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PERFORMANCE OF SEMI-METALLIC GASKETS WITH NUBBINS

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Content

- Issues with DMJ (Double Metal Jacketed) and Nubbins at Sinclair Wyoming Refining Company
- Purpose of Nubbins
- Testing and Results on DMJ & Kammprofile Gaskets with Nubbins
- Conclusions

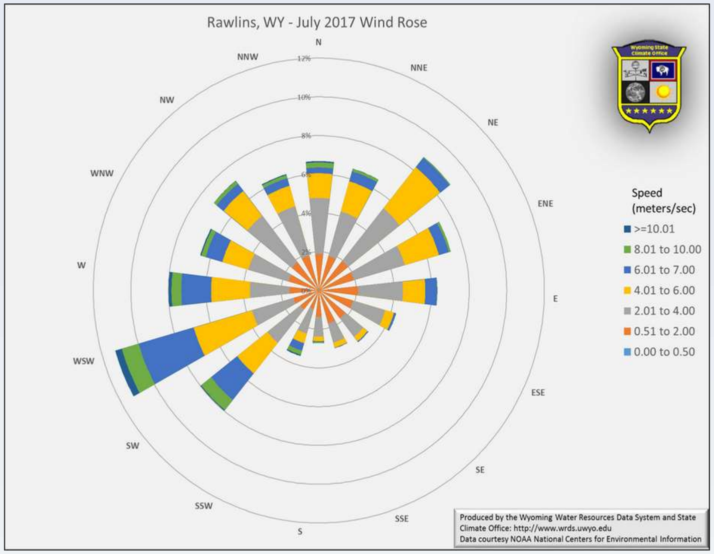
Sinclair Issues – Unit and Gasket Used

Sinclair Wyoming Refining Company is situated in Rawlins, Wyoming.
The refinery is ideal for projects like this due to:

- High elevation
- Atmospheric temperature
  - average minimum temperatures = 13 Deg F
  - average maximum temperatures = 87 Deg F
- High wind factor

All the above can greatly exaggerate refinery conditions and the bolted joint connection.

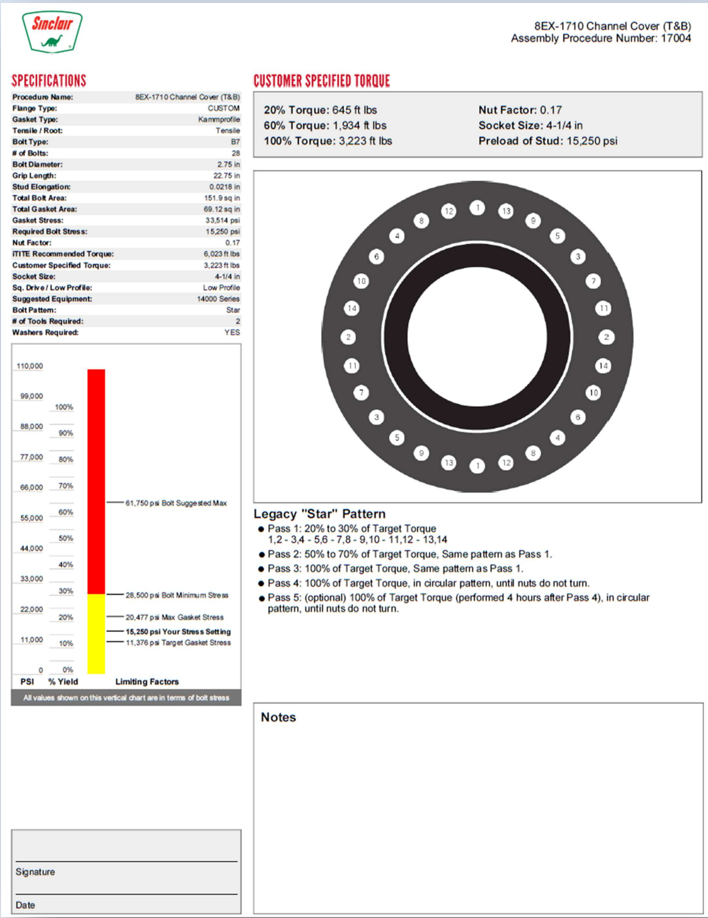
- Rapid temperature decreases
- Movement / Vibration



Sinclair Issues – Unit and Gasket Used

The Poly Unit at Sinclair Wyoming Refining Company (SWRC) is a series of five vertical vessels used to make Poly Gasoline. Four of these vessels were designed to originally use a Double Metal Jacket (DMJ) gasket running in a 1/2" wide groove around the reactor flange. The nubbin is positioned to sit in the center of the groove.

Sinclair Issues – Unit and Gasket Used



8EX-1710 Channel Cover (T&B)
Assembly Procedure Number: 17004

SPECIFICATIONS

Procedure Name:	8EX-1710 Channel Cover (T&B)
Flange Type:	CUSTOM
Gasket Type:	Kammprofile
Tensile / Root:	Tensile
Bolt Type:	B7
# of Bolts:	28
Bolt Diameter:	2.75 in
Grip Length:	22.75 in
Stud Elongation:	0.0218 in
Total Bolt Area:	151.9 sq in
Total Gasket Area:	69.12 sq in
Gasket Stress:	33,514 psi
Required Bolt Stress:	15,250 psi
Nut Factor:	0.17
ITITE Recommended Torque:	6,023 ft lbs
Customer Specified Torque:	3,223 ft lbs
Socket Size:	4-1/4 in
Sq. Drive / Low Profile:	Low Profile
Suggested Equipment:	14000 Series
Bolt Pattern:	Star
# of Tools Required:	2
Washers Required:	YES

All values shown on this vertical chart are in terms of bolt stress

Signature

Date

CUSTOMER SPECIFIED TORQUE

20% Torque: 645 ft lbs
60% Torque: 1,934 ft lbs
100% Torque: 3,223 ft lbs

Nut Factor: 0.17
Socket Size: 4-1/4 in
Preload of Stud: 15,250 psi

Legacy "Star" Pattern

- Pass 1: 20% to 30% of Target Torque
  1,2 - 3,4 - 5,6 - 7,8 - 9,10 - 11,12 - 13,14
- Pass 2: 50% to 70% of Target Torque, Same pattern as Pass 1.
- Pass 3: 100% of Target Torque, Same pattern as Pass 1.
- Pass 4: 100% of Target Torque, in circular pattern, until nuts do not turn.
- Pass 5: (optional) 100% of Target Torque (performed 4 hours after Pass 4), in circular pattern, until nuts do not turn.

Notes

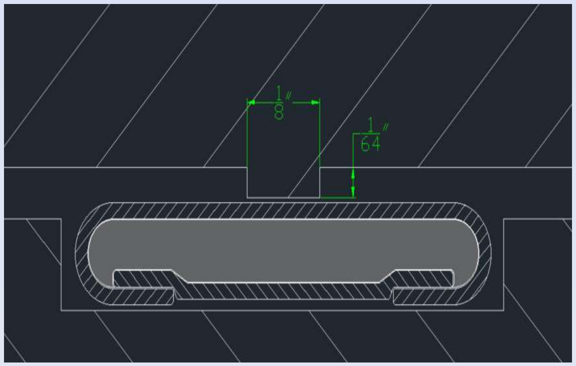
There have been many problems with the DMJ gaskets sealing even though a full written procedure is in place and the bolt to gasket stress checks out in theory.

Seal ability had become a major cost issue due to the inconsistency and down time of the reactors.

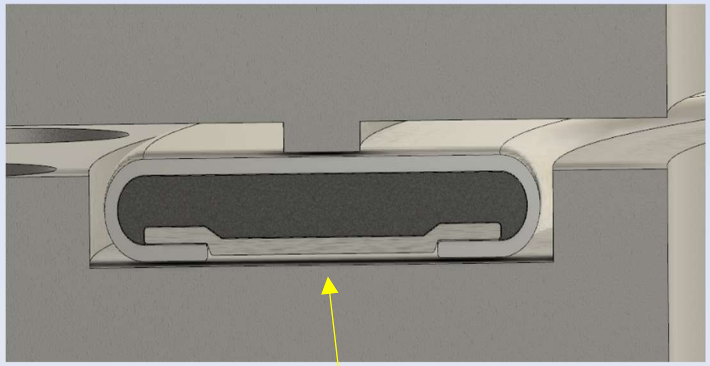
Leakage was occurring on both the top and bottom flanges of the poly reactors.

Purpose of Nubbins

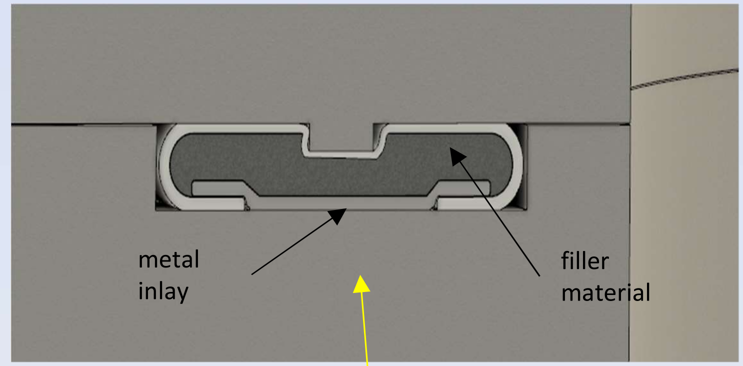
Typical dimensions of a Nubbin are 1/64” high by 1/8” wide



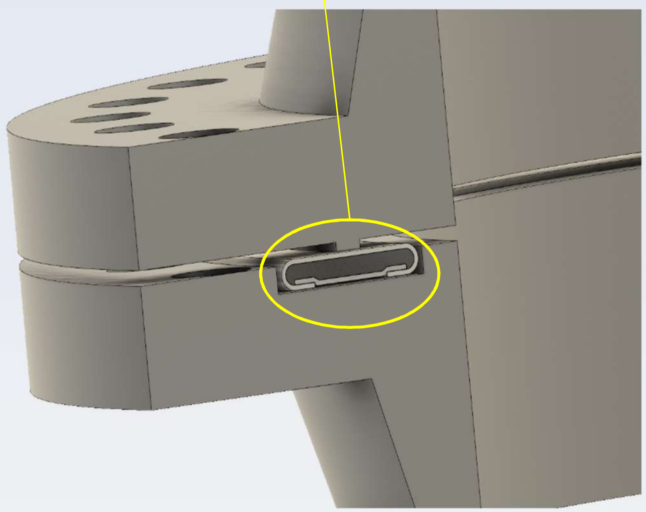
Un-Compressed DMJ Gasket. The Nubbin should sit in the center of the gaskets cross section

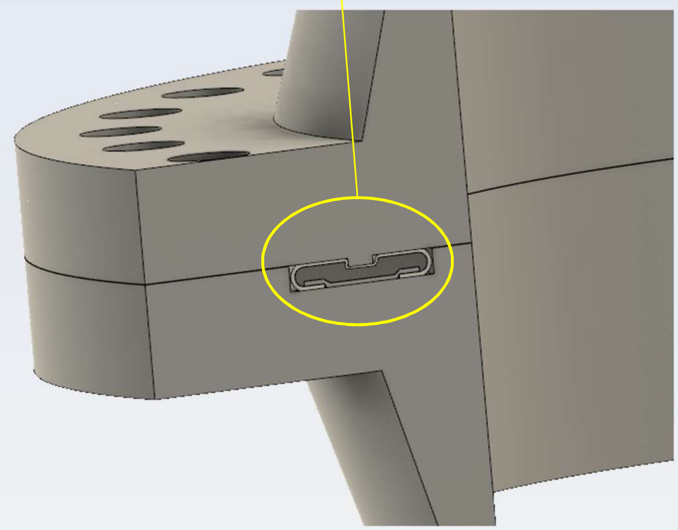


When load is applied to the gasket the nubbin will compress into the flat of the DMJ cross section in turn pushing the metal inlay through filler (e.g. graphite – PTFE) densification to the groove base.



Even though the nubbin creates a high stress point on one side of the gasket there is still large surface area contact (metal to metal) after gasket compression.





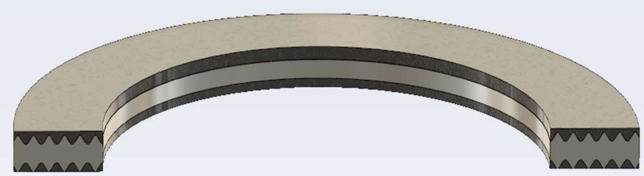
Laboratory Testing

One question that is frequently asked is "What type of gasket can I use on my heat exchanger when the old gasket is a DMJ and one of the flanges has a nubbin machined in?".
DMJ gaskets have limitations on leakage rates due to the large area of metal to metal contact.
One option available to the end user is to machine the nubbin off the flange, which is both time consuming and expensive.

Due to this lack of test data, it was decided to conduct a test program to understand how different semi-metallic gaskets would perform when a nubbin is present.

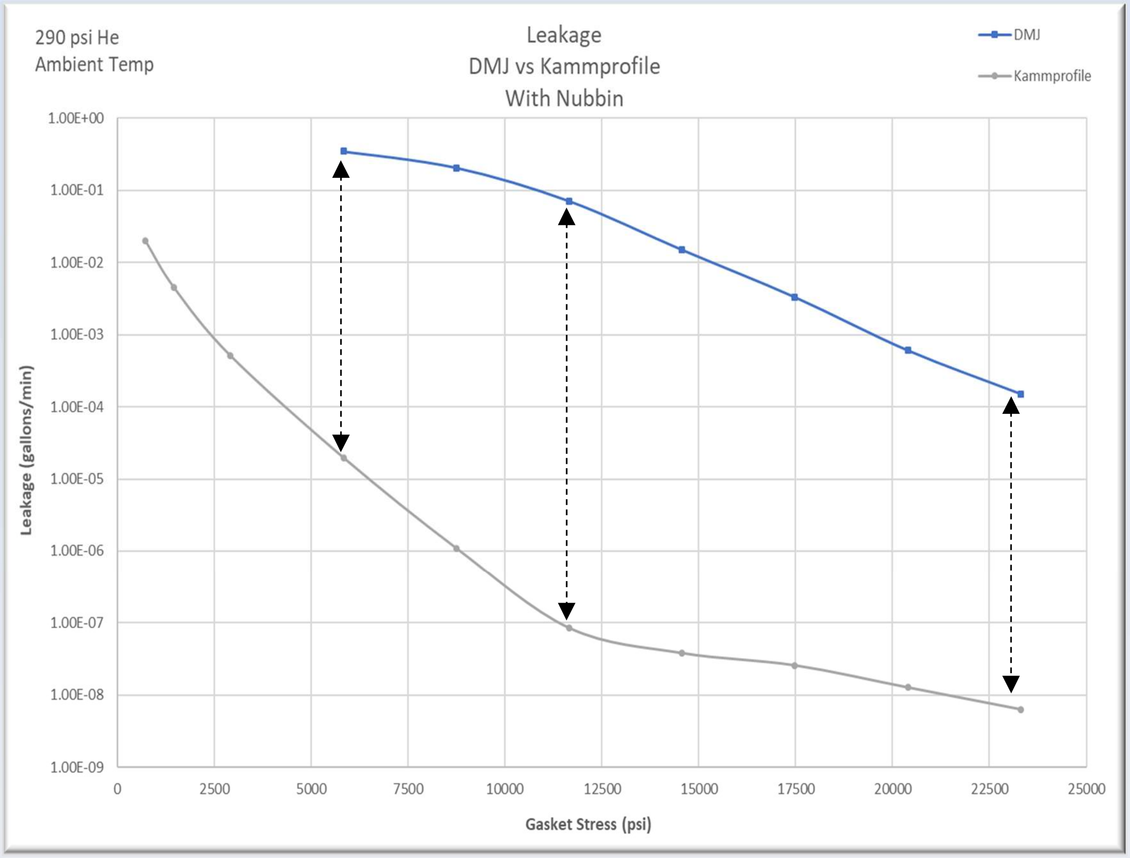
1. Understanding the leakage rate of a DMJ gasket against the preferred gasket type, a Kammprofile in Nubbin environments.
2. Understanding the leakage of the selected gaskets in temperature cycling conditions. This would replicate the Poly Unit conditions at Sinclair.

VS



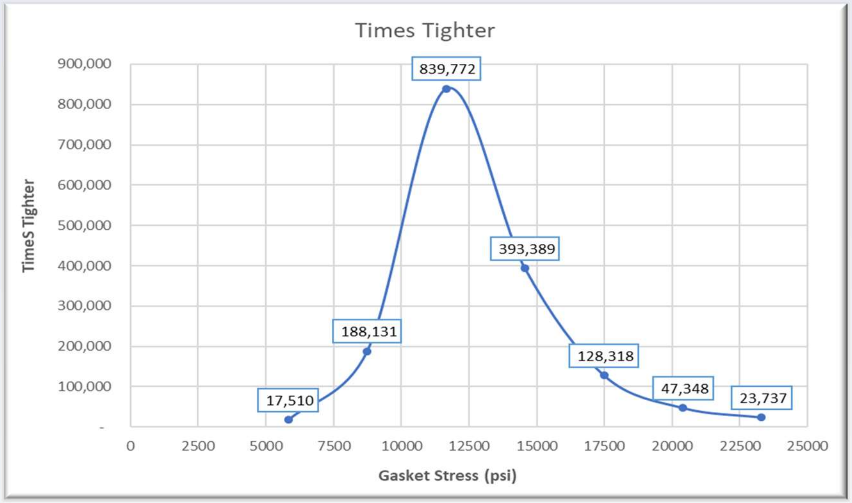
Laboratory Testing

Understanding the leakage rate of a DMJ gasket against the preferred gasket type, a Kammprofile in Nubbin environments.



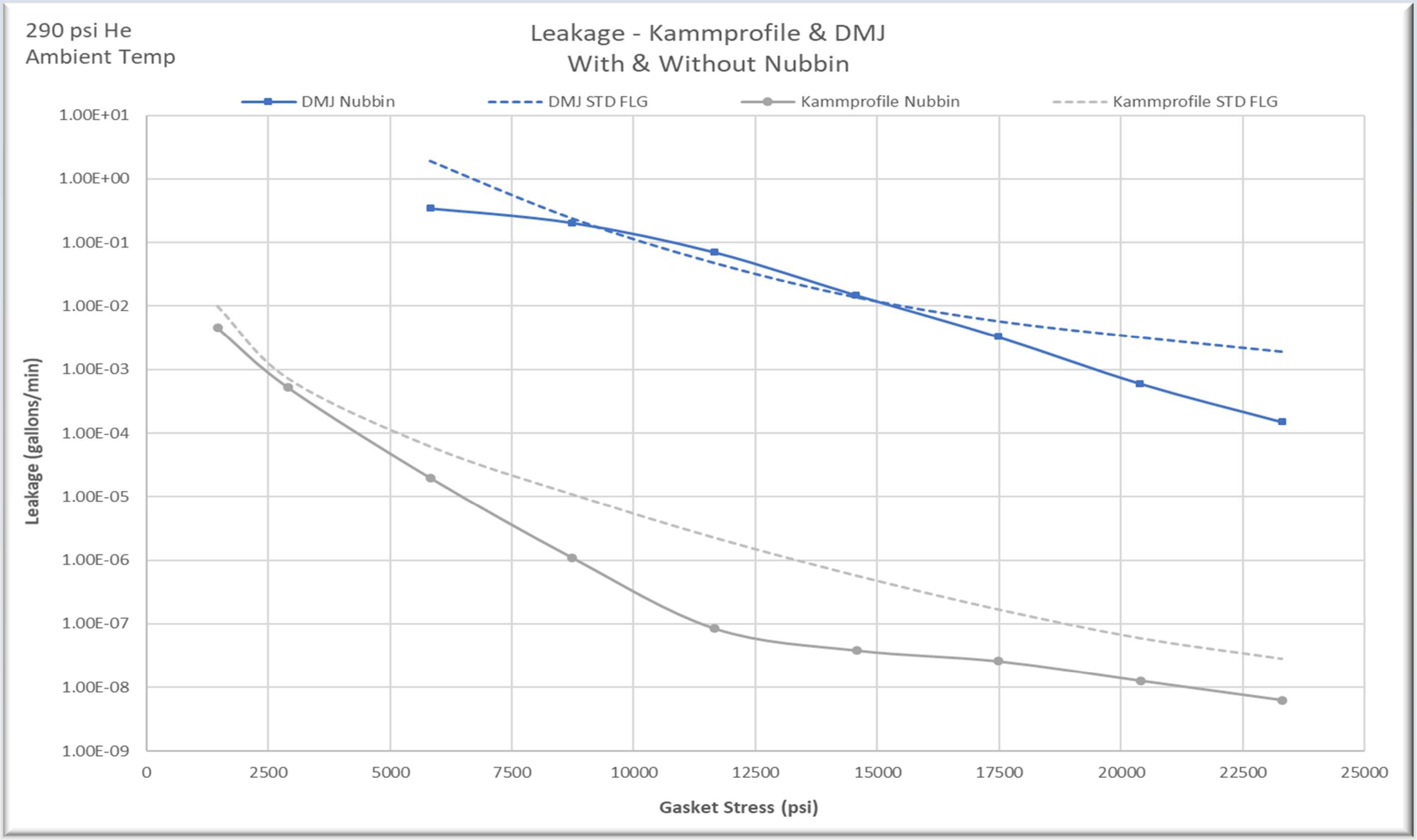
Gasket Stress	MPa	5	10	20	40	60	80	100	120	140	160
	psi	725	1450	2901	5802	8702	11603	14504	17405	20305	23206

The graph on the left shows results of a DMJ and Kammprofile at ambient temperature and an internal pressure of 290 psi (20 Bar).
The leakage is measured at an initial gasket stress of 725 psi (5 MPa). Load is then increase at steps following the below table and leakage measured at each stage.
The DMJ gasket had too higher leak rate at the first three gasket stress points for the test machine to read.
As can be seen from the results graph the Kammprofile out performed the DMJ gasket under the same test environment.



Laboratory Testing

The graph compares the selected gaskets “with and without nubbins” at ambient temperature and 290 psi (20 Bar) internal pressure.
As can be seen from the data there is very little difference between a flange with a nubbin and standard flat flanges for either style of gasket.



Gasket Stress	MPa	5	10	20	40	60	80	100	120	140	160
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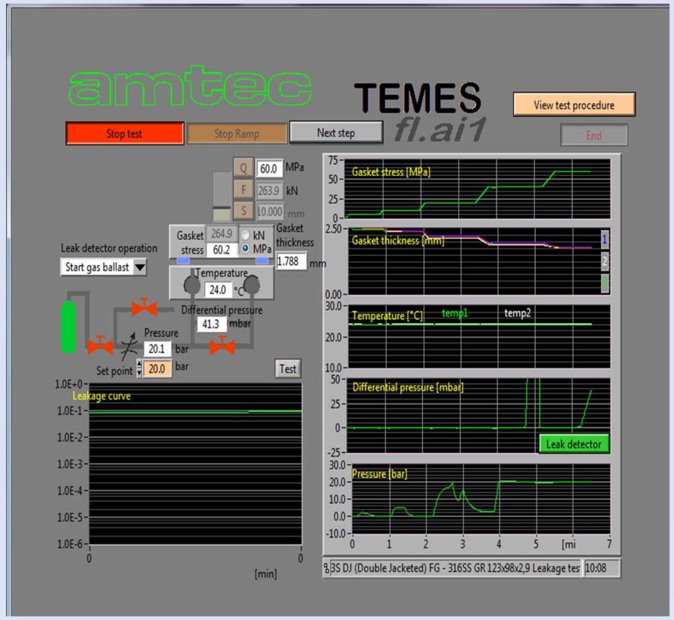
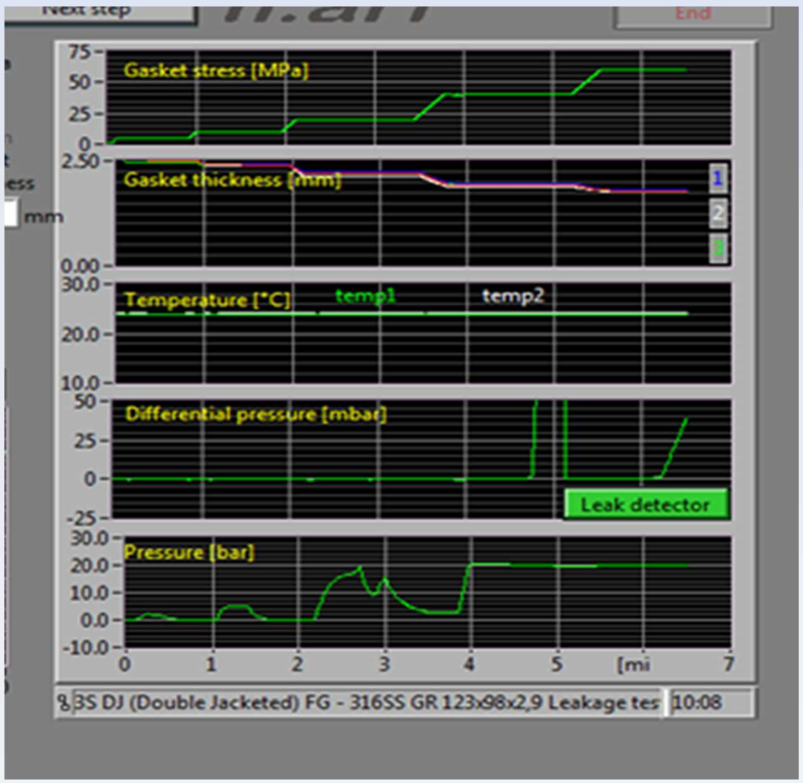
Laboratory Testing





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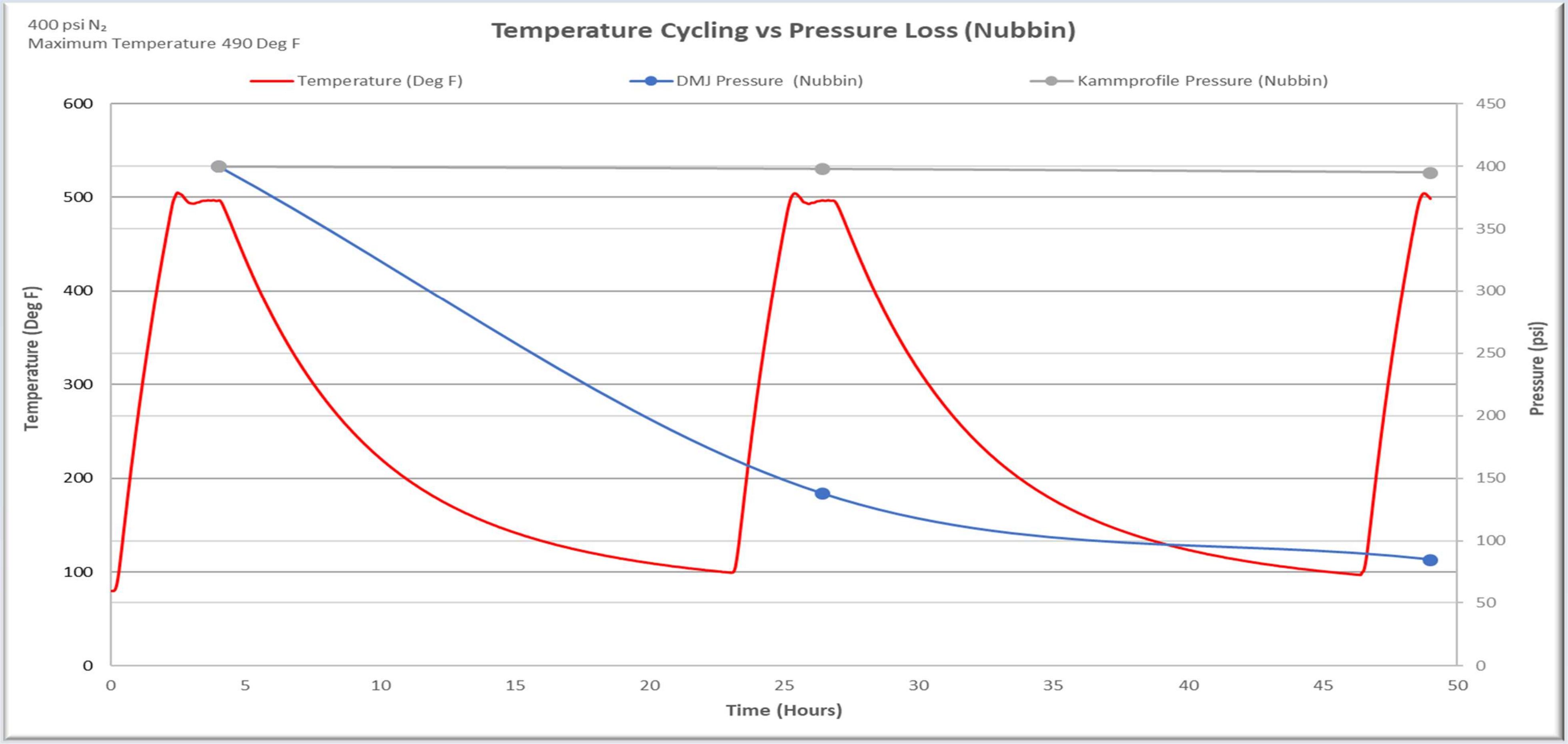
3S Laboratory Testing – Temperature Cycling



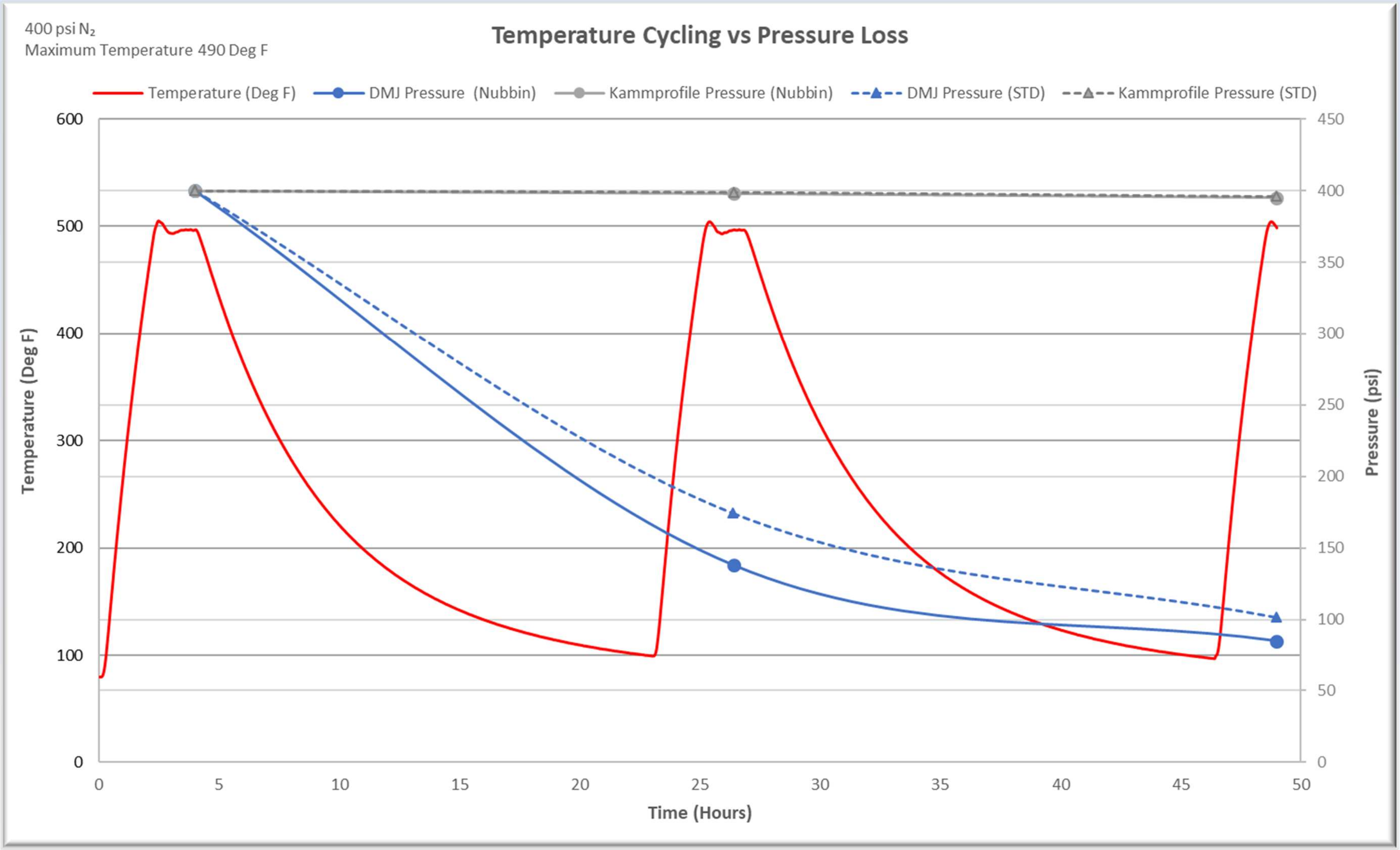
The above table outlines the remaining gasket stress after two temperature cycles. Even though the DMJ gasket lost significantly more internal pressure in the test this was not due to low gasket load.

The remaining bolt stress was obtained by intelligent bolting (SPC4®). This was then calculated back into a gasket stress *(estimated).*

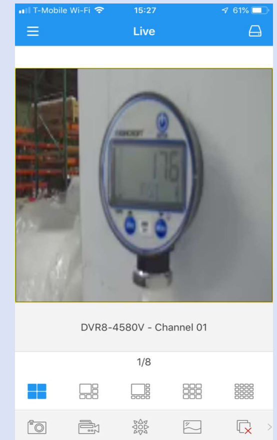
	DMJ	Kammprofile
Initial Bolt Stress	79000 psi (545 MPa)	79000 psi (545 MPa)
Gasket Stress	23100 psi (160 MPa)	23100 psi 160 MPa)
Remaining Bolt Stress	52630 psi (363 MPa)	53100 psi (366 MPa)
Bolt Joint Relaxation	33.3%	32.8%
Gasket Stress After Test ***(estimated)***	15419 psi (106 MPa)	15557 psi (107 MPa)

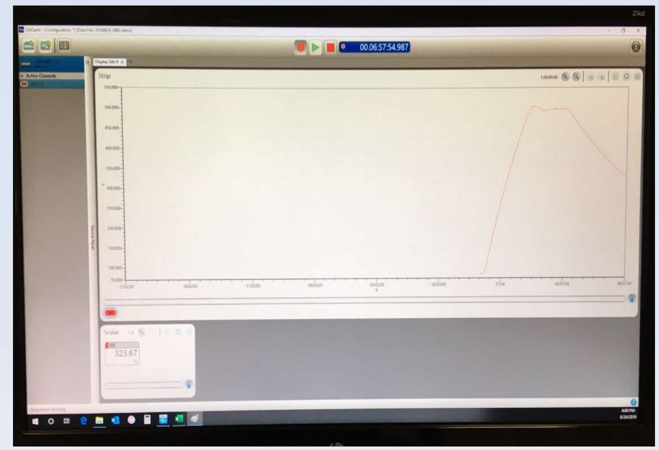
3S Laboratory Testing – Temperature Cycling

The graph compares the selected gaskets "with and without nubbins" in a temperature cycling environment as the previous slide.
As can be seen from the data there is very little difference between a flange with a nubbin and standard flat flanges for either style of gasket. This follows the same pattern as the leakage test performed at ambient temperature.



3S Laboratory Testing – Temperature Cycling





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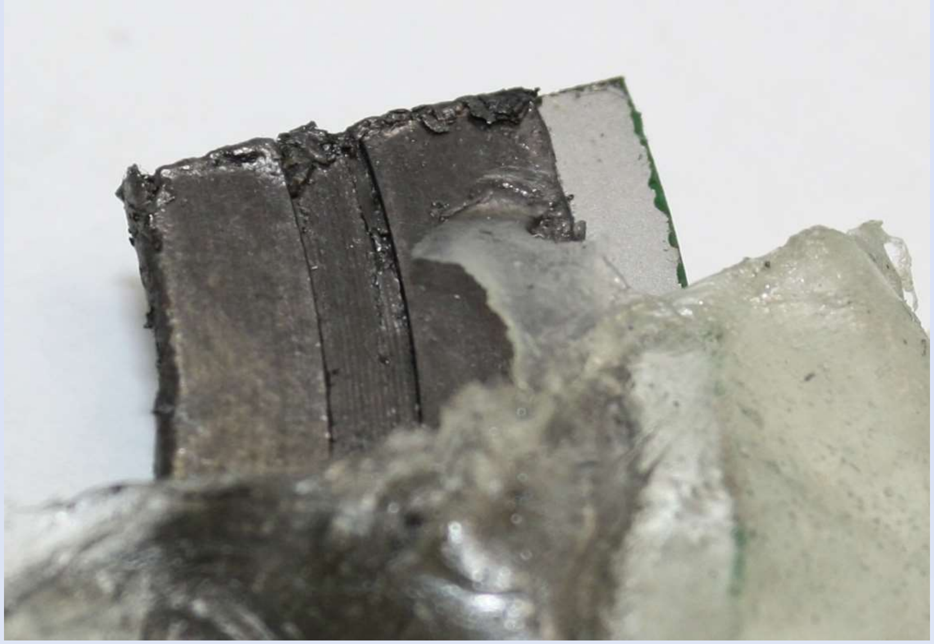
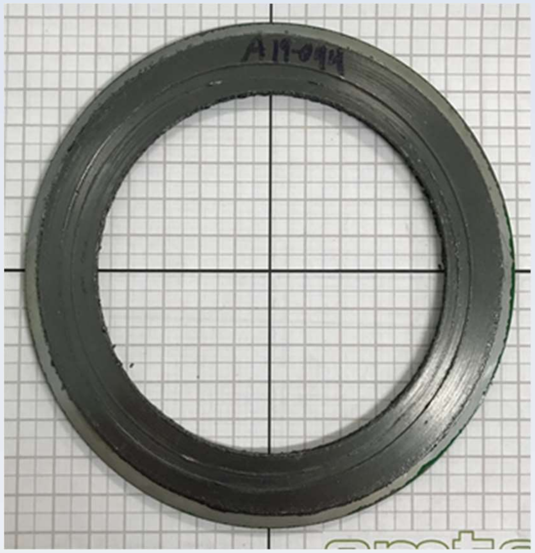
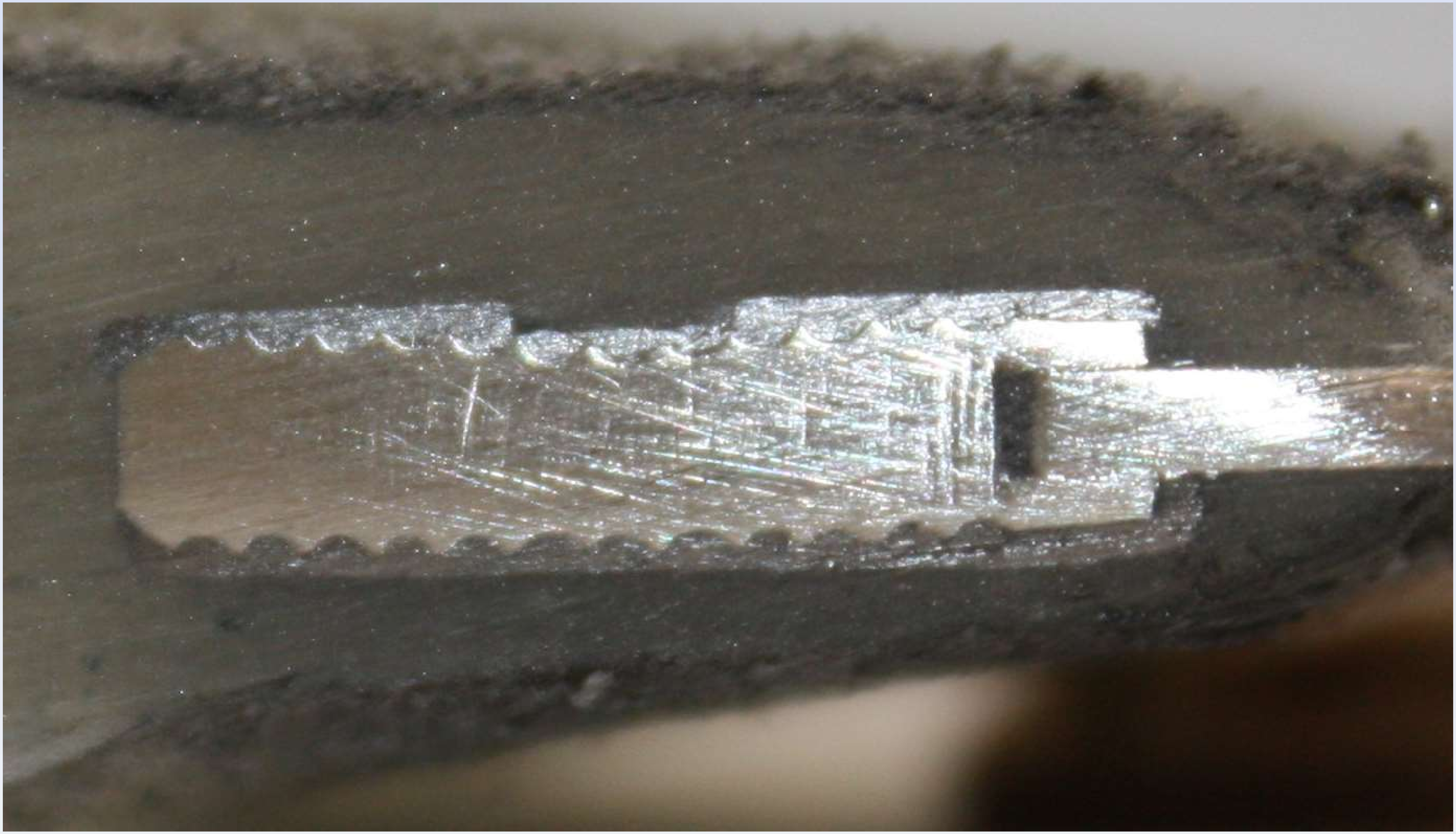
Laboratory Testing – Gasket Analysis After Testing

An analysis of the gasket cross section and surface was conduct after testing and on the Poly Unit. Examples if this is captured in the following pictures.
From this analysis there was no sign of stress damage around the nubbin area of the kammprofile.





Laboratory Testing – Gasket Analysis After Testing



Laboratory Testing – Gasket Analysis After Testing

Conclusions

Leakage Testing:
The DMJ gasket showed significantly higher leakage values than the Kammprofile gasket. Although the leakage reduced on the DMJ as the gasket stress increased, this was not at the same magnitude as the Kammprofile gaskets.
There was no difference in leakage rates on a DMJ and Kammprofile gasket between flat face and a nubbin setup, which indicates the nubbin is not reducing the leakage rate due to the higher stress point.
Temperature Cycle Testing:
Even though the remaining gasket stress was very similar on both gaskets, the pressure loss was significantly higher on the DMJ gasket proving the Kammprofile gasket provides a tighter seal.
No damage to gaskets or flange faces/nubbin occurred during testing.

Method of replacement:
To change the style of gaskets an MOC was written and divided into four parts. Part one was commissioned officially on the 25th of March 2018 with the last poly reactor changed and commissioned on the 8th of June 2018.
To date there have been no reports of leakage, damage, or bolting problems with the reactors. The Poly Units have run faithfully with Kammprofile style gaskets with no machining of the nubbins done.

Our view is that this experiment was a success and we will continue to make case-by-case determinations of switching over to Kammprofile from DMJ without machining off the nubbins.