

Bond Assembly FOD Zones – A Procedure for Assuring Acceptable Adhesion

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Rocket Motor Perspective on Adhesion



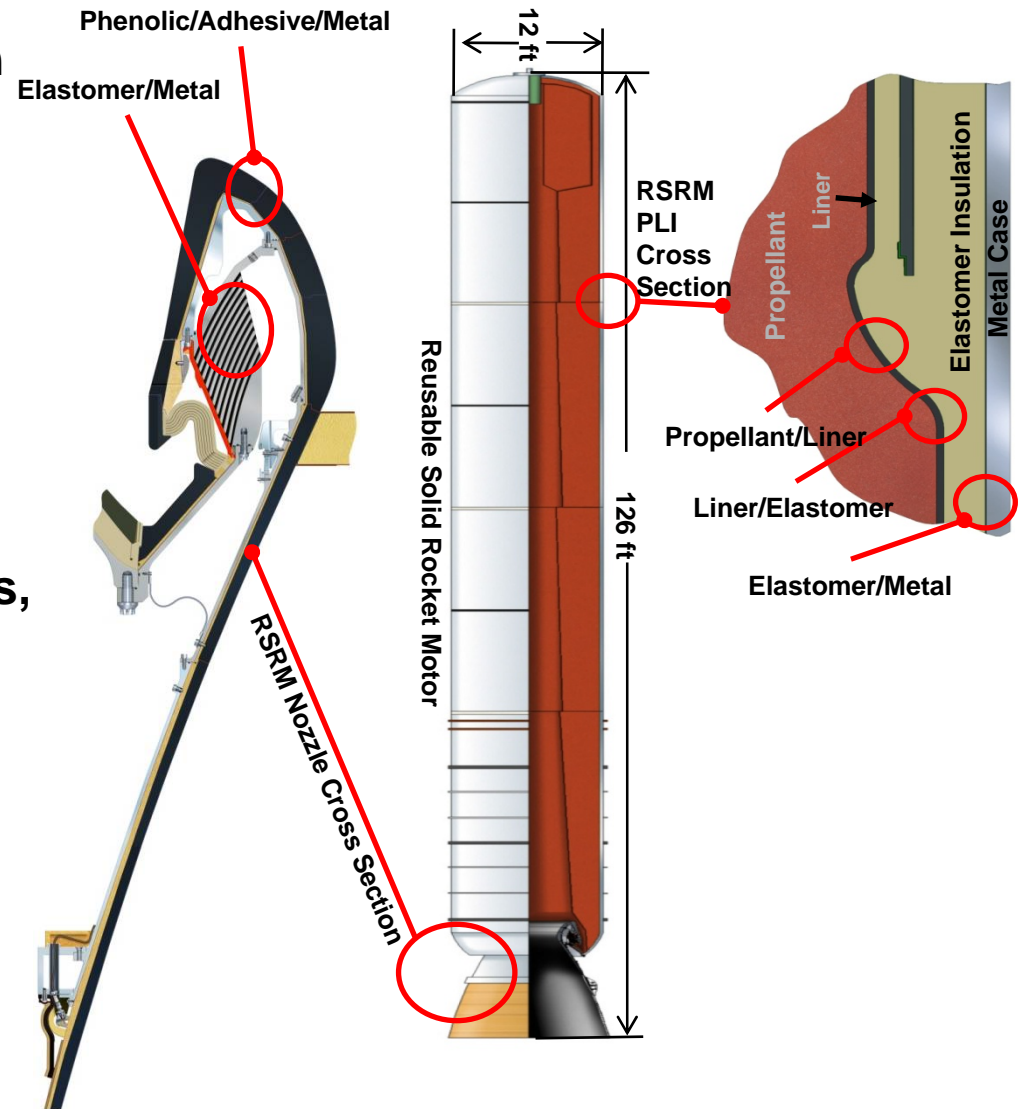
A premier aerospace and defense company

Rocket motor components are primarily assembled by adhesion

- The RSRM (Reusable Solid Rocket Motor—part of the Space Shuttle Boosters) system contains 10,000 ft² of bondline area
- Rocket motors contain a variety of adhesive/substrate bond systems
- Bond system performance requirements also vary

To assemble reliable components, ATK Space Systems and customers invest substantial resources on the study of bond assembly processes

- Surface and adhesion science
- Adhesive chemistry
- Process parameters
- Contamination effects

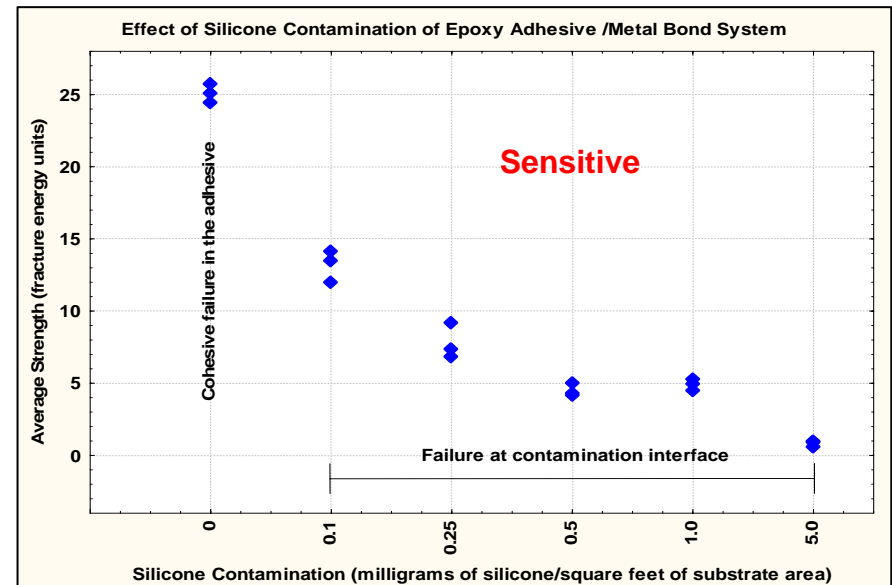
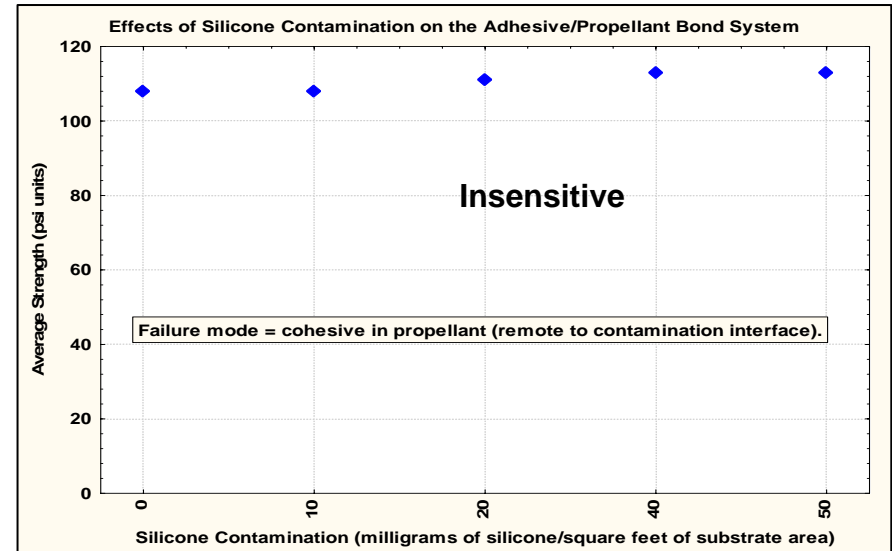


Contamination sensitivity of rocket motor bond systems vary

- Insensitive = no strength reduction, with failure usually remote to the contamination interface
- Sensitive = strength reduction and failure at the contaminated interface

To prevent bond system failure, operations is vigilant about contamination control

- Tight control is exerted on a wide range of process contaminants; e.g., greases, oils, tape residues, particulates, release agents, etc.



The effect of incongruous forces:

- ATK adopted a zero-tolerance contamination requirement
- ATK developed greater fidelity in contamination detection

Extreme Requirements + Better Detection = Production Paralysis

Over zealous contamination control negatively affected production **sensibility, efficiency, and ergonomics**

Sensibility

- Tight control – indiscriminately applied to all manufacturing areas regardless of bond system
- “Silicone-centric” – inordinate amount of focus on silicone contamination diverted attention away from other release agents such as dioctyl phthalate (DOP) or fluorocarbons
- Mandated a silicone-free plant regardless of its ubiquity
- “No silicone allowed” requirement applied to all process support materials (PSM) regardless of proximity to bond assembly processes
- Unusual requests to test PSM for silicone content

Silicone content testing atrocities

- Grease
- 3-in-1 oil
- Shoelaces
- Toothbrushes
- Ratchet tie-down
- Magnetic signs
- Cut back tool
- Bug sprayers
- Mold release
- Mouse pads
- Rubber mallets

Efficiency

- There was a higher rate of production discrepancy reports
- Many plant-wide shut-downs occurred because of detection of infinitesimal silicone amounts in PSM
- Quality Assurance Lab was inundated with requests to test materials for silicone content

Ergonomics

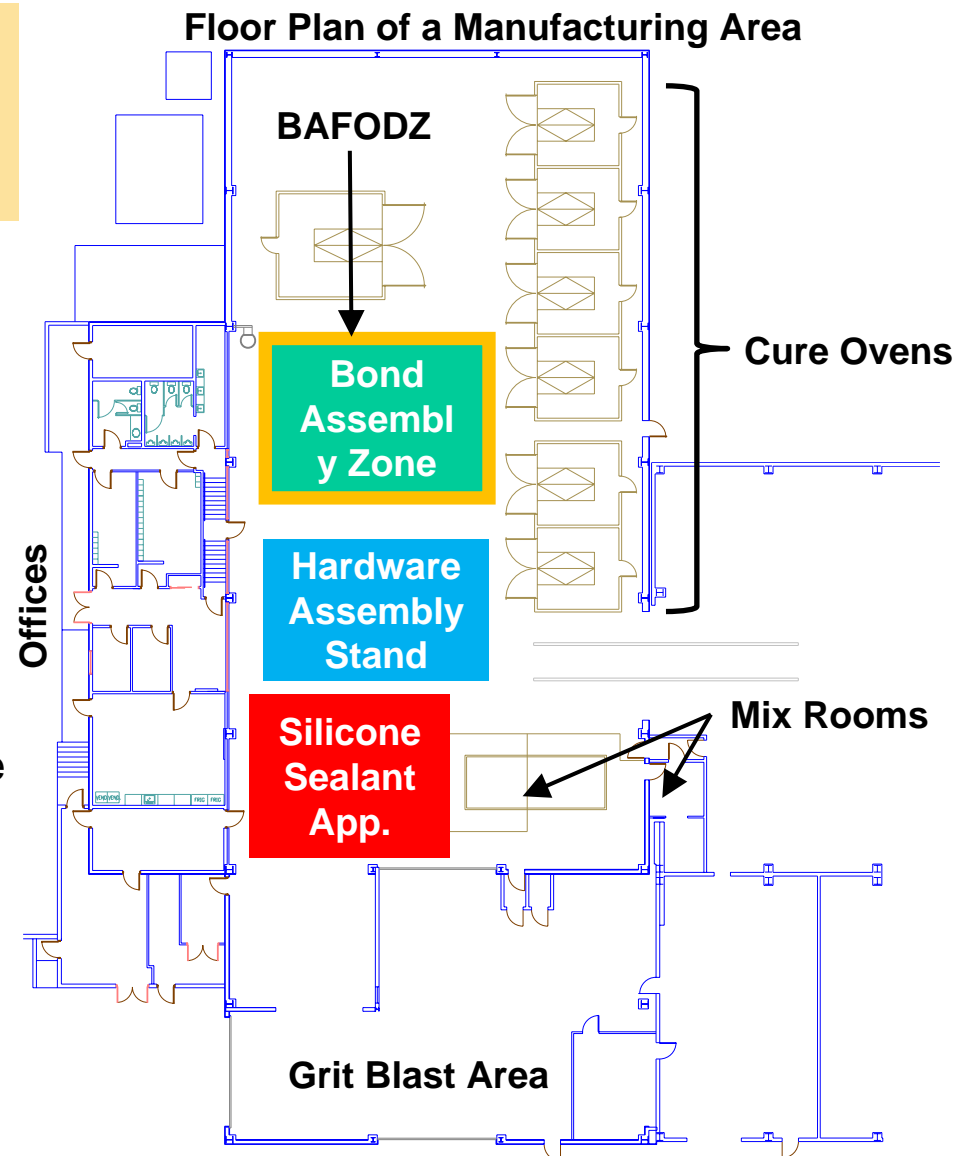
- Effective use of functional PSM was limited or even prohibited because of negligible silicone content
- In some cases, opportunities for safety improvement were missed



ATK Operations recognized the inefficiency of its contamination control approach and made a prudent change

The Bond Assembly FOD Zone (BAFODZ) Concept

- BAFODZ is a more tightly controlled area within a standard FOD zone
- Geographically-based zone—area within the manufacturing center
- Chronologically-bounded—delta time between substrate surface preparation and adhesive application
- Controls the flow of contaminants into the bond assembly area
 - Control is exercised according to bond system sensitivity
 - Control is applied during critical bond assembly steps
- Allows for more flexible use of PSM in other areas of the manufacturing centers



Manufacturing Centers

- Continue with standard FOD mitigation practices
- List allowable BAFODZ PSM in the manufacturing planning
- Consistently educate operators on contamination control practices
- Control PSM changes through quality and engineering review boards

Quality Assurance

- Diligently assess release agent levels in incoming PSM
 - Outside the BAFODZ—allow for reasonable release agent content in PSM that provide an ergonomic advantage to manufacturing
 - Inside the BAFODZ—exercise tight control of release agent content in PSM
- Work with vendors to procure release-agent-free PSM whenever practical

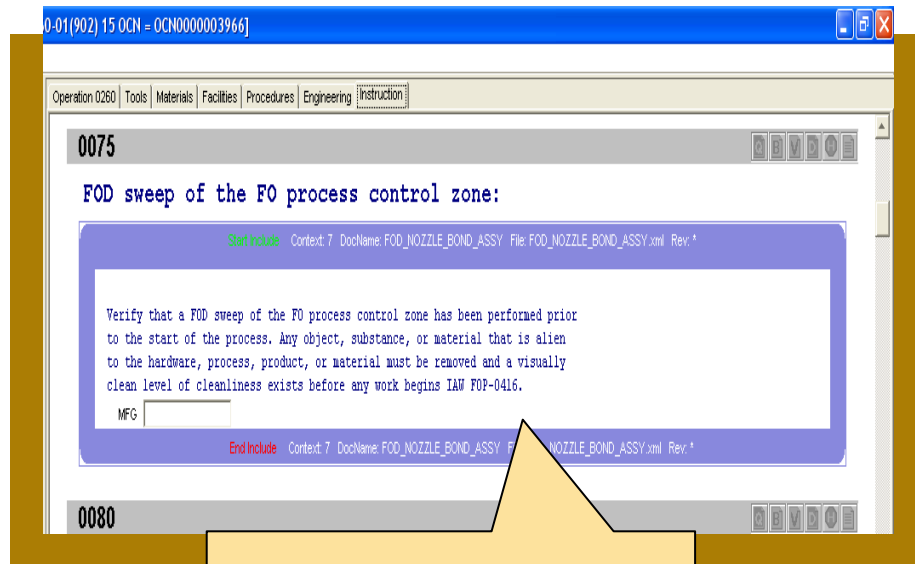
Engineering and Materials & Processes (M&P)

- Establish confidence in the contamination cleaning effectiveness of production surface preparation processes

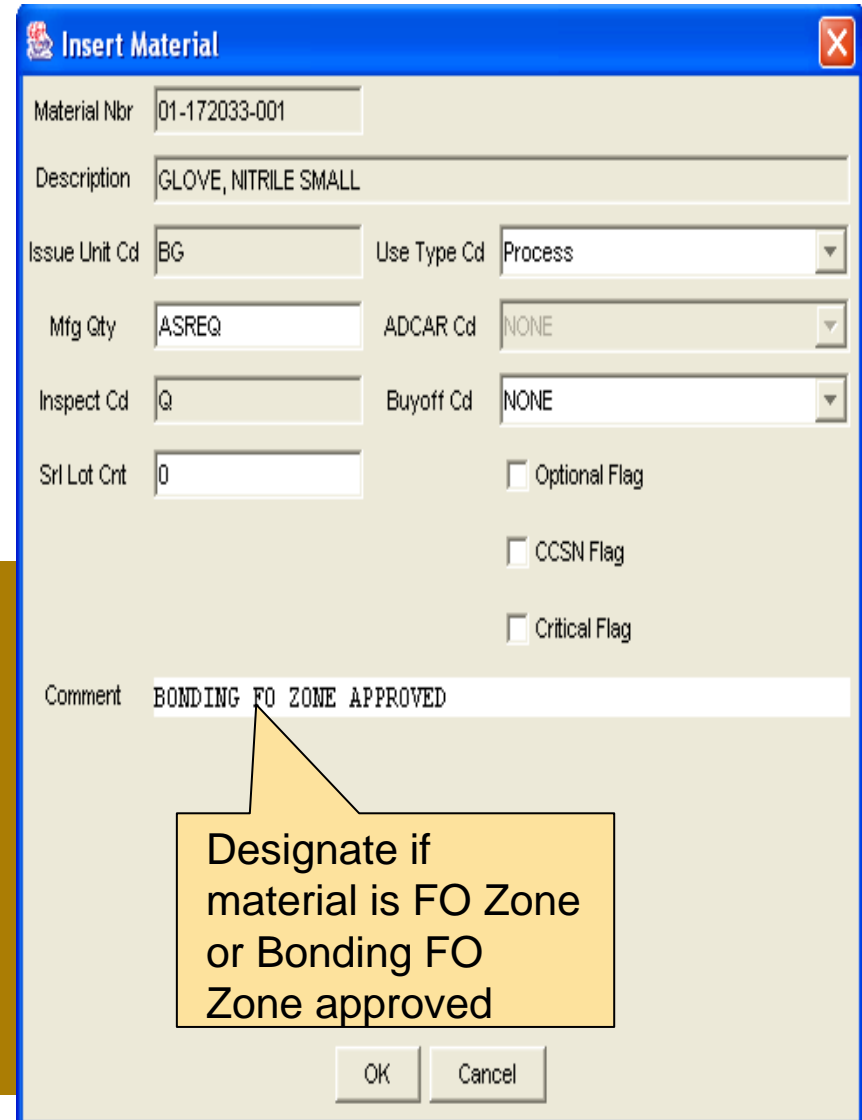


Hand cleaning—the beginning of the BAFODZ removes upstream contamination

- Continue with standard FOD mitigation practices
 - FOD sweeps
 - Contamination control area plan
 - Bonding area readiness check list
- List allowable BAFODZ PSM in the manufacturing planning
- Operator education
- Control PSM changes



Add similar Bonding FO Zone start designations



Designate if material is FO Zone or Bonding FO Zone approved

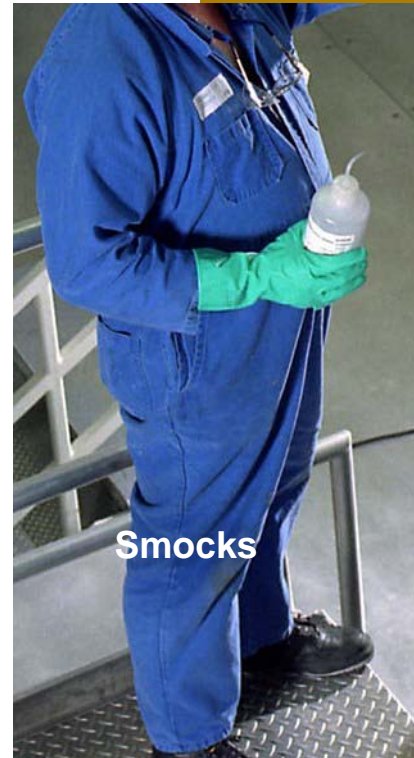
Diligently assess release agent levels in incoming PSM

- Outside the BAFODZ—allow for reasonable release agent content in PSM
 - Note that the allowables were determined from contamination sensitivity testing
- Inside the BAFODZ—exercise tight control

Work with vendors to procure release-agent-free PSM whenever practical

Success stories:

- ATK successfully negotiated a contract with 3M to provide silicone free Scotch Brite abrasion pads
- ATK successfully worked with Ansell to develop low silicone cut-resistant gloves
- ATK successfully worked with Westex Inc. and American Safety Clothing to eliminate the use of silicone in the production of protective garments
- ATK works with Elder & Jenks to manufacture paint brushes without brads, nails, and silicone



The Surface Preparation Process

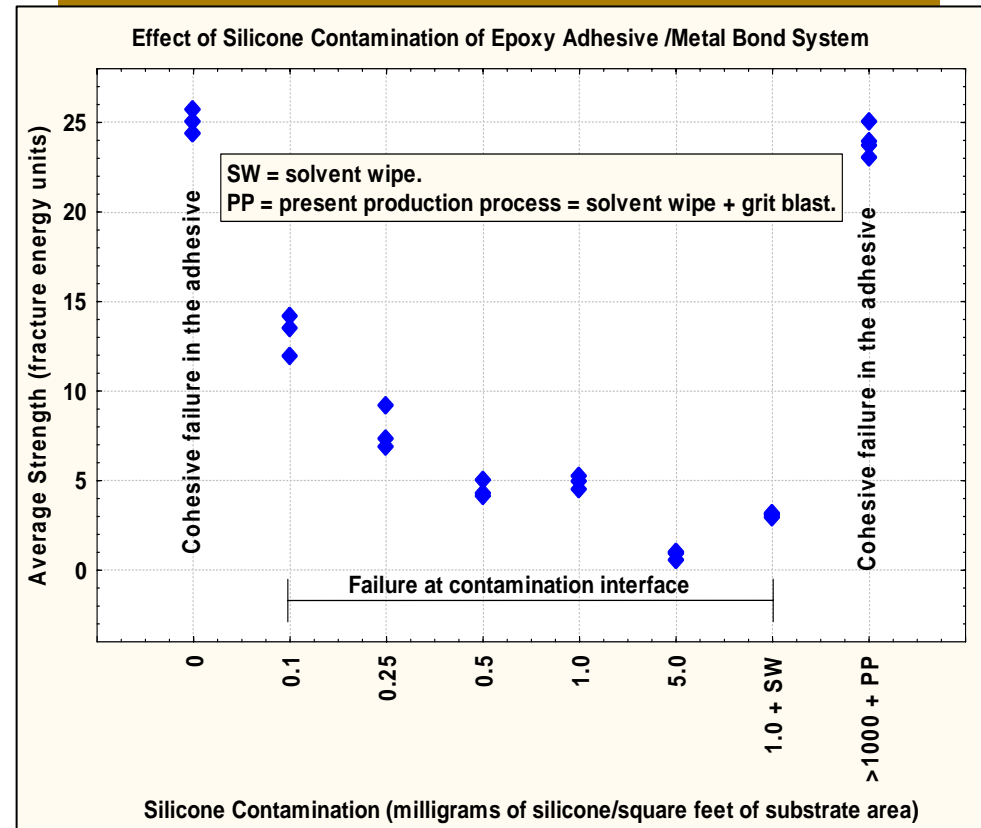
Chronologically defines the beginning of the BAFODZ

- Manufacturing applies a “no touch” practice after surface preparation

Impressive ATK database shows that surface preparation processes are generally effective contamination removal methods

- Confirms that production surface preparation processes remove contamination accumulation from upstream processing

- If the surface preparation process is insufficient then engineering and M&P must develop more effective method



Improved approach of manufacturing to contamination is more sensible

- Recognize the reality that release agent contamination is pervasive because of its functionality
- Some bond systems are sensitive to many contaminants and the substrates must be protected accordingly
- Other bond systems are insensitive and do not require the same degree of protection
- The risks of contamination can be managed in a more proactive manner BAFODZ
 - Trust the surface preparation process
 - Do not contact the hardware after surface preparation
 - Do not apply tight contamination content standards to PSM that are not used in a critical bond assembly area (BAFODZ)
 - Focus vendor attention on release-agent-free PSM for items where it is warranted by sensitivity

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