



Abdelhafid Boussouf University Center - Mila
2024-2025 Semester 1

**Water distribution and collection:
HAS PART I: DRINKING WATER SUPPLY**

– Course 3 –
Chapter **03** : **Protection of works .**



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Institute	Department	Year	Speciality
Science and Technology	GC and hydraulics	2nd year master's degree	Urban hydraulics

Course Objectives 3

1. **Identify the types of structures to be protected** in a drinking water network: reservoirs, pumping stations, water intakes, pipes, regulation equipment, etc.
2. **Analyze the potential risks** threatening the integrity or proper functioning of these structures (corrosion, pollution, malicious acts, aging, etc.).
3. applicable **protection measures** :
 - Physical protections: fences, shelters, locking.
 - Technical protections: anti-corrosion coatings, monitoring sensors, alert systems.
 - Health protection: anti-return devices, preventive treatments.
 - Regulatory protections: compliance with standards, periodic checks.
4. **Illustrate with concrete cases** of failures or good practices in terms of protection of works.
5. **Emphasize preventive maintenance and regular monitoring** as keys to effective long-term protection.

Introduction

The protection of drinking water supply network structures is essential to ensure the quality of the water distributed and the sustainability of the infrastructure. It takes several forms, including:

III.1. Protection against contamination

- **Water quality** : The implementation of strict measures is necessary to protect drinking water against all forms of pollution, whether of biological, chemical or physical origin.
- **Regulations** : In France, drinking water catchments are protected by protection perimeters (immediate, near, and distant) defined by prefectural decree, in accordance with the Public Health Code. These perimeters impose restrictions on land use and human activities around the catchment points to prevent pollution risks.

III. 2 Sources of contamination

Both human and natural factors influence the quality of a water source. When they exist, risks to water sources generated by human activity and those of natural origin represent a difficult challenge for a water treatment plant and can have repercussions on human and environmental health.

III.2.1 Water contamination from natural factors

Natural factors can contribute to drinking water contamination if left unchecked. For example, wildlife harbors microorganisms such as bacteria, parasites, and viruses that can cause illness in humans.

Continuous changes to the natural environment, such as wildfires, storms, floods, and erosion, can pose risks to water sources. Natural factors that affect water quality are often unpredictable and can occur very suddenly. For example, a heavy rainstorm can cause stream banks to erode and introduce sediment into a water source, increasing turbidity (cloudy water).

Natural landslides can also impact water quality by introducing debris and soil materials that cause high water turbidity. Human activities such as logging, urbanization, mining, and agriculture can exacerbate these natural conditions.

III.2 .2 Water contamination by human activity

The quality of water sources can be compromised by past and present land use activities that pose risks to human and environmental health. Land use activities, including agricultural activities, can introduce pesticides and nutrients into water sources. Many residential activities also introduce risks of water source contamination, for example, pets, sewage disposal systems, landfills, lawn care, road systems, road salt, personal care products, pharmaceuticals, and abandoned residential wells.

Commercial and industrial activities add additional risks in the form of waste, hazardous material transportation, toxic byproducts, dry cleaning waste, car wash wastewater, fuel storage leaks, etc. Previous industrial activities such as railway crossings, aging fuel tanks, mine tailings, and other past industries can also contribute to water quality degradation. Figure 01 illustrates the pathways of contamination from human activity.

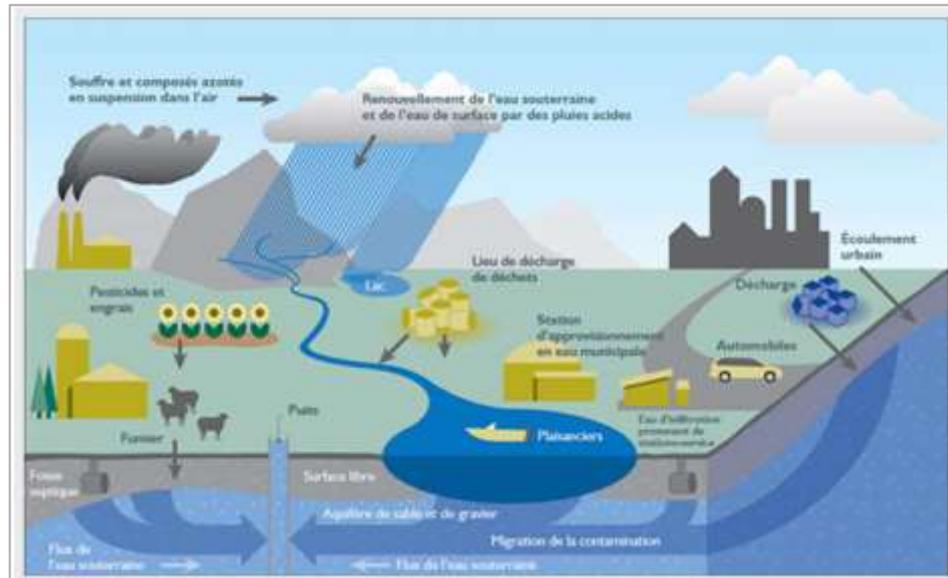


Fig. 01. Sources of groundwater contamination.

III. 3 Protection of infrastructure

- **Materials used** : Pipes and tanks must be designed with materials that comply with health standards and are resistant to local environmental conditions (corrosion, pressure, etc.).
- **Maintenance** : Regular maintenance of facilities (reservoirs, pipelines, pumping stations) is crucial to avoid leaks and ensure the durability of the infrastructure.
- **Physical security** : It is important to implement physical protection measures against vandalism, intrusions or malicious acts that could compromise the quality of or access to drinking water.



Fig. 02. Smart technologies for infrastructure protection.

III. 4. Protection against natural risks

- **Flooding** : Structures must be protected against the risk of flooding to prevent polluted surface water from entering the network.
- **Earthquakes** : In seismic zones, specific standards for construction and strengthening of structures are required to avoid damage during earthquakes.
- **Climate change** : Changing temperatures and the frequency of extreme weather events are placing new demands on infrastructure and resource management.



Fig.03. Protective measures against natural hazards.

III.5 Risk management and health safety

- **Monitoring systems** : Sensors and remote management systems allow water quality to be monitored in real time and anomalies (such as contamination or leaks) to be detected quickly.
- **Health Safety Management Plan (HSMP)** : This plan, required by European regulations, includes a risk assessment throughout the water cycle, from source to distribution, and defines preventive measures to be implemented.



Fig.04. The key steps of a Water Safety Management Plan (WSMMP).

III.6 Combating water loss

- **Leakage Reduction** : Modernizing aging networks and detecting leaks early are essential to avoid the loss of valuable resources and preserve the sustainability of the power network.
- Combating water loss involves reducing leaks and waste in distribution networks to preserve this vital resource. It involves several actions, such as:
 1. Modernization of infrastructure,
 2. Regular monitoring of pipelines,
 3. The installation of leak detection and control systems, as well as raising user awareness about responsible consumption. Limiting water losses not only improves the efficiency of the service but also the sustainability of the resource in the face of climate change and growing demand.

III. 7 Types of works to be protected

In a drinking water network, the structures to be protected are numerous and varied, each playing a specific role in the cycle of capture, treatment, transport and distribution:

- **Catchments** : springs, boreholes, wells.
- **Treatment stations** : clarification, filtration, disinfection.

- **Tanks** : on tower or buried.
- **Pumping stations** : transfer and elevation.
- **Main pipelines** : supply and distribution pipes.
- **Control elements** : valves, flow meters, non-return valves.
- **Inspection chambers and manholes** : access points to buried equipment.

These structures are exposed to several forms of degradation and aggression requiring appropriate protective measures.



Fig. 5. Types of structures to be protected in the drinking water and wastewater cycle.

III.8 Devices Hydraulics

THE pipes of transportation And of distribution of water drinkable below pressure are posed has a constant depth from the ground surface and therefore follow the contours of the terrain. High points, low points, and steep drops can thus occur one after the other and cause disruptions to the flow of water.

Two phenomena can be has the origin of disturbances important of the flow water in the network:

- There presence of air In there pipeline,
- There regulation of the pressures of water according to THE kind of functioning of network.

These disturbances can be avoided in equipping THE network of devices specific hydraulics .

III.8.1 Suction cups

These devices have the role of either eliminating air that has entered a pipe (suction cup has double effect), either At opposite of allow a entrance of air (suction cup has triple effect).

- **Role And functioning of the suction cups**

Air removal is necessary whenever a pipeline is put into service or put back into service following work. During this filling phase, the air contained in the pipeline accumulates at each high point. If it is not evacuated, it compresses and causes, due to the size and elasticity of the air pocket thus formed, of the disturbances In the flow of water by restriction local of there section passage. In some cases, it may be completely blocked, preventing any water from moving forward in the pipe.

This restriction can to have of the consequences very important during of strong requests or during exceptional requests such as fire protection.

Of the bubbles of air can also itself form in time normal coming from of the air dissolved in water. In certain cases the water flow can dissolve the air pocket formed, but over a relatively long time incompatible with the needs of the service. It is therefore advisable to equip all THE points tops of a system automatic elimination below pressure trapped air called **a suction cup**.

THE suction cups are constituted of a ball floating, locked up In a cavity closed in permanent communication with the interior of the pipeline and in a high position with the atmosphere through an evacuation orifice.

During the filling of the pipe, the ball is in the low position in the cavity and leaves escape the air of there pipeline by the orifice. After evacuation of the air, there cavity fills with water, the ball rises and closes the orifice in a watertight manner.

During of a drain, there cavity itself empty, there ball descend And cleared the orifice. There are two types of suction cups: “double” and “triple” effect.

- **Suction cup double effect**

They allow elimination of the air of filling And the evacuation of the air coming from of transported water (Figure III.06).



Fig. 06. Suction cup double effect.

III.1.1.1.2. Triple-effect suction cup

During of works on there pipeline requiring a drain of water, Or in case of accidental rupture, the flowing water will cause a vacuum in the pipe. This vacuum slows down the drainage flow, thus increasing its duration and above all can cause significant damage:

- Shift of the joints In their lodge being able to go until their suction In driving ,
- Detachment Or there deterioration of coating interior,
- Flattening of this conduct Who can itself deform of manner definitive Or No, to split, break, or even implode.

THE suction cups has triple effect (Figure III.07), installed to points tops of network therefore allow automatic entry of high-flow air.

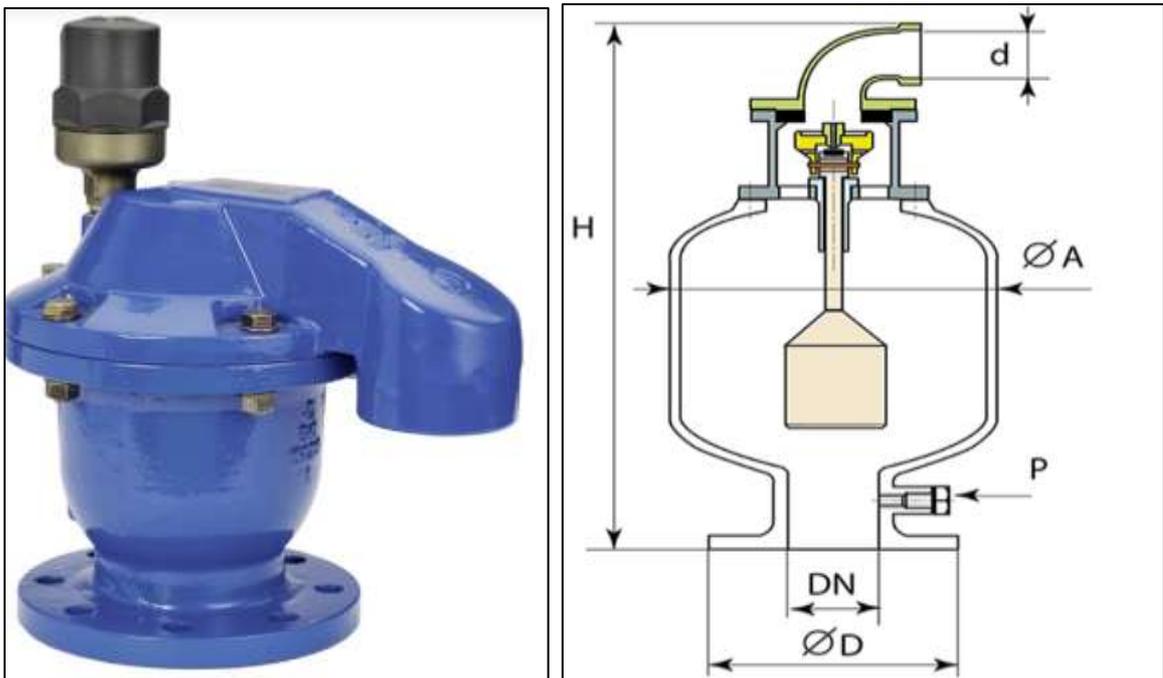


Fig III.07. Suction cup triple effect view exterior And view in cut.

▪ Terms installation of the suction cups

The suction cups are installed on water transport pipes. There is no need of it install on THE pipes of distribution of which THE pockets of air are eliminated by water consumption at the connections.

A suction cup East installed on each point high of there pipeline (Figure III.08).A detailed study of the longitudinal profile is necessary to define the most appropriate model.

THE two types of suction cups can be installed on a even pipeline. In In all cases, as accidental rupture of the pipeline can occur at any time, triple-effect suction cups must be provided.

In the case of a very low slope profile, regular suction is necessary at a distance between between 500 meters And 1 kilometer in order to to eliminate all accumulation of gas on the upper generator of the liquid vein.

In the case of rising pipes fitted with a shut-off valve, a suction cup should be installed upstream of the hydraulic direction of this valve in order to avoid depression. In there pipeline if there valve East closed (point HAS of plan below).

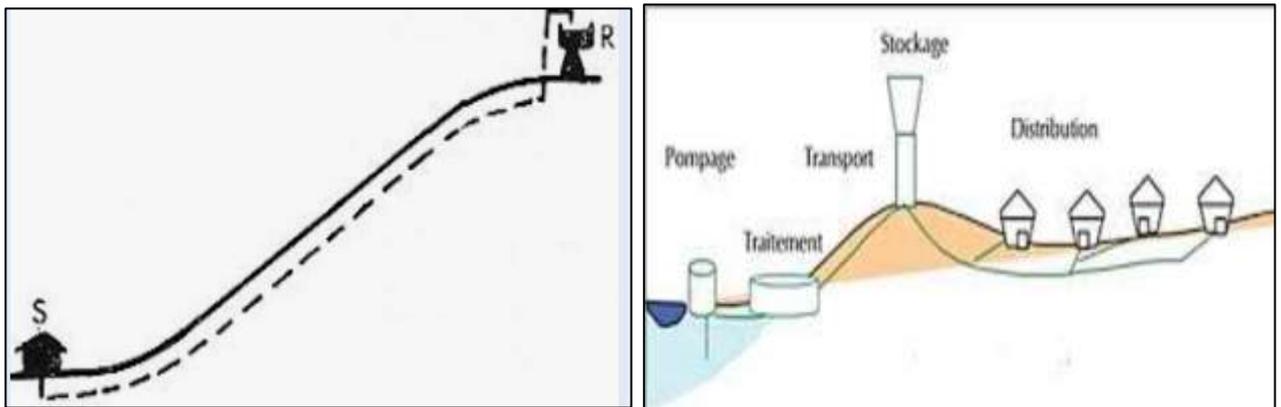


Fig III.08. Profile in long of a conduit adduction by repression.

All suction cups are installed in a manhole. They must therefore have at their base a valve isolation For in perform there maintenance. THE drainage of This glance is essential to avoid any stagnation of water near the device which could be detrimental to its proper functioning.

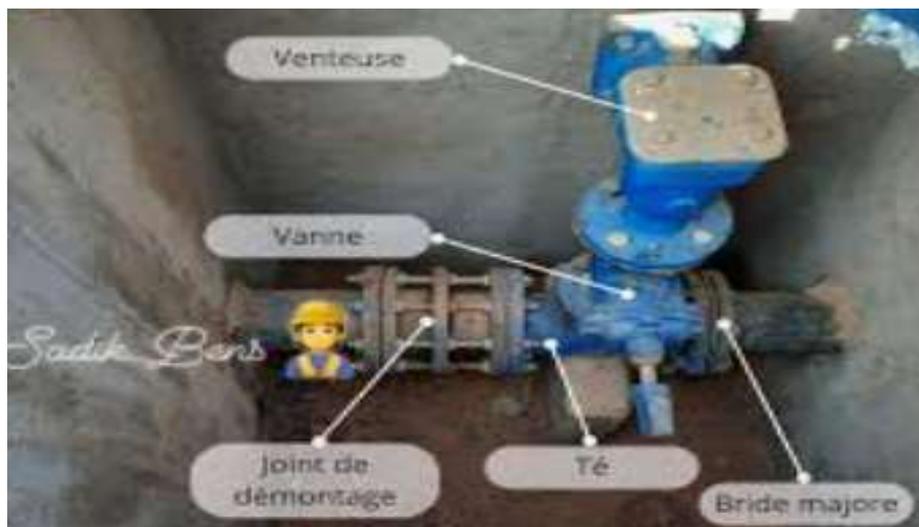


Fig III.09. Plan installation kind.

- **Valve of dump**

It is a tap located at the low point of the route for draining the pipe. Draining itself do either In A sewer (case of a network urban), either In A ditch Or in full air (case of a companion pipe). This valve will be installed in an easily accessible masonry manhole.

- **Post And mouth fire**

Each fire hydrant or fire post installation must have an isolation valve installed on the connection pipe connecting this device to the distribution network. This valve must always be open. Along THE valve located In THE The body of the fire hydrant (hydrant) must be operated during testing or use of these devices. The hydrants or fire hydrants must be connected to pipes capable of ensuring a minimum flow rate of 17 (l/s) with a pressure of 10 m (1 bar).

These poles fire must include At less two sockets lateral of 65 mm diameter to which a 100 mm front intake is added if the fire flow exceeds

500 l/min, Or if there pressure of water East weak. They must be connected to pipes from the network by connecting pipes of at least 90 mm diameter.



Fig.III.10 : Post fire

Fire hydrants will be installed along the edge sidewalks spaced 50 200 m and distributed according to the importance of unforeseen risks.

III.9 Protective works

Water **hammer protection** is necessary so that the rapid closing of faucets, appliances or other devices does not **damage** the drinking water supply network.

III.9.1 Definition of water hammer

Water hammer is an overpressure phenomenon which appears at the moment of a sudden variation in the speed of a liquid , following a rapid closing/opening of a valve , a tap or the starting/stopping of a pump .

This overpressure can be significant, it often results in a characteristic noise, and can cause the pipe to rupture in large installations, due to the quantity of water in motion. This problem can be resolved by installing an anti-water hammer .



Figure III.11. Deformation of metal bellows following a water hammer phenomenon or overpressure.

Water hammer is a wave that propagates in the pipe after a sudden change in the flow regime, for example:

- After a power outage when the pump is running.
- After closing a valve very quickly...

Causes and consequences of the phenomenon

The main causes are:

1. Instantaneous (too rapid) closing of a gate valve placed at the end of a supply pipe.
2. Sudden stoppage by unexpected disconnection of one or more groups of pumps, supplying a discharge pipe flowing into a tank.
3. Starting a group of open valve electric pumps.

4. Starting or stopping a pump delivering into a pipe that is already supplied.

III.9.2 Risks due to water hammer

In practice, the risks due to water hammer are significant:

a- Risk of high pressure:

Overpressures due to water hammer can be generated at more than the initial pressure; if their sum exceeds the maximum admissible pressure of the pipe, the latter may crack.

b- Negative pressure:

This pressure can appear either after a strong overpressure, or following an instantaneous stoppage of a pump if this pressure becomes lower than -10 mca

Adverse consequences can occur in the pipeline as a result of this negative pressure, such as pipeline implosion, suction of joints and detachment of the internal protective coating.

C- Driving fatigue:

The successive transition from overpressure to depression and vice versa can cause fatigue in the pipes; this phenomenon is very complicated in the case where the pipes are buried.

III.9.3 Means of prevention

Water hammer can cause accidents, but most often it is limited to ruptured pipes or the equipment connected to them. Lines carrying hazardous fluids require special attention during design, construction, and operation.

The following elements can reduce or eliminate water hammer:

- Reduce the water supply pressure by installing a pressure regulator.
- Reduce the fluid velocity in the pipe. To reduce the severity of water hammer, some sizing guides recommend a velocity equal to or less than 1.5 m/s.
- Install faucets with a slow closing speed.
- Use opening and closing procedures on an installation.
- The installation of a water hammer arrester, also called an anti-pulsation or anti-water hammer arrester .
- Set up a balance chamber .
- Reduce straight pipe lengths with elbows, as elbows reduce the influence of pressure waves.

- Use piping elements designed for high pressures (expensive solution).
- Install a flywheel on the pump.
- Install a pump bypass.
- Use an automatic pumping valve for the pumps.

III.9.4 Protection of pipes against water hammer

Water hammer protection is provided at the pumping station as well as at the pipe level.

III.9.3.1 At the pumping station:

Protection at the pumping station is achieved by using a flywheel, an air tank, etc.

The flywheel: This is a heavy cylinder, coupled to the pump, which absorbs some of the electrical energy at start-up, and as a result the pump will start slowly. Once the electrical current is cut off, this flywheel will release its kinetic energy to the pump so that it does not stop abruptly.

The flywheel is generally of little or no use, for the following reasons:

- ✓ This process is only used to limit depressions.
- ✓ In the case of a sufficiently large discharge pipe, it is necessary to consider flywheels with considerable weights, and therefore the system will not be economical in any case.
- ✓ Furthermore, the heavier the flywheel, the more powerful the motor must be to overcome the inertia of the flywheel when starting, which can lead to unacceptable current draws.
- ✓ This process is ultimately used for the protection of pipes with short or medium discharge lengths and which do not exceed a few hundred meters.

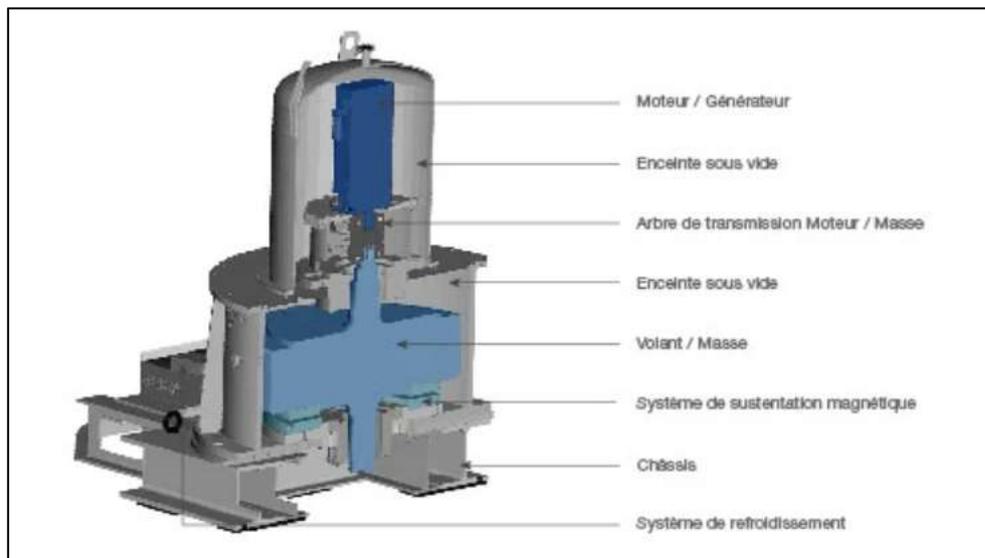


Figure III.12. Flywheel system with magnetic levitation and cooling.

The air tank

It is a tank filled with pressurized air that reduces overpressure and underpressure by further compressing or expanding the gas it contains. It is best to place it at the pumping station.

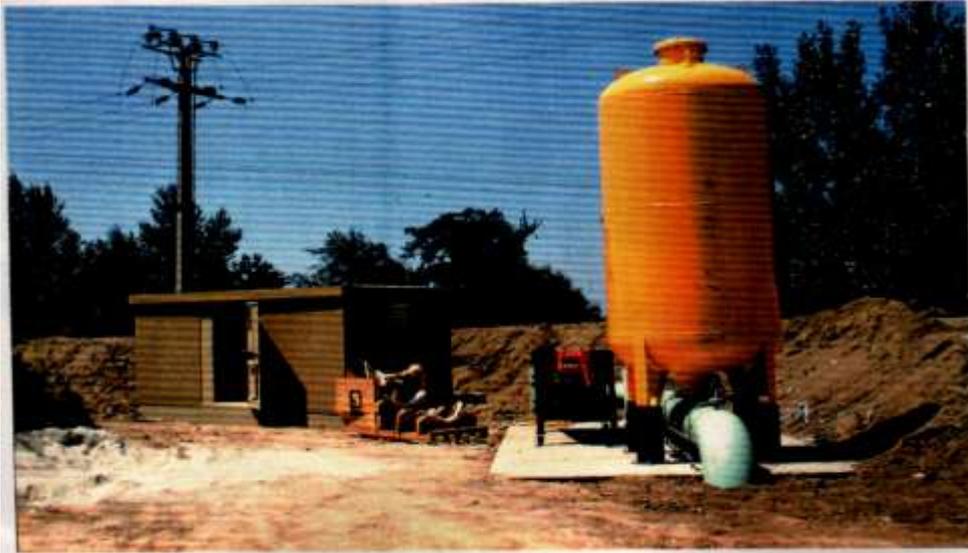


Figure 13. Location of the surge tank.

III.9.3.2 At the level of the pipes

- Balance Chimney

It is a structure that allows both overpressure and depression to be avoided, by retaining excess water or possibly releasing water, in order to cushion both overpressure and depression.



Figure 14. Equilibrium chimney.

- Relief valve

It is a device that opens and allows a certain flow to pass when there is excess pressure in the pipe exceeding the authorized limit. However, it has no effect against depressions.



Figure 14. Relief valve.

Conclusion

Protecting drinking water network structures is essential to ensuring a safe and continuous supply to populations. Whether through physical barriers, technological devices, or health measures, each protection tool meets specific needs in an increasingly demanding context regarding water quality.

Prevention, monitoring and the responsiveness of operators constitute the pillars of efficient management of hydraulic infrastructures, ensuring the safety of users and the sustainability of the public water service.

Useful links

- <https://youtu.be/QGrbuRI1BhM>
- <https://youtu.be/QGrbuRI1BhM>
- <https://youtu.be/kH-NcATBak>
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