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THE IMPORTANCE OF MAINTENANCE OPERATIONS IN NATURAL GAS DISTRIBUTION SYSTEMS AND ANALYSIS OF MAINTENANCE PROGRAM FOR ŞANLIURFA PROVINCE

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ABSRACT

Maintenance is of utmost importance in the continuous and safe supply of natural gas to settlements via pipeline. In natural gas distribution systems, maintenance operations must be carried out in order to minimize gas leaks and explosion risk, reduce energy losses and save energy, provide uninterrupted service and comply with the obligations under the legislation. In this study, the importance of maintenance of the systems on the natural gas distribution line and the control and maintenance stages applied are examined. The maintenance and repair costs and working hours of the last five years for the natural gas distribution line in Şanlıurfa province were analyzed. It was observed that the increase in maintenance costs and durations for Şanlıurfa is related to the aging and wear and tear of the natural gas distribution infrastructure and equipment over time, as well as the pandemic and global economic crises. Inspection and maintenance works on natural gas distribution lines have been found to increase safety and contribute to preventing potential failures by increasing the efficiency of the system. In order to ensure continuous natural gas supply to end consumers, it has been determined that the creation of annual maintenance programs and their traceability in digital environment is extremely important. In addition, it has been determined that keeping the necessary records and creating operation and maintenance manuals to manage operation and maintenance operations in natural gas supply are important issues.

Keywords: Natural gas distribution network, operation, maintenance, Şanlıurfa.

1. INRODUCTION

Natural gas is a non-renewable energy source that plays a critical role in meeting the energy needs of societies and stands out with its environmentally friendly features. The safe, uninterrupted and continuous delivery of this energy source to the end consumer depends on the effective operation of natural gas distribution lines. However, the safe and efficient operation of these lines is not only based on the quality during the construction phase; regular and meticulous maintenance operations are also of great importance. Over time, these lines may be subject to wear and deterioration due to environmental factors, mechanical stresses

and intensity of use. Therefore, regular maintenance works play a critical role in preventing potential hazards and ensuring energy supply security.
Within the scope of the license, natural gas distribution companies are under certain legal and technical obligations to ensure the safety and continuity of distribution lines. These obligations include regular maintenance and inspection work, effective use of gas leakage detection systems, and the creation and periodic review of emergency response plans. In addition, operating the network in accordance with current legislation and safety standards, minimizing environmental impacts and ensuring user safety are among the primary responsibilities of licensed companies. These obligations are of great importance in terms of protecting energy supply security and public safety.
The main threats to natural gas distribution lines include damage to pipelines during construction activities, underground leaks, and damage caused by rodents. In addition, natural disasters such as earthquakes and floods can cause cracks, breaks, displacements, and damage to connection points in underground pipelines, leading to energy outages and gas leaks. Gas leaks and leaks grow over time, reducing energy efficiency and increasing security risks. Regular inspections and the use of leak detection technologies are of great importance against these risks. In this study, the maintenance stages in natural gas supply to residential areas were analyzed and the operation and maintenance in natural gas supply for Şanlıurfa province were explained with sample applications.

2. NATURAL GAS SUPPLY

Maintenance and operational processes are of critical importance in the distribution process of natural gas from source to consumer. Because natural gas transportation and distribution systems are lines where gas is transported under pressure and require high security, maintenance work carried out in this process both increases security and ensures the efficiency of the system. Figure 1 shows a schematic representation of natural gas supply from source to end consumer via pipelines.

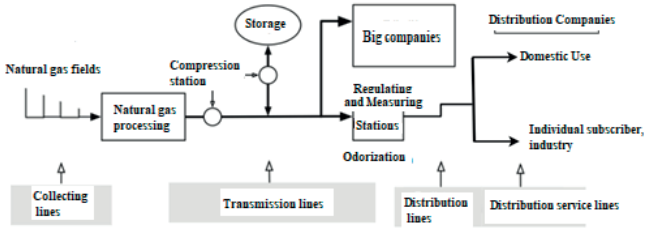

Figure 1. Natural gas lines from source to end consumer

2.1. . Natural Gas Distribution Line

Natural gas distribution lines refer to the line that the gas taken from the City Entry Station, which is the delivery point of the national gas supplier BOTAŞ, follows until it reaches the end user within the city. This line constitutes the last section of the natural gas transportation system and ensures that the gas is distributed safely and efficiently from industrial facilities to homes. Distribution lines vary according to the different needs of the infrastructure and consist of steel (ST), Polyethylene (PE) and service pipelines at a certain pressure level [1].

2.2. . Pressure Regulating and Metering Stations

Natural gas needs to be stored, measured and reduced to the appropriate pressure in order to be distributed safely to industry and residences. For this purpose, there are Regulating and

Metering Stations (RMS) on natural gas distribution lines. RMS stations are classified as Type A, Type B and Type C according to the level of gas pressure reduction [2]. Type A stations are systems operating under high pressure and include heaters. These stations also include ball valves, regulators, filters, manometers, thermometers, gas safety valves and measurement meters. Type B and C stations are designed for lower pressure needs and include some of these components [3].

3. MAINTENANCE AND SAFETY IN DISTRIBUTION LINES

Regular maintenance on natural gas distribution lines minimizes security risks and ensures uninterrupted service. Valves are located at strategic points to direct gas flow along distribution lines and to provide gas cut-off in emergency situations. Cathodic protection is a technique used to protect metal pipelines and other underground structures from corrosion. Regular cathodic protection measurements should be made to prevent oxidation and corrosion of metal pipes in natural gas systems. The cathodic protection system is checked regularly in measurement boxes [4].

In order to ensure traceability of natural gas lines and on-site determination of maintenance needs, line marker poles have been placed indicating the route of the line. These poles indicate the underground location of the line and provide accurate information to maintenance teams.

By monitoring the natural gas distribution pipeline with digital monitoring and analysis systems, the performance of the system can be tracked and maintenance needs can be proactively identified. In this way, faults on the distribution lines can be detected instantly and interruptions can be prevented by rapid intervention [5]. Supervisory Control and Data Acquisition (SCADA) systems are an important part of digitalization in the natural gas sector. The SCADA system plays an important role in fault prediction, energy optimization and risk management with remote control, automation and data analysis. In this way, operational costs are reduced, energy efficiency is increased and systems become more secure. Natural gas distribution companies monitor and control the gas distribution line instantly with the SCADA system. Anomalies occurring on the line are sent to the control centre as a SCADA warning via SMS and email.

3.1. Maintenance of RMS/A Type Stations

A- Type Gas Pressure Regulating and Metering Station – RMS/A is an important part that plays a key role in regulating gas pressure in gas supply and ensuring its safe distribution. Regular maintenance of these stations is vital for the efficiency and safety of the operation. During maintenance processes, operations such as preventing gas leakage risks, maintaining the sensitivity of regulators and measuring devices, checking valves and cleaning filtration systems are meticulously carried out. Thus, the continuity and safety of natural gas are guaranteed, and possible interruptions and risks are minimized. Şanlıurfa RMS/A OSB station is shown in Figure 2.

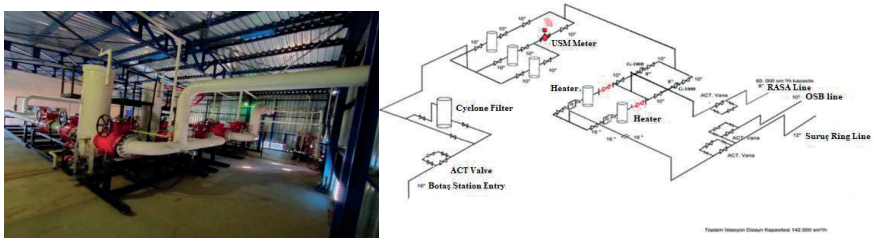

Figure 2. Şanlıurfa RMS/A OSB Station

In the RMS/A Type station, simple but critical operations such as filters, gas leakage, environmental lighting and area cleaning are performed on a monthly basis. Main equipment such as regulators, safety valves and meters are checked at longer intervals of 3 or 6 months. General maintenance of the system, such as complete maintenance of regulators, meter calibration and generator maintenance, are carried out annually. The maintenance and control operations carried out in the RMS/A Type station are given below. Figure 3 shows pictures of some maintenance and controls. As can be seen from the figures, occupational health and safety rules must be followed.

1. Filter and Equipment Control: The cleaning and functionality of filters is a critical process in RMS/A stations. During gas flow, clogging or contamination of the filter can cause disruptions in natural gas flow. This control process is usually carried out monthly. During the control of filters, gas pressure levels and flow rates are carefully examined.
2. Regulator and Equipment Control: Regulators are one of the most important components of the station and reduce the pressure of the gas and transfer it to the system. Regulator maintenance is carried out every 6 months and the regulators are tested to see if they adjust the gas pressure correctly. At the same time, the opening and closing mechanisms of the regulator valves are checked.
3. Safety and Relief Valve Control. These valves are activated in case of excessive pressure increase and ensure the safety of the system. Regular control of safety and relief valves is an important precaution especially in cases where pressure problems occur. Valves are checked every 6 months and tested for mechanical free operation.
4. Meter and Equipment Control: Meters are important equipment that ensures accurate measurement of natural gas. Checking whether the meters are working properly is critical for accurate calculation of gas quantity. Maintenance of meters is done annually and the measurement accuracy of the meters is tested. At the same time, the mechanical and electrical equipment on the meter is reviewed.
5 .. Gas Leakage Control. Gas leaks are one of the biggest risk factors in natural gas systems. Therefore, leakage control should be carried out at regular intervals in RMS/A stations. During leakage control, all pipelines, valves and connection points are scanned with gas detectors. When a leak is detected, immediate intervention is carried out.
6. Automation and Communication System Control: Automation and communication systems in RMS/A stations enable remote monitoring and control of the stations. Periodic maintenance of these systems is of vital importance, especially in emergency situations, for the activation of automatic systems. UPS (Uninterruptible Power Supply) system maintenance is also included in these processes. Battery levels, energy backup capacities and connection checks of UPS systems are performed.

RMS/A Filter Control

Regulator Control

Gas leakage Scanning Vehicle and Laser Detector

Figure 3. Some Maintenance and Control Procedures

3.2. Steel Valve Inspection and Maintenance

It helps protect valves, connection points and other equipment that are important for the safe transportation and distribution of natural gas. Manhole covers are resistant to external factors

(such as weather conditions, vehicle traffic). Before the manhole cover is opened, gas leakage is checked (Figure 4) and the ventilation hole is tested. In addition, the manhole cover is physically checked by looking at the surrounding concrete, cleanliness, water availability and paint coating conditions.
1.Valve Nameplate Control: It is checked whether the plate is in place and the information on it is legible.
2. Gas Leakage Control: Detectors are used to check whether there are any leaks in the valve discharge and lubrication pipes.
3. Check the Drain and Lubrication Valve: Ensure that the valves are in the closed position. Check the paint, coating materials and signs of corrosion on the valve.
4. Valve Position Control: It is examined whether the valve is in the correct position. The operation of the body discharge valve is tested (Figure 5).
5. Reducer Control: The reducer cover, body and rotation shaft box are visually inspected for cracks or breaks. The reducer is tested by quarter turning.

Before entering the valve room, gas leaks are checked. The paint coating of the valve and connection group is checked for damage. The valve's sealing bearings are cleaned and lubricated. The reducer is cleaned and lubricated with grease. These maintenance steps should be performed regularly to ensure the effective operation of steel valves and the safety of the system. These operations are carried out by field personnel such as maintenance engineers, technicians and team leaders. Valves are checked every 6 months, while comprehensive maintenance is applied annually.

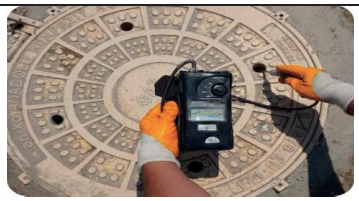

Figure 4. Manhole Cover Leakage Test

Figure 5. Embedded Valve Control

3.3. RMS/B (Regional Regulator) /RMS/ C (Customer Station) Control and Maintenance Processes

The stations that reduce the 20 bar pressure natural gas in the steel line to 4 bar and deliver it to the polyethylene distribution line in order to meet the gas demand of a certain region are called RMS/B (Regional Regulator). Inspection and maintenance procedures are carried out to regulate gas pressure, control gas flow and maintain the functionality of various equipment at the Regional Regulator and customer stations. The following maintenance and inspections are carried out:
1. Embedded Valve Control: The solidity of the valve cover, its surroundings and the ground structure is checked. Gas leakage is checked from the sleeve with a measuring device.
2. General Valve Control: Valves that must be closed and open are checked and their functionality is tested.
3. Cabin Checks: The external appearance of the cabin, paint, hinges, wire fences and bases are checked. Before opening the cabin, the ventilation ducts are checked for leaks. If a leak is detected, the cabin is carefully opened and the leak is pinpointed.
4. Pressure Controls: Inlet and outlet pressures are measured and processed into the system.
5. Differential Manometer Check: The differential pressure is checked.

6. Filter and Equipment Maintenance: Filters are checked for cleanliness and functionality. If there is any clogging in the filters, they are replaced.
7. Meter and Equipment Maintenance: Meters and connected equipment are checked for functionality and maintained as necessary.
8. Regulator and Equipment Maintenance: Regulators are periodically maintained to maintain the accuracy of pressure settings.
9. Safety and Relief Valve Maintenance: Safety valves are checked once a month and when faulty valves are detected, they are replaced after taking environmental safety into account.
10. Steel Valve Maintenance: Steel valves are periodically inspected and maintained. Necessary precautions are taken against corrosion by checking paint and coating.
11. Insulation Gasket Control: Physical control and electrical leakage controls are performed to ensure that the insulation gasket is protected from high electric current. Short circuit measurements are performed with a multimeter.
12. Polyethylene Valve Control and Maintenance: Polyethylene (PE) valves are one of the critical components of natural gas lines. Below are the inspection and maintenance tasks of PE valves:
13. Gas Leakage Control: Before opening the valve cover, a gas leakage check is made from the ventilation holes of the cover. A gas detection device is used for this process and the suction hose of the device is immersed at least 5 cm from the cover hole to measure the gas. If a leak is detected, the necessary interventions are made. If the leak cannot be eliminated, the valve may need to be replaced with a new one.
14. Valve Cover and Level Control: The valve cover (side -hole cover) must be at the same level as the surface on which it is located. In areas open to vehicle traffic, the cover must be 1 cm above the ground and 2 cm above the ground in other areas. If the cover cover pipe is broken, slipped or damaged, it is repaired and the interior is cleaned.
15. Valve Maneuver Controls: Valve opening and closing operations are performed at certain rates (20%) to check whether the valve shafts are working properly. Problems detected during this process are recorded in the maintenance list. Valve opening and closing operations should be performed at least once a year, especially in the summer months.
16. Cleanliness Check: If mud, water deposits or other foreign substances have accumulated in the inner parts of the valves, these areas are cleaned. If there are cracks or breaks in the cover or lid, they are replaced. If cleaning is not done, the valve may not close completely or may not open completely when closed. In this case, there may be a risk of gas leakage in the valve core.
17. Nameplate Control: The valve's nameplate and the information on it are checked.
18. Surrounding Concrete and Frame Condition: The concrete and frame condition around the valve is checked. Cover pins and cotter pins (elements that secure the nuts) are checked, cleaned and adjusted if necessary.

3.4. End of Line Pressure and Odour Measurement

In natural gas distribution networks, the end-of-line pressure measurement is performed regularly before the gas reaches the end consumer to ensure that the gas is delivered safely and efficiently. The measured and recorded pressure values are used to check whether the pressure is in the appropriate range in the network. Typically, the end pressure in natural gas distribution networks should be between 21 mbar and 25 mbar, but these values may vary depending on the system and region used. If the measured pressure values are below or above normal, it may be a sign that there is a problem in the line. A drop in pressure usually indicates a gas leak, a pipeline blockage, or a problem with the regulators. In such a case, the line is checked in detail by the technical team and the necessary corrective measures are taken.

End-of-line odour measurement is critical for the safe use of gas in natural gas networks. Natural gas is naturally odourless and is added with a special chemical, usually THT (Tetra Hydro Theophene) is added. In this way, gas leaks can be detected by smelling. End-of-line odour measurement is done to ensure that the gas is odorized at a sufficient level. End-of-line odour measurement is done at the point where the natural gas reaches the end user or at points near the end of the network. This is usually the customer station or the regional regulator outlet. The odour level in the network should be equal at all points in the gas distribution line; therefore, measurements can be made at different points. If the measured odour level is low, there may be a problem with the odorization system of the gas. In this case, adjustments may need to be made to the odorized unit. The odour level of the gas can be increased by adding odorants.

4. COST OF MAINTENANCE AND REPAIR PROCESSES IN NATURAL GAS DISTRIBUTION ENTERPRISES: ŞANLIURFA CASE

Maintenance and repair processes can create a significant cost for natural gas utilities, which ensure that the infrastructure remains operational at all times and guarantee uninterrupted service to consumers. Figure 6 shows the ratio of maintenance and repair costs to total operating expenses in Şanlıurfa province gas distribution company by years [6]. Figure 6 shows an increasing trend in the share of maintenance and repair in total operating expenses by year. The increase in the maintenance and repair rate observed between 2020 and 2024 has emerged as a result of many factors such as aging of the infrastructure, increasing labour costs, inflation and energy price increases, and new subscriptions and network expansion projects. Reducing these costs in natural gas companies can be possible with strategies such as effective maintenance planning, technological investments, and energy efficiency. However, if the increase in inflation and input costs continues, natural gas companies need to focus on long-term planning and optimization strategies in order to balance these costs. The increase in costs seen in 2021 and later is due to ongoing supply chain problems, increases in energy and raw material prices, and production costs, despite the recovery from the pandemic effects worldwide.

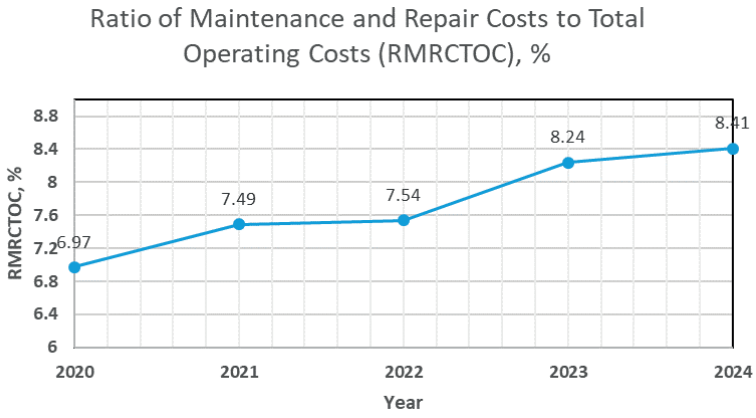

Figure 6. Change in the ratio of maintenance and repair costs to total operating expenses in Şanlıurfa province gas distribution company over the years.

Figure 7 shows the change in natural gas maintenance and repair times over the years [6]. The increase in maintenance hours every year indicates that the equipment in the network is

aging or the network is being expanded and therefore requires more maintenance. As infrastructure systems wear out over time, maintenance requirements increase accordingly. In addition, this increase also shows that the growth of the company, commissioning of more equipment or completion of new projects require more maintenance time. Maintenance hours per person have generally remained stable. In general, despite the increase in maintenance needs and jobs over the years, the fact that the time per person has not increased too much in the graph shows that the number of personnel has been increased in balance with the maintenance process or that efficiency has been achieved in maintenance processes. Figure 7 shows that although maintenance activities have generally increased, the workload per person has been kept under control by optimizing the workforce. This situation reveals the importance of planning and optimization in maintenance processes.

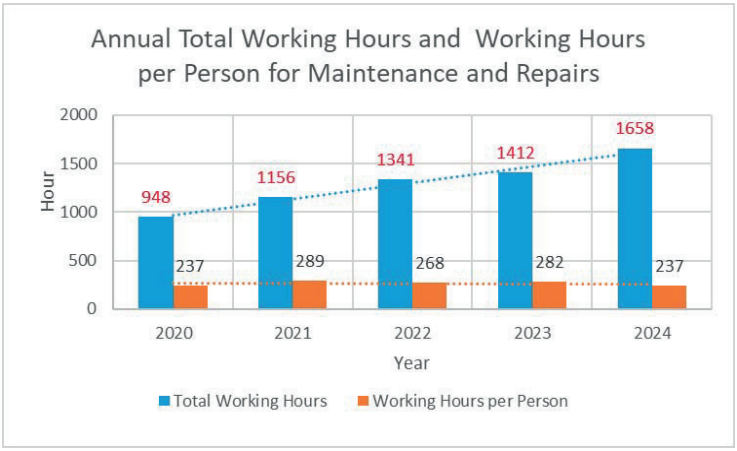

Figure 7. Change in Natural Gas Maintenance and Repair Times over the years

5. PREDICTIVE MAINTENANCE CONTROL

Table 1 shows the predictive maintenance checks and periods of equipment and systems in natural gas distribution lines [6]. The check period of each equipment is determined according to its importance in operation. For example, systems that require regular maintenance such as filters and meters are checked monthly, while less critical equipment such as steel valves and electrical installations are checked at longer intervals. Planned periods allow maintenance teams to use their workforce efficiently and help prevent potential failures. Thus, the safety and operational efficiency of natural gas systems are maintained.

6. PERIODIC PLANNED MAINTENANCE

Maintenance processes and estimated times for systems and equipment in natural gas distribution lines are given in Table 2 [6]. Maintenance is performed every 1, 2, 3 or 5 years depending on the importance of the equipment. For example, critical equipment such as filters, regulators, meters and valves are checked at more frequent intervals, while maintenance of other systems is performed at longer intervals. Maintenance times vary according to the complexity of the process and generally range from 60 to 360 minutes per piece of equipment.

Table 1. Predictive maintenance controls and durations in natural gas distribution lines

Process Description	Control Period (Month)				Planned Estimated Implementation Time (min /man)
	1	3	6	12	
Filter and Equipment Control	X				30
Control of Meters and Equipment	X				30
Regulator and Equipment Control		X			30
Safety and Relief Valve Control		X			30
Inlet and Outlet Actuated Valve Control		X			30
Steel Valve Control			X		30
Heating System Control	X				120
Gas and Smoke Detectors Control			X		30
Station Area General Environmental Control	X				30
Automation/Communication/UPS System Control			X		30
Electrical Installation Control				X	30
Gas Chromatograph Unit Control		X			240
Gas Leak Control	X				30
Generator Control		X			120
Control Switches Control			X		30
Insulation Gasket Control			X		30
Cathodic Protection Transformer/Rectifier/Drainage Unit			X		30
Natural Gas Stations Grounding Measurement Control				X	20
Transformer Facility Control				X	20
Odor Injection Unit Control	X				240

Table 2. Periodic Planned Maintenance and Durations

Process Description	Maintenance Period (Year)				Planned Estimated Implementation Time (min /man)
	1	2	3	5	
Filter and Equipment Maintenance	X				120
Maintenance of Meters and Equipment				X	360
Regulator and Equipment Maintenance		X			240
Safety and Relief Valve Maintenance		X			60
Inlet and Outlet Actuated Valve Maintenance		X			60
Steel Valve Maintenance		X			120
Heating System Maintenance	X				180
Station Piping, Instrumentation and Chassis Paint			X		360
Automation/Communication/UPS System	X				60
Cathodic Protection	X				60
Gas Chromatograph Unit Maintenance	X				60
Gas, Flame and Smoke Detector Maintenance		X			60
Generator Maintenance	X				240
Air Conditioning and Combi Boiler Maintenance	X				60
Control Switch Maintenance	X				60
Fragrance Injection Unit Maintenance	X				360
Transformer Facility Maintenance		X			60

7. CONCLUSION AND RECOMMENDATIONS

This study has shown that maintenance and control activities carried out in natural gas distribution lines are very important in terms of increasing safety and sustainability of system efficiency. Regular control and maintenance of natural gas distribution lines minimizes gas leaks and explosion risks, ensuring energy supply security. Reducing safety risks in lines where natural gas is transported under high pressure is not only a legal obligation but also a vital importance in terms of public safety.

Maintenance operations carried out on different components of distribution lines such as pipelines, regional regulators and customer stations should be supported by technical

operations such as gas leak detection, keeping cathodic protection systems active and regular checks of regulators. Especially in regions exposed to natural disasters such as Şanlıurfa, the security of the system should be increased by increasing the durability of the infrastructure and establishing emergency response plans. Regular maintenance operations carried out within this scope contribute to reducing costs by increasing energy efficiency and also minimizing environmental risks.

In the study, it was observed that with the use of digital monitoring systems (e.g. SCADA), maintenance needs can be determined proactively and possible faults can be detected at an early stage, thus accelerating the intervention process. This digitalization process has enabled maintenance programs to be carried out more efficiently and ensured the effective use of the workforce. Data analysis and remote monitoring opportunities provided by digitalization offer great advantages, especially for distribution networks spread over large geographical areas. Each maintenance process must be recorded and tracked through systems such as SAP PM (Plant Maintenance) Maintenance and Repair module.

The study found that the increase in maintenance costs and durations for Şanlıurfa is related to the aging and wear of the natural gas distribution infrastructure and equipment, as well as the pandemic and global economic crises. The increases in the costs of maintenance activities reveal the need for large-scale renewal projects in the system and the importance of continuously modernizing the infrastructure. It was concluded that in order for the network to operate safely and efficiently in the long term, periodic control and maintenance activities should be carried out regularly and this process should be supported by digital monitoring.

In summary, this study has revealed that maintenance operations in natural gas distribution lines are critical not only in ensuring safety but also in increasing energy savings and system efficiency. In particular, the integration of digitalization and maintenance management processes is of strategic importance in ensuring the sustainability of the energy infrastructure. As in the Şanlıurfa example, making natural gas distribution systems traceable on digital platforms is one of the best practices in terms of preventing failures and optimizing maintenance processes.

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