HEAT EXCHANGER WORLD CONFERENCE & EXPO AMERICAS

2022

High Temperature Gasket and Packing Testing

Mark Ruffin

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High Temperature Gasket Performance Testing

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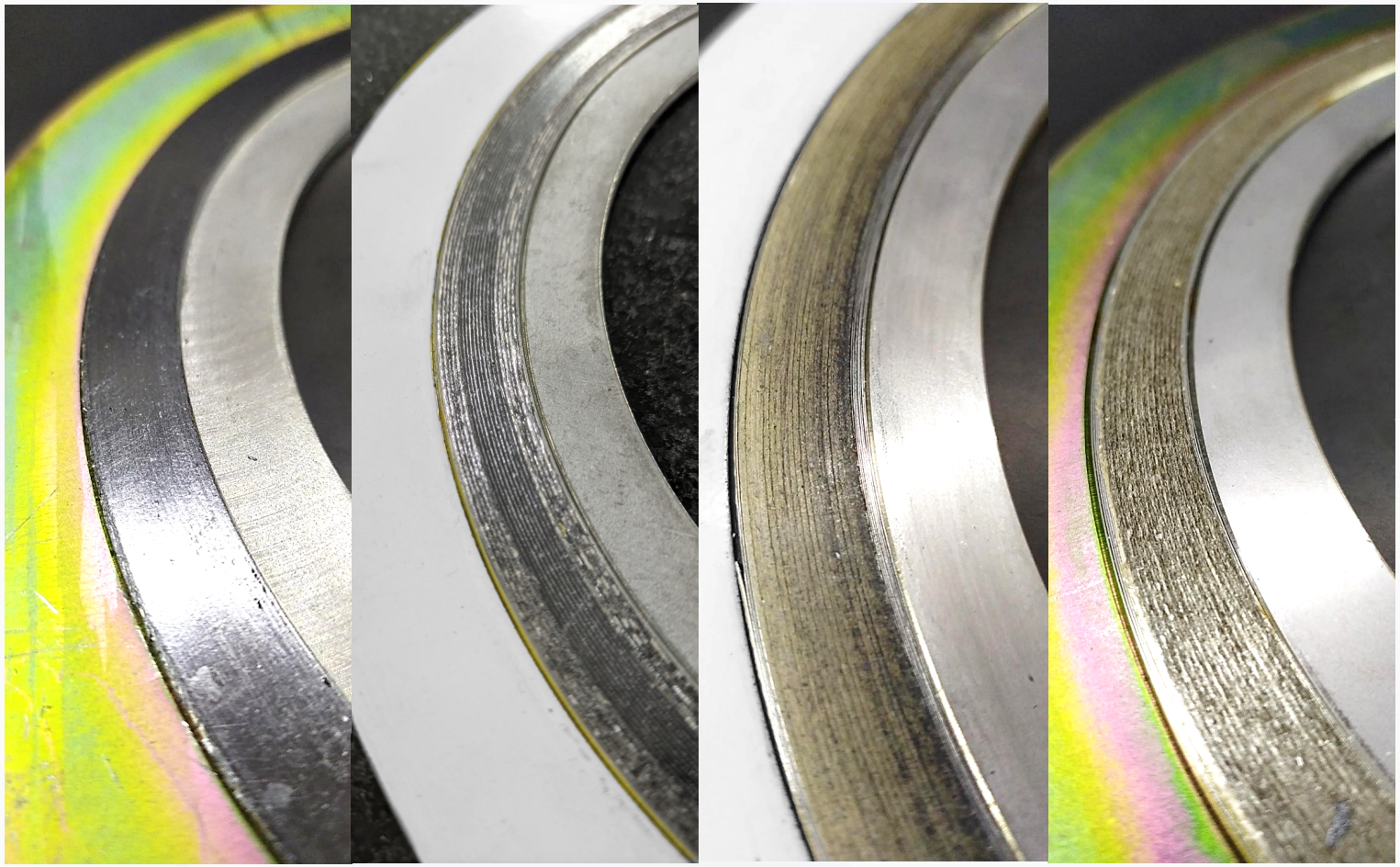
High Temperature

Issues and Challenges

Limited sealing materials can withstand **temperatures** above **850 °F** and provide an **effective seal.**

High temperature sealing materials, such as **Inhibited Graphite, Vermiculite**, **Mica** and combinations of these materials are commercially available.

There's no test method widely used to evaluate **long-term exposures to high temperatures**.



Style 1: Inhibited Graphite	Style 2: Graphite / Mica / Graphite	Style 3: Vermiculite	Style 3: Mica

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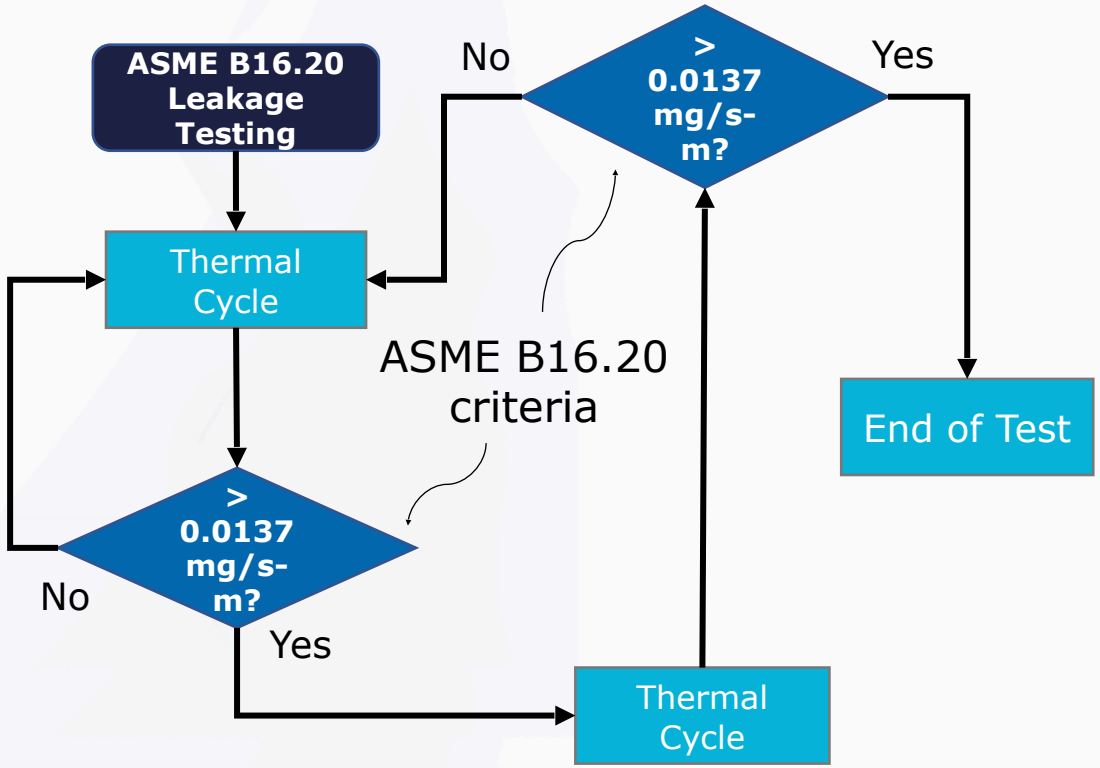
Test Protocol

- The ASME **B16.20 – 2017** performance test procedure was used to evaluate the sealability at room temperature.
- The **flange temperature** was **cycled** between **1200 F** and **room temperature. Sealability testing** took place during the **room temperature** portion of each cycle.
- Thermal cycling continued until the **leak exceeded** the failure criteria of ASME B16.20's performance test **two consecutive times** (0.0137 mg/m·s)
- Gasket Seating Stress: **8000 psi**
- Test Pressure: **580psi** with **Methane**.
- Test Samples: Inhibited Graphite (IG), Graphite / Mica / Graphite (GMG), Vermiculite (V), Mica (M)



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The Test Rig

Characteristics of the test rig

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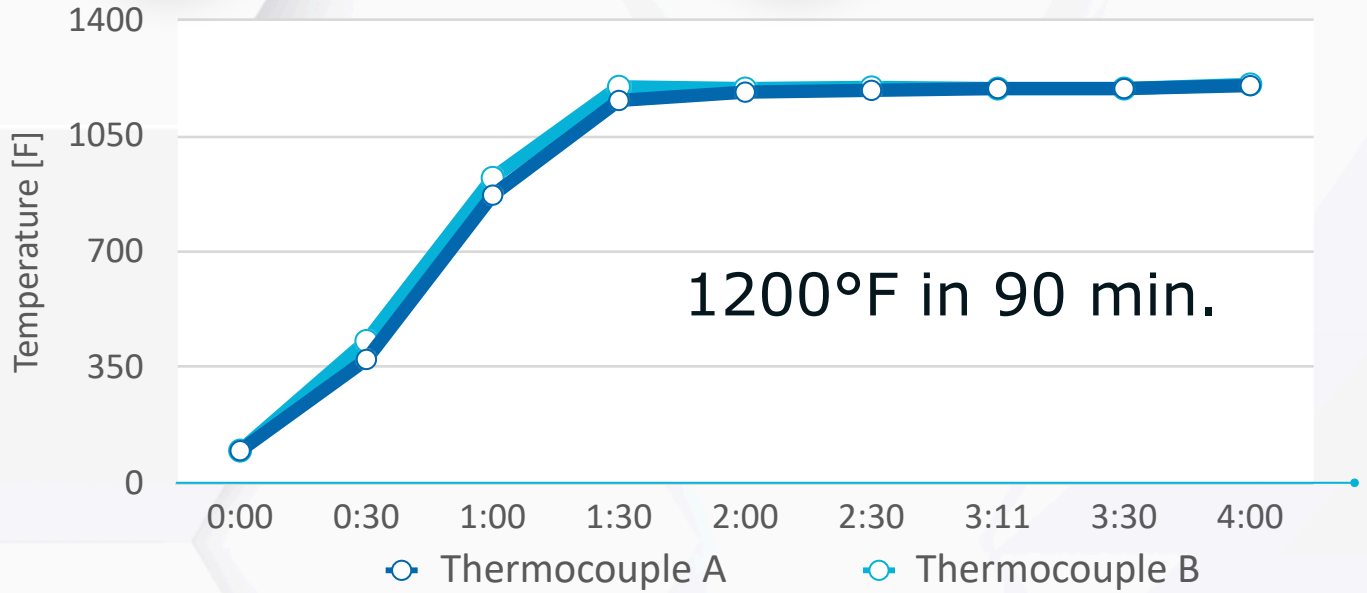
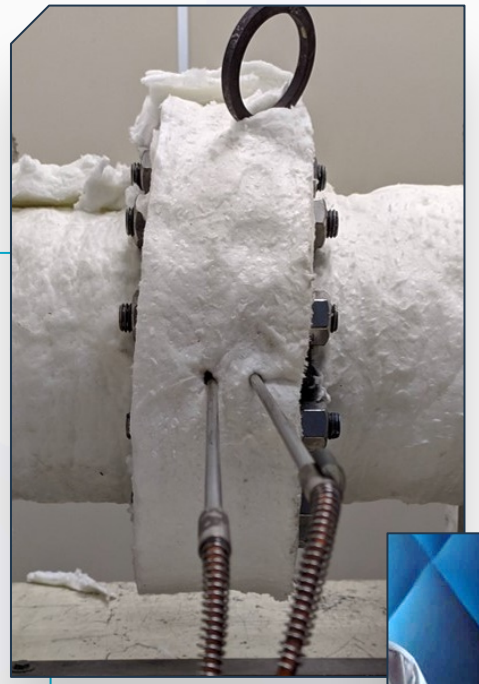
1832 F° MAX.

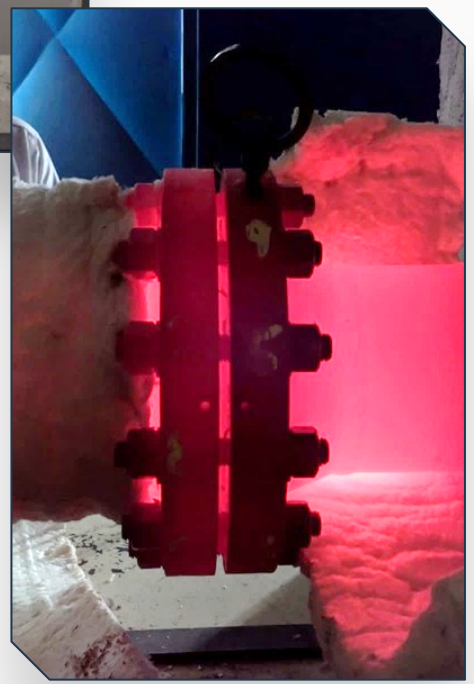
NPS 6, CL300 ASME B16.20 FLANGE





Room Temp

1200 °F



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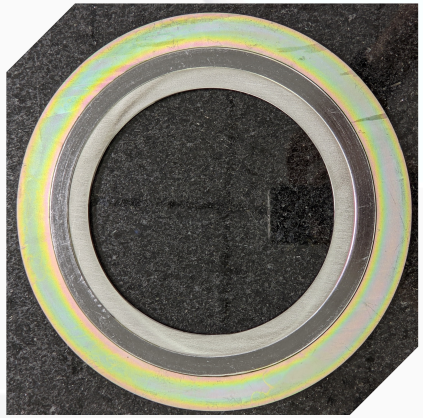
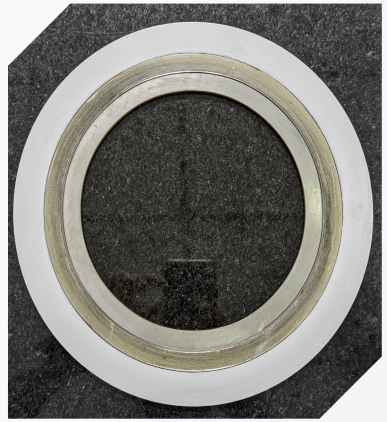
Test Materials



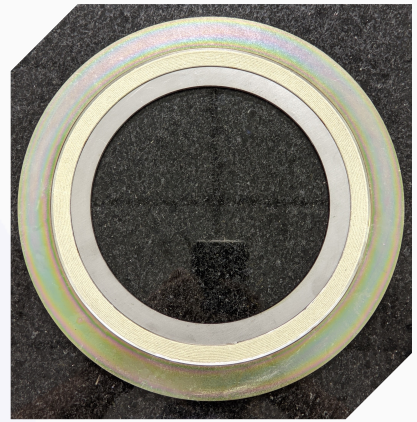
Style 1: Inhibited Graphite

Style 2: Graphite / Mica / Graphite

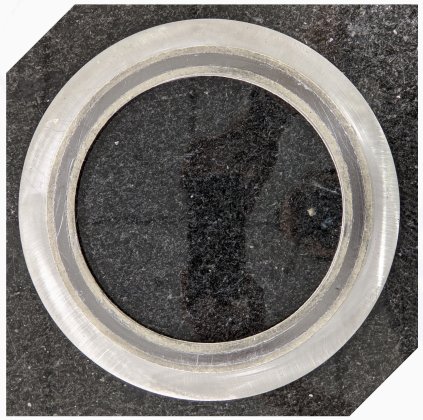
SWG



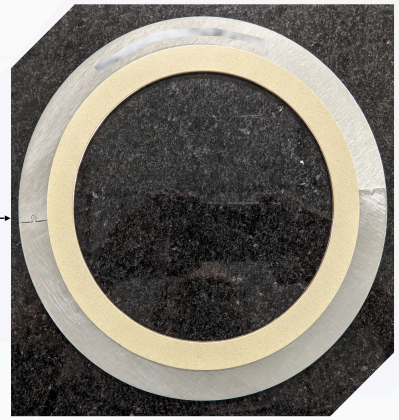
Style 3: Vermiculite

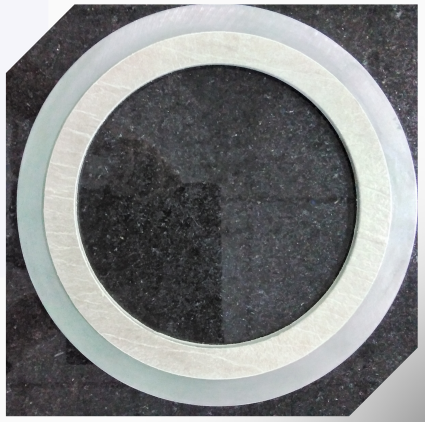


Style 3: Mica



KAM





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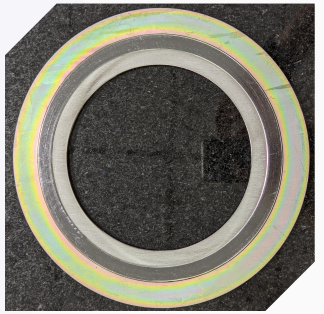
SWG

Test Results



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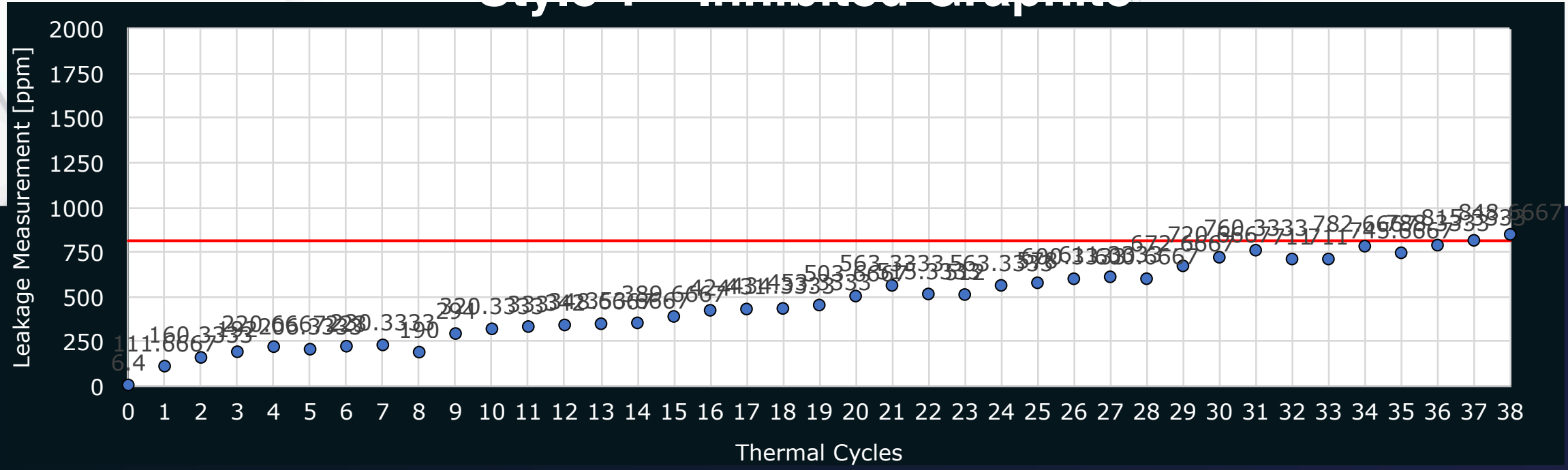
MAXIMUM ALLOWABLE LEAKAGE 813 PPM

Style 1 – Inhibited Graphite



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Test Results

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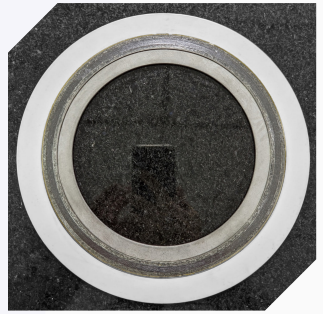
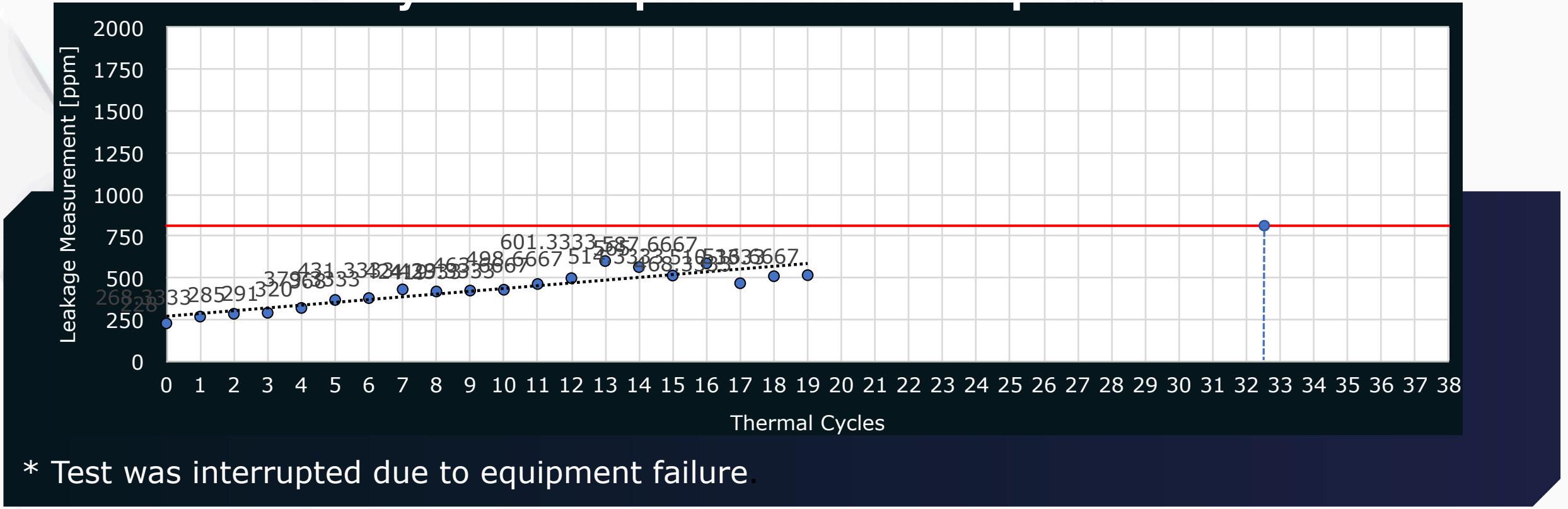
MAXIMUM ALLOWABLE LEAKAGE 813 PPM





* Test was interrupted due to equipment failure.

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SWG

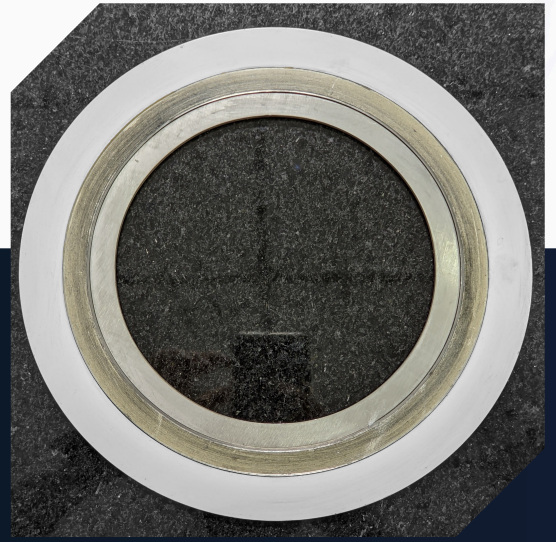
2022

Test Results

MAXIMUM ALLOWABLE LEAKAGE 813 PPM

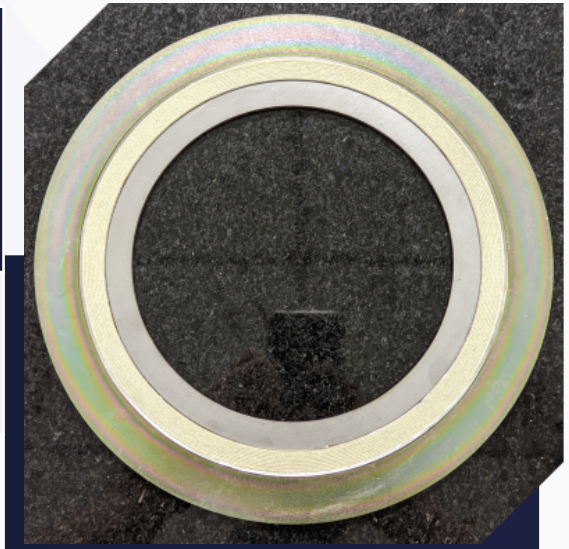
Style 3 - Vermiculite

Cycle #	Average Leakage [ppm]
Cycle 0	20
Cycle 1	> 10,000
Cycle 2	> 10,000



Style 4 – Mica

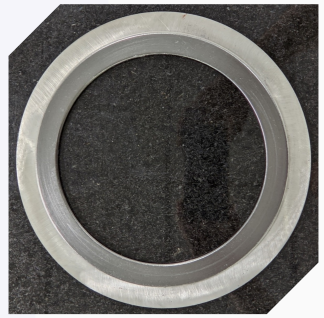
Cycle #	Average Leakage [ppm]
Cycle 0	> 6,000
Cycle 1	> 10,000

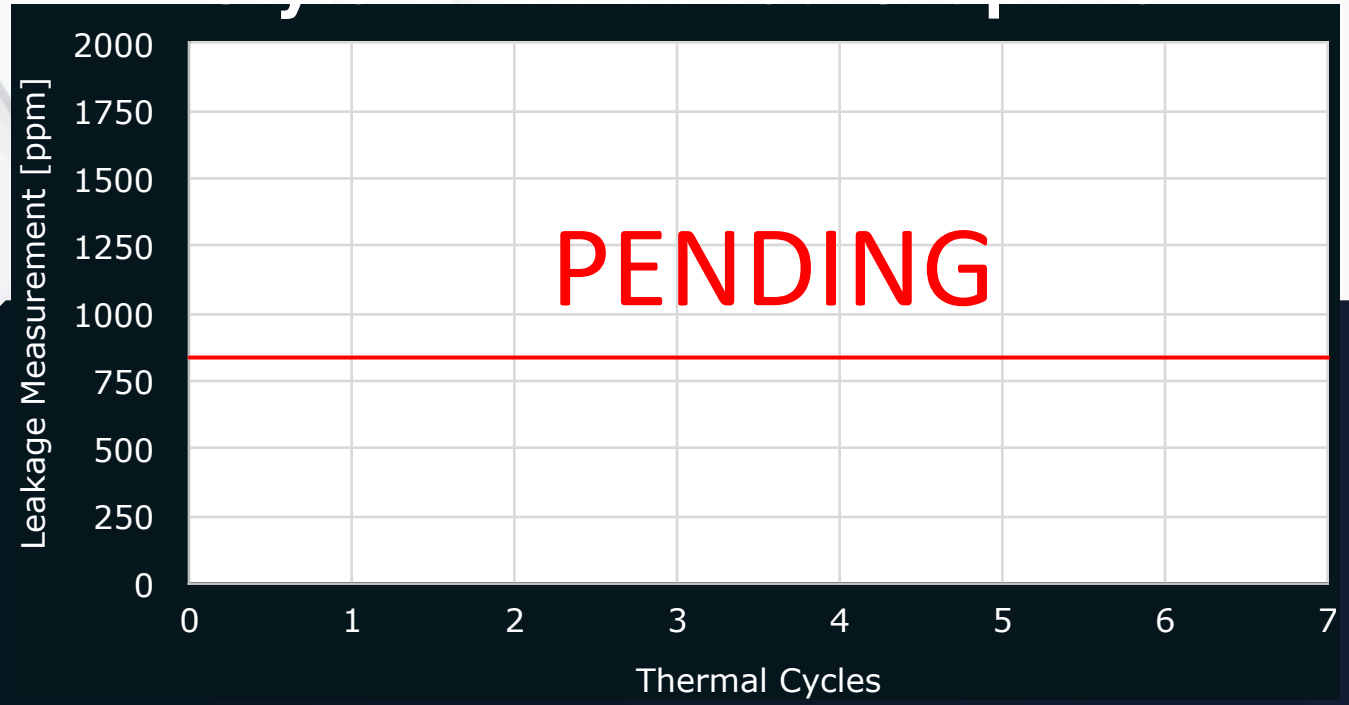


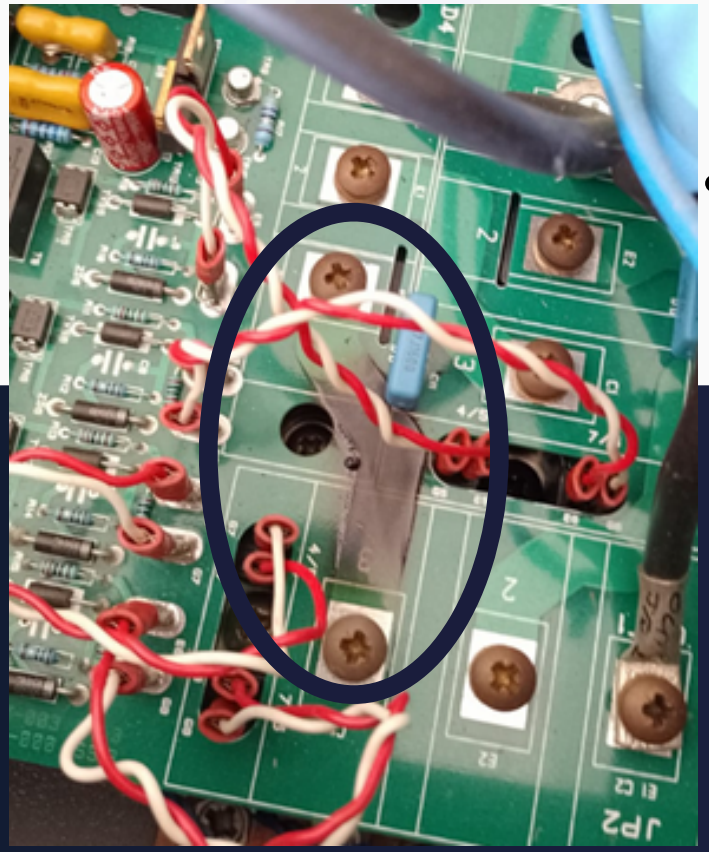
KAM

Test Results

MAXIMUM ALLOWABLE LEAKAGE 837 PPM







- IGBT short circuit

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Test Results

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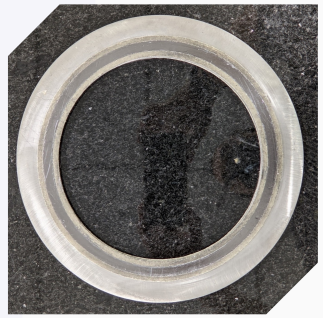
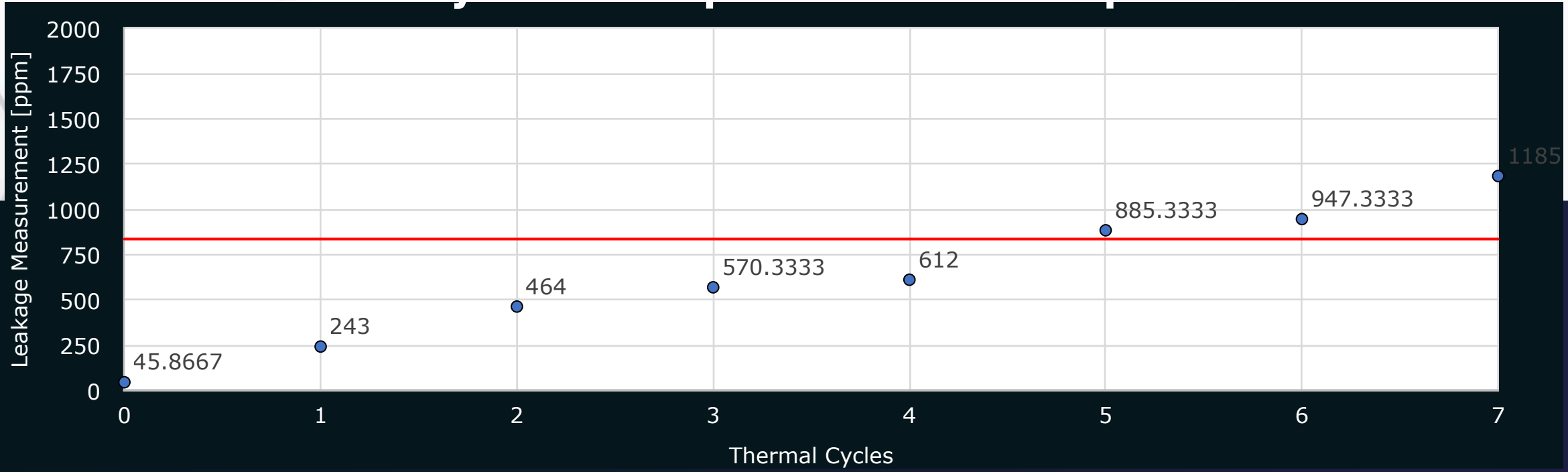
MAXIMUM ALLOWABLE LEAKAGE 837 PPM



Style 2 – Graphite / Mica / Graphite



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Test Results

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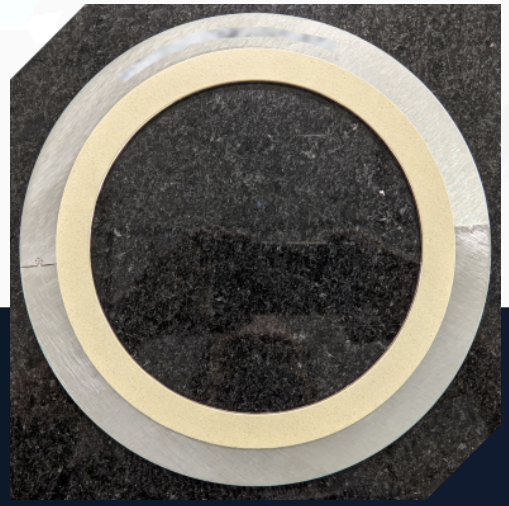
MAXIMUM ALLOWABLE LEAKAGE 837 PPM

Style 3 - Vermiculite

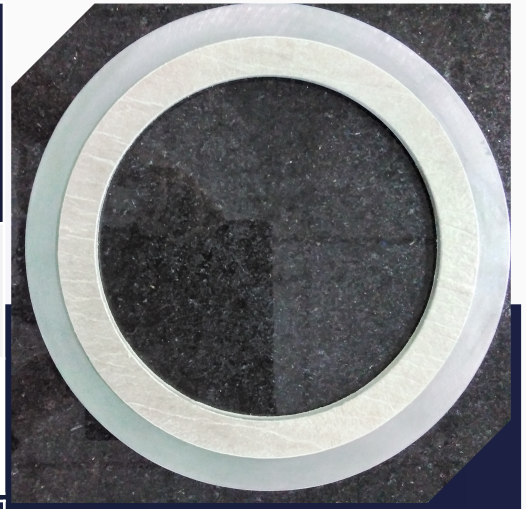
Cycle #	Average Leakage [ppm]
Cycle 0	0.2
Cycle 1	> 10,000
Cycle 2	> 10,000



Style 4 - Mica

Cycle #	Average Leakage [ppm]
Cycle 0	> 10,000
Cycle 1	> 10,000

Cycle #	Remaining Pressure [bar]
Cycle 0	10
Cycle 1	5



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Conclusions

Both Gasket Styles

Style 4 (M) did not meet B16.20 criteria at room temperature.

Despite its good sealability at room temperature, **Style 3** (V) **did not** maintain a **sufficient seal** after thermal cycling

Style 1: Inhibited Graphite	Style 2: Graphite Mica Graphite	Style 3: Vermiculite	Style 3: Mica

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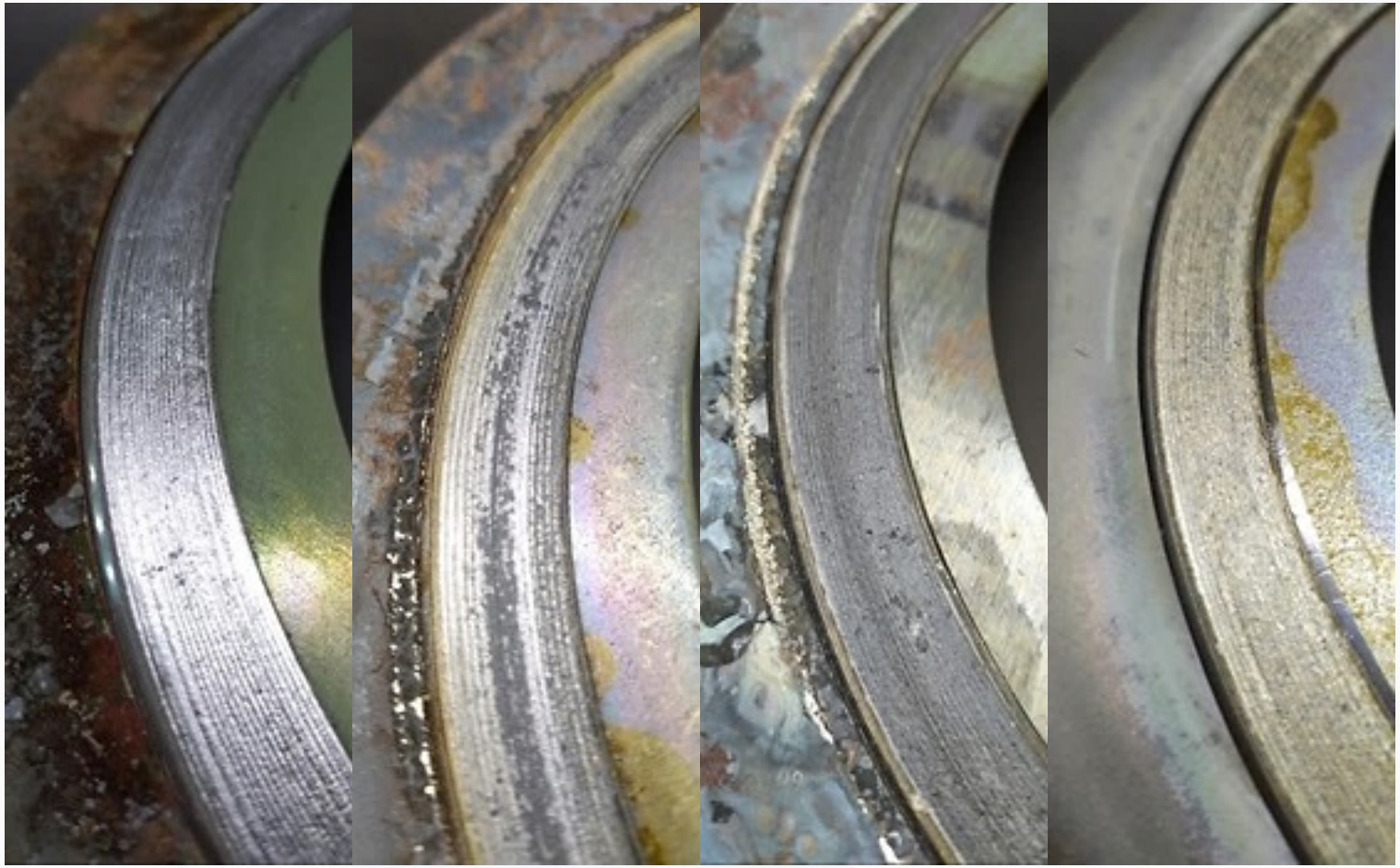
Conclusions

SWG Conclusions

Style 1 (IG) and **Style 2** (GMG) presented superior results when compared to **Style 3** (V) and **Style 4** (M). Long term testing is necessary for validation.

KAM Conclusions

Style 2 (MGM) presented superior results when compared to **Style 3** (V) and **Style 4**(M). Style 1 still needs to be tested. Long term testing is necessary for validation.



Style 1: Inhibited Graphite	Style 2: Graphite Mica Graphite	Style 3: Vermiculite	Style 3: Mica

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High Temperature Packing Weight Loss

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Packing in Heat Exchangers

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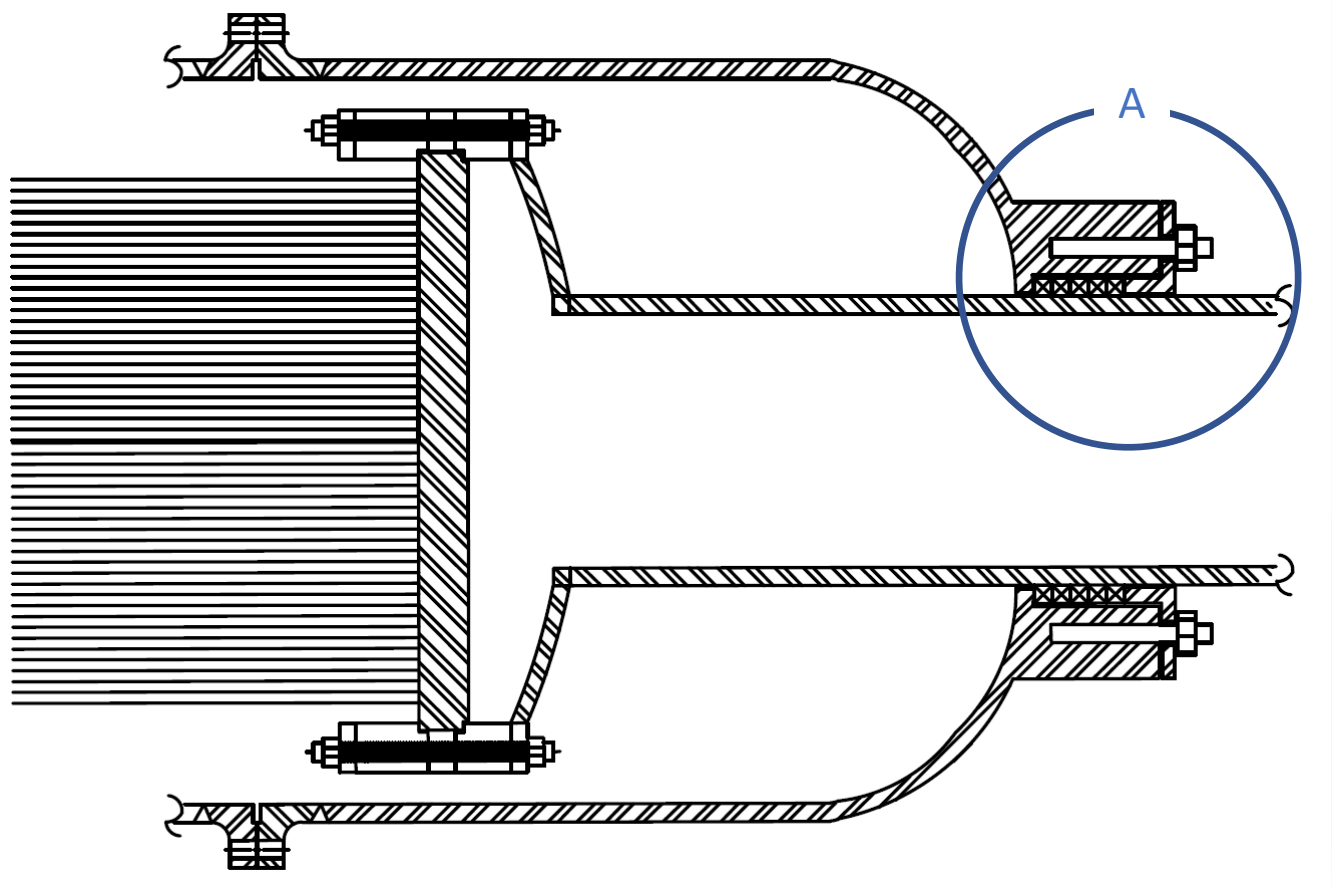

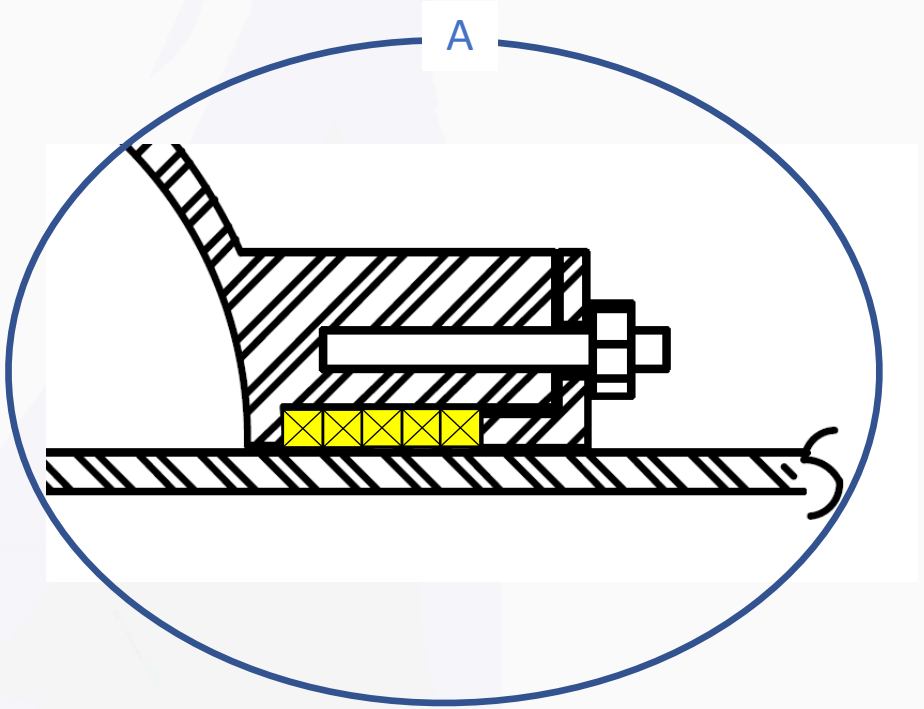

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General Packing Information

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3 General Categories for Packing

Dynamic Equipment (pumps, blowers, mixers etc.)

Control Valves

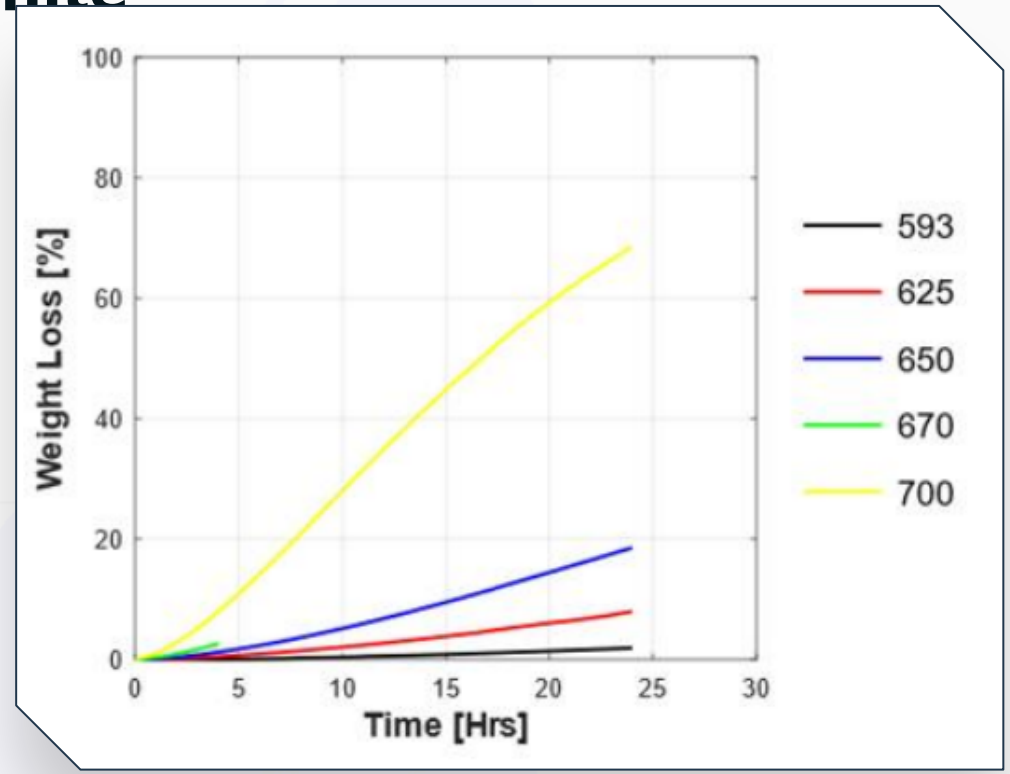
Isolating Valves

- Packing designed for slower shaft speeds
- Typical packing for isolating style valves operating in low emission services are primarily graphite based with Inconel mesh
- The addition of PTFE increases sealability performance and reduces stem drag

Graphite Oxidation

High Temperature Evaluation of Graphite

- In the presence of oxygen, graphite oxidizes
- Graphite oxidation can be quantified by measuring the weight loss of a sample at a particular temperature over a particular time period



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Fugitive Emissions Packing Weight Loss Testing

Test Objective

Determine if the weight loss characteristics of graphite based packing differ from graphite by comparing weight loss results

Test Procedure Summary

- Samples were weighed
- Heated for 1 hour at 302°F
- Cooled and weighed again
- Reheated to 1238°F for 4 hours
- Cooled and weighed again

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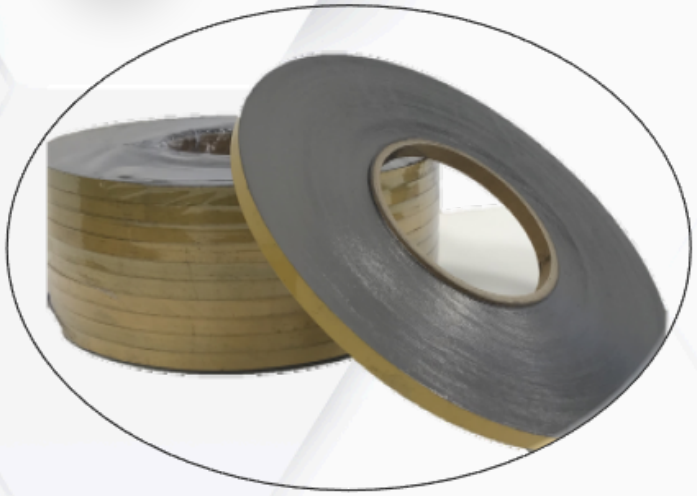
Fugitive Emissions Packing Weight Loss Testing

Test Samples

3 different graphite grades were used to make graphite tape, knitted yard and rope packing



GRAPHITE TAPE

KNITTED YARN

PACKINGS

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Fugitive Emissions Packing Weight Loss Testing

Test Results

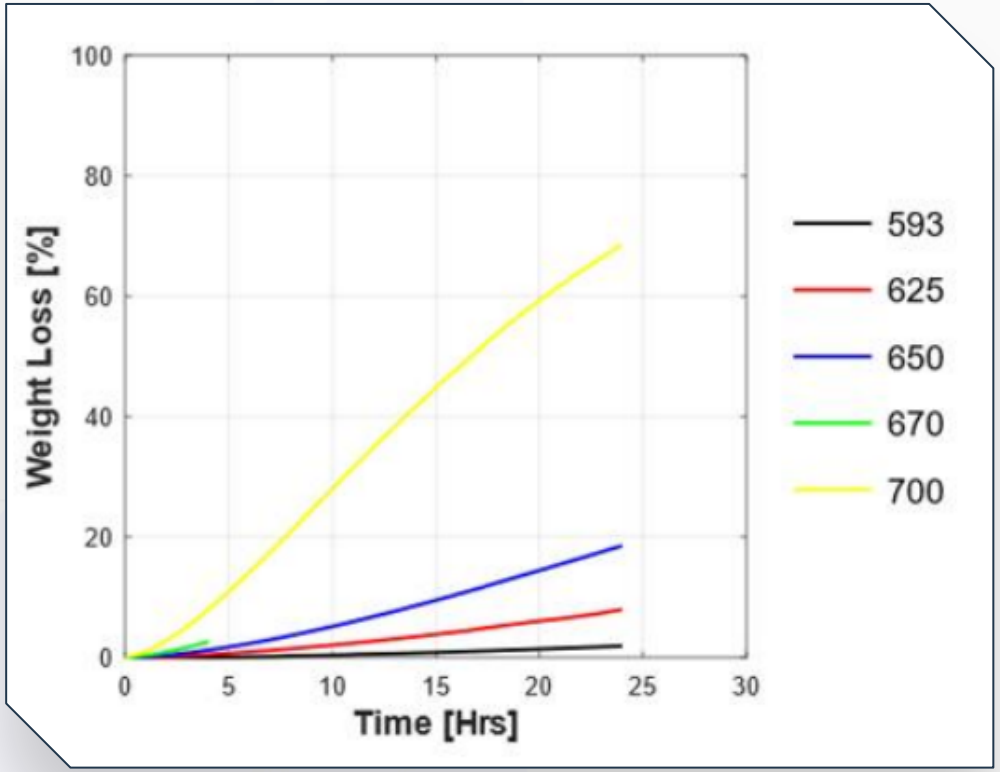
W_T (%/hr.)	Graphite 1	Graphite II	Graphite III
Tape	1.17 ± 0.12	1.07 ± 0.75	3.62 ± 1.08
Knitted Yarn Inconel®	1.51 ± 0.44	1.61 ± 0.26	5.48 ± 1.08
PTFE Imp. Packing (<10% PTFE)	7.06 ± 1.17	7.86 ± 1.71	15.49 ± 0.48

% Increase of W_T	Graphite 1	Graphite II	Graphite III
Tape - Knitted Yarn Inconel®	29	50	51
Knitted Yarn Inconel® - PTFE Imp. Packing	368	388	177

Packing Weight Loss

Conclusion

- Graphite based packing with Inconel® mesh and PTFE typically seals better than the same packing without PTFE
- The increase of weight loss for packing with PTFE is not proportional to the amount of added PTFE.
- When choosing heat exchanger tail pipe packing, the increase sealability created by the addition of PTFE should be weighed against the increase in weight loss at high temperatures.



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Thank You!

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