and technological polluted are installed at greater depth of water pipes, that they are possibly to pass in the vicinity;
- on all networks exhaust are expected inspection manholes in correspondence with changes in direction and gradient, junctions of two or three pipes and straight sections longer than 30-40 m;
- we try to avoid counterslopes, which would result in the execution of major excavations.

General criteria for the design

The basic concepts that develops the design of sewerage systems in an industrial area are:

- identifying the points of discharge of sewage and technological and, in the case of rainwater, the surface of convergence and of the impluvia in the area;
- definition of the flow rates of water to be pumped;
- study of the path of the networks on planimetry quoted also in the sense altimetric from the delivery terminal of each network;
- dimensioning of the various conduits according to the criteria given below.

Dimensioning of sewer

It comes to detecting the flow rate Q to be pumped into the manifolds.
Note Q, is fixed the slope of the collectors or the speed of the current in the same and is determines the useful section.
Assume, normally, greater slopes for channels of small diameter and minor slopes for those with high flow rates:
- diameter pipes from 0.15 to 0.30 m, slope from 3 to 0.6%;
- diameter pipes from 0.30 to 0.60 m, slope from 2 to 0.5%;
- diameter pipes from 0.60 to 0.90 m, slope from 1 to 0.3%;
- diameter pipes > 0.90 m, slope from 0.3 to 0.1%.

For the speed is imposed:
- for rainwater, not to exceed certain maximum values at flow rates of full;
- for cloacal water and polluted industries, not to fall below certain minimum values corresponding to the flow of minimum flows provided.

Dimensioning of sewer

The values usually considered for the speed of drainage sewers are:

- maximum speed of the white water and technology free of suspended matter: 2 -3 m / s (full section);
- minimum speed of sewage or water containing suspended solids and fine sands: 0,3 – 0,4 m/s;
- minimum speed of water containing coarse sands or heavy materials: > 1 m/s until 2 – 3 m/s.

To calculate the area of the liquid section using the formula of Chezy:

$$V = \chi \cdot (R \cdot i)^{0,5}$$

where:

i = slope of the collector (m/m pipe);

R = average radius (m), equal to ¼ of the diameter in the circular pipes;

V = average velocity in the pipe (m/s);

χ = coefficient, function on the roughness of the pipes and the average radius, defined by the relation:

Dimensioning of sewer

$$\chi = \frac{100 \cdot \sqrt{R}}{m + \sqrt{R}}$$

where:

m = roughness coefficient, which takes the value 0.35 for cement pipes and cast iron pipes, and 0.15 for resin or ceramic stoneware.

To limit the possibility of blockages in sewers or cloacal conveyed water containing settleable substances, you should not have pipes with a diameter of less than 200 to 250 mm. Are used smaller diameters for discharge from the machines and the columns of discharge above ground.

For round ducts full section, will have the following values:

Diameter (m)	Mean radius (m)	χ
0,04	0,010	22,2
0,06	0,015	25,9
....	....	....
0,90	0,225	57,5
1,00	0,250	58,8

Dimensioning of sewer

For this ducts, is R = r/2 (r = radius of the pipe), for which the flow with flow full section is given by:

$$Q = \pi \cdot r^2 \cdot V = \pi \cdot \chi \sqrt{\frac{r^5}{2}} \cdot \sqrt{i}$$

In the case of normal sections will have:

	A full section	Filling up to shutter of the vault semicircular
Total section	$S = 0,51 \cdot H^2 = 4,69 \cdot r^2$	$S = 0,336 \cdot H^2 = 3,02 \cdot r^2$
Total perimeter	$P = 2,64 \cdot H = 7,93 \cdot r$	$P = 1,596 \cdot H = 4,79 \cdot r$
Mean radius	$R = 0,193 \cdot H = 0,579 \cdot r$	$R = 0,21 \cdot H = 0,63 \cdot r$

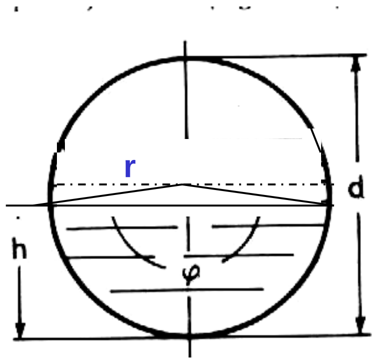
Dimensioning of sewer

In circular ducts, if the outflow does not take place in full section, is:

a) when h < r

$$S = \frac{r^2}{2} \cdot (\varphi - sen\varphi) \qquad P = r \cdot \varphi$$

$$R = \frac{S}{P} = r \cdot \frac{\varphi - sen\varphi}{2 \cdot \varphi}$$



Substituting the values, is obtained:

$$v = \chi \cdot \sqrt{\frac{r \cdot (\varphi - sen\varphi)}{2 \cdot \varphi}} \cdot \sqrt{i}$$

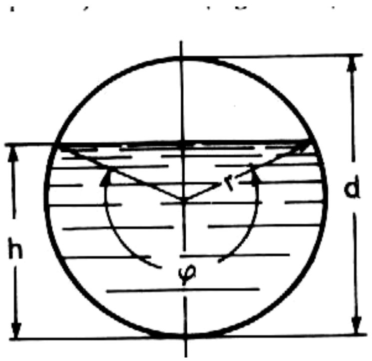
while the flow rate is given by:

$$q = \chi \cdot \sqrt{\frac{r^5 \cdot (\varphi - sen\varphi)^3}{8 \cdot \varphi}} \cdot \sqrt{i}$$

Dimensioning of sewer

In circular ducts, if the outflow does not take place in full section, is:

a) when h > r



$$S = \frac{r^2}{2} \cdot (\varphi + sen\varphi) \qquad P = r \cdot \varphi$$

$$R = \frac{S}{P} = r \cdot \frac{\varphi + sen\varphi}{2 \cdot \varphi}$$

Substituting the values, is obtained:

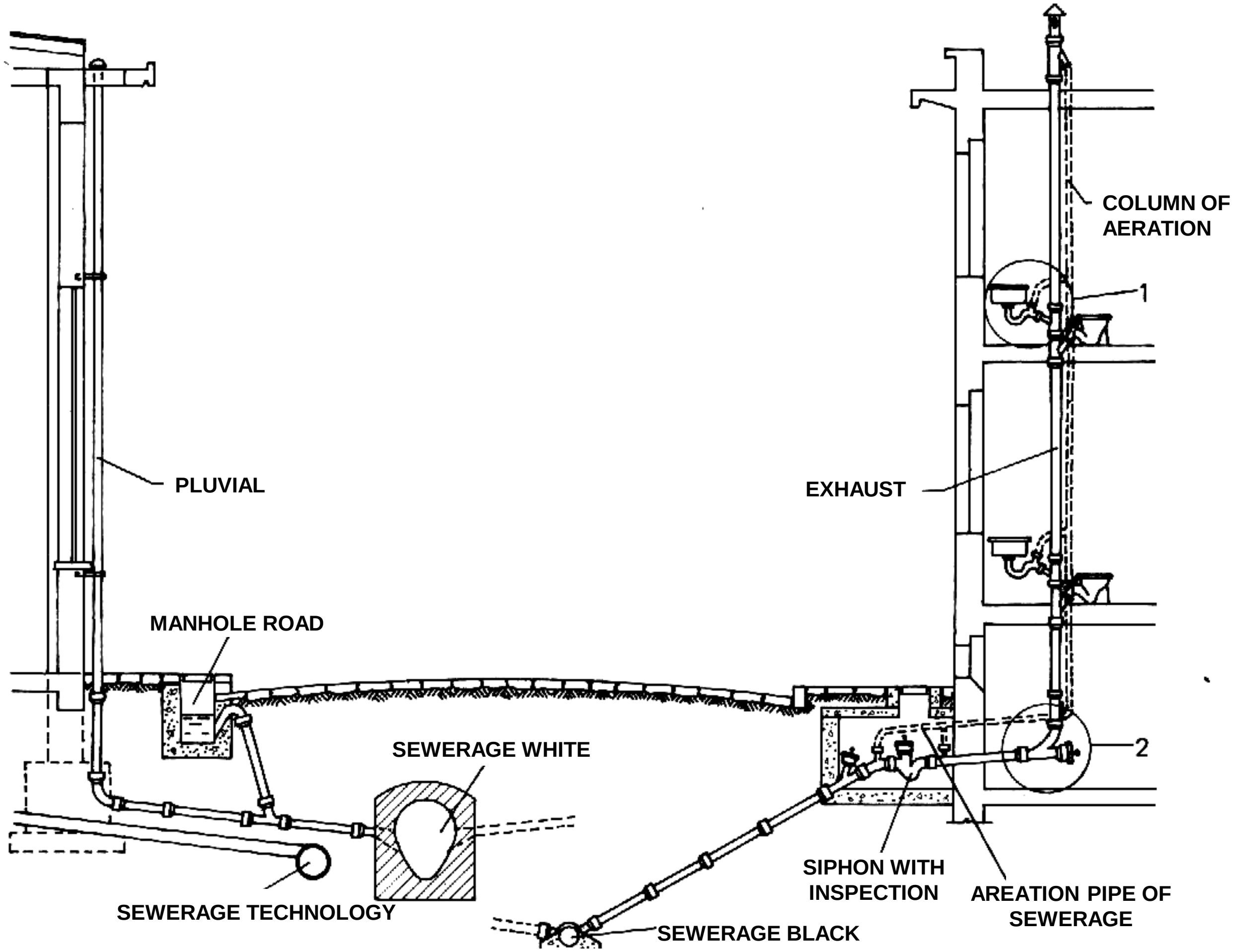
$$v = \chi \cdot \sqrt{\frac{r \cdot (\varphi + sen\varphi)}{2 \cdot \varphi}} \cdot \sqrt{i}$$

while the flow rate is given by:

$$q = \chi \cdot \sqrt{\frac{r^5 \cdot (\varphi + sen\varphi)^3}{8 \cdot \varphi}} \cdot \sqrt{i}$$

Sewers and networks for the recovery of water

Dimensioning of sewer



Dimensioning of sewer

The values of the speed v and the flow rate q in the ducts of circular cross section partially filled may be obtained from the corresponding values for outflow ducts with flat section, whereas the relations v/V and q/Q depend exclusively from the values of χ and of the angle φ, and then the height h reached by the water in the tube.

Similarly to the ovoid section normal partially full.

Flow of stormwater

The flow of water to be pumped into a white sewerage is detected based on the height of the rain, their duration and the surface of the area concerned.

The height of the precipitations (height of rain) is defined as the height of the water layer that would be formed on the ground, after each precipitation, if this were not waterproof and if there were no evaporation.

Each precipitation is therefore characterized by an overall height of rain h and of its duration t through the relation:

$$i = \frac{h}{t}$$

where i is the intensity of rain.

Typically, the height is measured in mm of rain, the duration in hours or minutes and the intensity in mm/I or mm/minute

Flow of stormwater

The dimensioning of the drainage system for the disposal of stormwater must take account of the maximum height of rain that may occur in the area concerned during a certain period of time: often it refers to the total heights of more intense precipitation of the last two years for the continuous duration of 1 hour.

Generally, not all the water that falls on a certain area flows to the sewer system: part evaporates, is captured in holes in the ground, it is absorbed by the ground etc., while another part may flow out of the canals, rivers etc.

Each time, you have to assess the extent of the easing the flow of water precipitated.

It therefore determines the coefficient of influx (or absorption), defined as the ratio between the outflow to the sewerages and the meteor influx during the precipitation considered.

Flow of stormwater

The values of the coefficient of influx ψ are:

- buildings: 0,85 – 0,95;
- roads and squares bituminous and well kept: 0,90 – 0,95;
- surfaces to macadam*: 0,40 – 0,60;
- unpaved surfaces, land not built: 0,10 – 0,30;
- lawns, parks and gardens: 0,05 – 0,25.

In allocating the value ψ of to different parts of the district, it must take account of conditions in the future under the plan of development of the plant.

In the case of the Po Valley if one considers 45 mm of rainfall height for the duration of an hour, it has an intensity of rain of 125 l/s per hectare and in the case is that an absorption coefficient of 0.80, the water flow that converges to the sewers is equal to 100 l/s.

Flow of black waters

The evaluation of the flow of black waters comes from the amount of water used in the sanitation services of the plant in coincide with peak periods, whose duration is around 20 minutes.

In principle, it can be assumed that reaches to the sewers the 90-95% of the amount of water fed to the sanitation services in these periods.

As the mean value can be assumed an hourly capacity equal to the total volume of water used throughout the day in the sanitation services divided by the number of working hours.

Sewers and networks for the recovery of water

<u>Capacity of technology water and related recoveries and recirculation</u>

The flow of water depends on the technological processes and the criteria adopted to reduce water needs at the plant, which are readily ascertainable. It must, however, seek, already from the design phase, to reduce the needs of primary water (groundwater, surface etc.) for technological uses, in order to have a correct and rational use of water within the industrial reality.

This can be achieved:

- reducing the water requirements by further use and/or recirculation of the water itself, with intermediate cooling and depuration;
- extending the use of brackish water and marine;
- resorting to differentiated supplies in relation to the requirements of use (use of surface water instead of water of deep wells).

Sewers and networks for the recovery of water

Capacity of technology water and related recoveries and recirculation

To reduce water needs, rather than making a distribution in "parallel" water to industrial users, you must implement a distribution "in series".

When such projects subsequent are not feasible, it is uses recirculation, ie recovery, via pipes, the water coming from previous uses, conveying in collection tanks and the subsequent pumping to other users, integrating only the losses and fuel consumption.

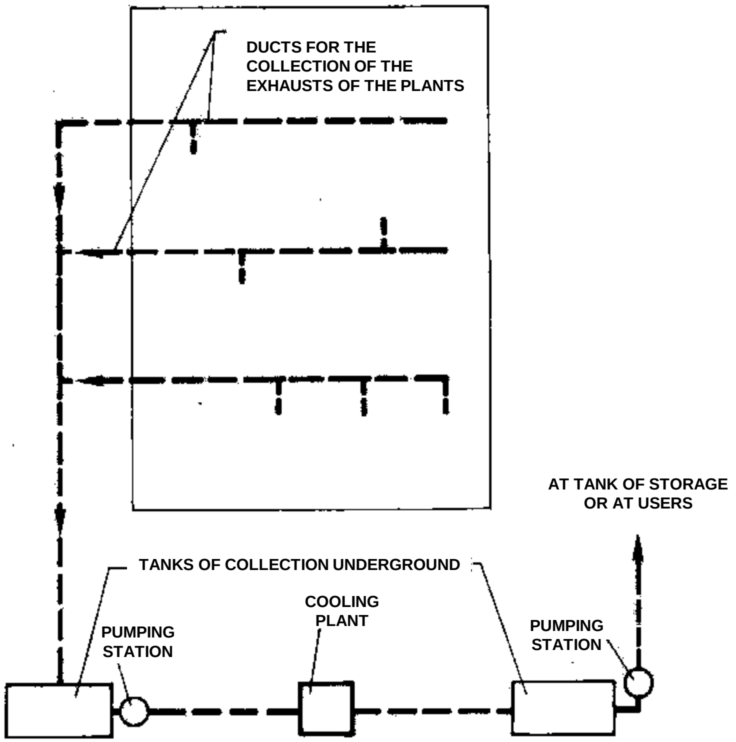
Usually, as a result of the uses and/or subsequent recirculation, the water is heated to temperatures no longer acceptable for other uses: it must therefore provide for its cooling in special plants (cooler in open circuit or closed by atmospheric air or by groups refrigerants.

Capacity of technology water and related recoveries and recirculation

In the case in which the water remains polluted in such a way that it can no longer be fed to other users without prior purification, it comes to applying the technique of "epicresi" (repeated use), which consists in purifying the polluted water and re-use them in the same establishment.

The figure shows a retrieval system, cooling and recycling of industrial water clean in a factory.

In the case of recovery of waste water using "epicresi" must be replaced to the cooling system to the treatment of waste water.



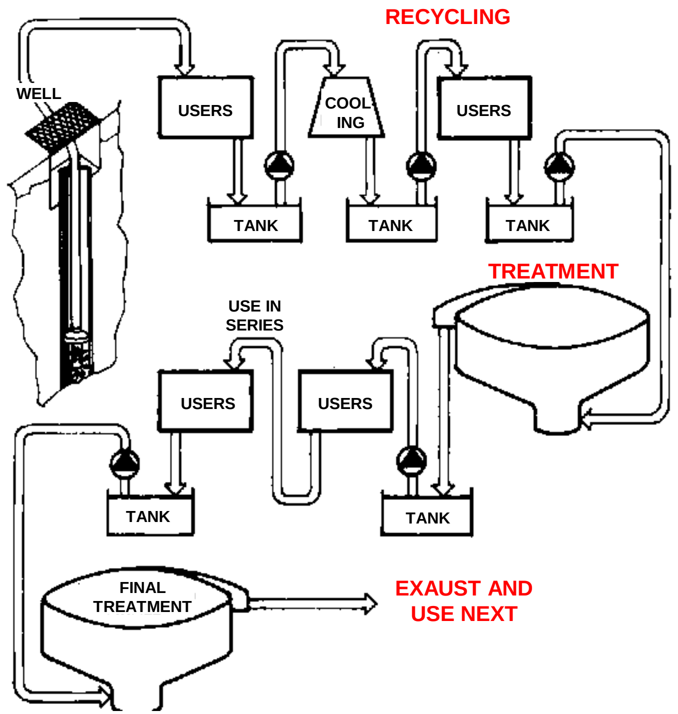
Sewers and networks for the recovery of water

Capacity of technology water and related recoveries and recirculation

The use in series of water requires more prevalences for the feed pumps. The recycling have in addition a network and a collection tank, a pumping station and a pipeline connecting with the distribution network to the users.

The intermediate cooling and the "epicresi" require in more, compared to recycling, an accumulation and an additional pumping.

This can therefore lead to integrated solutions, which allow a significant reduction in the primary water withdrawals and discharges of waste water.



Sewers and networks for the recovery of water

Capacity of technology water and related recoveries and recirculation

The adoption of the proposed solutions involve additional investments, which must include the careful economic analysis, which should take into account the expected tax on primary water withdrawals and fees on discharges.

As regards the recovery of the water after use, is apply the indications on the sewer networks, while in the collection tank in then falls in supply systems.

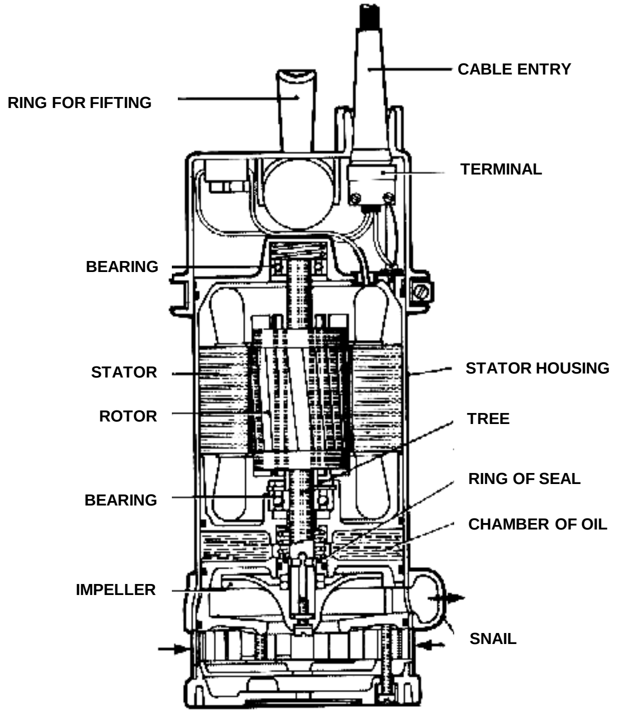
Sewage pumps

The lifting of water containing solids or semi-solids in suspension, sludge that is more or less dense, organic substances or abrasive or aggressive, is carried out by means of special pumps, devices of compressed air ("air-lift") and screw conveyors.

The special electropumps are:

a) to impeller backward

In this type of centrifugal pump, only a portion of the pumped fluid penetrates to the impeller blades receiving energy that then transfers the remaining part, which crosses the body of the same without coming into contact with the impeller;

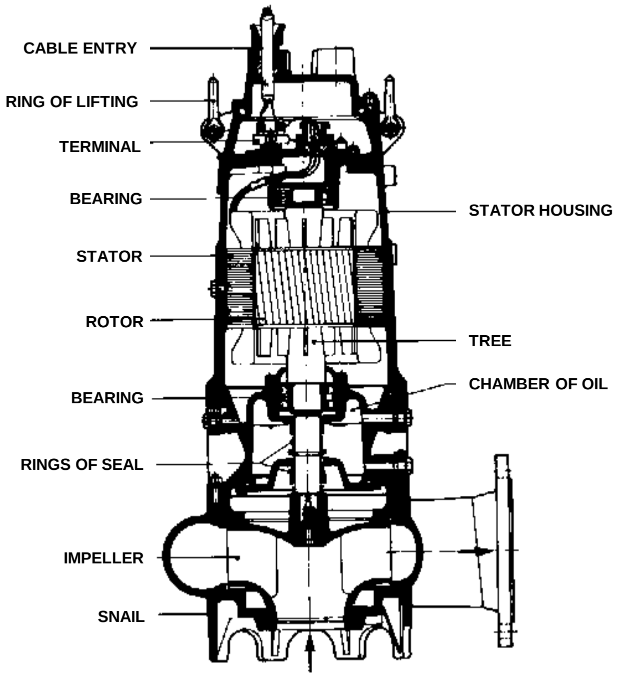


Sewage pumps

The special electropumps are:

b) single-channel or two-channel impeller

The sewage passes completely through the impeller, but the limited number of vanes (one or two) and the passage sections allow a very large flow without clogging.



The head pressures that can be obtained with the above-mentioned pumps are relatively low; for prevalences higher, it becomes necessary to install in series two or three units.

Sewage pumps

The pumps for sewage are manufactured in the following versions:

a) a axis monobloc, with electric motor suitable for submerged operation, made tight to the infiltration of water through appropriate mechanical seals;

b) a line of axis, where the pump is immersed in the liquid to be pumped, but the electric motor is external and the drive is through the shaft;

c) a horizontal axis, where the pump is external to the tank or to the tank containing the slurry and the drive takes place with electric motor with a horizontal axis.

The types characterized by low flow rates (up to 600 – 800 dm^3/min and prevalences of a few meters) are portable, others are part of fixed installations. These are installed in special rooms dimensioned so as to avoid the danger of too long retention (oversizing) or number of starts too high (undersize).

Sewage pumps

There are pumps for rainwater, cloacal, marine, muddy, corrosive, abrasive etc. The impeller and the diffuser are made of materials suitable for the type of sewage with which they are in contact (cast iron, bronze, stainless steel etc.).

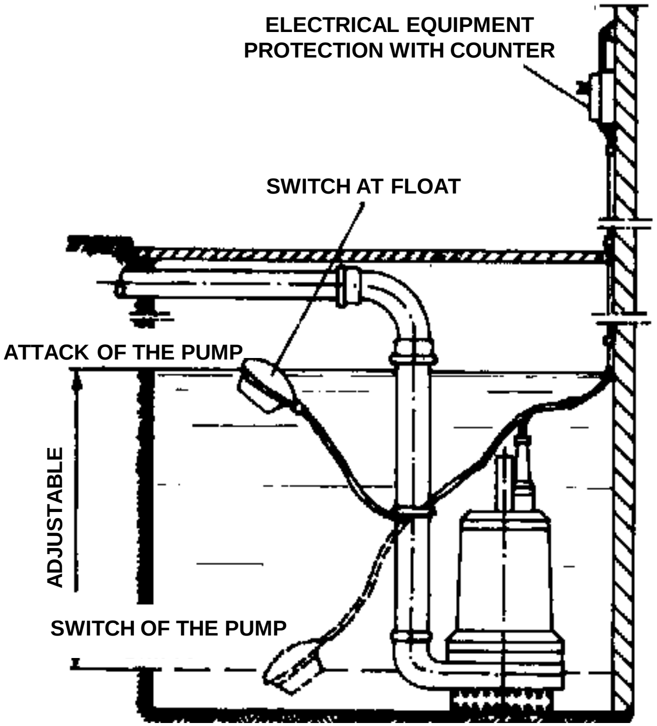
Submersible sewage pumps are available with explosion-proof motors, flammable gases etc.

The lifting of the sewage by means of "air-lift" is based on blowing the compressed air in the vicinity of the inlet opening in the appliance, thereby the suction piping, one has a mixture of air and liquid that, having a lower specific weight of the liquid to be lifted, tends to rise.

The group is devoid of moving parts; requires in addition to compressed air (produced by rotary compressors or blowers), washing water for cleaning the internal cavities.

Sewage pumps

The air-lift are suitable for lifting heights of limited water containing mud, sand etc. by tanks and pools for decontamination and collection.
For lifting-transporting large volumes of sewage over longer distances and height differences is limited, using the screw conveyors.



Design of sewerage plant into an industrial reality

The company considered

The company performs precision machining third parties.

It's specializes in machining by chip removal and works on the production of small and medium series aimed at different markets, including also the automotive market.

The company also carries out the mechanical assembly which, however, have a bearing on the volume of marginal activities. The ATECOFIN classification is as follows: Activity Code 25.62.00, general mechanical engineering.

The plant will be fitted with two saws, five multi-pallet horizontal machining centers vertical four centers, four lathes, three adjustments and other machine tools dedicated to minor jobs (drills, grinders).

Design of sewerage plant into an industrial reality

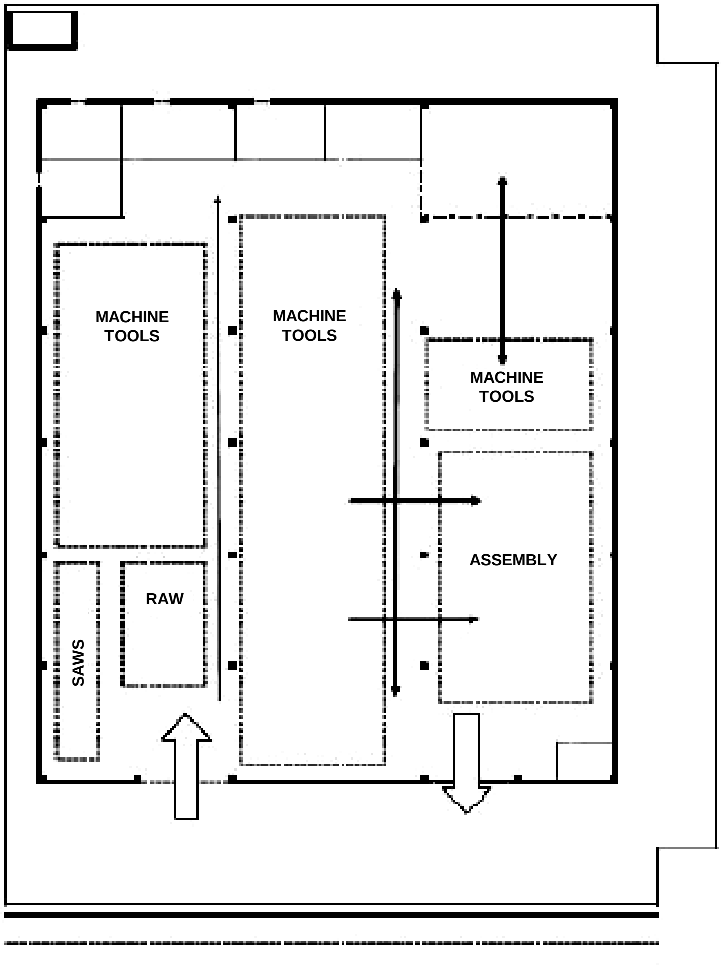
The company considered

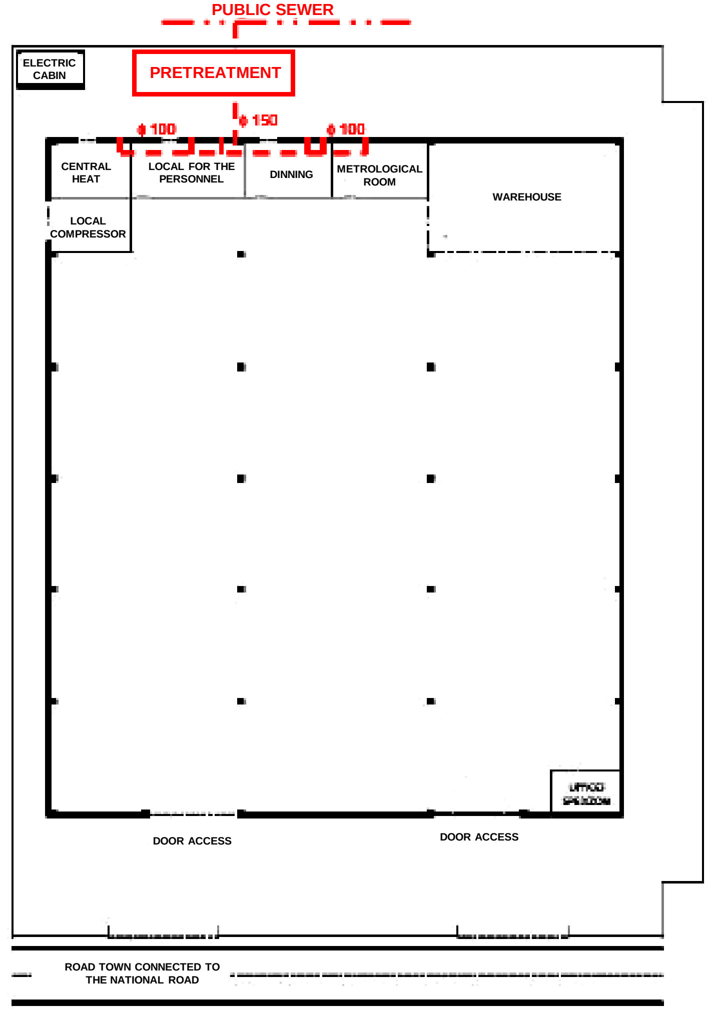
The processes are organized by lot, the individual workpieces are unlikely to exceed 50 kg, 100 kg ever, the internal movement is organized on pallets and bins, there is no need a bridge crane, except in the area of saws for operations handling of rough round or billet.

The process flow is as follows: purchase of raw materials and the design details, cutting rough machining processes, heat treatment and surface finishing of parts, assembly, packaging and shipping.

Design of sewerage plant into an industrial reality

The company considered





Design of sewerage plant into an industrial reality

The company considered

With regard to the drains, the annual consumption has been estimated at 870 m^3 of water for use as sanitation.

Whereas a working period of 220 days/year and a work shift of 8 h/day, the water flow theoretical discharge is 0.5 m^3/h.

Reversing the formula for calculating the flow rate Q:

$$Q = \pi \cdot r^2 \cdot V$$

we obtain the radius r of the exhaust pipe, for a minimum speed set to V = 0,4 m/s = 1440 m/h:

$$r = \sqrt{\frac{Q}{\pi \cdot V}} = \sqrt{\frac{0{,}5}{\pi \cdot 1440}} = 0{,}01 \ m$$

Being less than the minimum regulatory, one considers the value established by the norm of r = 0,25 m.

The company considered

From the values tabulated (table) is obtained, also, the value of the roughness of the pipe:

Diameter (m)	Mean radius (m)	χ
0,04	0,010	22,2
0,06	0,015	25,9
......	....	......
0,90	0,225	57,5
1,00	0,250	58,8

$$\chi = \frac{100 \cdot \sqrt{R}}{0{,}35 + \sqrt{R}} == \frac{100 \cdot \sqrt{0{,}125}}{0{,}35 + \sqrt{0{,}125}} = 50{,}25$$

and of the slope required at outflow (i = 1,8%).

The company considered

Occurs that the speed is higher than the minimum admissible value:

$$V = \chi \cdot \sqrt{R \cdot i} = 50{,}25 \cdot \sqrt{\frac{0{,}25}{2} \cdot 0{,}018} = 2{,}38 \;\; m/s$$

where:

R = mean radius (m), equal to ¼ of the diameter in the circular pipes.

Regarding the rainwater, in the industrial area where the shed is located has an intensity of rain is 125 dm^3/s. Using an absorption coefficient of 0.8-0.9, the flow rate of water that converges to the sewer channels is equal to 100 dm^3/s per hectare. The area occupied by the plant is about 4000 m^2, corresponding to approximately 0.4 hectares. The water flow rate, therefore, convergent channels in the sewer is 40 dm^3/s.