Substitute Sealants for Refractory Ceramic Fiber

1. Introduction

Various artificial mineral fibers have been developed and used as substitutes for asbestos. However, there is concern that some of them may be carcinogenic, and so regulations have been introduced in each country. In Japan, in November 2015, refractory ceramic fiber (RCF) was categorized as a Group-2 substance and specified chemical substance to be controlled under the Ordinance on the Prevention of Hazards due to Specified Chemical Substances (hereafter "Ordinance"). The major regulatory items and management tasks required in manufacturing are as follows.[1)]

＜Major management tasks＞
① Placement of local ventilation
② Nomination of an operational chief
③ Creation and preservation of notifications and operation records
④ Measurement of operational environment
⑤ Medical examinations

Although molded products in which binder is used to solidify RCF, and products in which RCF is sealed, are not subject to the regulation, when such products are cut or polished, RCF dust can be dispersed. Therefore, the Ordinance is applied to these products.

RCF is widely used as a refractory material and heat insulator, which can be used at high temperatures of 1,000°C or higher, at various plants including steel, oil and chemical plants. Meanwhile, sealants have been widely used in various products including gaskets and gland packings because of their excellent heat resistance. In line with legal regulations, VALQUA has adopted inorganic fibers to replace RCF, as they are soluble in living organisms, and has developed products which are both safe and functional. Since these fibers readily dissolve within the body when inhaled via the respiratory system, they are considered to pose low risks to health and so are not subject to legal regulations.

Table1 shows products subject to RCF substitution. This article introduces substitute products in terms of spiral wound gaskets, metal jacketed gaskets, rubber-coated woven fabric gaskets, and gland packings.

Table1　Products subject to RCF substitution

Applicable product group	VALQUA part number
Spiral wound gasket	No.8590 series
Metal jacketed gasket	No. N510, N520, N530, N570, N580, N6520, N6580
Rubber-coated woven fabric gasket	No.P-N314
Textile product	No. P-101S, P-102SF, P-102S, P-105S P-105SN, P-112S, P-112S-N
Gland packing	No. N340G-F, N340M-F

2. Spiral wound gaskets

Spiral wound gaskets are semi-metal gaskets designed for use under high temperature and high pressure, and also have excellent sealing properties and heat resistance. Therefore, they are used in a wide range of applications including general piping and devices, as seals for steam and heat media. In a spiral wound gasket, a V-shaped metal belt (hoop) and a soft sealing belt (filler) are wound together. Generally, spiral wound gaskets, to which inner and outer metal rings are attached, are used for various purposes depending on the conditions.

Inorganic paper is one of the fillers used in spiral

wound gaskets. In the paper-making process, organic/inorganic fibers, fillers, and rubber binders are mixed and then the mixture is made into paper. The maximum service temperature is 500°C. For inorganic-paper fillers, RCF used to be used as a substitute inorganic fiber for asbestos.

VALQUA developed inorganic-paper filler spiral wound gaskets (No. 8590 series) containing biosoluble rock wool as a substitute fiber for RCF (Figure1). Biosoluble rock wool is a fiber which is not regulated by the Ordinance; it is excluded from the carcinogenic category by Note Q of Commission Directive 97/69/EC "Carcinogenicity categorization and package display regarding artificial amorphous fiber."

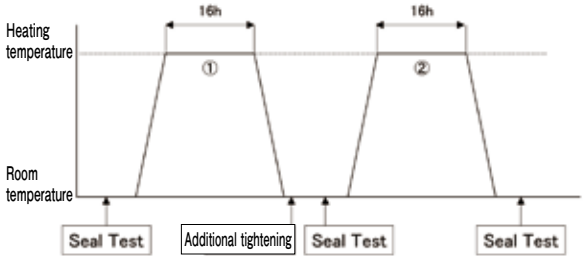
The performance of RCF-substitute products (hereafter "RCF-substitute (product)") containing biosoluble rock wool is shown below. The sealing properties of No. 8596V and No. 8596VL were evaluated under the condition of heating the two gaskets while connected to a flange, then cooling them to room temperature. Table2 shows the results. "Lined products" is a foamed-carbon filler in which inorganic-paper filler is placed at both ends of the filler to prevent oxidation loss of the filler. No leakage occurs in RCF-substitutes; they were confirmed to have adequate high-temperature sealing properties.

Table3 shows the results of evaluating steam resistance. Generally, loss of fiber strength of biosoluble fibers is a concern when the fiber comes in contact with steam or water. To evaluate steam resistance, we evaluated the sealing properties of the RCF-substitutes using nitrogen gas after steam exposure, and deterioration was confirmed. The result shows that no leakage developed with the RCF-substitutes, and RCF-substitutes have similar sealing properties to those of RCF-containing products.

Regarding design data including m/y values, there were no changes following the change in fiber; the RCF-substitutes can be used in a similar manner as conventional products containing RCF.

Figure1 No. 8590 series (RCF-substitute products)

Table2 Comparison of high-temperature characteristics between No. 8596V and No. 8596VL



Cycle number	Specimen	Leakage amount (Pa・m³/s) No.8596V (RCF-substitute)		No.8596VL (RCF-substitute lined products)
	Heating temperature	400°C	500°C	600°C
0		No leakage	No leakage	No leakage
1		No leakage	No leakage	No leakage
2		No leakage	No leakage	No leakage

Note: Test conditions
Internal pressure : 4 MPa (400°C and 500℃) , 1 MPa (600℃)
Tightening force : Bolt-fastening under a contact pressure equivalent to 70 MPa

Table3 Comparison of steam resistance regarding No. 8596V

Steam exposure time	Sealing-property evaluation, Inner pressure (MPa)			
	No. 8596V (RCF-containing product)		No. 8596V (RCF-substitute)	
	2.0	4.0	2.0	4.0
Pre-exposure	No leakage	No leakage	No leakage	No leakage
1 week	No leakage	No leakage	No leakage	No leakage
3 weeks	No leakage	No leakage	No leakage	No leakage

Note: Test conditions
Exposure fluid : 30 K steam (230°C, 3 MPa)
Tightening force : Bolt-fastening under a contact pressure equivalent to 70 MPa

3. Metal jacketed gaskets

Metal jacketed gaskets are semi-metal jacketed gaskets in which the outer side of felt (thick plate made from inorganic materials) is covered with a thin metal plate. Since complex shapes and narrow sizes can be manufactured using metal jacketed gaskets, they are used in towers and tanks as well as heat exchangers.

Metal jacketed gaskets are often used at temperatures of 500°C or higher. Since RCF has excellent heat resistance, it is used as a core material for felt. Since the

felt of a metal jacketed gasket is completely covered with metal, there is minimal exposure risk, and so the legal regulations do not apply to such gaskets. However, for even safer use, we developed metal jacketed gaskets (No. N510 and N520) which instead use inorganic fiber, which is not subject to the Ordinance (Figure2).

We compared the sealing properties between RCF-containing products and RCF-substitute products at a heat cycle of 600°C. In the comparison, gaskets were connected to a flange, several thermal cycles were applied, and the room-temperature sealing properties were compared. Figure3 shows the results. According to the figure, even after the heating cycles, the RCF-substitute products appear to have equivalent or superior sealing properties to those of RCF-containing products.

Regarding various design data, the same as in spiral wound gaskets, there were no changes in the metal jacketed gaskets. Therefore, RCF-substitutes can be used in a similar manner as RCF-containing products.

Figure2 No. N510, N520, and others (RCF-substitute products)

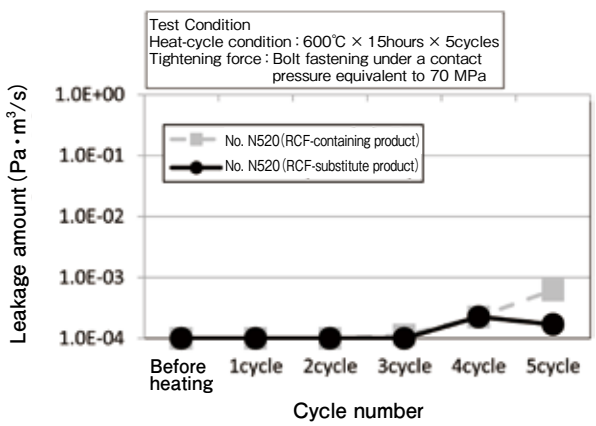


Figure3 Comparison of high-temperature characteristics regarding No. N520

4. Woven fabric gaskets

Woven fabric gaskets are gaskets using fabric, ribbon, or yarn. In these gaskets, RCF materials are used at temperatures of 500°C or higher. In some woven fabric gaskets, special treatments are applied using rubber-soaked cloth. They are used at places where leaking is relatively acceptable, such as in devices' manholes and the flanges of exhaust-gas ducts.

VALQUA started supplying gaskets that use biosoluble fiber (BSF) instead of RCF. BSF remains in the body for a shorter time than RCF and is not subject to the Ordinance.

When making RCF-substitute products, the woven fabric, which the main material of BSF, is added with a small amount of organic fiber and is soaked with rubber. Through this process, RCF-substitute has improved sealing properties.

The sealing properties of RCF-containing products are compared with those of RCF-substitute products at a thermal cycle of 800°C. Figure4 shows the results. According to the figure, RCF-substitute products appear to have equivalent or superior sealing properties to those of RCF-containing products.

Regarding the design data of rubber-soaked woven fabric gaskets, there were no changes. Therefore, rubber-soaked woven fabric gaskets can be used in a similar manner as RCF-containing products. However, when only cloth and ribbon are used as textiles that are not soaked with rubber, care should be taken

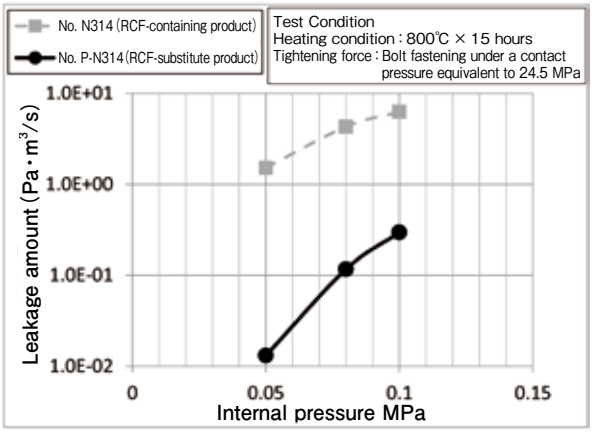


Figure4 Comparison of high-temperature characteristics between No. N314 and P-N314

regarding the maximum service temperature: that of woven fabric using the conventional RCF is 1,260°C, whereas that of woven fabric using BSF is 1,000°C. The temperature difference is due to BSF's inferior heat resistance to RCF. One inorganic fiber that can be used above 1,000°C is alumina fiber, but it is very expensive. Thus, challenges remain in this field.

5. Gland packings

Gland packings are widely used as sealed packings for valves, rotary pumps, and various other devices. In a gland packing, fibers are braided into a rope-like shape. The cross section of a gland packing is square, and so the packing is highly versatile as a sealant and is used for parts where some leakage is acceptable but heat resistance is required. Examples include the coupling of exhaust-heat ducts of boilers and turbines and the fixing parts of manholes.

Gland packings for these purposes are often used at temperatures above 400°C, and so heat-resistant RCF has been used for gland packings. However, RCF became subject to the Ordinance. Therefore, we used BSF, which is not subject to the regulation, instead of RCF, and started supplying the RCF-substitute gland packing (Figures5 and 6).

We compared the high-temperature characteristics of No. N340M (RCF-containing product) with those of N340M-F (RCF-substitute product) at 500°C. Figure7 shows the results. According to the figure, No. N340M-F (RCF-substitute product) appears to have equivalent or superior sealing properties to those of No. N340M (RCF-containing product).

Figure5　No. N340G-F (RCF-substitute product)

Figure6　No. N340M-F (RCF-substitute product)

On the other hand, BSF, which is used as an RCF-substitute, is biosoluble. Therefore, under high temperature and dry conditions (dry heat) involving blast furnace gas or exhaust gas, BSF shows similar performance as the conventional RCF-containing products. However, durability in the presence of steam or hot water (wet heat) is unknown; care is required.

Although BSF will not break down immediately in the case of slight wetting, usage after adequate drying is recommended.

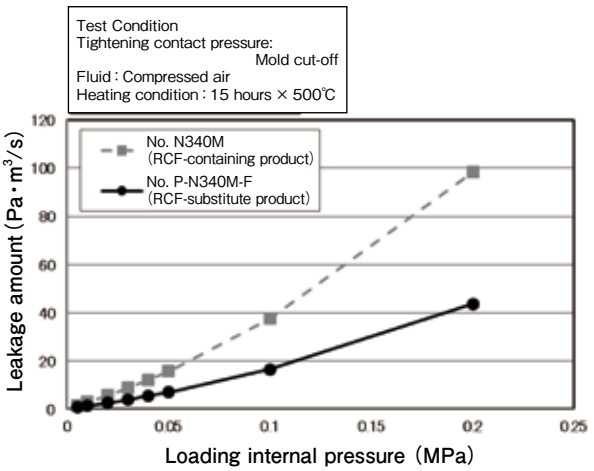


Figure7　Comparison of sealing properties at high temperatures

6. Conclusion

Sealants consist of combined materials with varying characteristics including heat resistance, chemical resistance, and high intensity to withstand various challenging conditions. However, international regulations have been tightened to reduce the

environmental burden and negative impacts on the human body, placing increasing restrictions on usable materials.

As a seal manufacturer, VALQUA will continue to reduce the environmental burden and develop products that do not negatively affect the human body, thus contributing to customers' safety.

7. Reference

1) Japan High Temperature Insulation Wool Association, Handling of ceramic-fiber products, revised edition (January 2016).

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