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Miniaturized Blown Sand Abrader for Eyewear Coating Evaluation

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Problem

- Arid, desert environments have blowing sand of differing size and shape that can significantly degrade equipment performance.
- Materials that pass slow time-scale rubbing abrasion tests can shatter upon sand impact or other kinetic events.
- Expensive lenses need better coating materials to improve useful lifetimes.
- Popular abrasion tests have geometry constraints that prevent use with actual lenses.

Standard Abrasion Tests

- **Taber Abrader** (ASTM D4060-5) - Sand imbedded in rubber wheel, rolled across surface.
  Test velocity ~ 0.2 m/s

- **Bayer Table** (ASTM F735-94) - Bed of sand is shaken while on top of lens, compared to standard (uncoated) lens.
  Sand velocity ~ 0.5 m/s

- **Falling Sand Test** (ASTM D 968-93) - Sand dropped from 36 inches.
  Velocity ~ 2.0 m/s

- **Eraser Test** - Spring-loaded pumice-rubber eraser rubbed on lens.
  Velocity ~ 0.05 m/s

- **Various Steel Wool Tests** – Steel wool rubbed on lens.
  Test velocity ~ 0.05 m/s

Velocities of Impact Events

- Blowing sand can range from **4-17m/s**
- Dropping lens from standing
- (2m height) ~ **6 m/s**
- Dropping lens from elevated position (4m), e.g. tank, truck, velocity ~ **9 m/s**
- Running, velocity ~ **3-4 m/s**

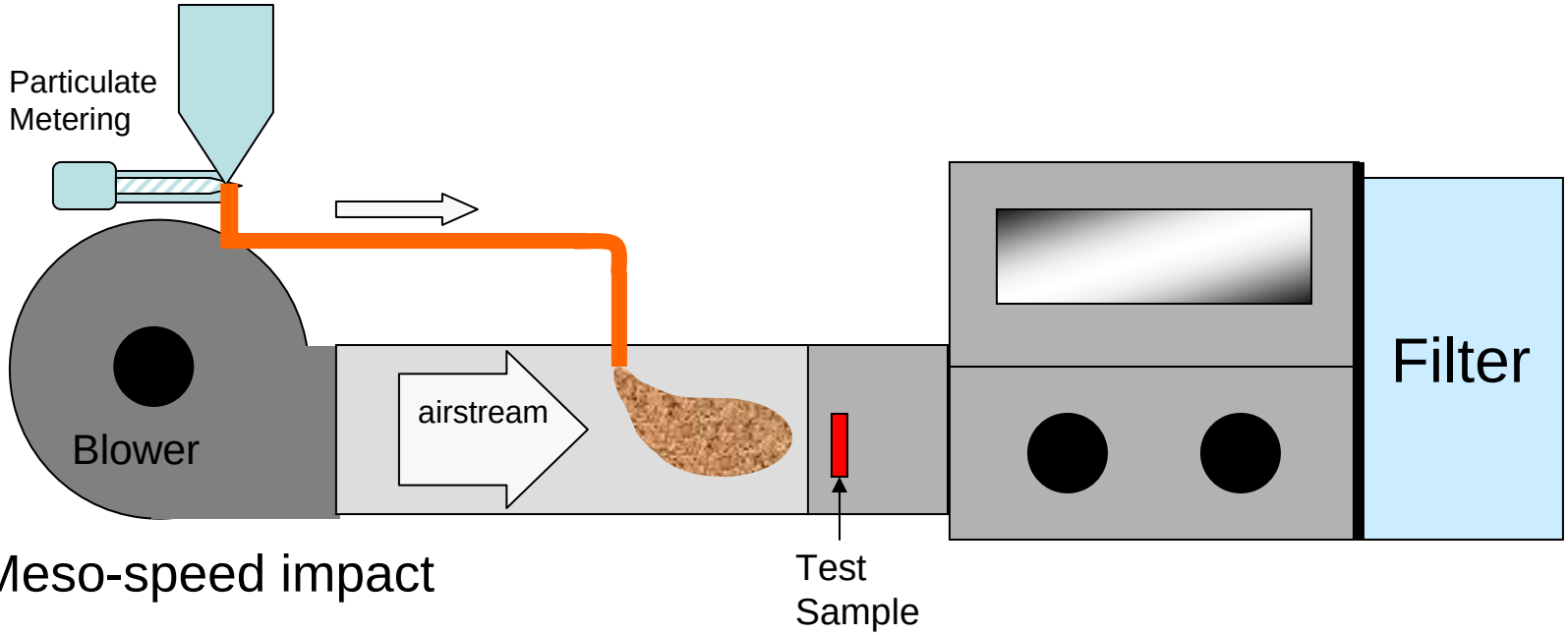
Faster velocities tend to induce brittle failure in most materials.

Blown Sand Abrader

A new Blown Sand Abrader has been developed for the MCEP to simulate real-world blowing sand conditions in the laboratory.

- Blown sand test air velocity: 16.5 m/s
- First-generation model
- Second-generation (miniaturized) model

Blown Sand Abrader – First Generation



- Meso-speed impact
- No sample geometry constraints
- Variable-

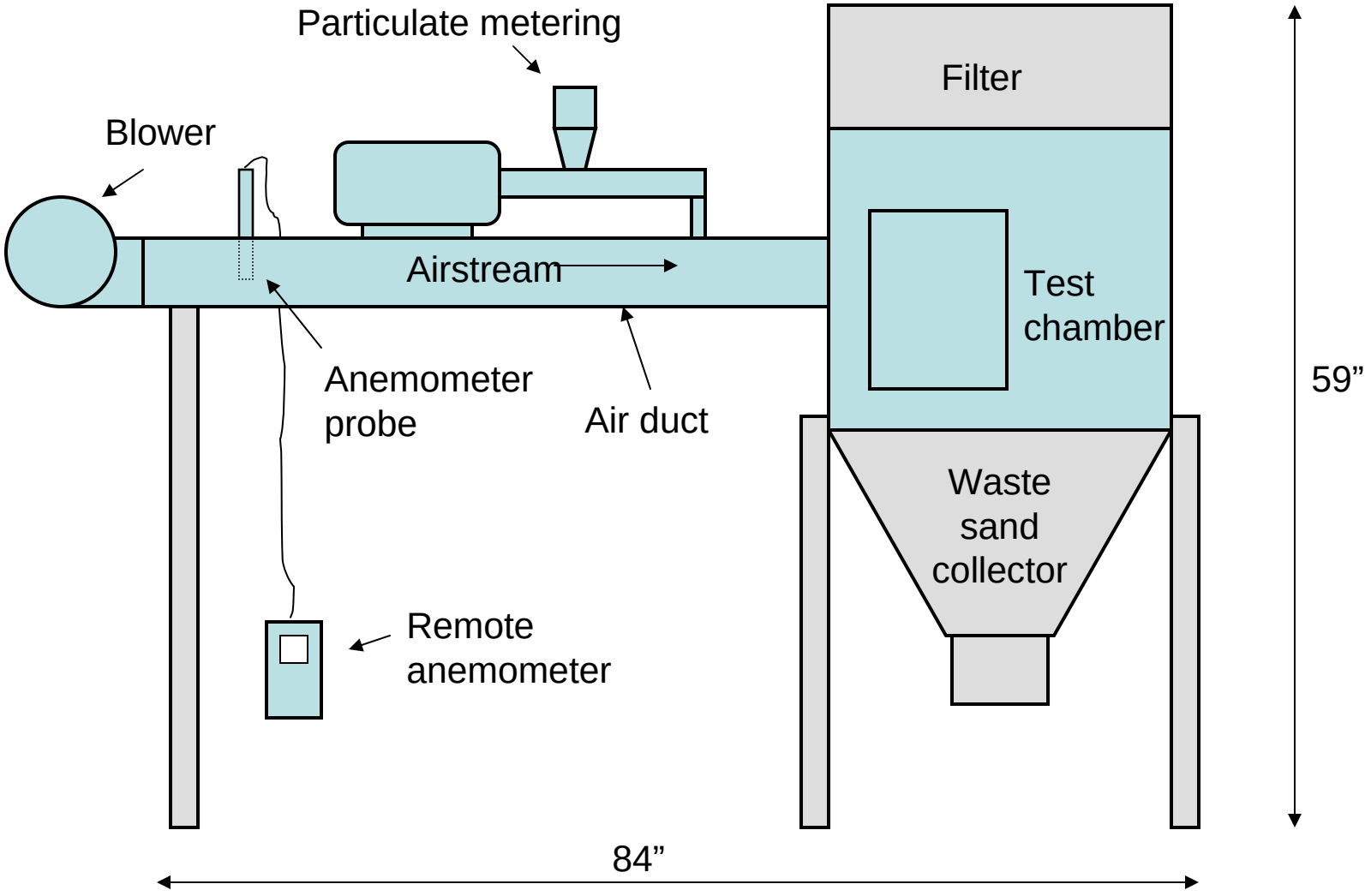
  air speed, particle density, sand type, sample orientation

- Standard Test Conditions:
  - 10 minutes
  - 16.5 m/s (38mph)
  - 400 μm diameter quartz sand
  - 6.0 g/m^3 sand density in air
  - Lens perpendicular to air stream

Blown Sand Abrader - Redesigned

- More space-efficient
- Reduced quantity of sand
- More efficient post-test sand removal
- Continuous monitoring of air speed

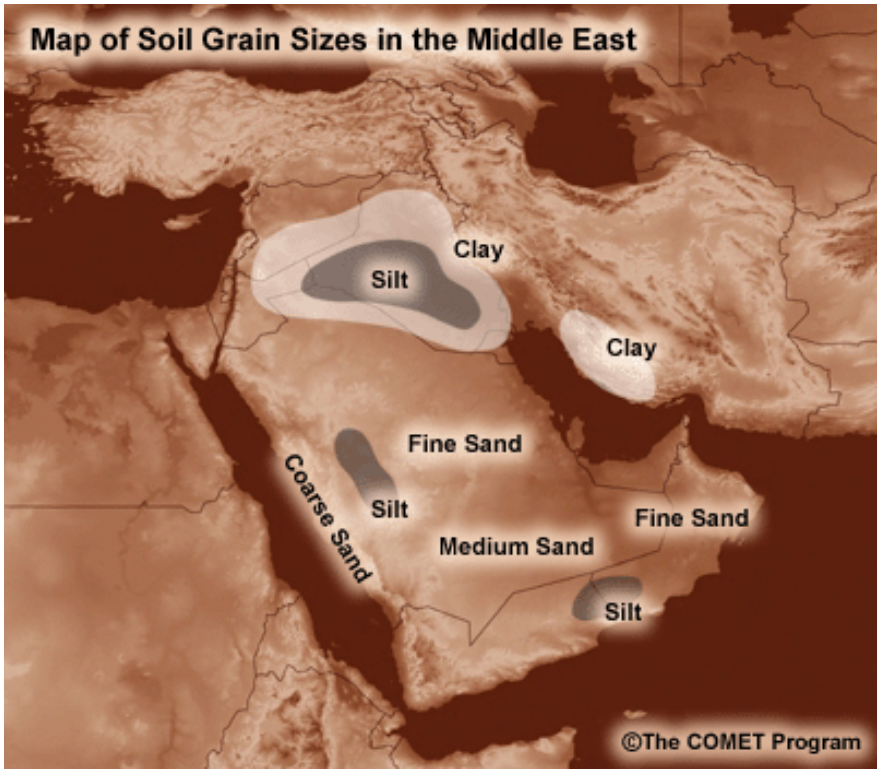
Miniaturized Blown Sand Abrader



Miniaturized Blown Sand Abrader - Test Chamber

- Sample is mounted perpendicular to direction of blowing sand
- Eyewear can be mounted on headform

Sand Types by Size



Sand size and composition vary throughout the world. Smaller particles tend to adhere into larger aggregates.

Geological Classifications

Coarse Sand:	0.2 - 2.0 mm
Fine Sand:	0.02 - 0.2 mm
Silt:	0.002 - 0.02 mm
Clay:	< 0.002 mm

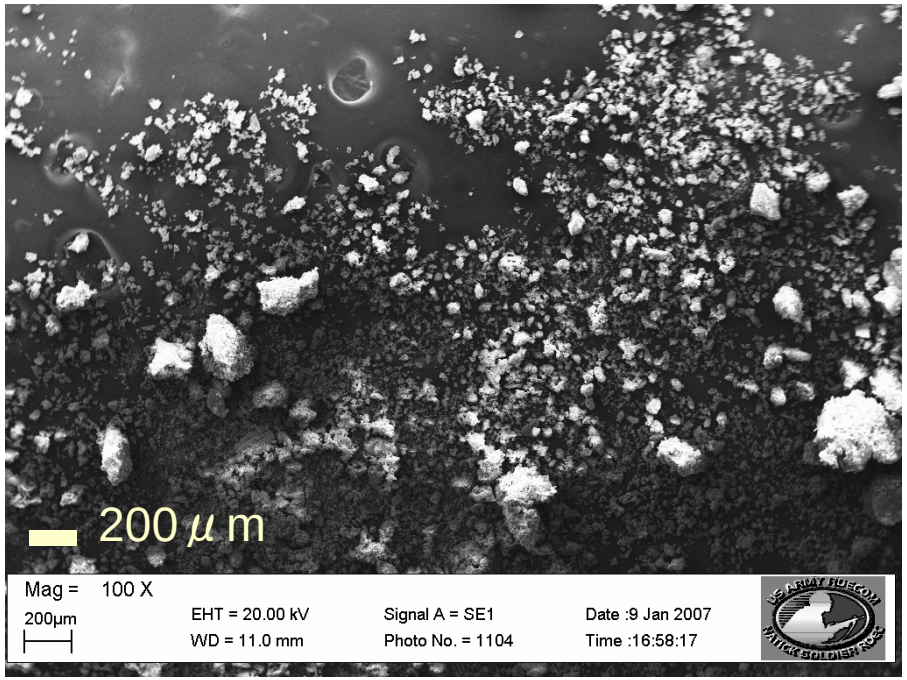
Sand

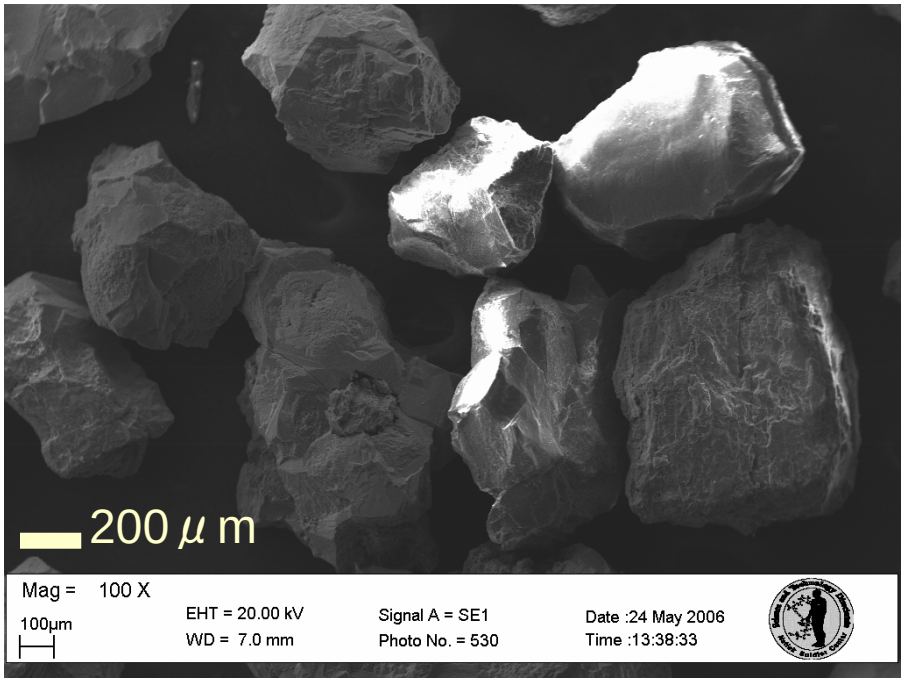
- Test sand was chosen as most abrasive case.
- Damage from fine sand and coarse sand similar.
  - Both will cause damage to lens surface.
  - Rate of damage development is faster with larger particles.
  - Aggregates of smaller sand particles can have similar kinetic energy to large particles.

Blown Sand Abrasion Test

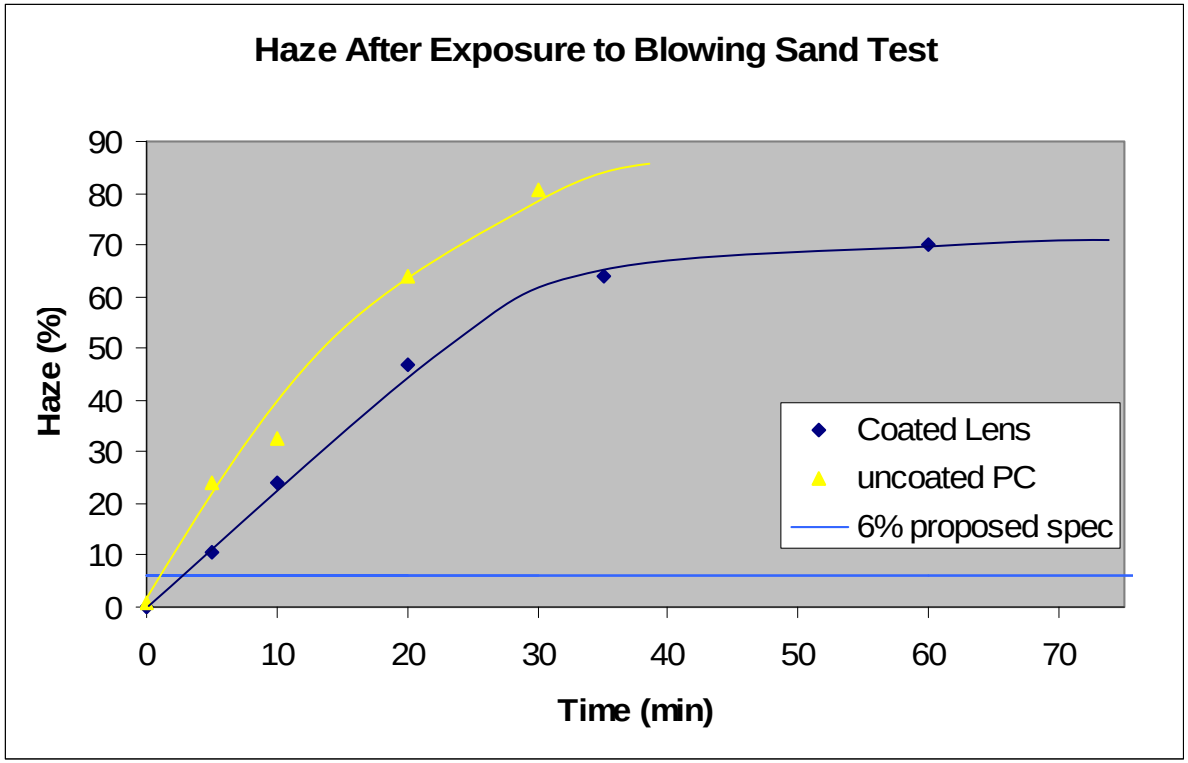
SWA Sand-
Al, Ca, Fe, Mg, Na, K, Ti (oxides)
Hardness: ~4 Moh
Mean diameter: 10 μm
Aggregate size: 3+ mm
Mean mass $1x10^{-8}$ mg

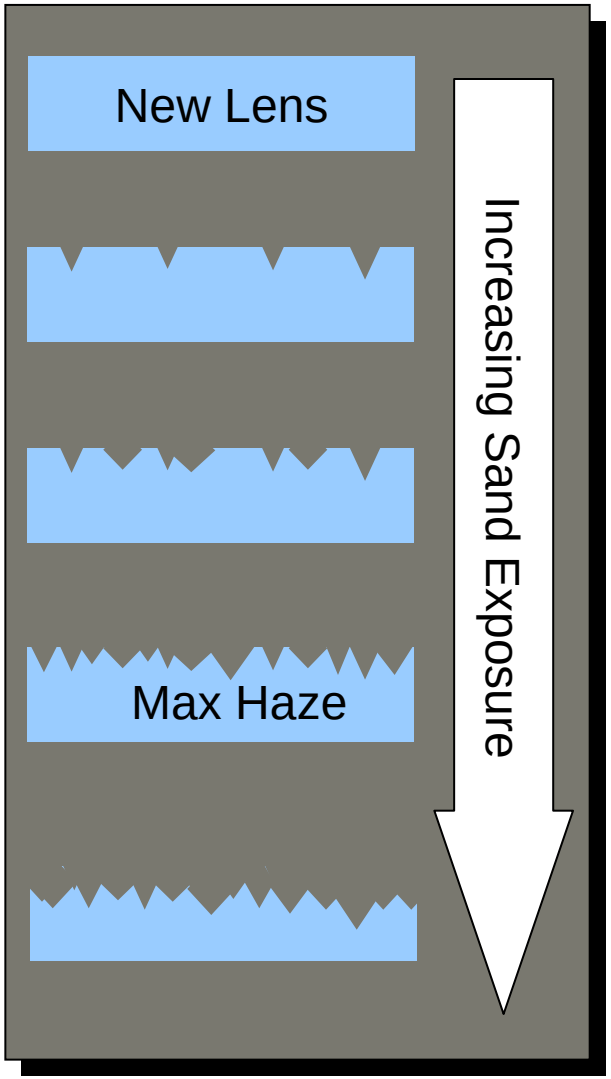
Test Sand-
100% Quartz Silica
Hardness: 7 Moh
Mean diameter: 400 μm
Mean mass: 0.09 mg





Haze Development

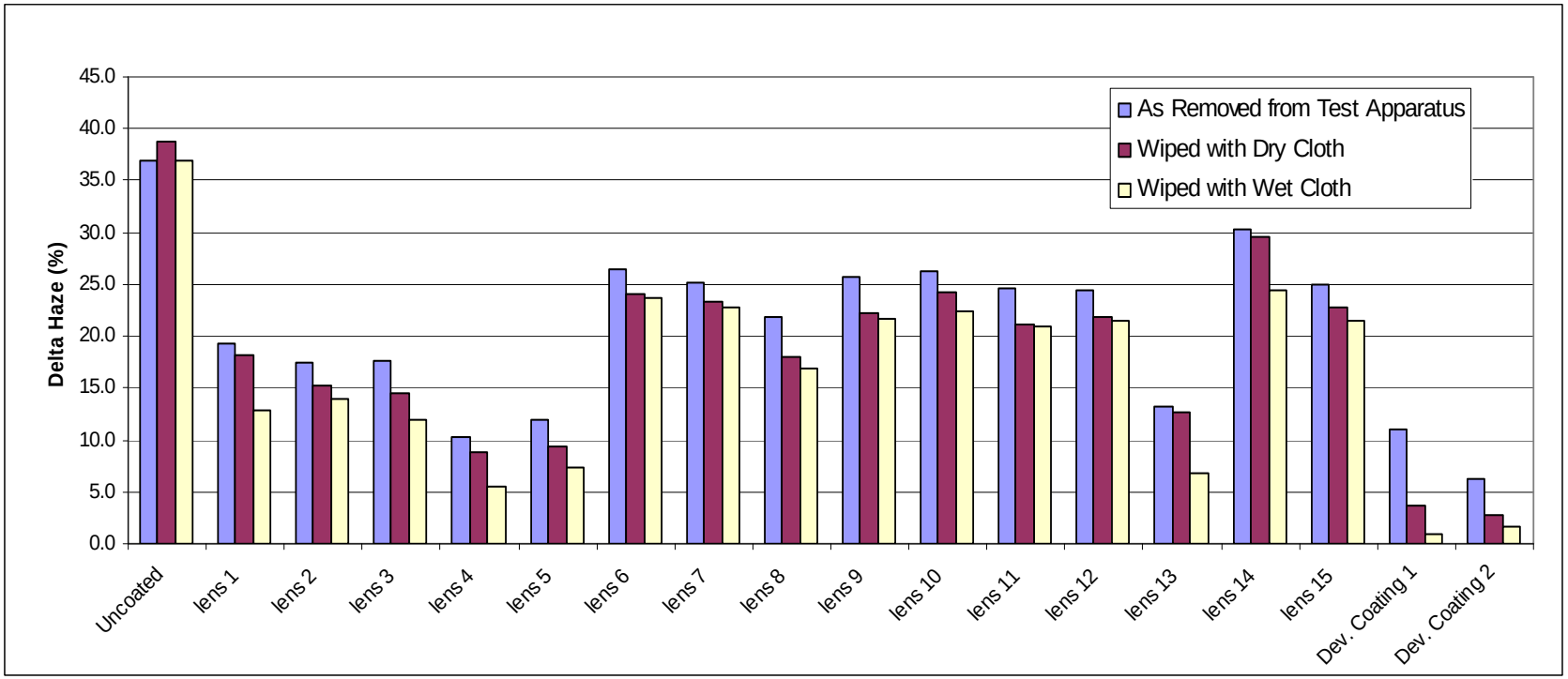




As the lens surface becomes damaged, haze increases until the surface is completely roughened. Further exposure erodes the surface but roughness remains constant.

Sand Abrasion Resistance

Haze after 10 minute Exposure in Sand Blower



Industry Evaluation of Blown Sand Abraders - Objectives

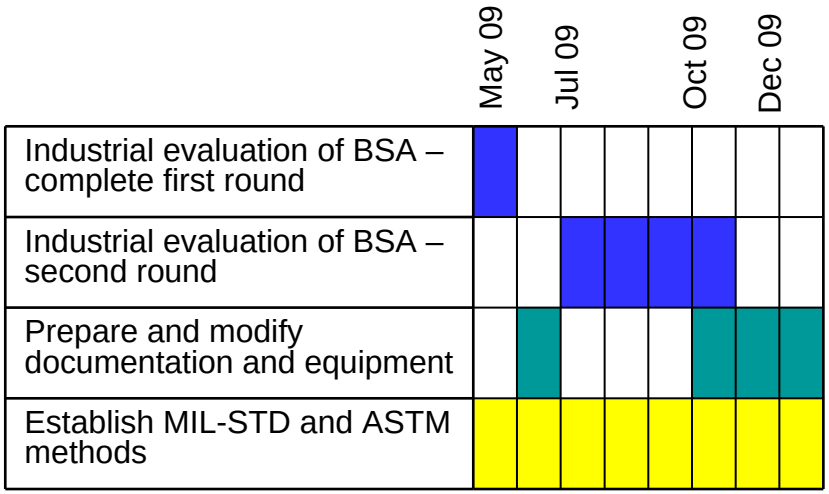
- Test the adaptability of the BSA to an industrial environment
- Measure reproducibility of results from identical machines in different facilities
- Solicit suggestions from users regarding modifications to machine design and test protocol
- Evaluate durability of machines over time

Industry Evaluation of Blown Sand Abraders - Progress

- Second and third BSA have been assembled and tested in-house
- Good performance and reproducibility
- First round of industry evaluation is in progress
- Second round of industry evaluation projected for Jul – Oct 2009

Development of miniaturized BSA

- Milestones
  - 5/09 Complete first round of industrial evaluation
  - 7/09 – 10/09 Second round of industrial evaluation
  - 12/09 Established Standard



Summary

- Blown Sand Abrader has been developed for simulation of sandstorm conditions in a laboratory environment
  - Baseline
  - New coating development
- Miniaturized version has been developed and is in use
- Advantages:
  - Better predictor of wear under field conditions
  - Can test actual eyewear lens
  - Better direct coating research: Government and private
- Industry evaluation of Blown Sand Abraders is in progress
- New standard test method for resistance to abrasion by blowing sand is being developed
- Looking for industry participation