

# KGPR65D – High-pressure Hydrogen Regulator for Fuel Cell Vehicles



*Fuel cell vehicles are drawing attention as eco-friendly vehicles, and in order to stably supply hydrogen to fuel cells—which are the vehicles’ power sources—high performance regulators are being required. We have developed a small, reliable, high precision regulator that can firmly seal hydrogen gas for about 20 years, a vehicle’s lifespan, based on the fluid control technology that has been developed through our many years of developing and manufacturing hydraulic devices. And the regulator was highly rated by Daimler and adopted for the mass production of the fuel cell vehicle Mercedes-Benz GLC F-CELL.*

## Introduction

As awareness of global environmental problems is increasing, it is necessary to make efforts to reduce greenhouse gases to zero for the future.

## 1 Background

Electric vehicles and fuel cell vehicles (FCVs) are drawing attention as eco-friendly vehicles that are replacing gasoline-powered vehicles. These new types of vehicles work not only as a means of transportation but as energy sources in the event of a disaster. An FCV is a vehicle powered by a motor driven by electricity that a fuel cell generates by causing oxygen from the air to chemically react with hydrogen on-board. FCVs are known as more environmentally friendly than gasoline-powered vehicles and feature shorter refueling time and longer range than electric vehicles.

The majority of the current FCVs use an on-board system that has hydrogen in a super high-pressure gas state of 70 MPa (700 atmospheres, but up to 87.5 MPa at high temperatures) and reduces the pressure of the hydrogen causing it to react with oxygen in the fuel cell.

Based on the fluid control technology that Kawasaki has developed through its many years of developing and manufacturing hydraulic devices, we have developed a regulator that precisely turns the super high-pressure gas

into a gas of the order of 1 MPa.

## 2 Product Overview and Specifications

The high-pressure hydrogen regulator KGPR65D has been integrated into a unit of a regulator valve that regulates gas and a pressure relief valve that automatically relieves the gas to the outside to protect downstream devices when the controlled pressure becomes abnormal. System configuration of a general fuel cell vehicle is shown in **Fig.1**, the outside view of the high-pressure hydrogen regulator KGPR65D is shown in **Fig. 2**, and its major specifications are shown in **Table 1**.

## 3 Features

Hydrogen is the lightest and smallest substance as indicated by the fact that it is the first element in the periodic table. So, it has specific features such that it may degrade mechanical characteristics by penetrating metal materials (hydrogen embrittlement) and it easily leaks as it can permeate even rubber molecules.

So, for metal, since high-strength materials cannot be used as they are easily subject to hydrogen embrittlement, the necessary strength is secured by refining shapes of parts and paths based on strength analysis.

And the seal portions have been designed to endure

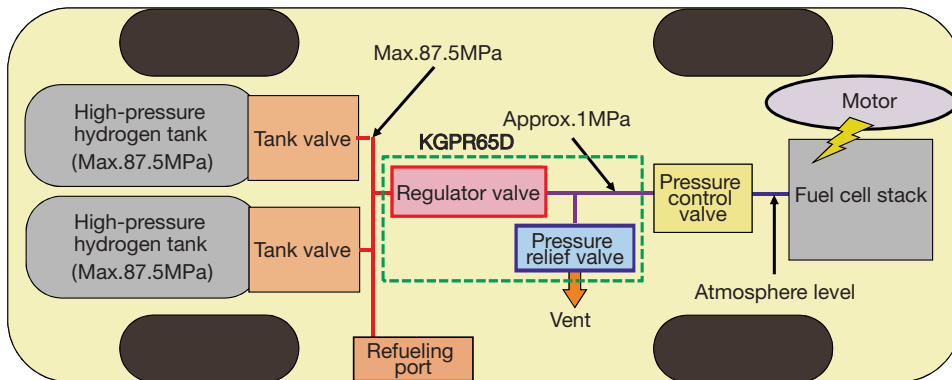


Fig. 1 System configuration of fuel cell vehicle

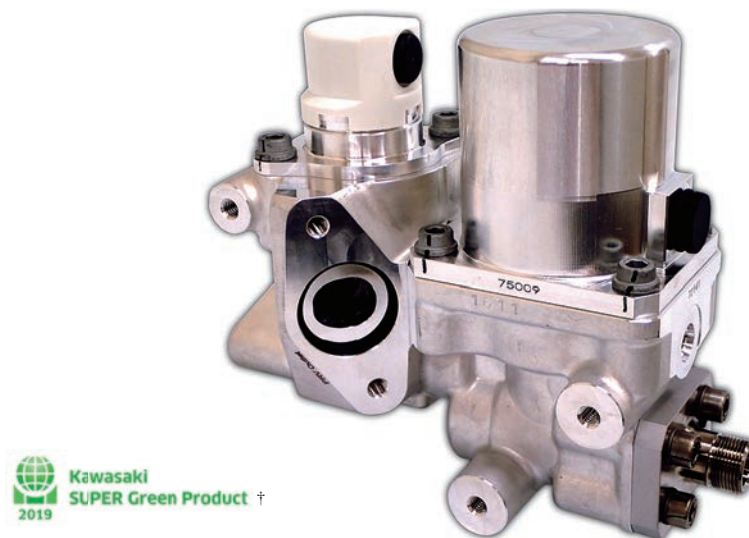


Fig. 2 High-pressure hydrogen regulator KGPR65D

super high-pressure by refining their materials and shapes and are manufactured in a highly precise manner in terms of the dimensions of their metallic parts and surface roughness by taking advantage of technology developed through manufacturing hydraulic devices.

From the above, this product is capable of sealing high-pressure hydrogen gas over a wide range of temperatures from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  without requiring any maintenance for 20 years, which is a vehicle's lifespan.

† The KGPR65D, a hydrogen regulator with high-precision gas control, contributes to achieving zero  $\text{CO}_2$  emissions of running fuel cell vehicles (FCVs).

**Table 1 Major specifications**

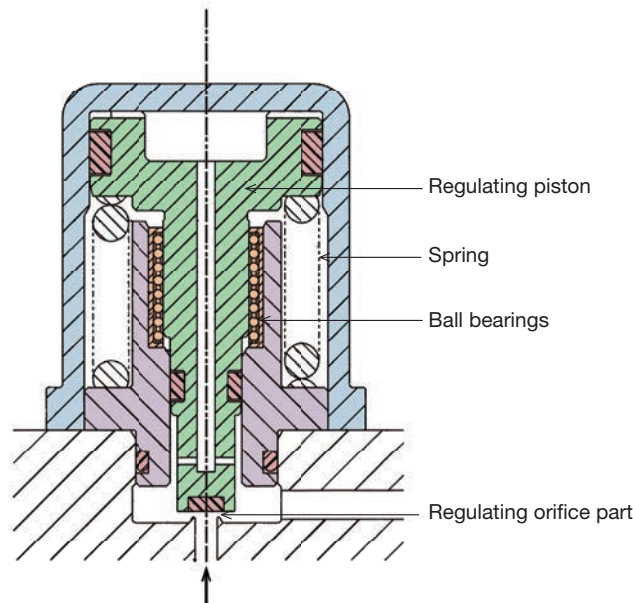
Inlet pressure range [MPaG]	2.0 to 87.5
Regulator control pressure [MPaG]	0.9 to 1.4
Rated operating flow rate [g/s]	1.6
Operating temperature range [°C]	-40 to +85
Pressure relief valve working pressure [MPaG]	Approx. 2.0
Mass [kg]	Approx. 1.9

**(1) Small and highly precise**

This product can instantly reduce the pressure of gas from an extremely high-pressure to a pressure of approx. 1 MPa (10 atmospheres), allowing it to be made smaller than a product that gradually reduces the pressure in multiple steps. This technology is based on the fluid control technology fostered through the development of defense products about 40 years ago and has been

improved and evolved over time.

As shown in **Fig. 3**, the product is designed so that its moving parts that adjust the orifice opening for pressure reduction are supported by ball bearings isolated from the hydrogen gas atmosphere, offering highly precise pressure adjustment capability as well as durability that can endure for the lifespan of a vehicle.



**Fig. 3 Construction of regulator**



Fig. 4 Fuel cell vehicle Mercedes-Benz GLC F-CELL

## (2) Highly reliable

To drive an FCV on public roads, the vehicle must basically be certified in the respective countries or regions. This is because it is necessary to maintain safety when a vehicle that has installed hydrogen gas compressed at an extremely high-pressure runs close to us.

Such certification requires various types of testing such as vibration and shock, temperature humidity cycle, pressure cycle, and operation durability, and they all assume a vehicle lifespan of 20 years. European certification requires 14 test items including hydraulic cycle test requiring three times the number of cycles of the assumed load, and North American certification requires 17 test items including fracture resistance test against 2.5 times or higher the maximum inlet pressure to be carried out with a certifying officer from a certified third party organization being present.

In addition, this product has passed all the various reliability tests of about 25 items that German-based Daimler AG independently requires their suppliers to pass.

## 4 Adoption

The high-pressure hydrogen regulator KGPR65D has been adopted for the mass production of the fuel cell vehicle Mercedes-Benz GLC F-CELL shown in **Fig. 4**, and we have started delivering the regulator from January 2018. This FCV is now being sold only in European markets but is going to be marketed in Japan as well in the future.

## Conclusion

This regulator won a mobility related department award of the Super MONOZUKURI (manufacturing) Parts Grand Prize at MONOZUKURI Nippon Conference in 2018 held by NIKKAN KOGYO SHIMBUN, LTD. Since hydrogen is an environmentally friendly energy source, we will continue developing new products and delivering them to the market to “create new value-for a better environment and a brighter future” as in our group mission.

Yutaka Suzuki

### Contact

Industrial Machinery Sales Section,  
Industrial Machinery Sales Department,  
Marketing & Sales Group,  
Industrial & Marine Machinery Sales Department,  
Eastern Sales Section  
Tel: +81-3-3435-6893 Fax: +81-3-3435-2023