1. Introduction

Gaskets are fastened to flanges to prevent fluid leakage from pipes or equipment parts. They are important parts that support stable operations in many industries, including petroleum refining, petrochemicals, shipbuilding, electric power, and steel. Gaskets are classified by the type, pressure, and temperature of the fluid flowing through pipes or equipment parts. In July 2019, NICHIAS added the spiral wound gasket TOMBO™ No.1838R-NM Vortex® Gasket-NM (hereafter “Vortex-NM”) to its lineup. This gasket can be used in the ultra-high-temperature range of up to 1000℃ (Figure 1). The Vortex-NM filler is oxidation-resistant, originally developed by NICHIAS, and has excellent sealing properties compared to conventional oxidation-resistant fillers.

This report introduces the main features of Vortex-NM.

2. What is the Vortex® Gasket?

The Vortex® Gasket comprises of ‘hoop’ or steel strips and ‘filler’ or cushion material alternately stacked and wound in a spiral shape. It is widely used for pipes or equipment intended for high temperatures and pressures (Figure 2). The filler types include expanded graphite and mica which are selected according to the target usage conditions (Table 1).
The GRASEAL® Vortex® Gasket (hereafter “Vortex-GR”), which uses expanded graphite for the filler, is used in a wide range of applications because of its excellent sealing and compression/restoration properties. This gasket cannot be used in temperatures exceeding 450°C or in oxidizing fluids, such as molten salt, because the expanded graphite is oxidized, destroying the sealing function.

Gaskets of composite types such as Vortex-GH are used in conditions like the above, where the oxidation of expanded graphite is suppressed by the mica filler wound around the inner and outer peripheries. Gaskets of composite types can suppress, but not completely prevent, the oxidation of expanded graphite; therefore, there are conditions under which these gaskets cannot be used.

### 3. Outline of Vortex-NM

The new product, Vortex-NM, maintains a long stable sealing performance in high-temperature conditions where conventional Vortex gaskets cannot be used. The Vortex-NM filler is an original product developed by NICHIAS. It has both excellent sealing and oxidation resistance properties. In addition, it is patent pending.

Table 2 summarizes Vortex-NM product specifications. This gasket also passed the API Standard 6FB, Third Edition fire test. Thus verifying that the gasket function is unlikely to degrade and that leakage due to a fire is unlikely.

### 4. Product features

The room-temperature sealing and compression/restoration properties of Vortex-NM are equivalent to those of Vortex-GR, which is used in a wide range of applications because of its excellent sealing and compression/restoration properties. This gasket cannot be used at temperatures exceeding 450°C or in oxidizing fluids, such as molten salt, because the expanded graphite is oxidized, destroying the sealing function.

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The room-temperature sealing and compression/restoration properties of Vortex-NM are equivalent to those of Vortex-GR, which is used in a wide range of applications because of its excellent
properties. In addition, because of the excellent oxidation resistance of the filler, Vortex-NM can also be used for ultrahigh-temperature ranges of up to 1000°C and in molten salt which is strongly oxidizing (heat transfer salt, hereafter “HTS”). The details of the characteristic evaluations are as follows.

4.1 Room-temperature sealing and compression/restoration properties
(JIS B 2490 pipe flange gasket sealing property test)

The sealing property test at room temperature of a gasket for pipe flanges with internal pressure is specified in JIS standards. In the JIS test, the gasket seating stress is changed step-by-step and the basic leakage amount and compression deformation amounts are measured. Figure 3 shows the test conditions and the gasket sealing pressure sequence.

<table>
<thead>
<tr>
<th>Test conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
</tr>
<tr>
<td>Fluid</td>
</tr>
<tr>
<td>Internal pressure</td>
</tr>
<tr>
<td>Leakage measurement method</td>
</tr>
</tbody>
</table>

Sealing at room temperature is thus another important property. The pass judgment criterion in the airtight test was defined as the detection limit for the soap water foaming method (i.e. $3 \times 10^4$ Pa·m$^3$/s), which sprays soap water on pipes and detects leaks by the presence of foaming. The required seating stress to pass the test was then compared with Vortex-GR.

Figure 4 shows the test results. In Step 3, Vortex-NM reached a leakage that passed the airtight test, which was equivalent to Vortex-GR.

4.1.1 Room-temperature sealing properties

Before operation is started in a plant or equipment, an airtight test may be conducted using soap water in order to check for leaks in piping lines by checking for foaming of the soap water.
4.2 Heating cycle sealing property

Gaskets are more prone to leakage due to loose bolts when the operation is at a standstill (i.e. the flange fastened section is cooled) than during operation when they are continually heated. Thus, in order to evaluate the heat-resistant sealability of the gasket, a heating cycle seal test of repeated heating to 1000°C and cooling to room temperature was conducted. Afterwards it was compared with oxidation-resistant filler product A, which was a conventional product manufactured by a competitor (hereafter “Competitor Product A”). Figure 6 shows the test conditions and the heating program. At an ultrahigh temperature of 1000°C, the seating surface pressure of the gasket decreases due to relaxation of the bolt stress. By inserting a spacer between bolts to mitigate this effect, adjustment was made so that the specified surface pressure would be applied to the gasket even if the bolts relaxed.

Figure 7 shows a chart of the leakage amounts in the respective cycles. The leakage amount of Competitor Product A increased due to heating, making it unmeasurable, whereas Vortex-NM demonstrated stable sealing without increasing the leakage amount even during a 1000°C heating cycle.

4.3 HTS resistance

HTS, a strongly oxidizing fluid, causes expanded graphite filler to disappear independently of the fluid temperature. Thus Vortex-GR cannot be used for HTS. Vortex-NM, however, can be used for...
such fluids. In order to evaluate the HTS resistance, the original Vortex-NM filler and the Vortex-GR filler were immersed in HTS at 450°C for 200 hours before the fillers’ weight reduction rates were measured. Figure 8 shows the test results. After testing, the expanded graphite filler disappeared completely, whereas the original filler neither oxidized nor disappeared and only exhibited binder-derived weight reduction. This demonstrates that the Vortex-NM filler is resistant to HTS.

<table>
<thead>
<tr>
<th>Product name</th>
<th>Vortex-NM</th>
<th>Vortex-GR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filler</td>
<td>Original filler</td>
<td>Expanded graphite filler</td>
</tr>
</tbody>
</table>

Before immersion

After 200 hrs immersion at 450°C

Weight reduction rate [%]

<table>
<thead>
<tr>
<th>Filler</th>
<th>Original filler</th>
<th>Expanded graphite filler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight reduction rate [%]</td>
<td>5</td>
<td>Unmeasurable due to disappearance</td>
</tr>
</tbody>
</table>

Test conditions

<table>
<thead>
<tr>
<th>HTS</th>
<th>Sodium nitrate 40 wt%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sodium nitrate 7 wt%</td>
</tr>
<tr>
<td></td>
<td>Potassium nitrate 53 wt%</td>
</tr>
</tbody>
</table>

Immersion conditions: 450°C × 200 hrs

**Figure 8** HTS immersion test results (*immersion test of filler alone*)

5. Conclusion

This report introduced the spiral wound gasket Vortex® Gasket-NM, which can be used in the ultrahigh-temperature range of up to 1000°C. Vortex-NM is a new spiral wound gasket with significantly improved sealing compared to conventional oxidation-resistant fillers. Vortex-NM can be used for a long period of time both at ultrahigh temperature and for HTS which cause oxidization to expanded graphite filler.

We will continue to develop products that meet customer needs. We welcome your feedback and requests.

For inquiries or questions about this product, please contact the Piping / Equipment Parts Technology Development Department of the Industrial Products Division.

*TOMBO is a trademark or registered trademark of NICHIAS Corporation.
*GRASEAL and Vortex are registered trademarks of NICHIAS Corporation.
*The measurements presented in this report should be used only as a guide and not as guaranteed values.

*Due to the components of the material, this product may generate a trace amount of silicon fluoride gas when heated above 500°C. Please see the SDS for your risk assessment.