

Development of Truck-Mount Compressor for Reducing Medium Pressure "ECOPURGE"

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Abstract

Surveys of internal gas holders and pipe construction in medium- or high-pressure pipe lines are usually executed after internal gases are decompressed to low atmospheric pressure levels. When difficulties ensued when reducing gas pressure levels from medium to low by a governor (pressure regulator), resulting in decompression in districts where gas holders or pipelines were installed, methods such as burning or diffusing gas in the air were used; wasteful gases were consumed and greenhouse gases such as methane or carbon dioxide were also diffused.

In order to decompress medium-pressure gas holders and pipelines, Osaka Gas developed a compressor-mounted truck called "ECOPURGE" for reducing gas levels economically, without discharging greenhouse gases and wasting gas consumption. ECOPURGE sucks in the internal gas that needs to be reduced by a compressor, then performs the decompression and releases the gas through adjacent pipe lines.

ECOPURGE also has environmental, safety-based, and economical advantages. The environmental advantage is the reduction of 5,000 tons of CO₂ greenhouse gases per year, which comprises 3% of Osaka Gas' gross discharge. As a safety advantage, it suppresses obstacles caused by ignition or gas odors when evacuating high-rise buildings, railways, or highways during disasters. And as a cost advantage, ECOPURGE clears 2.5 million yen profit per year, even after deducting development and maintenance expenses. 2,000,000 Nm³ reduction in wasteful gas consumption was achieved in March 2013, and an additional 300,000 Nm³ in reductions was recorded for the remainder of the year. We also have actual results in the gas decompression business which were ordered by other gas utility companies. ECOPURGE is a small-sized compressor truck with a gas engine, and is powerful, easy, and safe to operate. Compared to same-size devices developed in the past, it features a 300-percent higher decompression capacity. And as a compressor truck for medium-pressure decompression utilizing gases from medium-pressure gas holders and fuel pipes, ECOPURGE acquired patents for the first time in Japan.

ECOPURGE's source of energy is the "Wing Compressor"--a small, lightweight, large-capacity 55 kW gas engine. This truck is elaborately designed to achieve its large decompression capabilities by utilizing the maximum performance of both a small Wing Compressor and another small gas engine while keeping heat balanced via compressed gas and gas-engine cooling,

pressure loss balanced by cooling air amounts and duct noise, and noise reduction, weight reduction, miniaturization, and clean exhaust gas processing throughout the experiment.

The main specifications are as follows. Maximum decompression ability: 3,000 Nm³/h at 0.65 MPa.

Average flow rate: 1,000 Nm³/h (when reducing from medium-pressure A(0.65MPa) to low-pressure (0.002MPa)).

Application pressure: 0.002-0.7MPa.

Vehicle length and weight: 5.5 m, total 7.8 tons.

Noise level: 67 dB at 7 m.

ECOPURGE was introduced after its development in 2004. In order to meet increased needs in recent years, noise reduction and miniaturization have been continuously improved. Further application expansions are expected for this technology.

1. Background & Purpose

Conventionally, when reducing the pressure of medium-pressure gas holders we consume gas in areas where gas holders were installed; where it is difficult to adopt these gas-pressure reducing methods, alternatives such as burning gas to reduce pressure are used. Therefore, we developed a truck-mounted compressor for reducing medium pressure called "ECOPURGE", which can reduce the medium pressure of gas holders without burning for consumption.

2. Principles for Reducing Pressure

Usually, gas-holder pressure is reduced by burning gas using large-size burners, as shown in Figure 1. On the other hand, ECOPURGE, which mounts a gas engine-driven compressor package, reduces the pressure by discharging gas into the adjoining medium-pressure pipeline after sucking it from decompression objects (as shown in Figure 2), and compressing it with its compressor. This leads to less wasteful gas consumption by conventional methods such as burning, and fewer emissions of greenhouse gases.

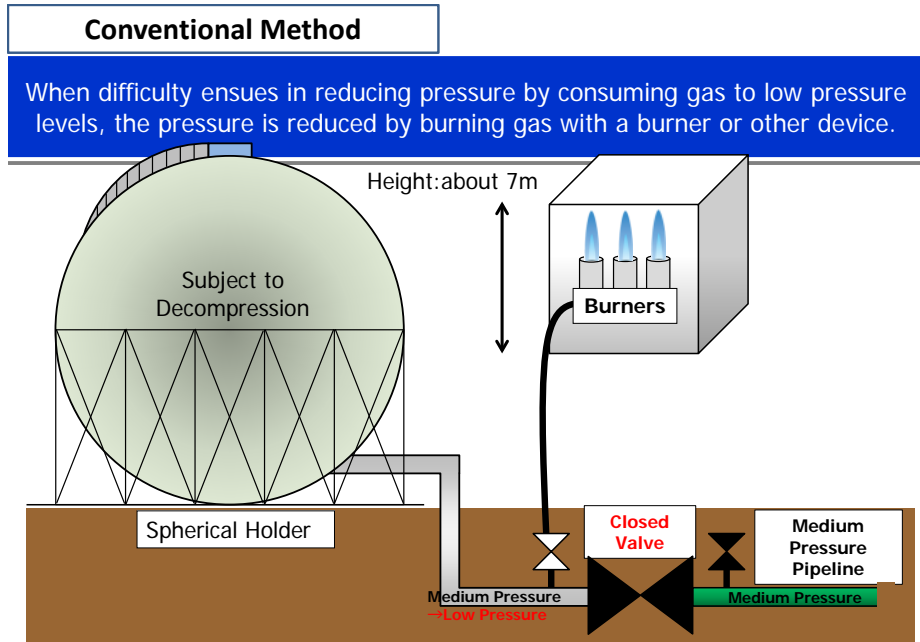


Fig.1. Conceptual Diagram of Conventional Method (Burning) for Reducing Holder Pressure

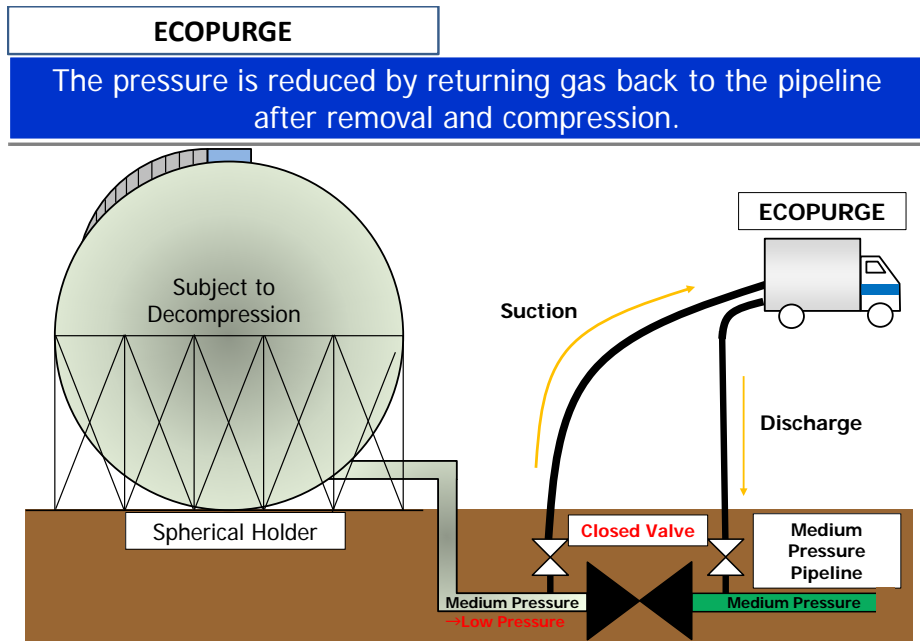


Fig.2. Conceptual Diagram for Using ECOPURGE for Reducing Holder Pressure



Fig.3. Decompression Example in Holders

3. Technology That Makes Compressor Truck-Mountable Packages Possible

To provide decompression-treatment capabilities on a truck which can be practically used on-site, the compressor package is elaborately designed to achieve multidimensional integration which satisfies strict requirements such as the efficient use of space, weight reduction and compression, noise-reduction, and cooling performance. This section introduces some key technologies.

(1) Compressor Unit Development (Hori, Engineering Co., Ltd.)

As a compressor, we adopted the multidimensional, highly-efficient Wing Compressor which is city gas-compliant and simultaneously features a compact design, reduced noise and vibration, and is oil-free. Figure 4 shows the Wing Compressor's structure.

While focusing on the compressor, we implemented the device's entire design production, including noise and vibration reduction. In addition, specifications were added that the gas-recovery unit would leak zero gases.

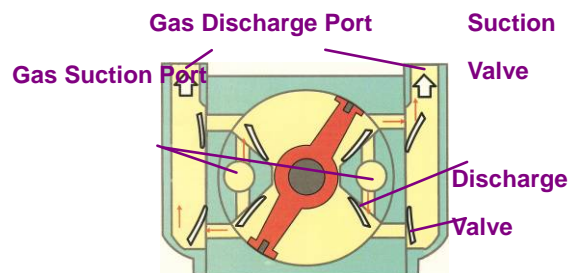


Fig.4. Wing Compressor

(2) Gas-Engine Unit Development (ALTIA Co., Ltd.)

As a power source, we adopted a lightweight, compact, high-performance gas engine. This engine is extremely reliable, and also employs cogeneration. In addition, because the gas supply could be obtained from the decompression object pipeline, we successfully removed a fuel tank from the vehicle, freeing up space and weight. Table 1 indicates the gas engine's specifications.

Displacement	4,169cc
Fuel	Natural Gas (13A)
Cooling System	Radiator on Board
Control Method	Operation Control by on Board Automatic Start Up Plate With Fixed Rotation Number Operation Control and Exhaust Emission Control System

Table 1. Gas Engine Specifications

4. Specifications of the Medium-Pressure Reduction Compressor Mounted in ECOPURGE

(1) Application Object

Pressure-reducing work and pressure-increased filling for medium pressure gas holders or the like

- Suction pressure: 0.7MPa - 1kPa
- Discharge pressure: 0.7MPa or less

(2) Compressor Specifications

1) Wing Compressor

- Completely oil-free specifications, oil-free lubrication

2) Drive System

- Gas engine: Output about 55kW
- Exhaust gas treatment: Ternary catalyst

(3) Vehicle Specifications

- Vehicle size: Overall length 5.48m × overall width 2.15m × overall height 2.88m
- Gross weight: 7,700kg (Figure 5 shows ECOPURGE's exterior.)



Fig.5. ECOPURGE's Exterior

(4) Safety Devices

Listed below are emergency stop items used in case of emergencies.

- Emergency stop button
- Gas-leak detector alarm activation (LEL25%)
- High-discharge pressure
- Low-suction pressure
- Temperature increases in discharged gases
- Ventilation fan defects
- Electricity generator all-stop
- Hydraulic pressure compressor reduction
- Engine defects (increase in water temperature, hydraulic pressure reduction, emission defects)
- Gas control defects (high- and low-burning gas pressure, emergency stop)
- Water pump defects, cooling water reduction amounts

5. ECOPURGE Features

(1) Decompression ability

Because ECOPURGE controls fixed rotation numbers based on the compressor's maximum operational rotation numbers, its decompression abilities are highly dependent on the pressure in the pressure-reduction side.

Figure 6 shows the changes over time and the pressure on the pressure-reduction side, when one kilometer of steel pipe 600a (geometric cubic capacity 273m^3) is decompressed from 0.65MPa to 0.0023MPa . The decompression of $1,655\text{Nm}^3$ was completed in 98 minutes; the average decompression rate was $1,013\text{Nm}^3/\text{h}$.

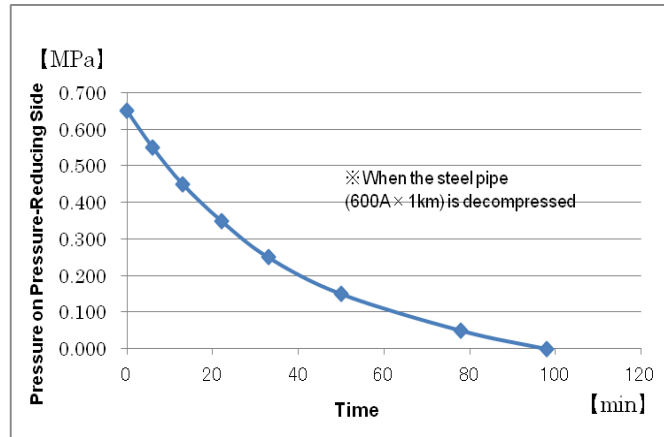


Fig. 6 Time vs. Pressure on the Pressure-Reduction Side (600A x 1km)

ECOPURGE automatically stopped operating when the pressure reached the set decompression-completion pressure. In addition, to prevent the pipeline network from pressure increases, when unusual pressure increases on the discharging side are detected, operation is quickly halted. These functions can prevent too much pressure reduction in the pipelines caused by careless workers and increasing pressure during pipeline network operation.

Figure 7 is a graph which shows the pressure changes on the pressure-reduction side and the decompression ability. The maximum decompression ability was 3,000Nm³/h, when the pressure on the pressure-reduction side was 0.65MPa.

To facilitate calculations required for decompression times, we used following values:

Medium A → low pressure average: 1,000Nm³/h

Medium B → low pressure average: 500Nm³/h

Medium A → medium B average: 1,500Nm³/h.

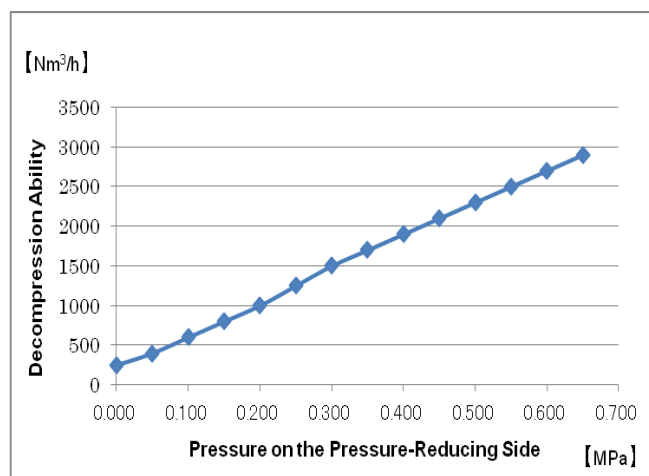


Fig. 7. Pressure on the Pressure-Reduction Side vs. Decompression Ability

(2) Interactive-Type Control Panel

Because the operational procedures including valve operations and operating conditions are indicated on the touch-screen LCD display, you can safely operate ECOPURGE without any mistakes. Each step has a wide variety of interrelated features.



Fig.8. Interactive-Type Control Panel

(3) Noise Reduction

ECOPURGE drastically reduces noise by housing the gas-engine compressor in a soundproof box. And in order to meet the increased needs of workers operating on-site, we have continued to focus on reducing noise.

A. Countermeasures Against Membrane Vibration

The analytical results of the conventional device suggests that the blue part of the soundproof box (shown in Figure 5) vibrated like a drum's tympanum, mainly generating low-frequency sounds which caused a thrumming noise when reaching the windows of neighboring private residences. To counter this membrane vibration we added oblique beams to the door, readjusted a lock bar, and injected urethane foam.

B. Reducing Vibrations and Weight

Because the entire device's vibrations were one of the causes of noise, we enhanced the floorboard where the device was attached. Because we had reached the maximum gross vehicle mass, at first we implemented readjustments of weight balance and reduction, then increased the thickness of the floorboard iron plate and readjusted the position and direction of the beams.

C. Readjustment of Acoustic Absorbents

The acoustic absorbents of the whole soundproof box were changed from conventional rock wool to automotive composite felt, which has good low-pitched sound absorbing abilities.

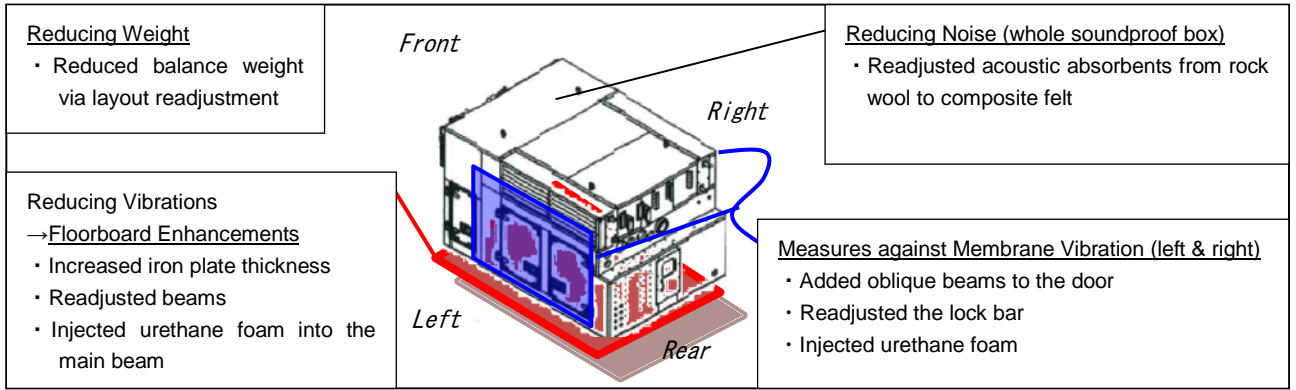


Figure 9. Noise Reduction Measures for the Soundproof Box

D. Results of Noise Reduction Measures

We reduced noise associated with customer issues in the distance range from three to seven meters. Great effects were noted in the low-frequency waves causing the thrumming noise on windows.

Noise-Measuring Distance	1m	3m	5m	7m
Noise-Measuring Result	79dB(A)	74dB(A)	71dB(A)	67dB(A)

Table 2. ECOPURGE's Noise Values (Vehicle, Left Compressor Side)

(4) Pressure-Keeping Governors

ECOPURGE is equipped with pressure-keeping governors, which can maintain low pressure even after operation stops after the completion of reducing pressure.

6. Effects

In July 2004, one ECOPURGE truck began operations. Then in 2005 and in 2006, trucks were added, one by one. Recently, their frequency usage has increased. In 2013, another truck was added; now we operate them in a four-device framework. In addition, the gases inhibited by ECOPURGE has topped 200 million m³. Since the three-device framework was established, about an average of 0.3 million m³ of gas is inhibited annually. In terms of reducing CO₂ elimination amounts, about 5,000 tons of CO₂ is reduced annually.

7. Conclusion

Since its introduction in 2004, ECOPURGE has been proactively used within the jurisdiction of Osaka Gas and has made considerable contributions from environmental, safety, and economic standpoints.

As there is a growing need for increasing the number of devices and small vehicles, we are continuing our project to develop small devices that can be deployed in our district pipeline business.