

Solutions Flash

Corrosion-Resistant Compressor Abradable Reduces
Maintenance and Operating Costs

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Today's situation

The reality for today's aircraft fleets is exposure to multiple environments that can result in corrosion of aluminum-silicon-based compressor abrasible coatings for clearance control. While these coatings have been used for more than a half century in power plants and have a highly successful track record for increased engine efficiency and safety, they can be susceptible to corrosion that is influenced by geographical location, season and aircraft usage. For example:

- Engines that are flown only occasionally or parked overnight are candidates for corrosive attack regardless of their geographical location
- Engines that operate in coastal areas and areas of high humidity are especially prone to corrosion, which can start to occur in as little as two days

Such corrosion can occur in any gas turbine exposed to these conditions, including aerospace gas turbines, marine propulsion power plants, industrial gas turbines and others.

If left unchecked, this corrosion can damage rotating components, thus reducing safety margins and decreasing operating efficiency. Smaller gas turbines tend to be more prone to these issues than larger engines, as a result of their tighter gas path clearance and surface roughness requirements where any swelling or blistering related to corrosion can seriously affect performance.

The Oerlikon Metco solution

Oerlikon Metco, the original developer of Metco 601NS (Al 7Si / 40 Polyester blend) — the most widely used compressor abrasible coating material worldwide for gas turbine engines — has now developed Metco 1602A, which is a new compressor abrasible that:

- Provides the same clearance control efficiency as our legacy compressor abrasible materials
- Maintains the safety margins needed for today's engines
- Creates abrasible coatings that are significantly more corrosion resistant than legacy materials
- Does not negatively impact engine weight
- Can generally be applied using existing Metco 601NS spray parameters
- Applies more reliably and repeatedly than many legacy abrasible materials



Figure 1. Corroded abrasible coating on CFM56-7 stage 1 booster vane assembly outer shroud. Photograph courtesy of Sjap (www.sjap.nl).

Many operators have turned to daily engine washes; however, washing only mitigates the problem, it is not a cure.

A more corrosion-resistant and cost-effective abrasible coating that can provide the same efficiency as legacy coatings seems to be the solution.



Figure 2. Metco 1602A produces abrasible coatings for gas turbine compressors with improved corrosion resistance compared to legacy materials.

Solution description and validation

1. New chemistry and manufacturing process

While it would seem that the composition of Metco 1602 is similar to that of other AlSi-polyester abrasives produced by Oerlikon Metco, the modification of the composition,

combined with a proprietary manufacturing process, provides a very significant difference in the way coatings of Metco 1602A act in service to resist corrosion.

Product	Weight Percent (nominal)							
	Al	Si	Mo	Cr	Polyester	Polyimide	Boron Nitride	Organic Binder
Metco 601NS	Balance	7	---	---	40	---	---	---
Amdry 2010	Balance	7	---	---	40	---	---	---
Amdry XPT-268	Balance	9	---	---	20	---	6	---
Amdry 2000	Balance	6	---	---	---	47	---	6
Metco 1602A	Balance	6	1	1	40	---	---	---

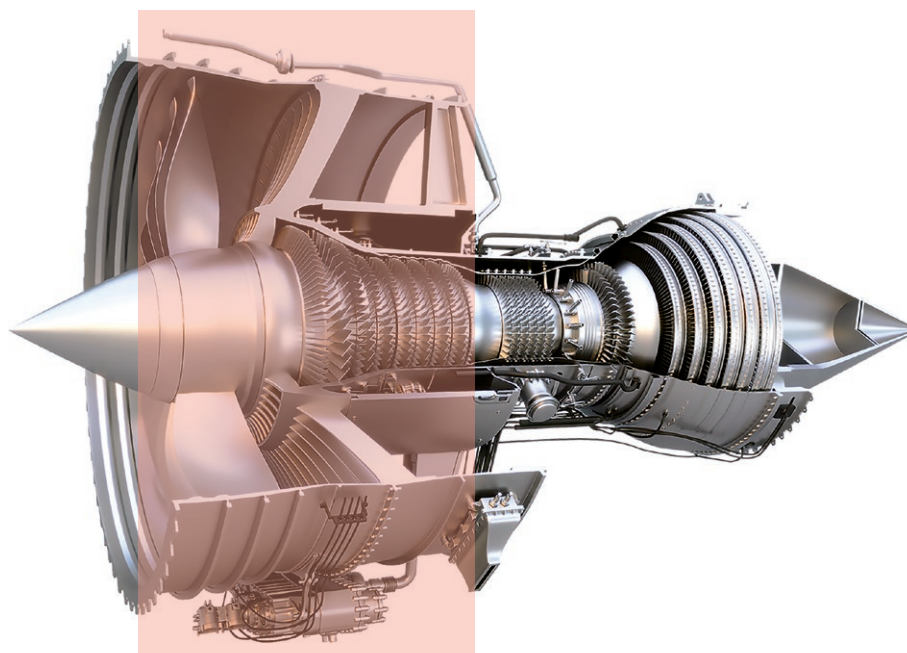


Figure 3. Gas turbine sections where Metco 1602A is used: Booster / Low Pressure and Intermediate Pressure Compressor for temperatures up to 325°C (615 °F).

2. Effect on engine efficiency

The performance driver for abradable coatings on gas turbine engines is to control the clearance between the rotating blade tips and the respective stationary shrouds. A smaller gap size reduces losses arising from vortex-induced air flow at the blade tips, thereby maintaining the efficiency of the stage and increasing the overall surge margin (stall margin) for the engine.

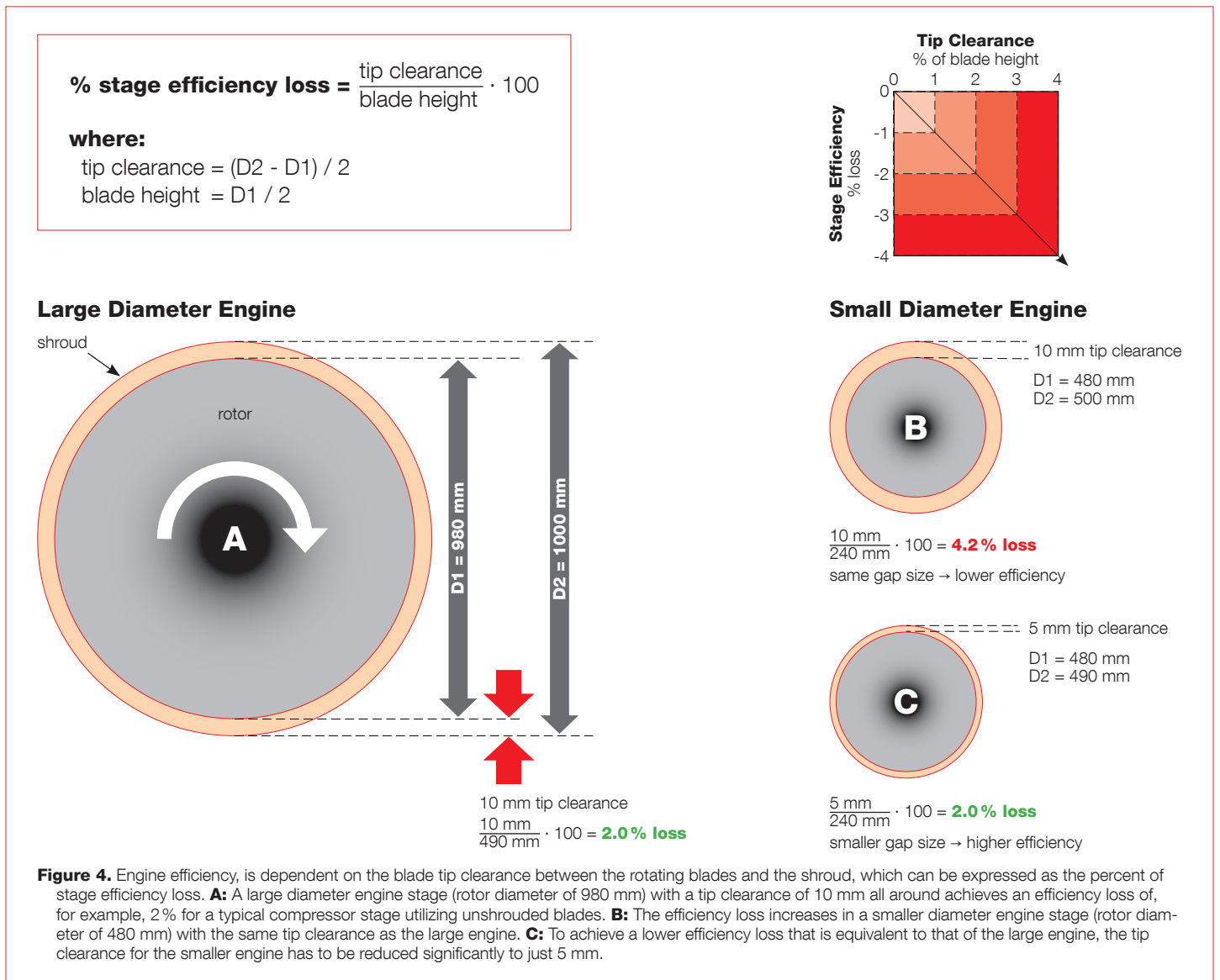
This can be calculated as a loss of efficiency for each stage of the engine. When the same tip clearances are used in a large diameter engine (Figure 4A) as that of a smaller diameter engine (Figure 4B), the efficiency loss for the smaller engine is significantly higher. Therefore, tip clearances in the smaller engine must be reduced to achieve an equivalent efficiency (Figure 4C).

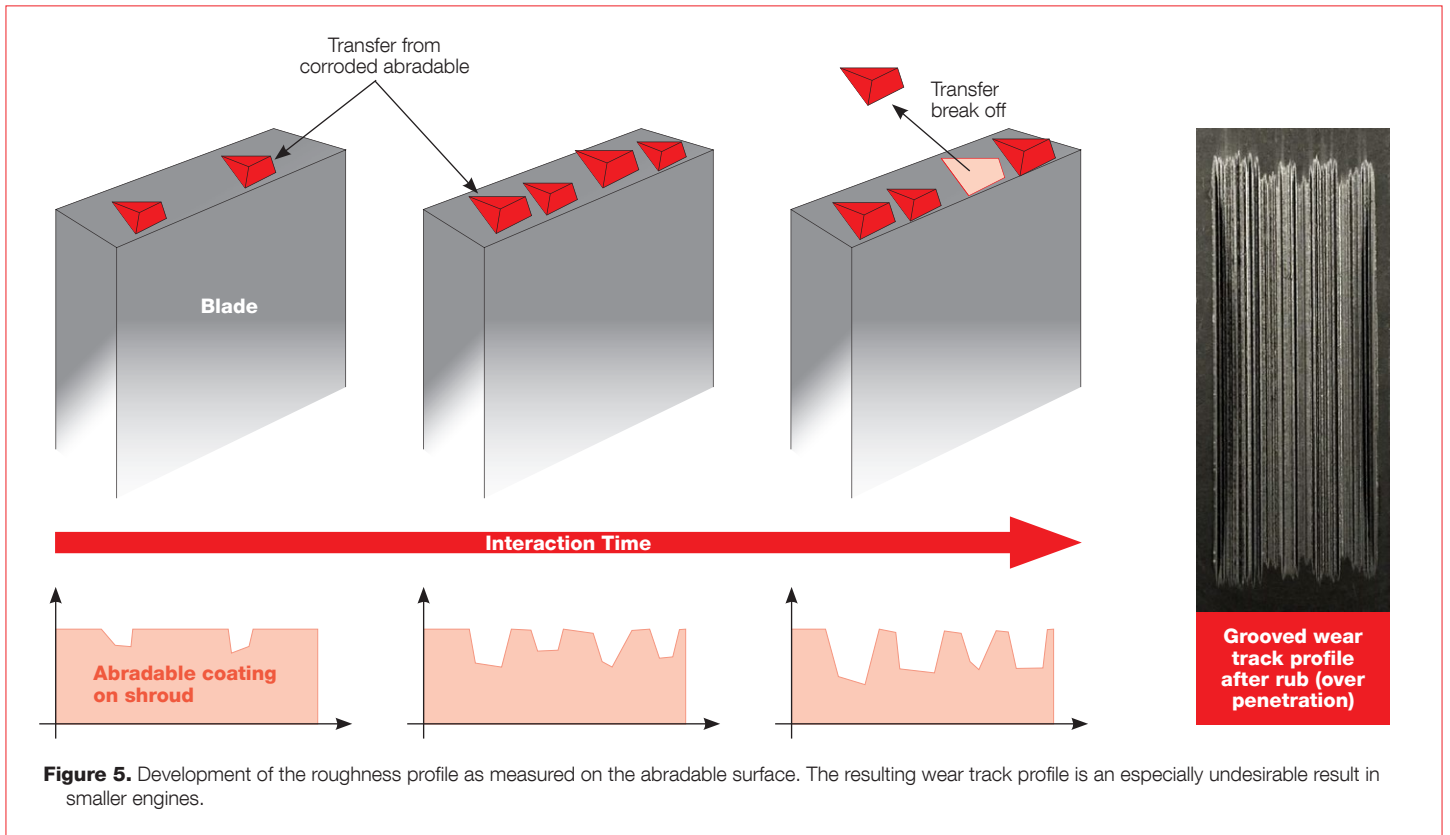
The smaller clearances also mean that engines with smaller diameters are more susceptible to the surface roughness of the stationary shroud. The abradable coating on the shroud

must be as smooth as possible — both pre- and post-rub — to minimize ‘grooving’ and material transfer onto the blade tips.

Post rub surface roughnesses of aluminum-based abradable coatings on shrouds can be degraded by the phenomena of grooving in the rubbed areas, arising from transfer of aluminum alloy to blade tips (Figure 5). Here under specific rub conditions, the grooving phenomena deteriorates engine efficiencies by effectively opening up the clearances and introducing unwanted air flow effects.

Unfortunately, when the abradable coating on the shroud is affected by corrosion, it tends to become very rough due to swelling, blister formation and accumulation of corrosion by-products, all of which can obstruct the clearance with resultant uneven irregularities (Figure 5). The likelihood of rubbing is much higher with increased risk of spallation (Figure 1) of the corrosion degraded coating.

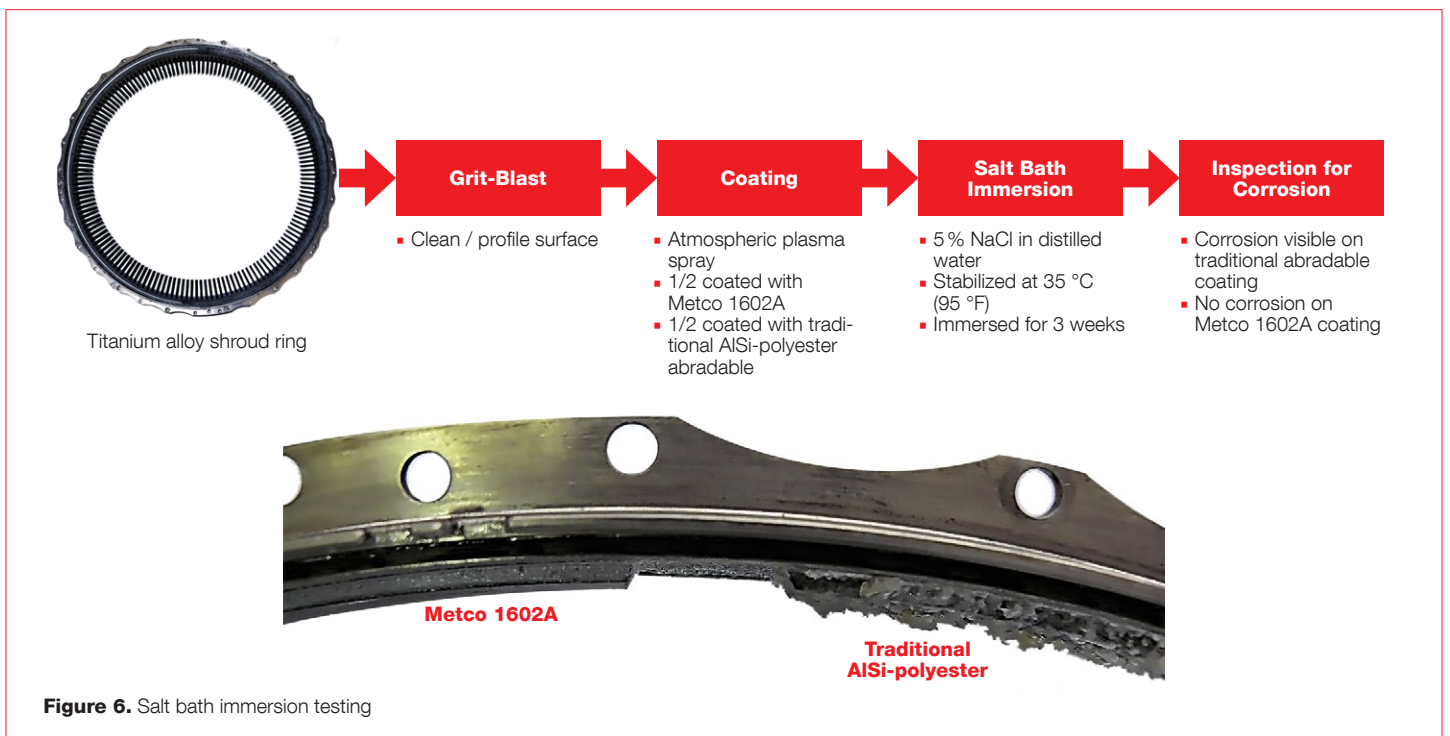




3. Corrosion testing

To test the corrosion characteristics of Metco 1602A compared to traditional AlSi-polymer materials, half of a titanium alloy shroud ring was coated with Metco 1602A and the other half coated with the traditional abradable material. The

ring was then immersed in a salt spray bath for three weeks. Where the traditional AlSi-polymer coating exhibited severe corrosion, the half of the ring coated with Metco 1602A exhibited almost no corrosion.



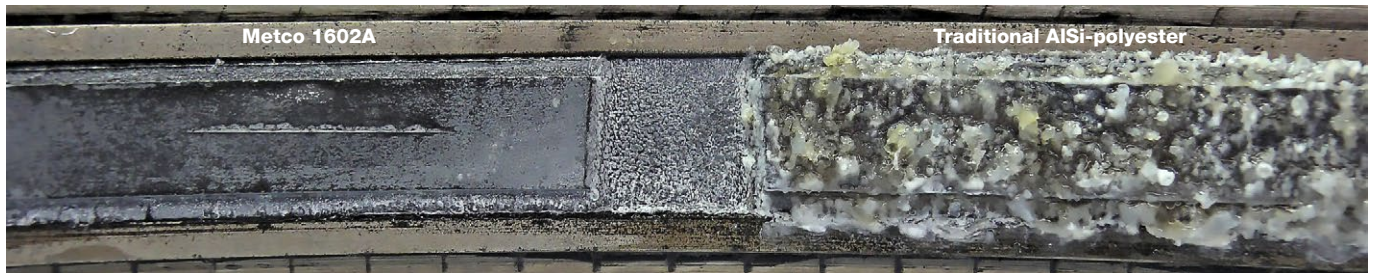


Figure 7. Salt bath immersion testing results, prior to cleaning. **Left:** Metco 1602A coating. **Right:** Traditional AISi-polyester.

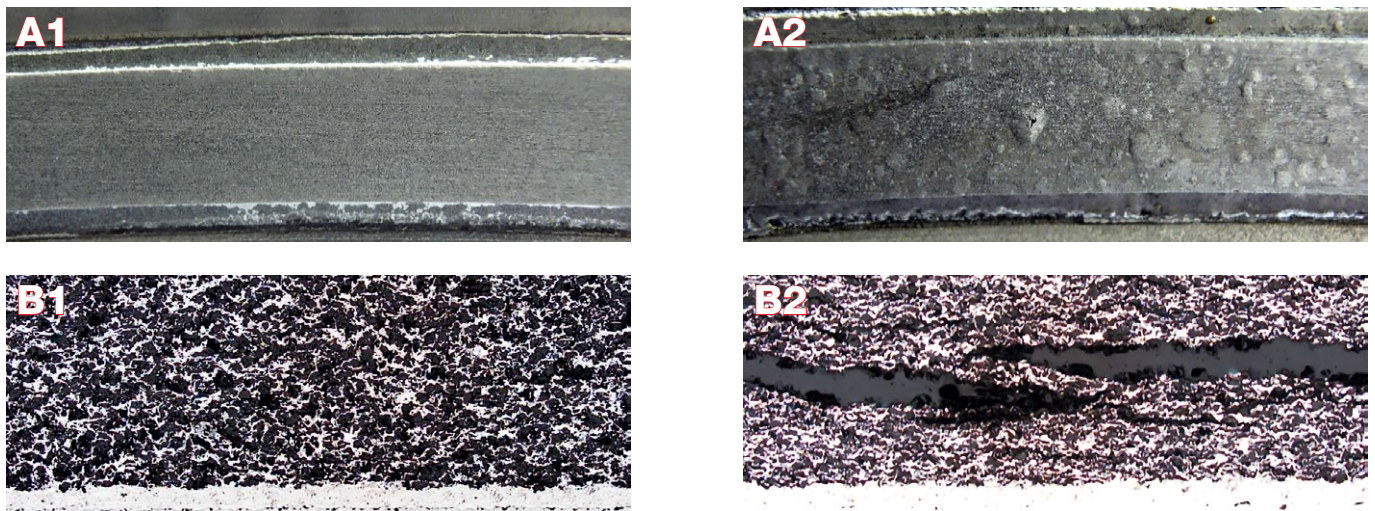


Figure 8. Salt bath immersion testing results, post cleaning. **A1:** Metco 1602A coating exhibits no corrosion. **A2:** The traditional AISi-polyester coating exhibits corrosion and blistering. **B1:** A photomicrograph of the Metco 1602 coating shows an intact structure that is identical to that of the as-sprayed coating microstructure. **B2:** The traditional AISi-polyester coating microstructure exhibits delamination as a result of corrosion.

4. Abradability testing

Abradability testing for Metco 1602A was done on Oerlikon Metco's abradability test rig, using titanium-alloy dummy blades. The test rig can control tip speed, incursion rate and

depth and temperature. The results of our test rig are well known within the industry to correlate very closely to actual engine operating conditions.

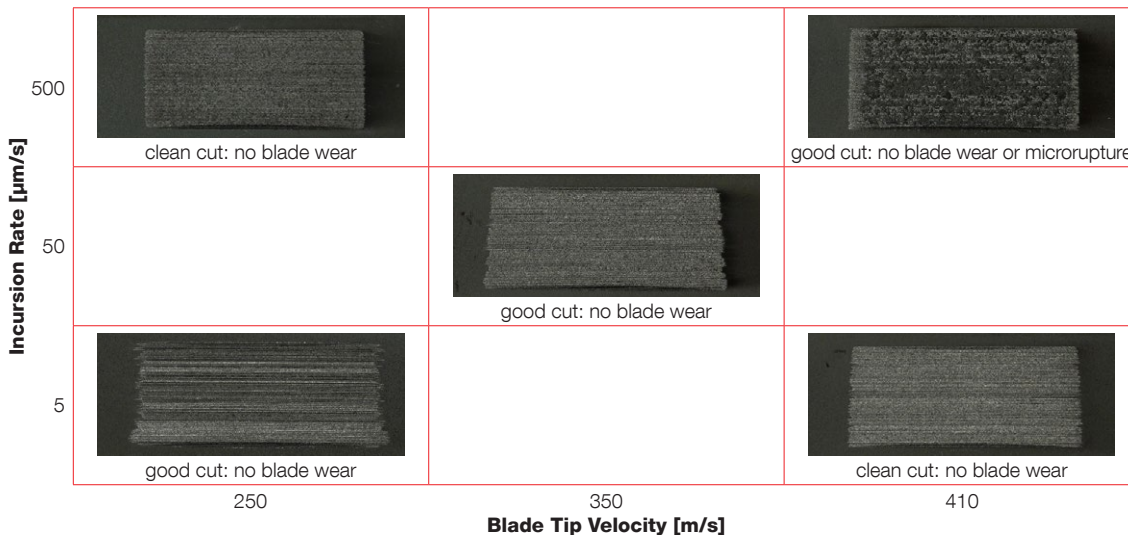


Figure 9. Abradability testing using the Oerlikon Metco test rig at various incursion rates and blade tip velocities.

Test Conditions:

- Shroud temperature: 300 °C
- Incursion depth: 1.0 mm
- Blade material: Ti 6Al 4V
- Tip width: 0.7 mm

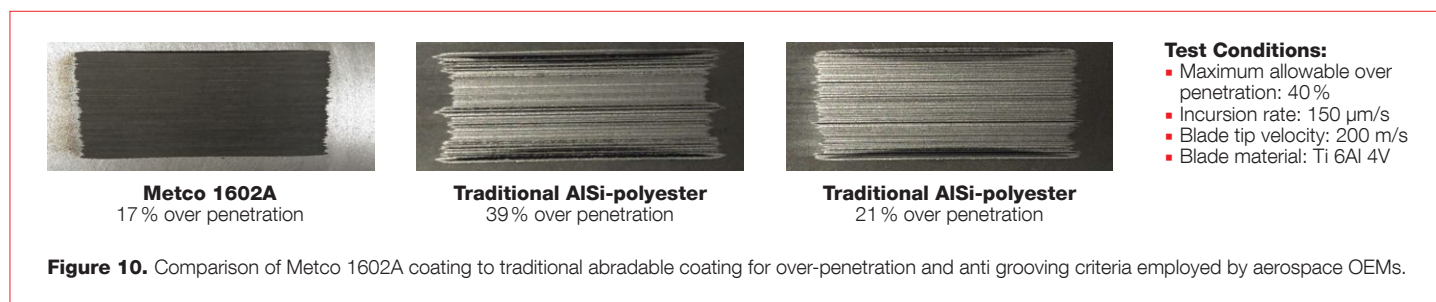
Coating Data:

- Material: Metco 1602A
- Hardness: 73 HR15Y
- Tensile strength: 10.3 MPa
- Erosion: 5.7 s/0.001 in

5. Abradability versus traditional AlSi-polymer coatings

The abrasability of Metco 1602A coatings compare very well against traditional AlSi-polymer coatings, with abrasability

that is as good as, or even somewhat better. Even for stringent aerospace OEM criteria for “over-penetration and anti-grooving”, the Metco 1602A outperformed known traditional coatings (Figure 10).



6. Comparison of Metco 1602A to traditional AlSi-polymer abrasibles

Metco 1602A compares very favorably with traditional AlSi-polymer abrasible materials in application, performance

and cost criteria.

Feature		Metco 1602A	Traditional AlSi-Polymer	Competitive Product
Cyclic corrosion	6 wk, 5% NaCl (10 to 15 yr on engine)	Excellent	Complete coating failure (swelling / blistering / delamination)	Complete coating failure (swelling / blistering / delamination)
	12 wk, 5% NaCl (20 to 30 yr on engine)	Very good		
Spray parameter		= Metco 601NS	Varies with chosen product	Large deviation from Metco 601NS
As-sprayed hardness	HR15Y	55 to 85, robust!	50 to 85	50 to 80, often erratic
Spray process		APS	APS	APS
Deposition efficiency	%	> 75	> 75	> 75
Rub incursion	Titanium blades	Excellent	Excellent	Excellent
	Grooving resistance	Very good	Good	Good
Erosion resistance		≈ 0.216 s/µm ≈ (5.5 s/0.001 in)	≈ 0.197 s/µm ≈ (5.0 s/0.001 in)	≈ 0.197 s/µm ≈ (5.0 s/0.001 in)
Coating density		≈ 1.55 g/cm ³	≈ 1.55 g/cm ³	≈ 1.55 g/cm ³
Service temperature		325 °C (615 °F)	325 °C (615 °F)	325 °C (615 °F)
QESH / REACH		Less impactful	More impactful	More impactful
Material cost		Moderate	High	Moderate
Value	Performance / Cost	Excellent	Fair	Fair

Customer Benefits

Experience

- New and improved abradable material from the leading developer of thermal sprayed clearance control solutions

Efficient

- Uses the same spray parameters as Metco 601NS, with little or no adjustment necessary
- Provides the same abradability as traditional LPC abradables
- Maintains engine safety margins and efficiency
- Coatings apply more reliably in terms of overall coating hardness and porosity
- No negative weight impact on the engine as coatings have same density as traditional LPC abradables

Effective

- Excellent corrosion resistance compared to traditional LPC abradables
- Abradable material designed for LPC clearance control applications
- Provides abradability that is as good or better than traditional AlSi-polymer abradables

Economical

- Cost competitive with moderately-priced traditional LPC abradable materials
- More robust sprayability can reduce processing time and rework
- Corrosion resistance can lead to fewer inspections and reprocessing of corroded parts