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PS2: Impact of Net Zero on the Lifetime Management of SF_6 filled equipment

Paper No: 106

SF_6 gas management in substations

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SUMMARY

As attention to climate change issues increases, decarbonisation efforts are accelerating around the world. The Chubu Electric Power Group has set the "Zero Emissions Challenge 2050" to achieve net-zero greenhouse gas emissions across its operations by 2050 as a new goal in its efforts to "contribute to the realisation of a decarbonised society". SF_6 gas is widely used as an insulating medium in gas insulated switchgear (GIS) due to its excellent electrical insulation properties. However, since the global warming potential (GWP) of SF_6 gas is very high at 25,200, Chubu Electric Power Grid (hereinafter referred to as "CHUBU PG"), one of the companies of the Chubu Electric Power Group, is promoting the introduction of SF_6 alternative gas equipment. On the other hand, because CHUBU PG has a very large number of SF_6 gas equipment in its substations, it would take a long time to replace all of them with SF_6 alternative gas equipment. Therefore, during the transition period, it is important to control the amount of SF_6 gas released into the atmosphere by properly managing the existing SF_6 gas equipment. This paper presents CHUBU PG's approaches to improving the management of SF_6 gas equipment.

KEYWORDS

SF_6 gas, Gas management, Carbon-neutral, Environmentally friendly

1 Introduction

In recent years, extreme weather events have become more frequent in many parts of the world, and the damage caused by natural disasters has increased. Global warming is thought to be one of the causes of extreme weather events. Under the Paris Agreement adopted at COP21, more than 120 countries have pledged to achieve a carbon-neutral society by 2050[1]. In October 2020, Japan also declared its goal of achieving net-zero greenhouse gas emissions by 2050 to combat global warming. In Japan, greenhouse gas emissions from the power sector account for approximately 85% of total emissions, [2] so the power industry needs to take a more proactive approach. The Chubu Electric Power Group has set the "Zero Emissions Challenge 2050" to achieve net-zero greenhouse gas emissions from all Group operations by 2050[3], as a contribution to the realisation of a decarbonised society. In this roadmap, as shown in Figure 1, one of the actions in the power transmission and distribution sector is the introduction of SF_6 alternative gas equipment.

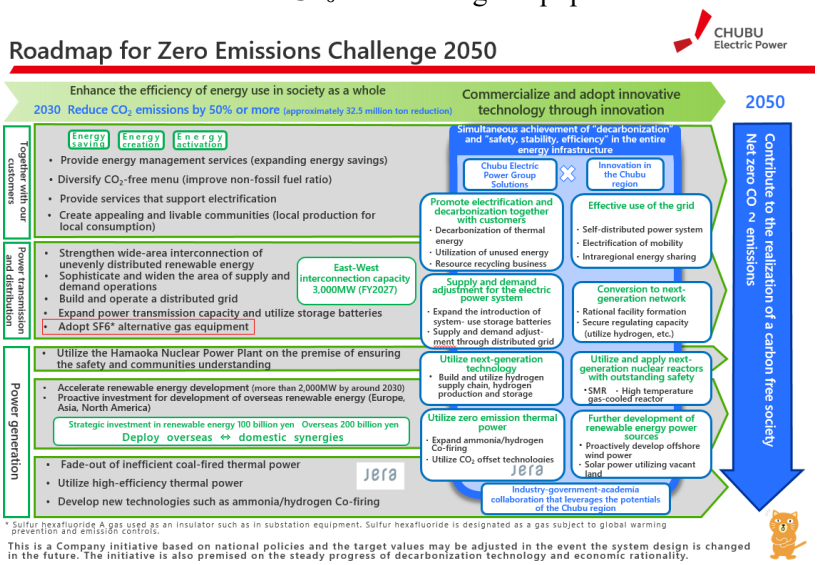


Figure 1: Chubu Electric Power Group's Zero Emissions Challenge 2050

SF_6 gas has been widely used as an insulating medium in gas insulated switchgear (GIS) and other electrical power equipment due to its excellent insulating and arc extinguishing performance and extreme stability. However, SF_6 gas has a very high global warming potential (GWP) of 25,200 and is designated as one of the greenhouse gases to be reduced by COP3 due to its high environmental risk when emitted into the atmosphere.

Against this background, CHUBU PG, a member of the Chubu Electric Power Group, is promoting the adoption of SF_6 alternative gas equipment. However, as shown in Figure 2, CHUBU PG has a lot of existing SF_6 gas equipment (e.g. about 5,700 GCBs and 4,000 GIS), so it would take a long time to replace them all with SF_6 alternative gas equipment. Therefore, during the transition period, it is important to control the amount of SF_6 gas released into the atmosphere by properly managing existing SF_6 gas equipment.

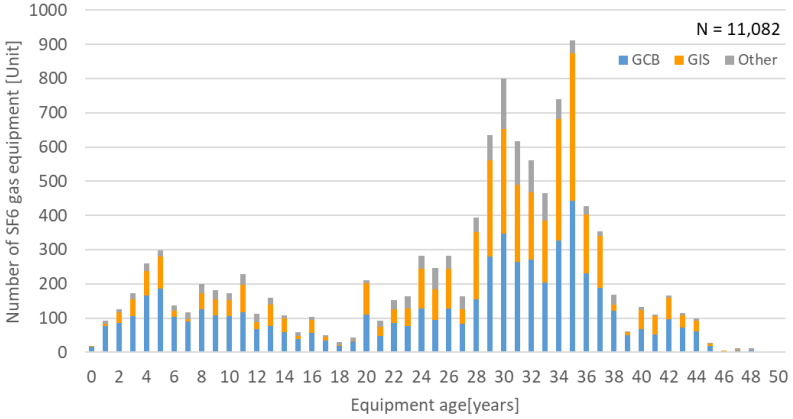


Figure 2: Number of SF6 gas equipment by age in Chubu Electric Power Grid

2 CHUBU PG's approaches to improve the management of SF_6 gas equipment

2.1 Minimisation of SF_6 gas holdings and systemisation of gas amount recording

After SF_6 gas was designated as a greenhouse gas at COP3 in 1997, the power industry in Japan set targets 97% of recovery rate for equipment inspection and 99% recovery rate for equipment removal in its SF_6 gas handling standard. [4] Based on this, Japanese power companies, including CHUBU PG, have been handling SF_6 gas more carefully to reduce gas leakage. In addition, CHUBU PG has improved its own gas management in various ways to control SF_6 gas emissions, as described below.

About 20 years ago, CHUBU PG had as much as 26 tonnes of SF_6 gas in cylinders due to frequent purchases of gas for replenishment during breakdown handling and each equipment inspection. The fewer cylinders we have, the easier it is to manage the amount of gas. The minimum amount of SF_6 gas required to maintain the equipment has therefore been reviewed. CHUBU PG has also revised its policy so that only sampled equipment is inspected during overhaul inspections, which were previously carried out on a 12-year cycle for all gas equipment to monitor the deterioration of components in the equipment. In addition, the development of new gas recovery equipment has improved the gas recovery rate during gas equipment overhaul inspections.

As a result of these efforts, it was found that the amount of SF_6 gas to be stored could be significantly reduced. Therefore, CHUBU PG has decided to stop purchasing SF_6 gas for each inspection and to use the SF_6 gas already in stock for the installation, replacement and inspection of SF_6 gas equipment. In this way, as shown in Figure 1, CHUBU PG has reduced the amount of SF_6 gas stored in cylinders by approximately 80% from 1999 (26 tonnes) to 2021 (5 tonnes).

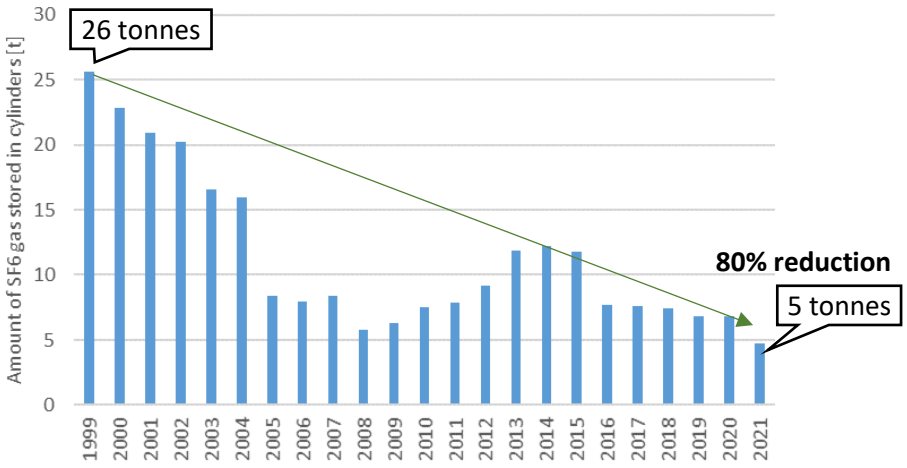
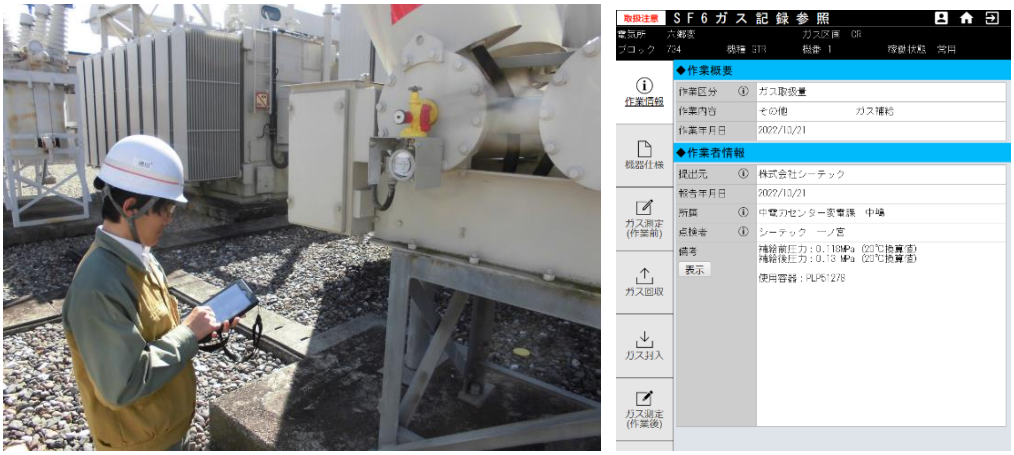


Figure 3: Amount of SF6 gas stored in cylinders in Chubu Electric Power Grid

CHUBU PG has also improved the way it records the amount of SF_6 gas handled. Previously, paper forms were used to record the handling of SF_6 gas. After receiving reports on the amount of gas contained, collected and removed on paper forms, staff had to manually input, aggregate and transcribe the data into various forms for internal records and external reports. As the amount of SF_6 gas handled had to be tracked for a very large number of equipment, a lot of time was spent filling in and checking forms. To solve this problem, a system has been developed that automatically generates record and report forms when gas handling amounts are input into a tablet terminal on site, as shown in Figure 4. The overview of the new management system is shown in Figure 5. This system has made the management of SF_6 gas more efficient by reducing the time and effort required to collect and transcribe data and by eliminating errors associated with manual work.



(a) On-site input (b) Example of system screen

Figure 4: Tablet terminal for on-site input of gas handling data

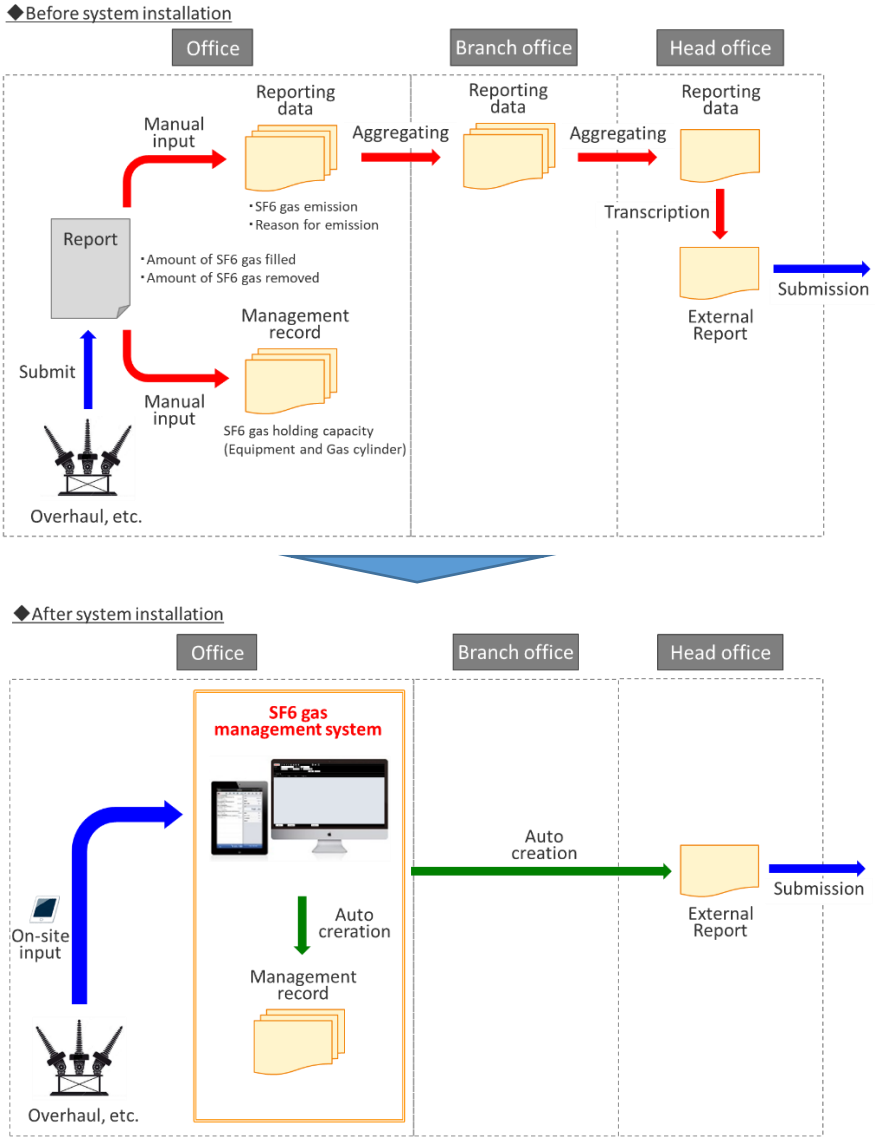


Figure 5: Improvement of SF_6 gas recording methods

2.2 Prevention of gas leakage by caulking

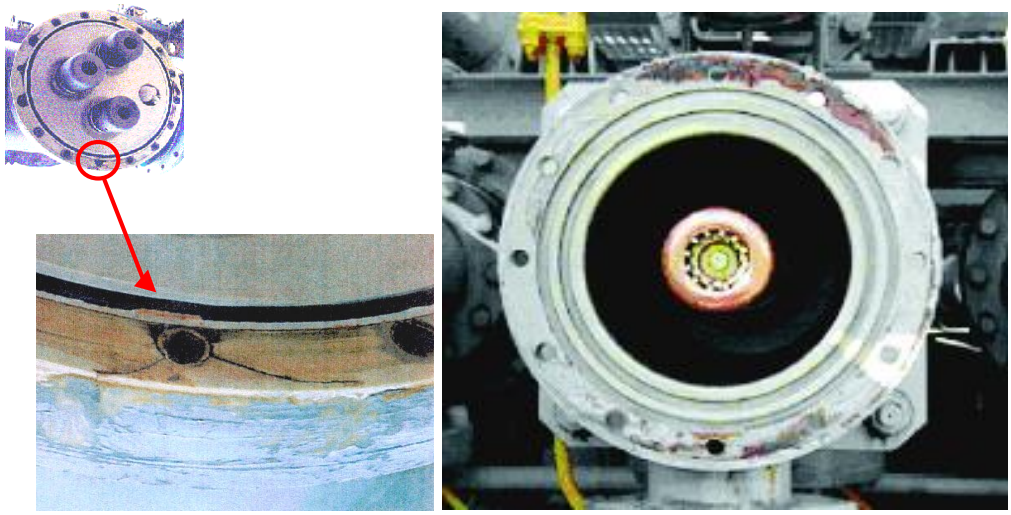
While the previous section described improvements in the efficiency of gas management, it is also important to prevent and reduce gas leakage from SF_6 gas equipment.

In the past, gas leaks have occasionally occurred due to "spacer cracking due to icing" and "corrosion of the O-ring sealing area" caused by rainwater ingress through the flange of SF_6 gas equipment, as shown in Figure 6. Since it is very difficult to replace all the gaskets in a GIS, the service life of the gaskets practically determines the life of GIS.

Therefore, CHUBU PG has tried to extend the life of the GIS by caulking the bolted part of the GIS flange to prevent rainwater ingress. Initially, measures to remove the existing caulking and then re-caulk were implemented once every 12 years for each GIS. However, the problem was that the removal of the existing caulking required considerable time and effort. Research was carried out into methods of improving the efficiency of the caulking operation while maintaining the watertight performance of the caulking. This led to the following findings, which we have adopted as a new labour-saving caulking policy.

(1) The waterproofing performance can be achieved by applying a thick layer of caulking material over the existing caulking without removing the existing caulking, as shown in Figure 7. The simplicity of this operation means that the quality of the finished work does not vary according to the skill level of each worker and it is easy to maintain the waterproofing quality above a certain level.

(2) Tensile and watertightness tests were carried out on test flanges caulked by the method described in (1) after accelerated degradation. The test results indicated that the re-caulking cycle could be extended from 12 years to approximately 40 years. Taking into account the safety margin and the GIS inspection cycle, the re-caulking cycle was set once at 24 years.



(a) Spacer cracking due to icing (b) Corrosion of O-ring seal area

Figure 6: Gas leaks from the flange of SF_6 filled equipment

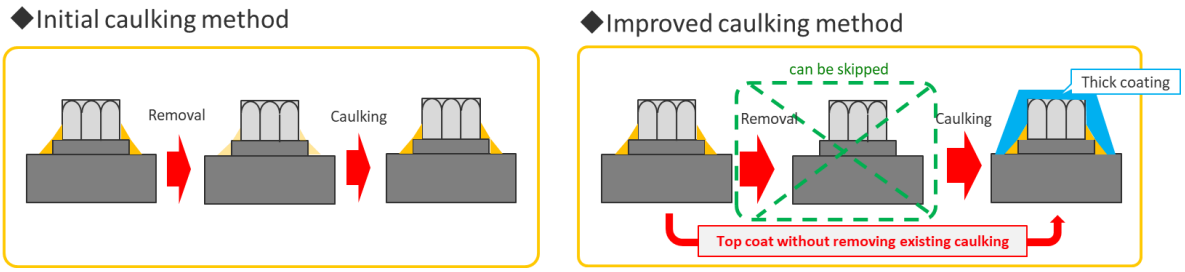


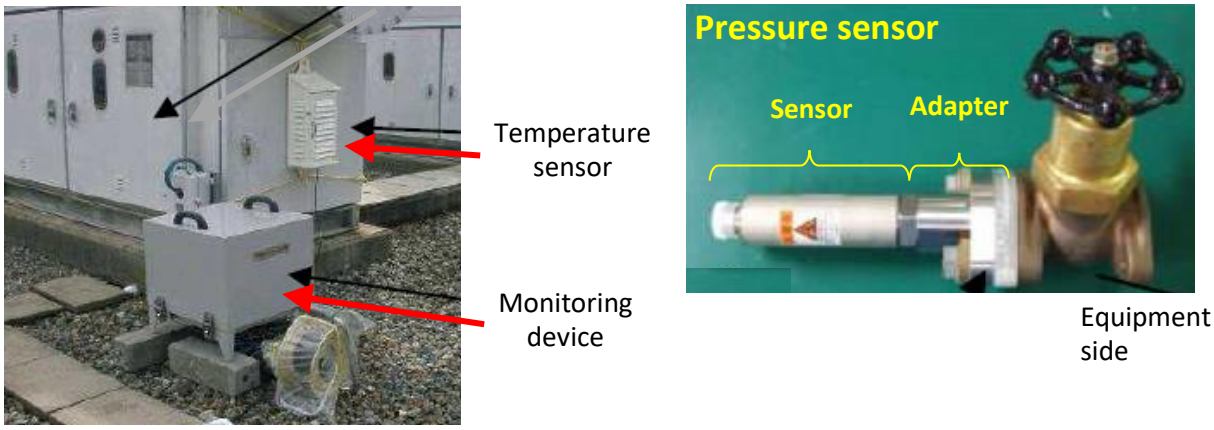
Figure 7: Improved caulking medhods of flanges on SF_6 gas equipment

2.3 Deployment of gas slow leak monitors

The previous section described methods to prevent gas leaks from GIS. On the other hand, it is also important to detect gas leaks from SF_6 gas equipment at an early stage and to minimise the amount of gas leaked even if they do occur.

Typically, gas leaks from SF_6 gas equipment are detected by a drop in the indication of the gas pressure gauge. However, in the case of slow gas leaks, the gas pressure gauges in the equipment have a minimum scale of 0.05 MPa, which means that the leak cannot be detected immediately.

CHUBU PG has therefore installed SF_6 gas slow leak monitors (minimum detection sensitivity: 0.0001 MPa), as shown in Figure 8, to monitor the gas pressure online and in real-time for early detection of trace leaks, as shown in Figure 9. Prompt maintenance against gas leaks minimises the amount of gas leakage. Figure 10 shows an example of a slow leak of approximately 1% per year measured with a gas slow leak monitor. To detect a gas leak in this example, it would take several years of monitoring with a conventional gas pressure gauge, but only about six months with a gas slow leak monitor.



(a) Monitoring device (Main unit) (b) Pressure sensor

Figure 8: Appearance of SF_6 gas slow leak monitor.

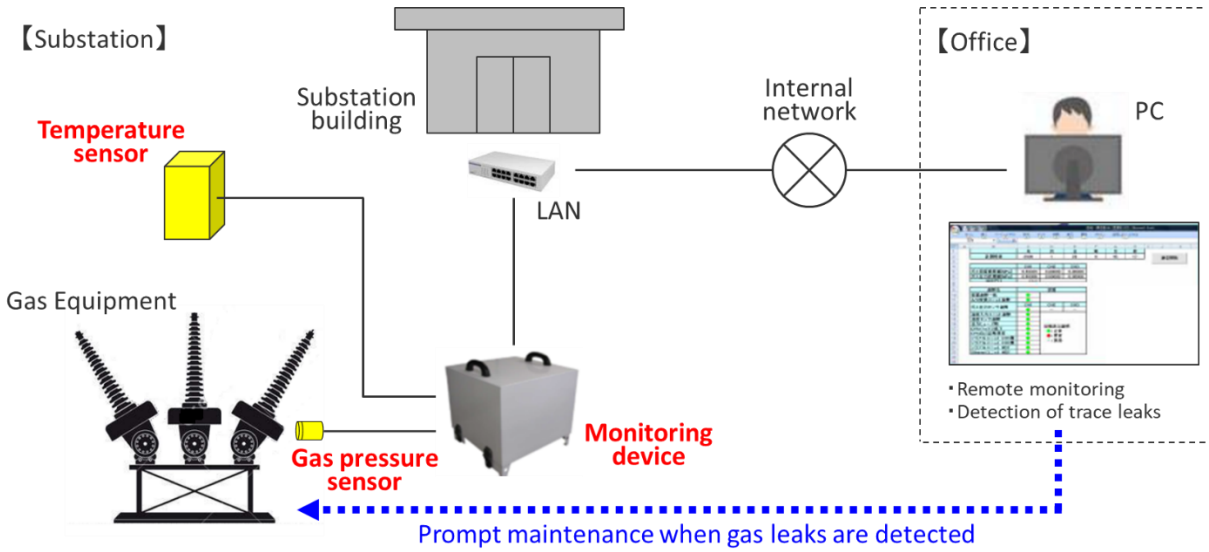


Figure 9: Online gas pressure monitoring using gas slow leak monitors

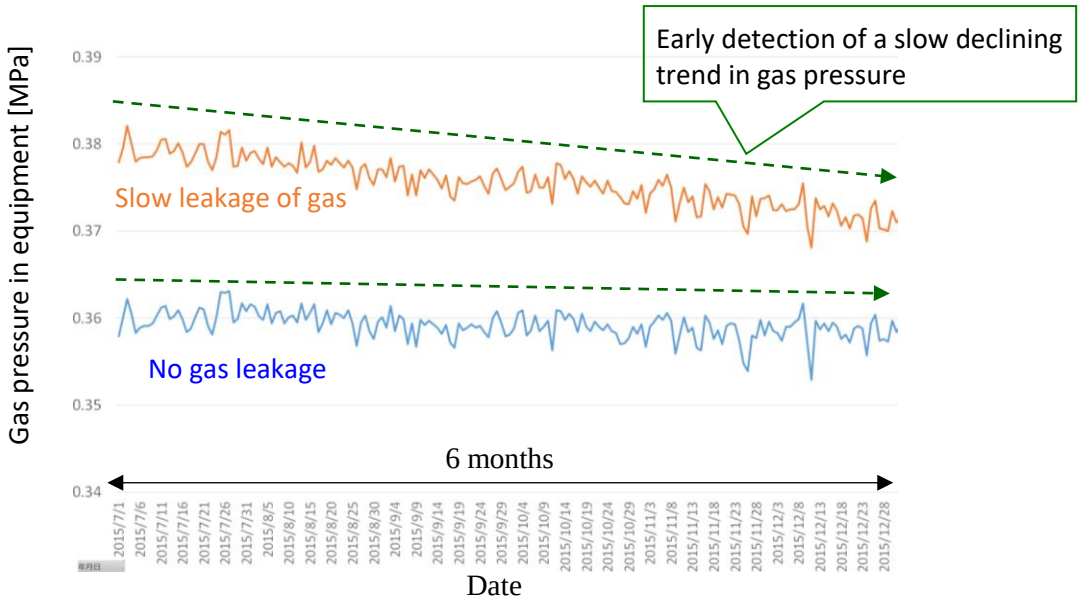


Figure 10: Example of actual data measured by SF_6 gas slow leak monitor.

3 Conclusions

Over the past 20 years, CHUBU PG has implemented various initiatives to improve the SF_6 gas management described in this paper, and has carefully handled the gas in accordance with the SF_6 gas handling standards including gas recovery rate targets set by the Japanese power industry.

As a result of these efforts, as shown in Figure 11, the SF_6 gas leakage rate has been consistently kept below 0.2% per year since 2000, and in recent years (2021) the leakage rate has been lowered to about 60% of the leakage rate in 2000.

CHUBU PG will continue its efforts to reduce SF_6 gas leakage in order to meet the Group's decarbonisation target, “the Zero Emissions Challenge 2050”.

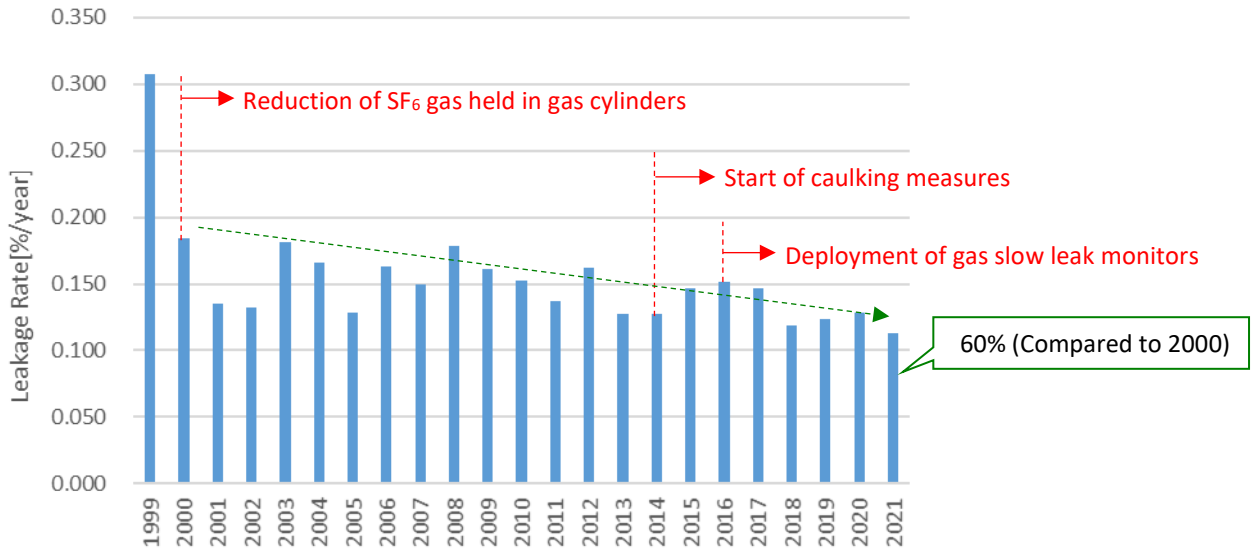


Figure 11: SF_6 gas leakage rate of substation equipment in Chubu Electric Power Grid

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