Path Forward to Resolution of Coatings Issues

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Purpose of Presentation

Provide results of recently completed NRC sponsored coatings transport testing.

Provide the industry with an update on NRC activities and positions related to evaluation of GSI-191 Protective Coatings.

Discuss plans for timely resolution of remaining issues.

Presentation Topics

- Results of NRC sponsored research on transport of coating chips
- Current status of staff evaluation efforts for Coatings Issues
- Challenges remaining on Coatings Issues
- Path forward for resolution of Coatings Issues
  - NRC planned actions
  - NRC expectations of industry
- Summary

Coating Transport Research - Scope

1. Parametrically characterize the transport of a selected set of coatings debris in water
   - Quiescent tank to measure time to sink and terminal velocity
   - Water velocity needed to transport chips from bottom of flume
   - Water velocity needed to transport chips in the bulk fluid
2. Five coating systems tested:
   - One-coat alkyd- 1g/cc) "**ALK**"
   - Two-coat epoxy-1.78 g/cc "**E2**"
   - Zinc primer/epoxy topcoat-2.58 g/cc "**ZE**"
   - Epoxy concrete sealer/epoxy surfacer/two-top coats epoxy-1.85 g/cc "**E3C**"
   - Six-coat Epoxy-1.77 g/cc "**E6**"
3. Three size ranges tested: 1/64 to 1/32 inch, 1/8 to ¼ inch, and 1 to 2 inch. – No particulate debris was included in this testing
4. Flat and curled chips tested (zinc/epoxy in curled only, alkyd and concrete system in flat only)

Settling Tests – Quiescent Tank

- In time to sink tests, light-weight coating chips (alkyd) dropped onto water surface tended to remain on the surface indefinitely; heavy coating chips mostly sank immediately with a fraction (10 to 20 percent) remaining on the surface indefinitely.

- In steady-state terminal velocity tests, the terminal velocities, generally, ranged from .04 ft/s for smallest-lightest chips to 0.46 ft/s for the large E6 curled chips.

Transport Test-Tumbling Velocity

- Tumbling velocity is the water velocity required to initiate chip movement along the floor. Incipient Tumbling velocity is the velocity at which first chip begins to move. Bulk tumbling velocity is when 80 percent of chip begin to move.

- Tumbling velocities were significantly influenced by chip density and shape.
  - Shape:
    - For the six-coat epoxy coating chips (E6), the incipient tumbling velocity was 0.04 ft/s for the curled, and 0.68 ft/s for flat chips
  - Density:
    - 1”-2”, flat, E6 (1.75 g/cc), incipient/bulk tumbling velocity = 0.68 & 1.36 ft/s, respectively
    - 1”-2”, flat, alkyd chips (1.15 g/cc), Incipient/bulk tumbling velocity = 0.16 & 0.46 ft/s, respectively

Steady-State Transport Test

- Coating chips were immersed into the moving water and released. The distance transported before coming to rest was recorded.

- Two transport tests conditions:
  1. 0.2 ft/s (an upper-bound velocity, based on observations during the tumbling test, at which the coatings did not appear to transport)
  2. The tumbling velocity of the specific sample

Steady-State Transport Test (Cont'd)

- Observations At 0.2 ft/s:
  - Almost all the chips came to rest at the bottom of the stream within one to 13 feet of the release point. Two percent of the 1 to 2 inch ALK and four percent of curled E2 transported to the end of the flume but did not enter the collection screen. Also, three 3 percent of the 1/8" to 1/4" ALK was retrieved in the top section of the strainer.

- Observations at the bulk tumbling velocity:
  - The results were more mixed as the bulk tumbling velocities varied widely between the samples.
  - The 1 to 2 inch flat and curled chips of all coatings, in general, sank to the bottom of the flume and a significant percent did not transport to the strainer located at the end of the flume. However, 77 % of ALK, 48 % of curled E6, 13 % of ZE, 70% of E2, 18% of E3C, and 24 % of flat E6 were recovered in the bottom 3 inches of the strainer and 15 % of alkyd chips were recovered in the top section of the strainer.
  - For the 1/8" to1/4" samples, 92% of ALK transported in the middle or top of the stream. E2, E3C and ZE had 50 % to 60 % of chips transport at the bottom. Further 4% of E2 and 12 % of E3C transported at the middle or top.
  - The 1/64" to 1/32" debris exhibited transport characteristics similar to the 1/8" to1/4" samples

Transport Research Summary

- Submerged coatings debris in the size range of 1/64 inch to 2 inches have limited potential for transport at stream velocities of 0.2 ft/s and less.
- If dropped onto the water surface, alkyd coatings debris and a fraction of the heavier coatings debris may remain buoyant and transport.
- This test series did not include particulate debris
- Licensee's must be able to justify the characteristics (size, density, shape) of their coating debris in order to take credit for lack of debris transport to the sump

Current NRC Activities

- Staff awaiting official submittal of coatings Zone of Influence (ZOI) test reports
- Staff reviewing EPRI test reports for Original Equipment Manufacturer (OEM) unqualified coatings
- NRC Office of Research analyzing results of NRC sponsored coating transport tests
- Staff interacting with industry to resolve concerns about Assessment of Qualified Coatings for degradation in service

Remaining Challenges

- Need formal submittal of coatings ZOI reports
- Need industry input on how licensees will apply the EPRI OEM unqualified coatings test data in order to focus the staff's review
- For licensees assuming coating debris will not transport to the strainer surface, staff needs to verify adequacy of licensee's analysis and testing
- Need to resolve staff concerns on the adequacy of current industry assessment techniques for degradation of qualified coatings

Challenges: Qualified Coating ZOI Tests

- No clear process for submittal of reports and resolution of NRC staff concerns
- Staff's review will focus on the characteristics of the two-phase jet and the associated calculations of destructive pressures
- Staff's review will examine the specific coating systems tested and the applicability of the test data to actual plant coatings

Path Forward: Qualified Coating ZOI Tests

- NRC Expectations:
  - ZOI reports submitted for review by NRC staff
    - FPL/AREVA
    - USA/STARS
  - Process defined for coordination of industry responses to NRC concerns
- NRC Actions:
  - Staff will resolve issues through agreed upon process
  - Any site specific issues (unique coating configurations) will be addressed on a plant specific basis as necessary

Challenges: Unqualified Coatings Tests

- No clear process for resolution of NRC staff concerns.
- Industry clarification of the intended use of the EPRI testing is needed to help the staff focus its review on critical aspects of the testing
  - % of unqualified coatings that delaminate
  - characteristics of debris generated
  - coating types and relative performance

Path Forward: Unqualified Coatings Tests

- NRC Expectations:
  - NEI will facilitate the staff's request for industry feedback on the intended use of the EPRI report
  - Process defined for coordination of industry responses to NRC concerns
- NRC Actions:
  - Staff will resolve issues through agreed upon process

Challenges: Coating Transport

- Some licensees will use strainer testing to prove that the coating debris will not transport to the strainer surface and will not cause unacceptable head loss
- Licensees must demonstrate:
  - adequacy of test procedures and analysis
  - debris is prepared consistent with its expected failure mode – based on test data or position in staff SE
  - concerns about flume testing have been addressed (near field, scaling, debris introduction)
  - coating debris does not contribute to chemical effects

Path Forward: Coating Transport

- NRC Expectations:
  - Licensees, and their screen vendors, who credit settling of coating debris will address NRC concerns about debris preparation, scaling, near field effect, and debris introduction
- NRC Actions:
  - Staff will resolve generic issues through the screen vendors and contracted test facilities
  - Staff will use NRC sponsored coatings transport testing to confirm the adequacy the licensee's coating transport testing and/or replacement strainer proof testing

Challenges: Coating Assessment

- Recent observations of coating degradation at several facilities has caused the staff to question the adequacy of industry's practice of performing visual coating assessments

- Coatings that exhibit visual signs of degradation most likely have been in a degraded state for an extended period, representing a potential source of debris in a design-basis accident (DBA)

- Appropriate physical testing of the coating systems could identify areas of degradation prior to visual manifestation of the problem

Challenges: Coating Assessment

- Interactions between the NRC and the industry to date have not resulted in resolution of this issue – a new approach or new data is necessary
  - NRC participation in ASTM D33 Meetings, 1/27-28/05, and 2/2/06
  - Public Meeting with ASTM and NUCC representatives 7/25-26/05
  - NRC letters to NEI dated 1/16/06, and 4/26/06
  - NEI letter to NRC dated 3/31/06
  - NRC participation in EPRI Coatings Aging Task Group 1/31/06
  - Numerous public meetings regarding GSI-191

Path Forward: Coating Assessment

- NRC Expectations:
  - Licensees will pursue one of the following options for coating debris in their final strainer design:
    - Prove that visual assessment provides adequate assurance that qualified coatings will not fail during a DBA
    - Perform physical testing of the containment coatings that provides assurance that the qualified coatings will remain adhered in a DBA
    - Assume 100% failure of the containment coatings and perform transport testing and strainer proof testing to ensure adequate head loss margin exists to account for the coating debris

Path Forward: Coating Assessment

- NRC Actions:
  - Staff will evaluate licensees' approaches to resolve this issue for GSI-191
  - Staff will continue to interact with NEI, EPRI, NUCC, and ASTM to improve coating assessment techniques

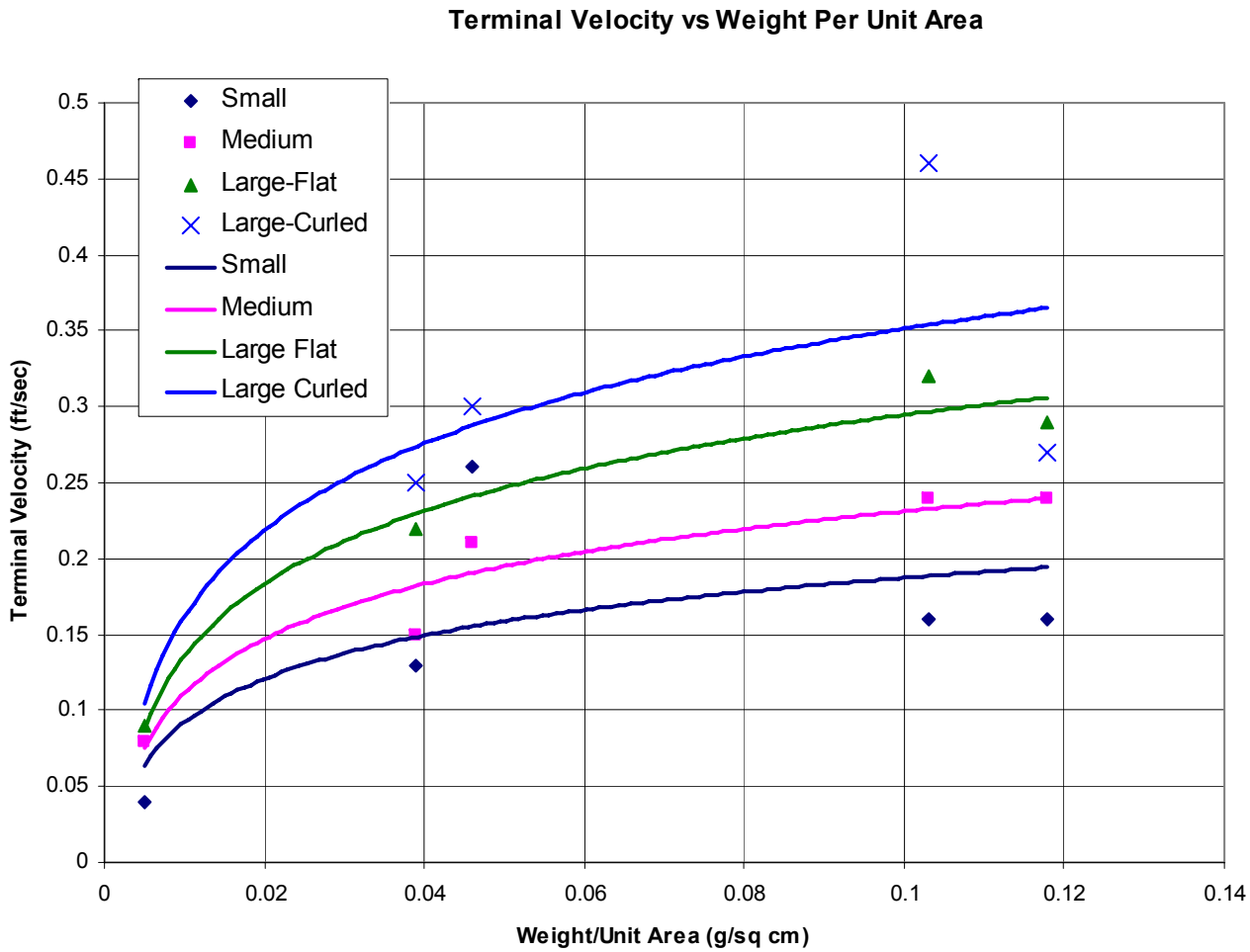
Summary

- Caucus
- Discussion
- Agreement on a path forward for:
  - ZOI
  - Unqualified Coatings
  - Transport
  - Assessment

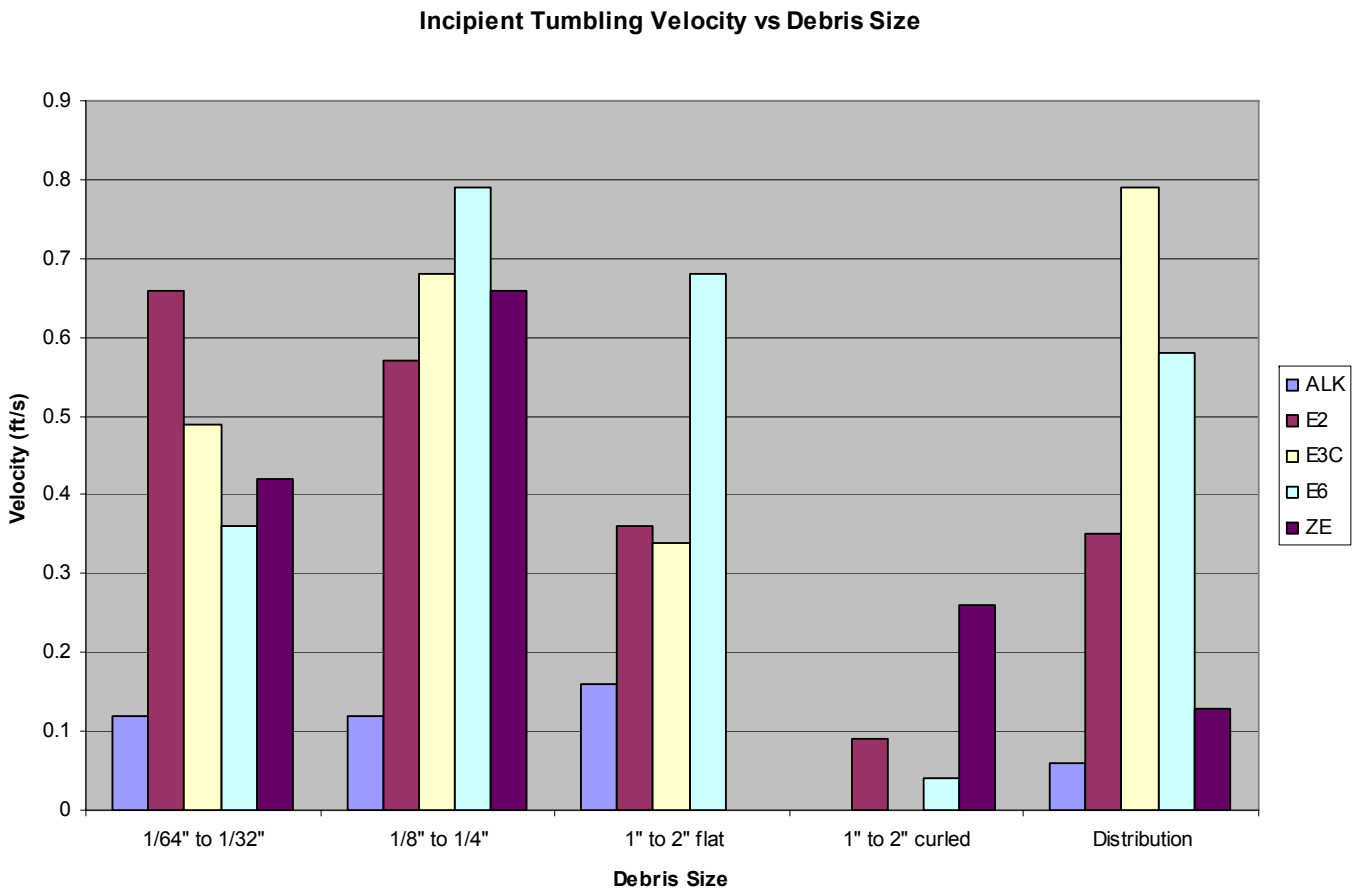
Additional Transport Data

- The following slides are provided for information and will not be covered during the NRC presentation.
- These slides present preliminary data from the NRC sponsored coating transport research.

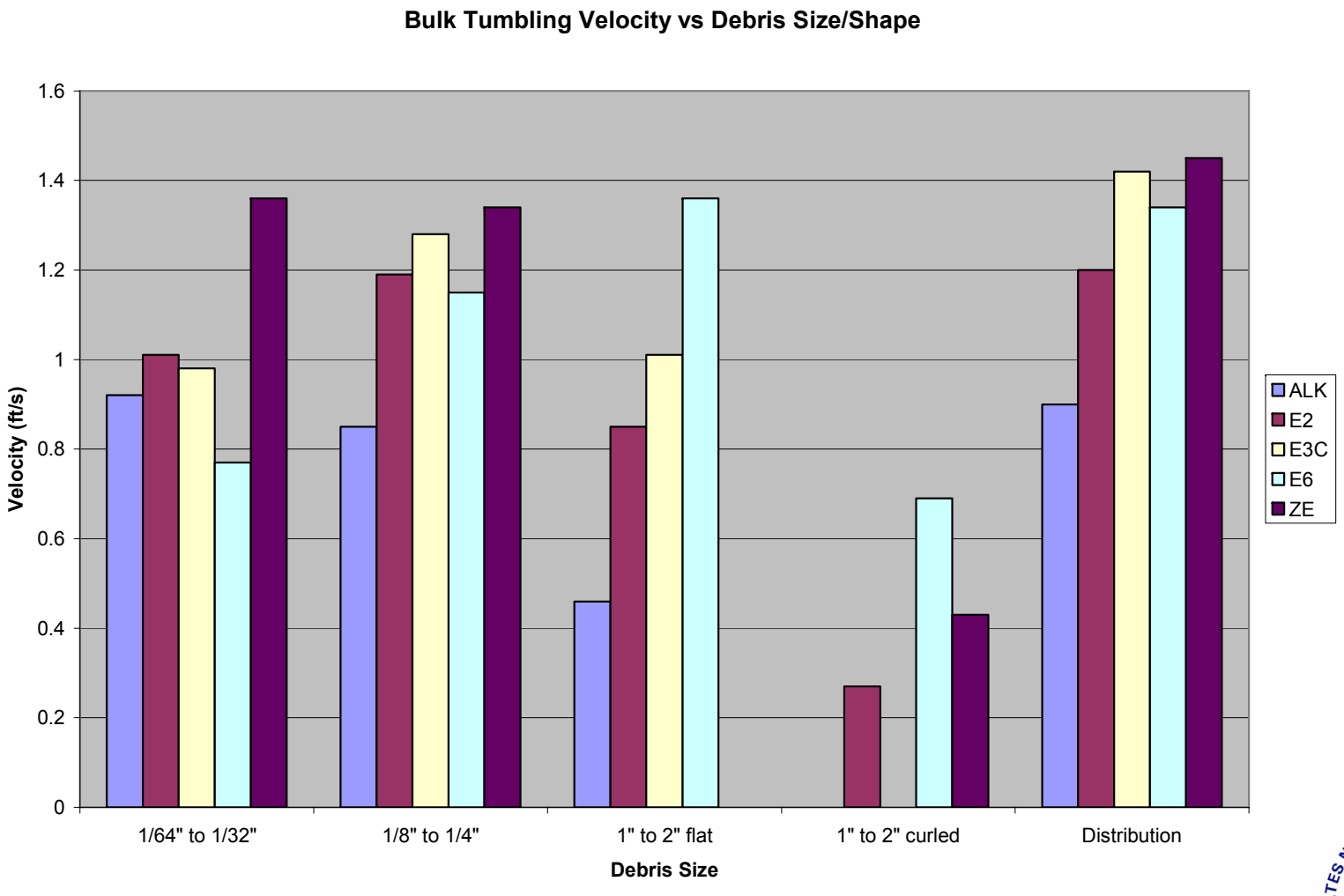
Terminal Velocity



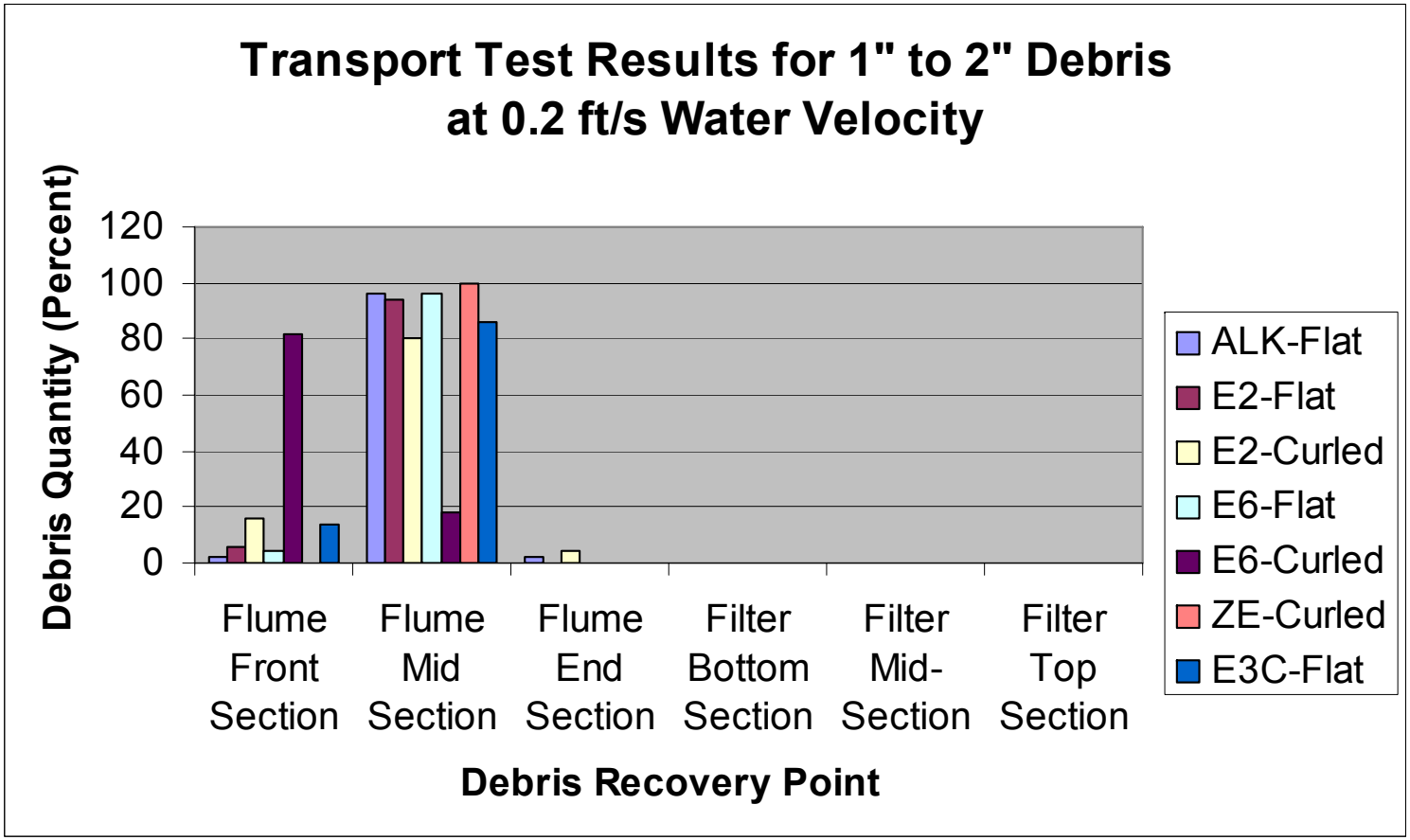
Incipient Tumbling Velocity



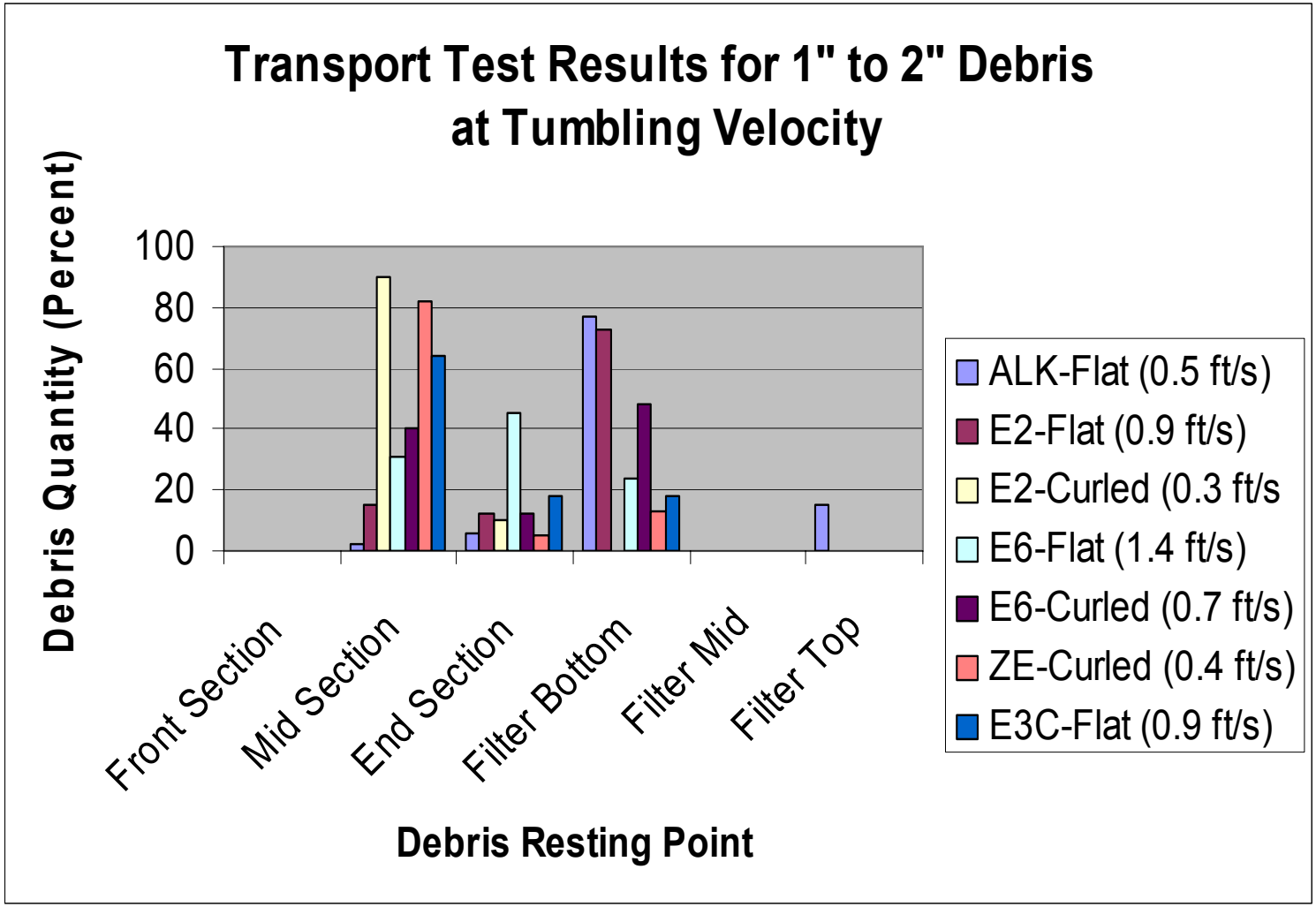
Bulk Tumbling Velocity



Coatings Transport at 0.2 ft/s



Bulk Tumbling Velocity Transport



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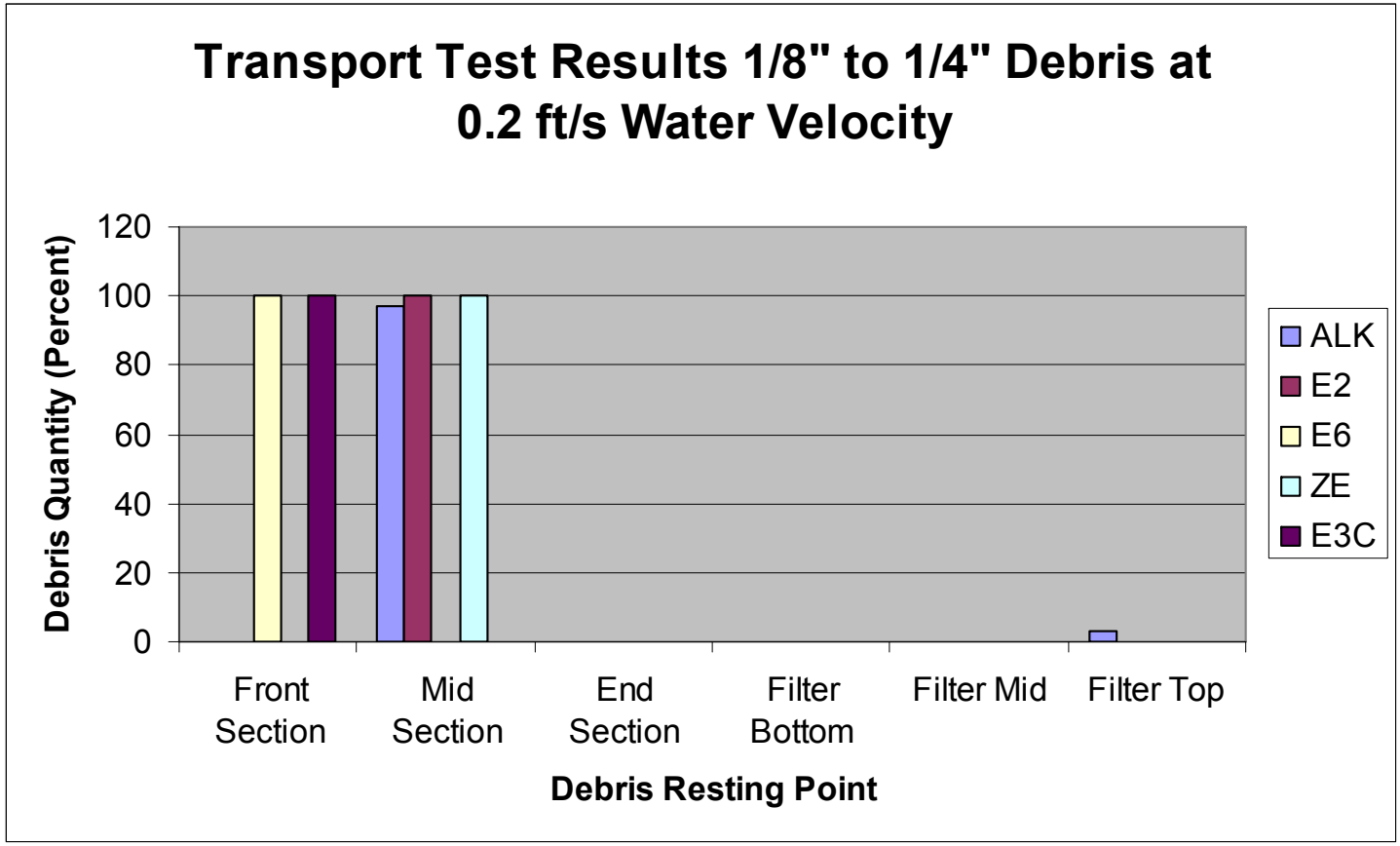
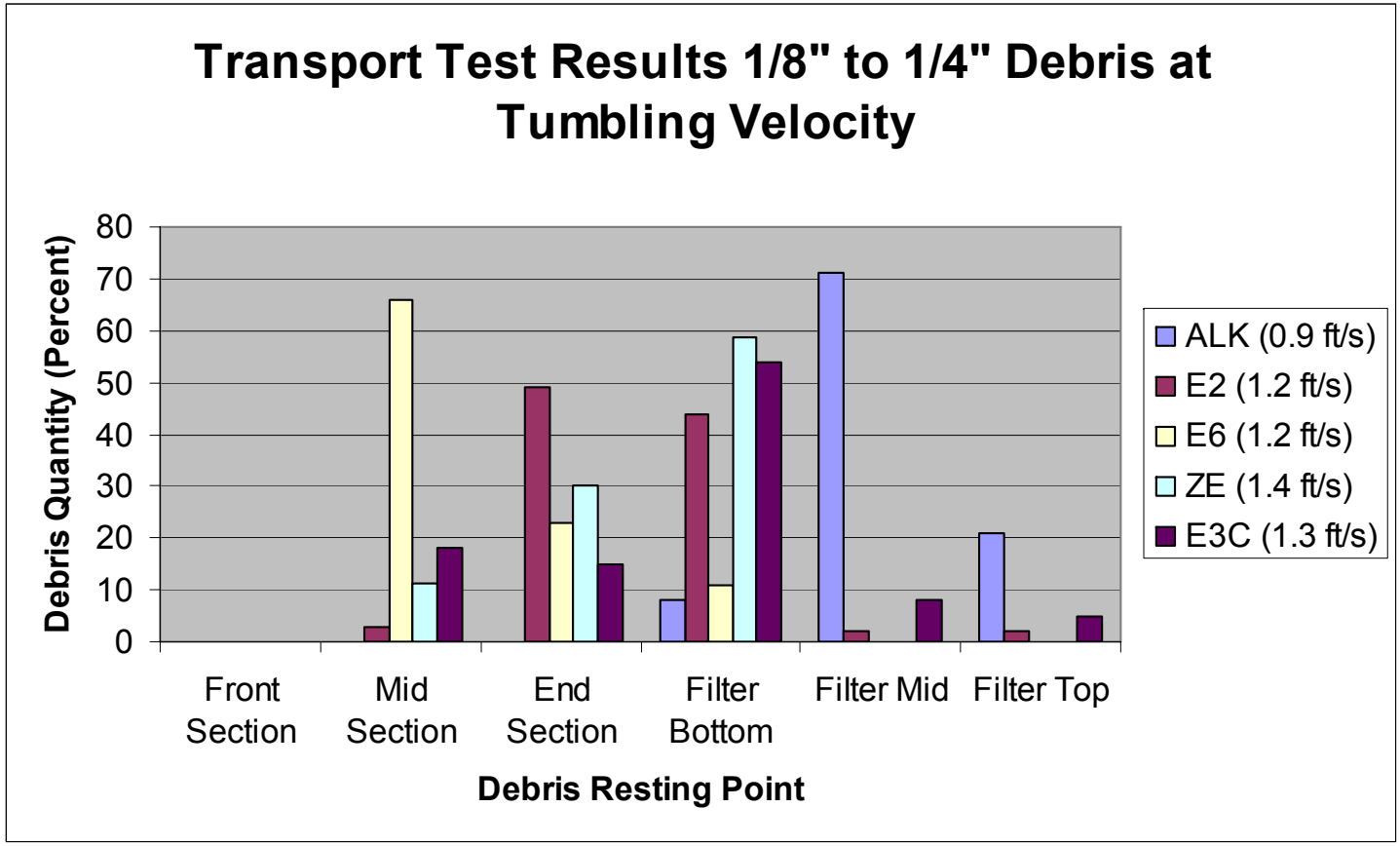


Bulk Tumbling Velocity Transport



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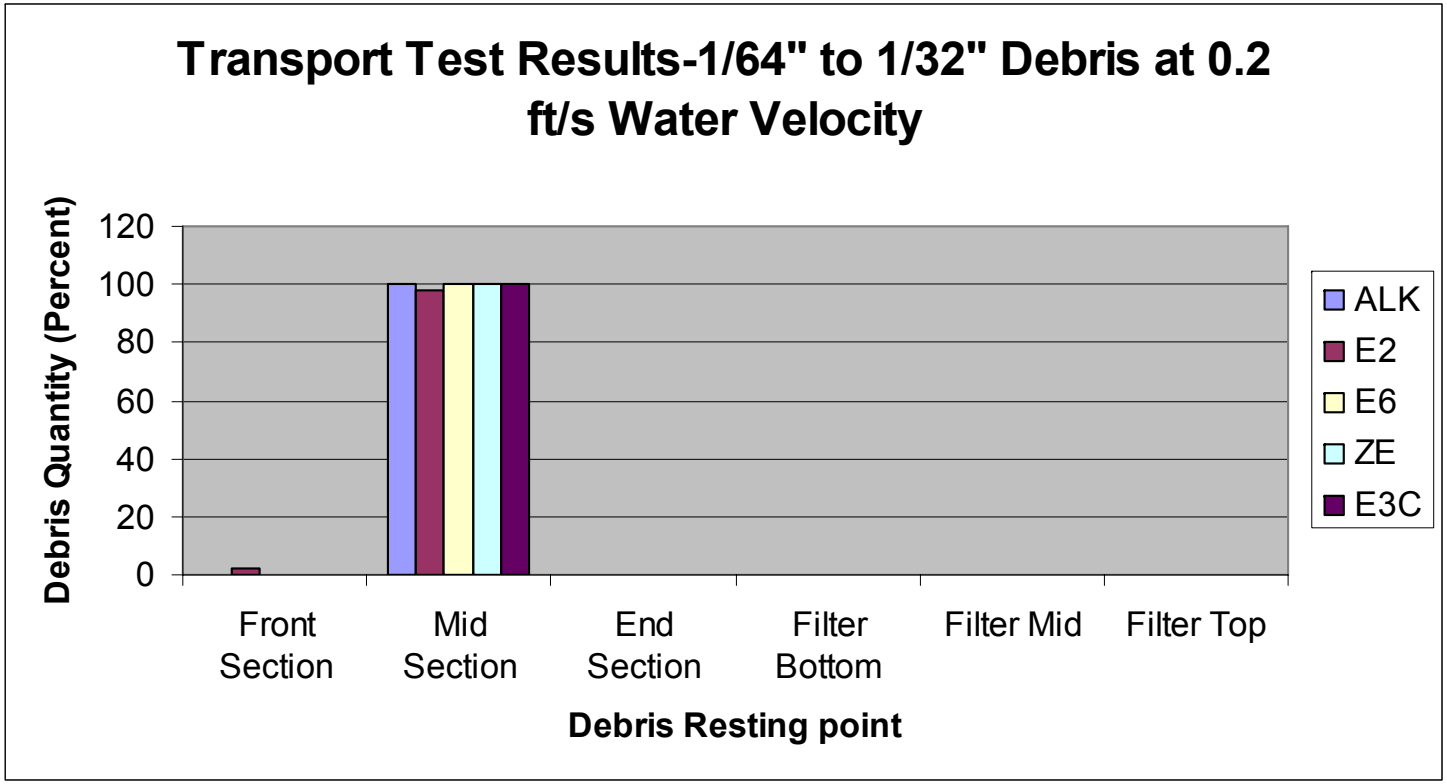

Bulk Tumbling Velocity Transport