THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 3 - 2024, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2024.3.01

STUDIES AND RESEARCH ON THE REPLACEMENT OF PIPES MADE OF STEEL P355N, INTENDED FOR DOMESTIC WATER

Beatrice Daniela TUDOR, Dumitra STERIAN
"Dunarea de Jos" Univeristy of Galati, Romania
e-mail: beatrice.tudor@ugal.ro

ABSTRACT

The paper presents an analysis regarding the need to replace pipes made of P355N steel, intended for domestic water. This replacement presents a necessity, due to the degradation and exceeding the lifespan of the domestic water network in the city of Galati. The microscopic analysis of the samples from steel pipe, shows an advanced degree of degradation of the steel pipes. The pipes will be replaced with polypropylene pipes, which have certain advantages in terms of corrosion resistance and in terms of ease of intervention in case of damage in the water network.

KEYWORDS: pipes, replacement, corrosion

1. General information regarding the drinking water supply system, in the municipality of Galati

The water distribution network serves 99.6% of the population of the city of Galati, which according to the last census is approximately 250,000 inhabitants. The city of Galati is fed from two sources: the surface source and the underground source.

The Danube is the source of raw surface water. The intake of raw water from the Danube is carried out through the outlet located on the left bank of the Danube, upstream of the confluence with the Siret, and is pumped through a Dn 1200 mm pipeline, with a length of 6 km, to the station for water treatment.

After micro-sieving (removal of solids) the raw water is treated with coagulants and reaches the decanters, where the turbidity of the water and the content of organic substances are reduced.

After settling, the water is directed to the filters, where an advanced water clarification process takes place by passing the settled water through a filter layer (quartz sand). This treatment step is the last clarification phase for drinking water production and has an essential role in obtaining quality indicators.

The filtered water is stored in tanks, where disinfection with chlorine gas takes place. The physico-chemical indicators, to control the quality of the water sampled, treated and distributed, is determined in the technological process laboratory, is within the Plant. The laboratory staff constantly monitors the characteristics of the water throughout the technological flow and sets the working doses for the water treatment reagents (aluminium sulphate and chlorine).

The raw deep-water source is represented by the two catchment fronts: Salcia-Liesti and Vadu-Roșca. The technical solutions required that the fronts be built approximately 70 km apart, one in the west of Galați city (Salcia-Liesti front), and the other in Vrancea county (Vadu-Roșca front). The aquifer is fed by the Siret River [1, 2].

From the two intakes, the raw water reaches the Șerbești Pumping Station, through a reinforced concrete and steel pipe, Dn 1200 mm, respectively Dn 1000 mm, for crossings, and from here to the Filești Pumping Station through two supply lines: Dn 1000 mm, respectively Dn 800 mm.

The water distributed from the catchment fronts is disinfected by chlorination in the Filești Pumping Station before being pumped into the distribution network.

From the surface source, the water is pumped into the distribution network directly or pumped back into the distribution network through Turnul de Apă and Traian Reservoir.

The drinking water distribution network of the municipality of Galati has a total length of 572 km.

In terms of the age of the drinking water networks, 24% have less than 10 years of use, 32% have between 10-36 years of use, 44% have more than 36 years of use.

Practically, more than 50% of the drinking water distribution networks in the municipality of Galati

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
Nº. 3 - 2024, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2024.3.01

have exceeded their normal operating life according to HG 2139/2004 (they have a usage life of more than 24 years [1, 2].

2. Study regarding of the need to replace degraded pipes made of steel P355N, intended for domestic water

The cumulative study of the data, shows us the need to replace degraded pipes made of P355N steel, intended for domestic water.

The rehabilitation of the sewage system contributes to the significant reduction of the quantities of pollutants, discharged into the water resources, and to the registration of the discharged wastewater in the quality conditions, regulated by the technical norm NTPA 001/2002 [6].

P355N steel domestic water mains are known for their high-pressure resistance and durability over time. P355N steel has high mechanical strength, being able to withstand high pressures and various environmental conditions. It is usually used in industrial applications and in the construction of underground water pipes.

The pipes used in the water distribution networks in the old water supply network were made of P 355 N steel. Although steel has advantages in terms of resistance to high temperatures, the weight with which an intervention is carried out after a damage to the supply system and last but not least its high cost, leads to the replacement of pipes with other lighter and more flexible materials [5].

Also, exceeding the normal duration of operation, led to their advanced corrosion, endangering the health of the population. Corrosion leads to reduced life of metal components, loss of structural integrity and high maintenance and replacement costs.

The pipes of the domestic water circuit suffered the phenomenon of corrosion, deposits of oxidizing residues and mineral deposits, and for this reason it is necessary to replace them with pipes made of polypropylene and polyvinyl chloride (Fig. 1).

Fig. 1. *The pipes with an advanced degree of corrosion and deposits*

In order to study the degree of degradation of the pipes in the distribution network, it took a sample from a pipe that needs to be replaced and was made a microscopic analysis of the surface (Fig. 2).

The analysis was carried out at the metallurgy-physics laboratory within the Faculty of Engineering, following examination with the optical microscope OLYMPUS BX51M.

The P355N steel sample was examined using an electron microscope. On both sides of the sample, it can be observed an advanced degree of oxidation and corrosion.

Following the examination, with the help of the electron microscope and with the help of a monitor, the image materialized that gives a wider view of the microstructure of the material (Fig. 3).

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
Nº. 3 - 2024, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2024.3.01

Sample preparation – side 1 *Sample preparation – side 2*

Fig. 2. *Preparing the sample for examination*

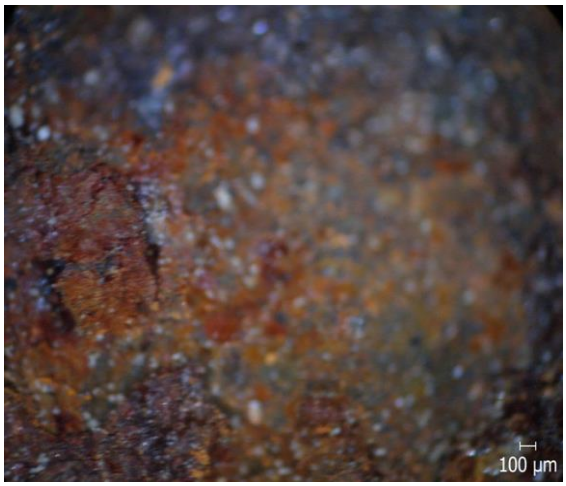

Fig. 3. *Microstructure of the material*

As can be seen, the surface is strongly corroded and almost entirely covered by oxides, requiring the urgent replacement of the P355N steel pipes, with polypropylene pipes.

Metal corrosion is the process of damage or degradation of metals as a result of their interaction with the environment. Corrosion usually occurs when metals come into contact with water, moist air, chemicals, or other elements that cause chemical oxidation reactions.

The main mechanism of metal corrosion is oxidation, where metals react with oxygen in the air or other chemicals in the environment. This process can lead to the formation of solid chemical compounds such as rust on iron or aluminium oxide on aluminium. These compounds are generally weaker and more brittle than the original metal, resulting in the loss of the metal's mechanical and chemical properties.

Corrosion of metals can have significant negative consequences in many fields, such as the chemical industry, building and ship construction, energy infrastructure and many others. This can lead to reduced life of metal components, loss of structural integrity and high maintenance and replacement costs.

To prevent or control the corrosion of metals, are used various methods, such as applying protective layers such as paints and enamels, using corrosion-resistant metals (such as stainless steel), adding inhibitory substances to the environment, or applying electrochemical protection processes such as galvanizing or anodizing.

Fig. 4. *Main steel P335N*

As can be seen in the Figure 4, the pipes of the domestic water circuit have suffered the phenomenon of corrosion, deposits of oxidizing residues and

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 3 - 2024, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2024.3.01

mineral deposits, and for this reason it is necessary to replace them with pipes made of polypropylene and polyvinyl chloride.

PP (polypropylene) pipes, and PVC (polyvinyl chloride) pipes, are used in a variety of applications, including potable water distribution systems, sewer and drainage systems, heating and cooling systems, irrigation systems, and more.

Polypropylene (PP) pipes have many advantages:

- Chemical resistance: PP pipes are resistant to a wide range of chemicals, including diluted acids and bases. This chemical resistance makes them suitable for use in the transport or storage systems of chemicals and aggressive fluids.

- Durability: PP pipes are durable and have a long service life. They are resistant to corrosion, rust and degradation, making them suitable for applications where durability is important, such as drinking water systems, heating and cooling systems, sewage systems and more.

- Impact resistance: PP pipes have good impact resistance, which makes them more resistant to mechanical damage or cracks compared to other materials. This aspect gives them a greater ability to cope with external forces and withstand difficult conditions of use.

- Light weight: PP pipes are lighter than other types of pipes such as steel or cast iron. This facilitates their handling, transport and installation, reducing the costs and effort required.

- Thermal resistance: PP pipes have good thermal resistance and can be used in a wide range of temperatures. They can withstand high and low temperatures, making them suitable for heating and cooling applications as well as transporting fluids at extreme temperatures.

- Pressure resistance: PP pipes can withstand high pressures, which makes them suitable for potable water distribution systems or other applications where pressure is important [3].

- Easy installation: PP pipes are flexible and can be installed easily. They are available in different shapes and sizes, and their connection can be done by various methods, such as welding, soldering or using special fittings. This facilitates installation and reduces the associated time and costs.

- Hygienic: PP is an inert material and does not allow the development of bacteria or the formation of deposits inside the pipes. This makes PP pipes suitable for use in potable water systems and other applications where hygiene is crucial.

Although polypropylene (PP) pipes have many advantages, there are also some disadvantages associated with them:

- Temperature sensitivity: PP pipes are more sensitive to high temperatures than other materials such as steel or copper pipes. In case of extreme temperatures or prolonged exposure to high temperatures, PP pipes can suffer deformation or even melting.

- Thermal expansion: PP has a higher coefficient of thermal expansion than other materials, which means that PP pipes can undergo significant expansion at large temperature variations.

- Resistance to extreme chemical shocks: Although PP pipes are resistant to a wide range of chemicals, there are some very aggressive chemicals that can damage or corrode their surface. In highly corrosive environments, other materials such as stainless-steel pipes may be more suitable.

- Pressure and diameter limitations: Compared to other materials such as steel pipes, PP pipes have lower pressure and diameter limitations. This means that thicker pipes or additional fittings may be required to provide adequate strength in high pressure applications or larger system sizes.

- UV protection: PP is sensitive to prolonged exposure to ultraviolet (UV) radiation from sunlight. If PP pipes are exposed to direct sunlight for long periods of time, they may suffer damage such as discoloration or embrittlement of the material.

The same disadvantages we find at the PVC pipes [4].

PVC domestic water mains do not provide the same thermal insulation as steel and may require the addition of additional insulation to control heat loss or prevent condensation. In addition, PVC mains may be more susceptible to noise generated by water flow compared to steel, and this may require additional soundproofing measures.

The rigid multilayered PVC-U pipes are used for buried sewage installations, comply with the SR EN 13476 quality standard and the maximum temperature at which they can be used is 60 °C.

Fig. 5. *Polypropylene pipes for the water network*

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
Nº. 3 - 2024, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2024.3.01

3. Conclusions

P355N steel domestic water mains are known for their high-pressure resistance and durability over time. P355N steel has high mechanical strength, being able to withstand high pressures and various environmental conditions. It is usually used in industrial applications and in the construction of underground water pipes.

PVC domestic water mains do not provide the same thermal insulation as steel and may require the addition of additional insulation to control heat loss or prevent condensation. In addition, PVC mains may be more susceptible to noise generated by water flow compared to steel, and this may require additional soundproofing measures.

P355N steel domestic water mains can be more expensive compared to PVC or PP. Steel is a more expensive material and the manufacturing process of steel mains can require specialized equipment. Steel mains can also be more complex and expensive to install and maintain.

PVC domestic water mains are generally more affordable from a financial point of view. Plastics are cheaper than steel and the manufacturing process of PVC busbars can be simpler and faster. PVC mains are easier and less expensive to install and maintain than steel mains.

Keeping these aspects in mind, PVC pipes are favourable for cities because there are lower costs involved, their easier maintenance of course, and the durability and fluidity of the liquids inside that they offer. We also take into account the fact that they are affordable in terms of price and installation and do not require such complex work as traditional ones.

In conclusion, this pipes are clearly superior to the traditional ones for the fact that they are financially more profitable, in addition to the other advantages that the PVC material offers.

More than 50% of the drinking water distribution networks in the municipality of Galati have exceeded their normal operating life. HG 2139/2004 (have a duration of use greater than 24 years) and it requires replacing the pipes.

The pipes used in the water distribution networks in the old water supply network were made of P355 N type steel. Although steel has advantages in terms of resistance to high temperatures, the weight with which an intervention is carried out following a breakdown in the supply system and last but not least its high cost, leads to the replacement of pipes with other lighter and more flexible materials.

References

[1]. ***, *Documentație internă Apă Canal Galați*.
[2]. ***, https://www.apa-canal.ro.
[3]. ***, https://materiale.pvgazeta.info/utilizator-164/avantajele-si-dezavantajele-tevilor-din-pvc-si.html.
[4]. ***, www.scribd.com/document/460594458/Policlorura-de-vinil-Neamtu-Svetlana.
[5]. ***, www.ro.wikipedia.org/wiki/Policlorur%C4%83_de_vinil.
[6]. ***, https://www.damila.ro/produse-metalurgice/tevi/tevi-sudate-elicoidal/tevi-sudate-elicoidal.html.