



# **Preventing Slurry & DIW Cross Contamination**

Using  
***Malema™ Interconnect Interlock Device (MIID)***

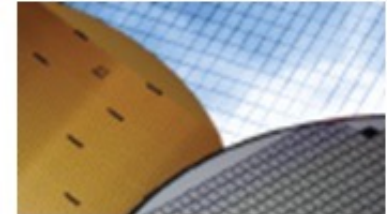
Jay Rajagopalan, President, Malema Sensors

April 22, 2021

## Malema at a Glance

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- Leading flow measurement and flow control devices manufacturer
- Founded in 1981. Over 40 years serving Semiconductor industry
- Head office: Boca Raton, Florida; West Coast office: San Jose, California
- R&D & Manufacturing locations:
  - USA, Singapore and India
- Strong R&D program with several key patents in flow measurement and control
  - First to introduce PFA Coriolis Flow Controller to Semiconductor industry
  - First to introduce PFA Ultrasonic flow controllers to Semiconductor industry
  - First Ultrasonic dispense verification meter for photoresist, SOD and SOG applications



**SEMICONDUCTOR**



**LIFE SCIENCES**



**INDUSTRIAL**

# Preventing Slurry & DIW Cross Contamination

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## Agenda:

- Problem Statement
  - Cross Contamination of DI Water and CMP Slurry was disrupting operations and depressing yield at a major multinational semiconductor manufacturer
- Investigation
  - Unpredictable bypass leaks in three-way valves allowed slurry and DI water to contaminate each other
- Detection
  - Multiple techniques were evaluated to catch a bypass leak event when it happened
- Prevention
  - A novel valve assembly was developed to prevent the leaks from happening and return the fab to full production and yield

## Slurry & DIW Cross Contamination

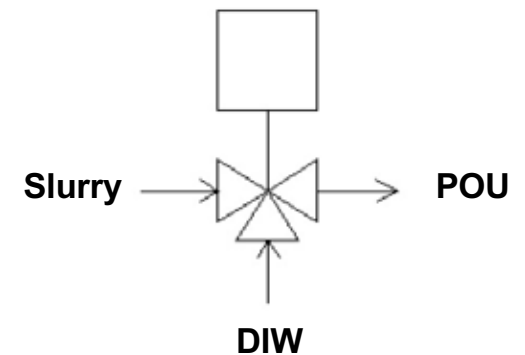
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CMP Slurry and DI Water cross contamination events were disrupting operations and depressing yields at a major multinational semiconductor manufacturer.

- Sometimes when a wafer polishing tool requested DI water, slurry was delivered, and at other times DI water would be delivered when slurry was requested. This would cause wafers to be lost or damaged, reducing overall yield.
- There were also occasions where the CMP slurry supply system was found to be diluted with water.
- At other times, the fab-wide DIW supply was contaminated with CMP slurry. These events would force the entire production suite to be shutdown for cleaning.
- The semiconductor manufacturer reached out to Malema to help investigate the issues and develop solutions that would detect, and hopefully eliminate these events.

## Investigation – Cross Contamination

- Root cause – Three-way valve
  - CMP tools include a three-way diverting valve to deliver DI water or CMP slurry to the polishing platen.
  - Investigation determined that the underlying problem was a bypass leak in this valve.
  - The valves were not always damaged by these events and could return to normal function after a failure, making it difficult to determine the source of the leak.



## Investigation – Cross Contamination

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In reality all valves leak. Final test criteria for all valve manufacturers is essentially an acceptable leak rate. As valves age and normal wear takes place, leak rates increase. The problem is leakage in the reverse flow (or backflow). Often these reverse flows occur at very low flow rates [ $<5$  ml/min] and are very difficult to detect. Yet these small leaks allow contamination or dilution of the cross connected liquids.

Backflow can cause expensive damage. Cross contamination caused by backflow may lead to loss of productivity, reduced yields and semiconductor fabrication plant (FAB) shutdowns. Unplanned shutdowns to repair/replace leaking components and cleanup contaminated plumbing systems reduce financial performance and introduce unexpected delays into tight delivery schedules. It may take a long time before a small leak is discovered, resulting in the loss of much product and productivity.

## Cross Contamination – Finding a Solution

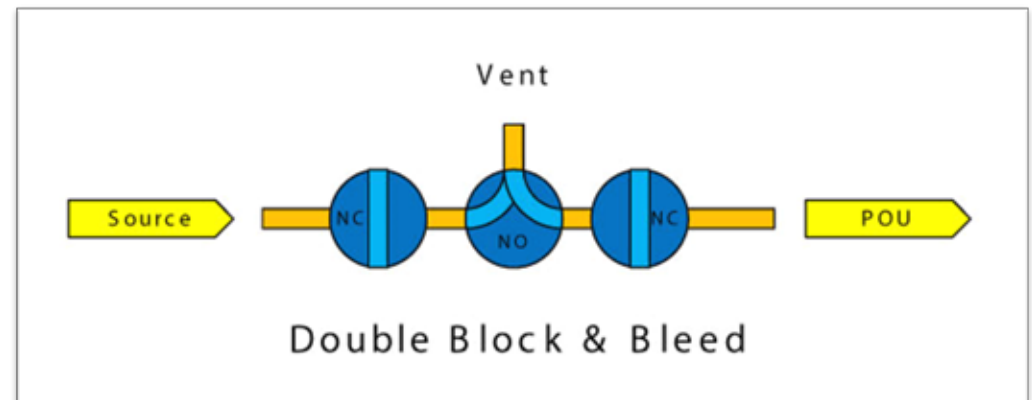
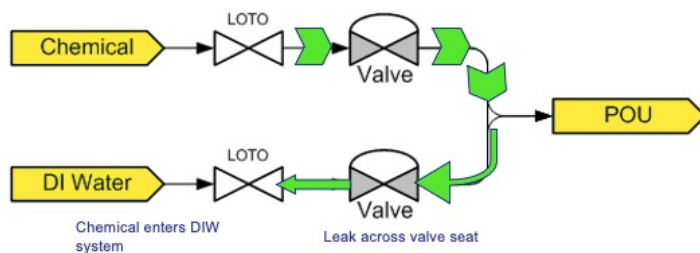
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- Malema and the end user tested numerous methods to detect the leaking valve condition
  - Flow switches, including uni- and bi-directional, and special low flow switches
  - Flow meters
  - pH and conductivity meters
- While the bypass leak condition could be detected with these methods, detection alone didn't prevent the cross-contamination events and the resulting wafer loss and tool or fab downtime
- A solution was needed to prevent the bypass leak events from happening

## Double block and bleed approach

- Solving the actual problem required using a different method to control the delivery of slurry and DI water to the platen.
- The double block-and-bleed valve arrangement prevents bypass leaks. Isolation valves up- and down-stream of a vent valve means even a leaking valve will not bleed through to the other side of the valve block. Instead, any fluid that does leak is vented out of the tool.

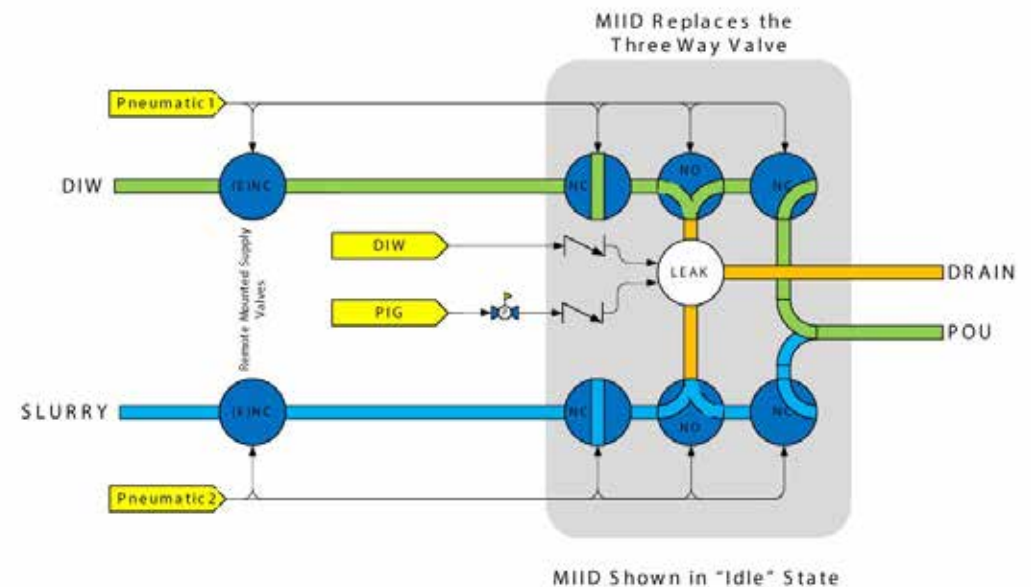
One might try this approach replacing 3-way valve, but this approach also doesn't prevent cross contamination





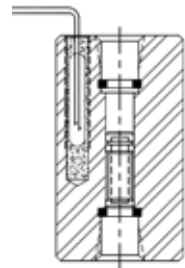
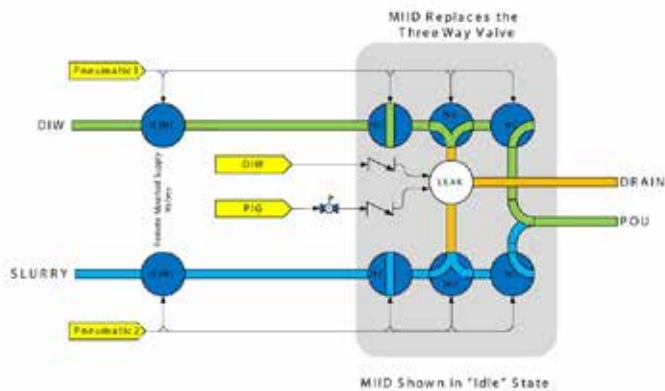
## Detection & Prevention in single block

- By using a double block and bleed (DB&B) valve arrangement on both the DI water and CMP slurry lines, the cross-contamination events are eliminated.
- Malema was able to integrate this valving solution into a single block, allowing the end user to retrofit their tools easily.



# Preventing Slurry & DI Cross Contamination

- In a single block manifold, the Malema™ Interconnect Interlock Device (MIID-1000) combines the features of two DB&Bs with special Leak detection and drain management functions
- The negative effects of internal and by-pass leaks are completely eliminated. A warning signal is available if such leaks develop.



Leak detection



**Single MIID-1000 valve block**  
US Patent 8,997,789

# Preventing Slurry & DI Cross Contamination

- Installation of a three-line MIID-1000 retrofit kit can typically be completed in less than two hours.
- No modification of host tool software is required.
  - The MIID retrofit kit includes a tiny PLC in a watertight enclosure that manages up to five MIIDs.
  - Existing plumbing and pneumatic signals are simply repurposed for MIID operation.



**MIID-1000 control PLC**

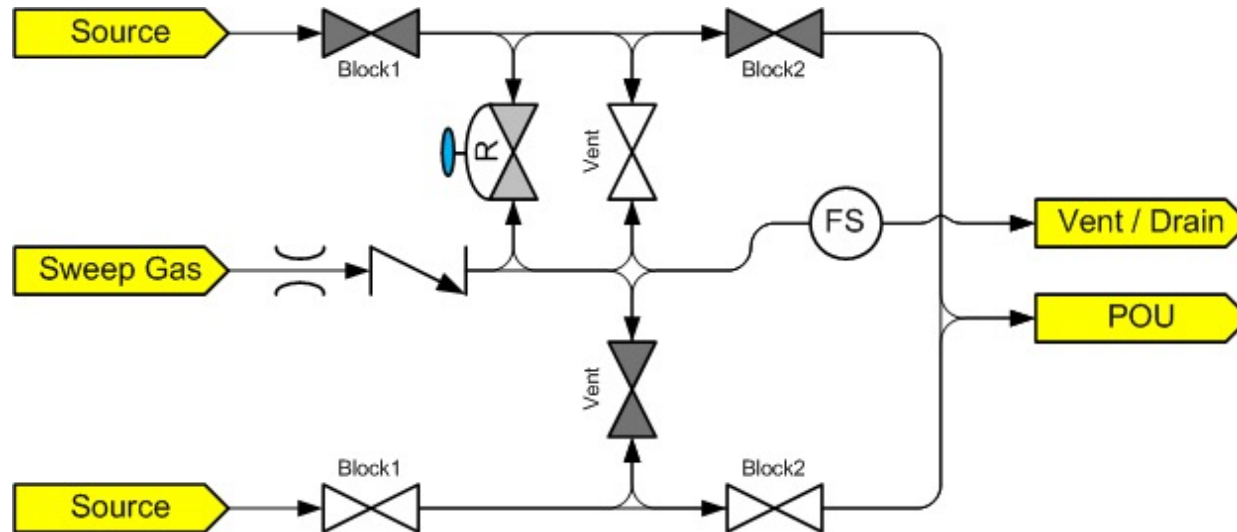


Up to 5 MIIDs

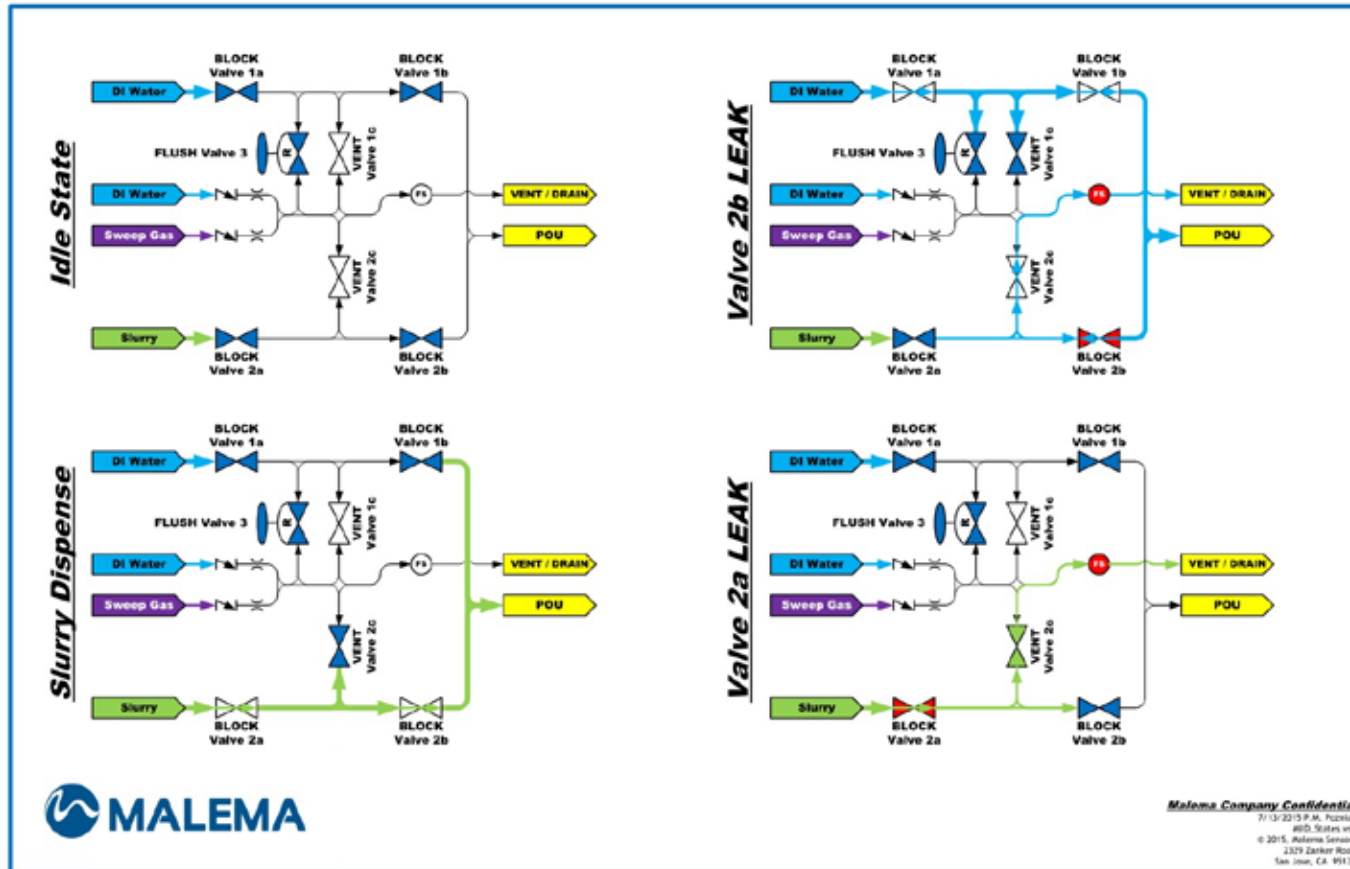


# MIID: General form for Slurries

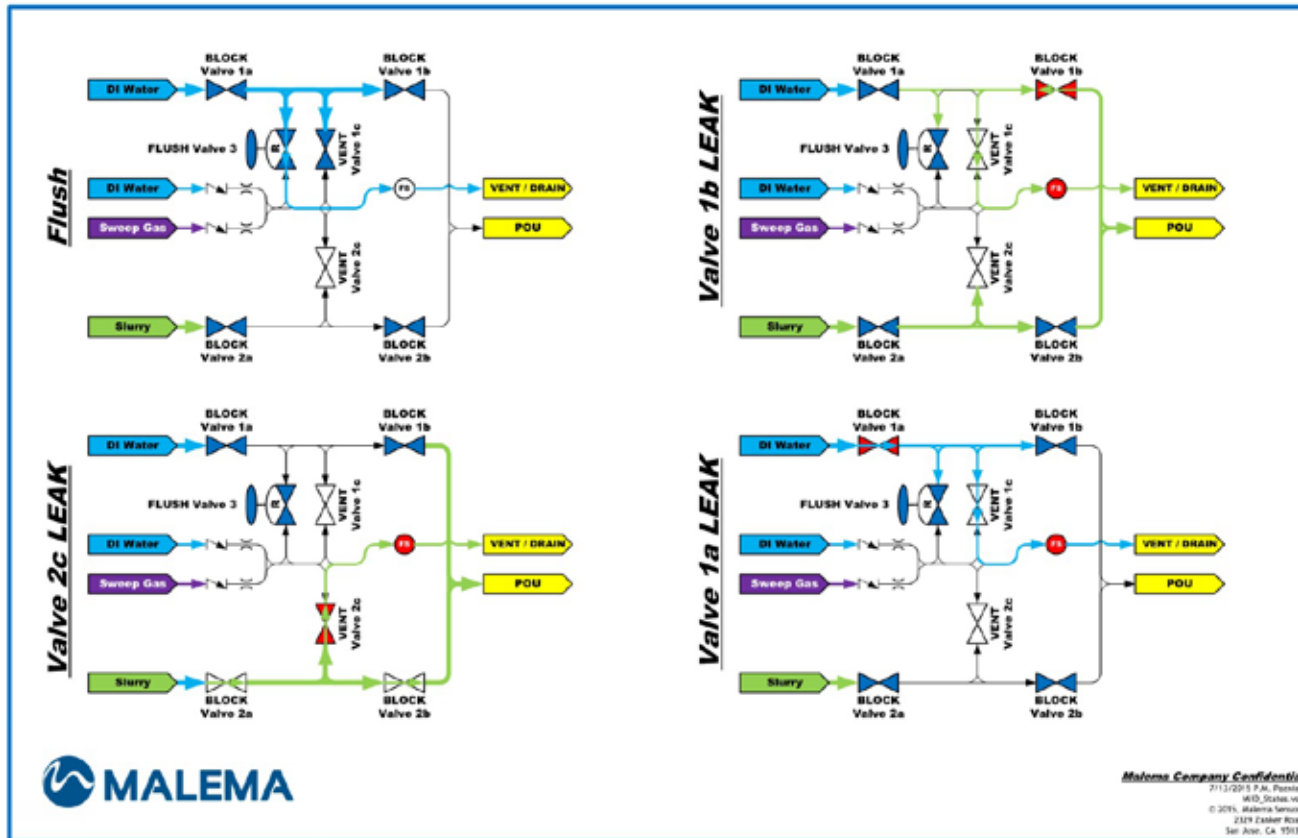
Vent / Drain line automatically flushed after each dispense cycle



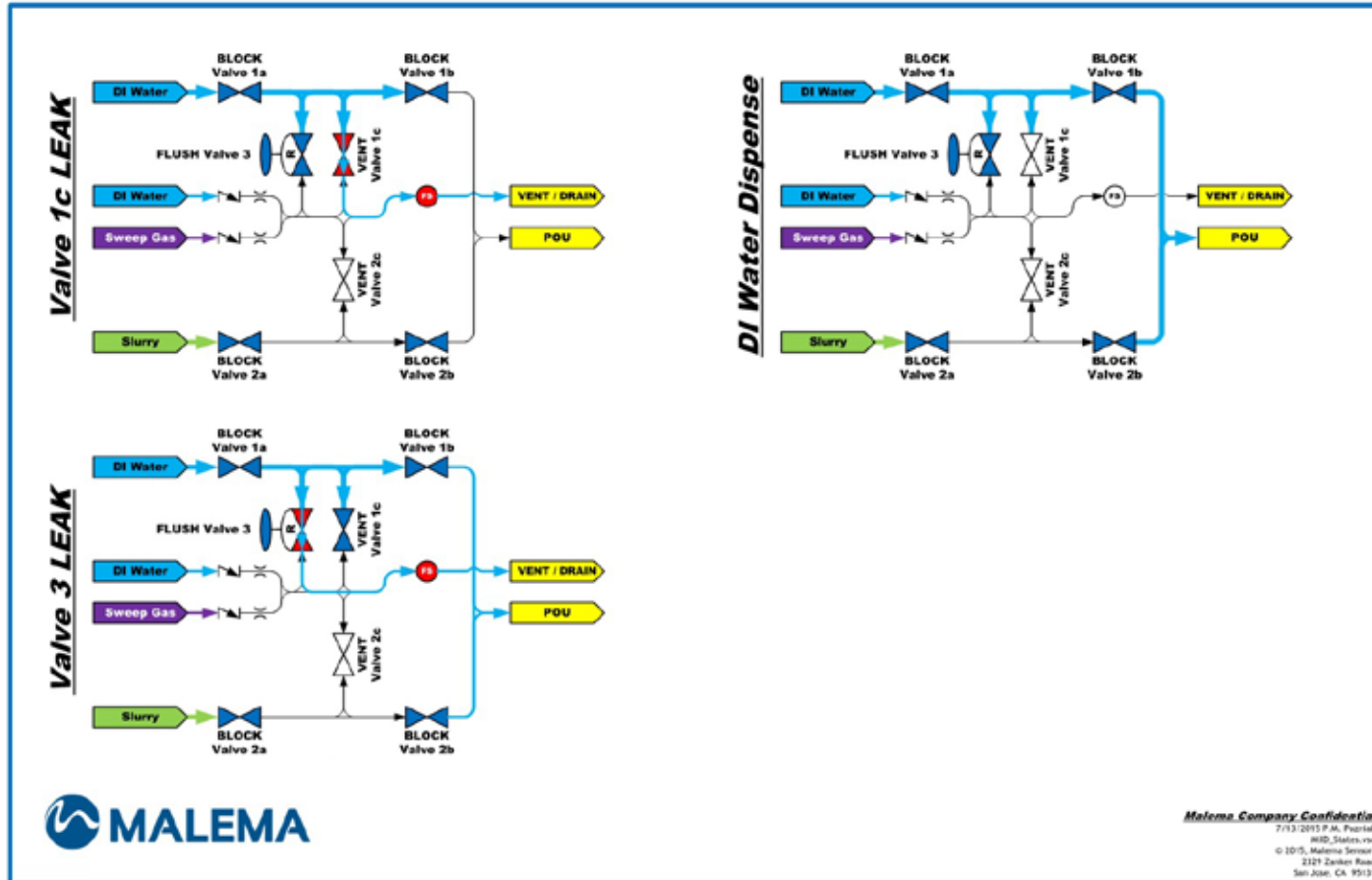
# MIID States were Tested for Cross Contamination



# MIID States (continued)



# MIID States (continued)



# Testing & Validation

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- Malema validated the MIID design by equipping all valves in the assembly with known leaking valve seats
- No cross contamination occurred — even when every valve in the assembly was forced to leak
- MIID have been installed in working CMP tools for several years.
  - No cross contamination events
  - No process impacts were observed
  - Tested life cycle with SS-12 slurry: 2,050,000 cycles.
  - Tested life cycle with DI Water: 10,000,000 cycles.

**1500+ MIID-1000 blocks in the field  
with no reported failures**



Questions?

Thank you