



# **Tests to Assess the Potential for Moisture Damage in Asphalt Mixtures**

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# Moisture Damage Tests

## ⇒ Pre-SHRP

- Immersion-Compression Test
- Boil Test
- Texas Freeze-Thaw Pedestal Test
- Swell Test (Hveem)
- Lottman Test
- Root-Tunnicliff Test



# Moisture Damage Tests

## ⇒ Post-SHRP

- Environmental Conditioning System
- Modified Lottman Test
- Root-Tunnicliff Test
- Hamburg Wheel Tracking Test



# Modified Lottman Test

## ⇒ Standard Procedure

- AASHTO T-283

## ⇒ Specimen Size

- 4-inch (100-mm) diameter; 2.5-inch (63-mm) height
- 6-inch (150-mm) diameter; 3.75-inch (95-mm) height ?

## ⇒ Percentage of Air Voids

- Construction air voids
  - $7.0 \pm 1.0\%$



# Modified Lottman Test

## ⇒ Aging

- Loose Mix

- 16 hours at 60C in forced draft oven

- Compacted Specimen

- 72-96 hours at ambient temperature (20-25C)



# Modified Lottman Test

## ⇒ Specimen Conditioning (Conditioned Subset)

### ■ Partial Vacuum Saturation

- After compacted specimen aging
- Initial saturation of 55-80%



# Modified Lottman Test

## ⇒ Specimen Conditioning (continued)

- Freeze Cycle
  - 15 hours at -18C
- Thaw Cycle
  - 24 hours at 60C



# Modified Lottman Test

- ⇒ Specimen Conditioning (All Specimens)
  - Temperature Equilibration
    - 2 hours at 25C (water bath)

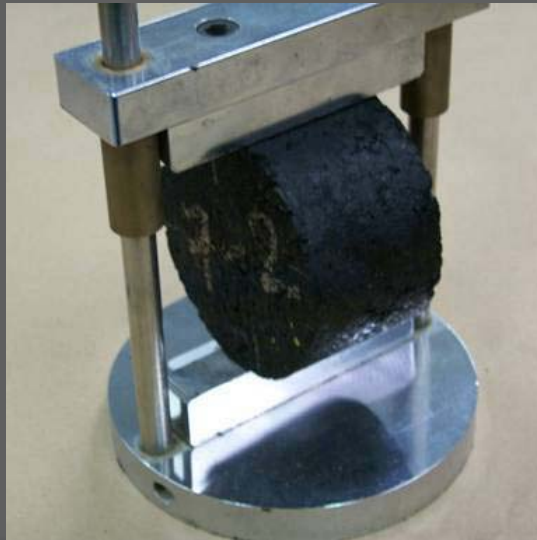


# Modified Lottman Test

## ⇒ Mechanical Test

### ■ Indirect Tensile Strength

- 50 mm/min. displacement rate
- Peak Load at Failure



# Modified Lottman Test

## ⇒ Test Result

### ■ Tensile Strength Ratio

- Average Indirect Tensile Strength of Conditioned Specimens ( $S_{t,wet}$ )
- Average Indirect Tensile Strength of Conditioned Specimens ( $S_{t,dry}$ )

$$TSR = \frac{S_{t,wet}}{S_{t,dry}}$$



# Modified Lottman Test

## ⇒ Interpreting the Results

- $\text{TSR} \geq 0.80$ 
  - Acceptable resistance to moisture damage
- Some agencies use  $\text{TSR} \geq 0.70$  as criterion

## ⇒ Mix Adjustments for Poor TSR

- Liquid anti-stripping additives
- Hydrated Lime
- Change of aggregate/mix design



# Root-Tunnicliff Test

## ⇒ Standard Procedure

- ASTM D4867

## ⇒ Specimen Size

- 4-inch (100-mm) diameter; 2.5-inch (63-mm) height
- 6-inch (150-mm) diameter; 3.75-inch (95-mm) height ?

## ⇒ Percentage of Air Voids

- Construction air voids
  - $7.0 \pm 1.0\%$



# Root-Tunnicliff Test

## ⇒ Aging

- Loose Mix

- None required

- Compacted Specimen

- None required (cool)

## ⇒ Specimen Conditioning (Conditioned Subset)

- Partial Vacuum Saturation

- Initial saturation of 55-80%



# Root-Tunnicliff Test

## ⇒ Specimen Conditioning (continued)

- Freeze Cycle

- 15 hours at -18C (OPTIONAL)

- Thaw Cycle

- 24 hours at 60C

## ⇒ Specimen Conditioning (All Specimens)

- Temperature Equilibration

- 2 hours at 25C (water bath)

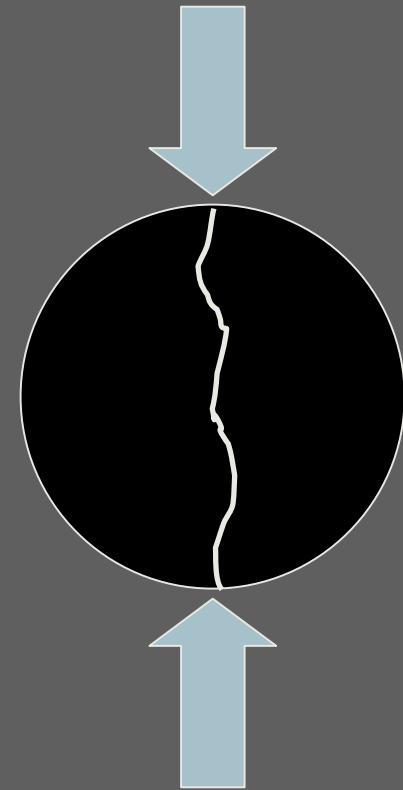
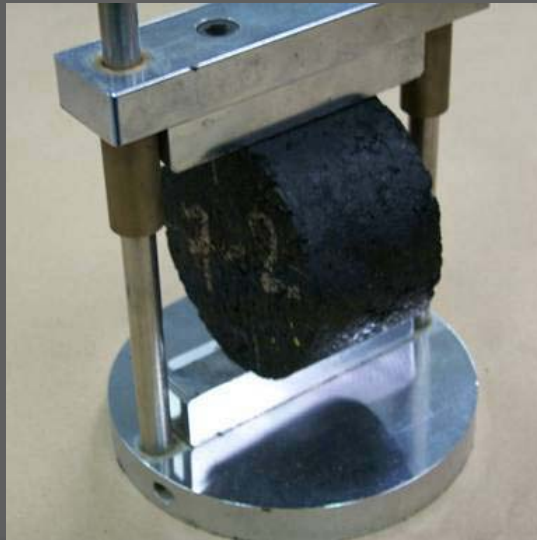


# Root-Tunnicliff Test

## ⇒ Mechanical Test

### ■ Indirect Tensile Strength

- 50 mm/min. displacement rate
- Peak Load at Failure



# Root-Tunnicliff Test

## ⇒ Test Result

### ■ Tensile Strength Ratio

- Average Indirect Tensile Strength of Conditioned Specimens ( $S_{t,wet}$ )
- Average Indirect Tensile Strength of Conditioned Specimens ( $S_{t,dry}$ )

$$TSR = \frac{S_{t,wet}}{S_{t,dry}}$$



# Root-Tunnicliff Test

## ⇒ Interpreting the Results

- $\text{TSR} \geq 0.80$ 
  - Acceptable resistance to moisture damage
- Some agencies use  $\text{TSR} \geq 0.70$  as criterion

## ⇒ Mix Adjustments for Poor TSR

- Liquid anti-stripping additives
- Hydrated Lime
- Change of aggregate/mix design



# Environmental Conditioning System (ECS)

## ⇒ Standard Procedure

- SHRP-developed (A-003A)
- Oregon State University (Terrel et. Al.)

## ⇒ Specimen Size

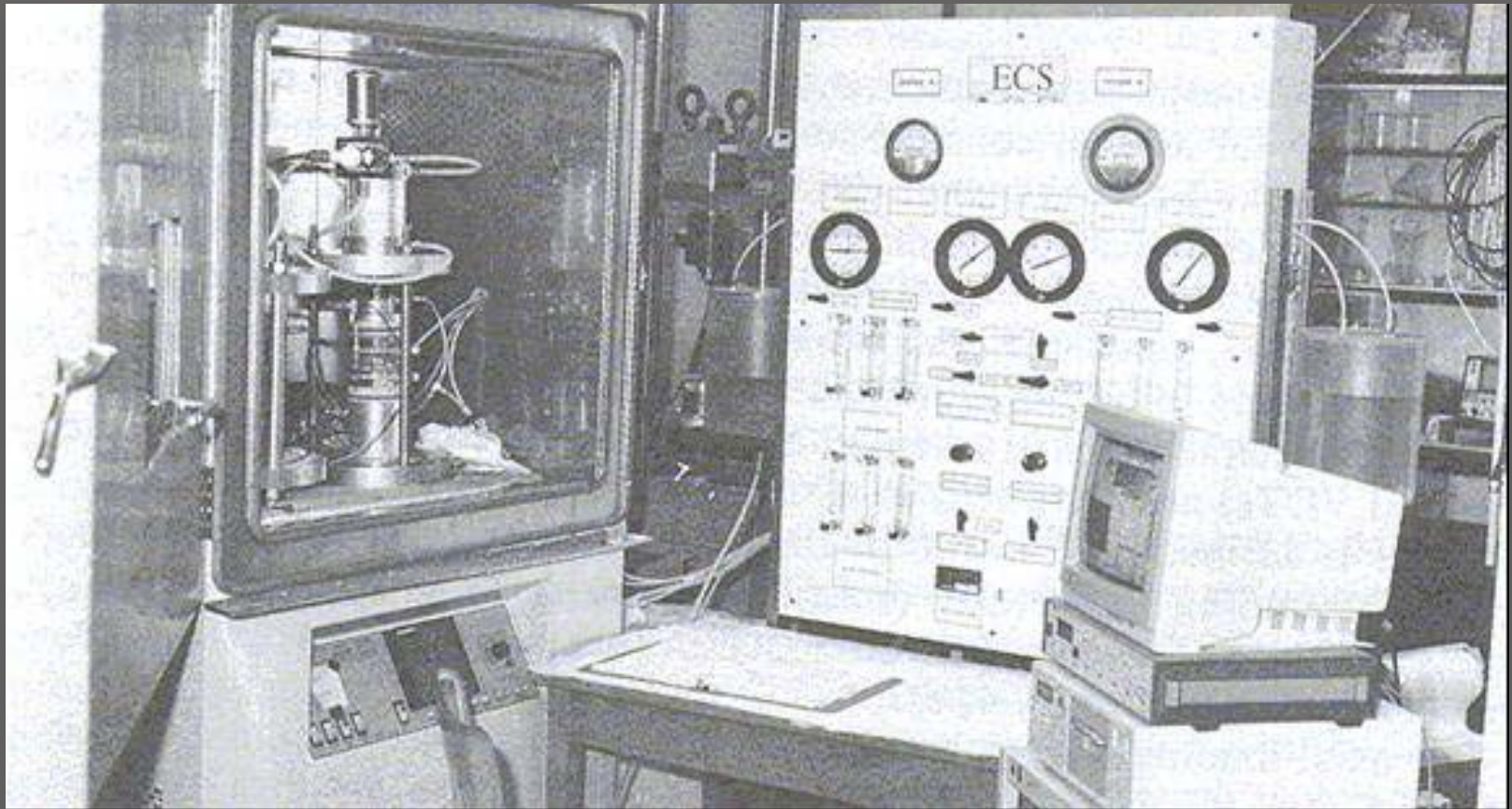
- 4-inch (100-mm) diameter; 4-inch (100-mm) height

## ⇒ Percentage of Air Voids

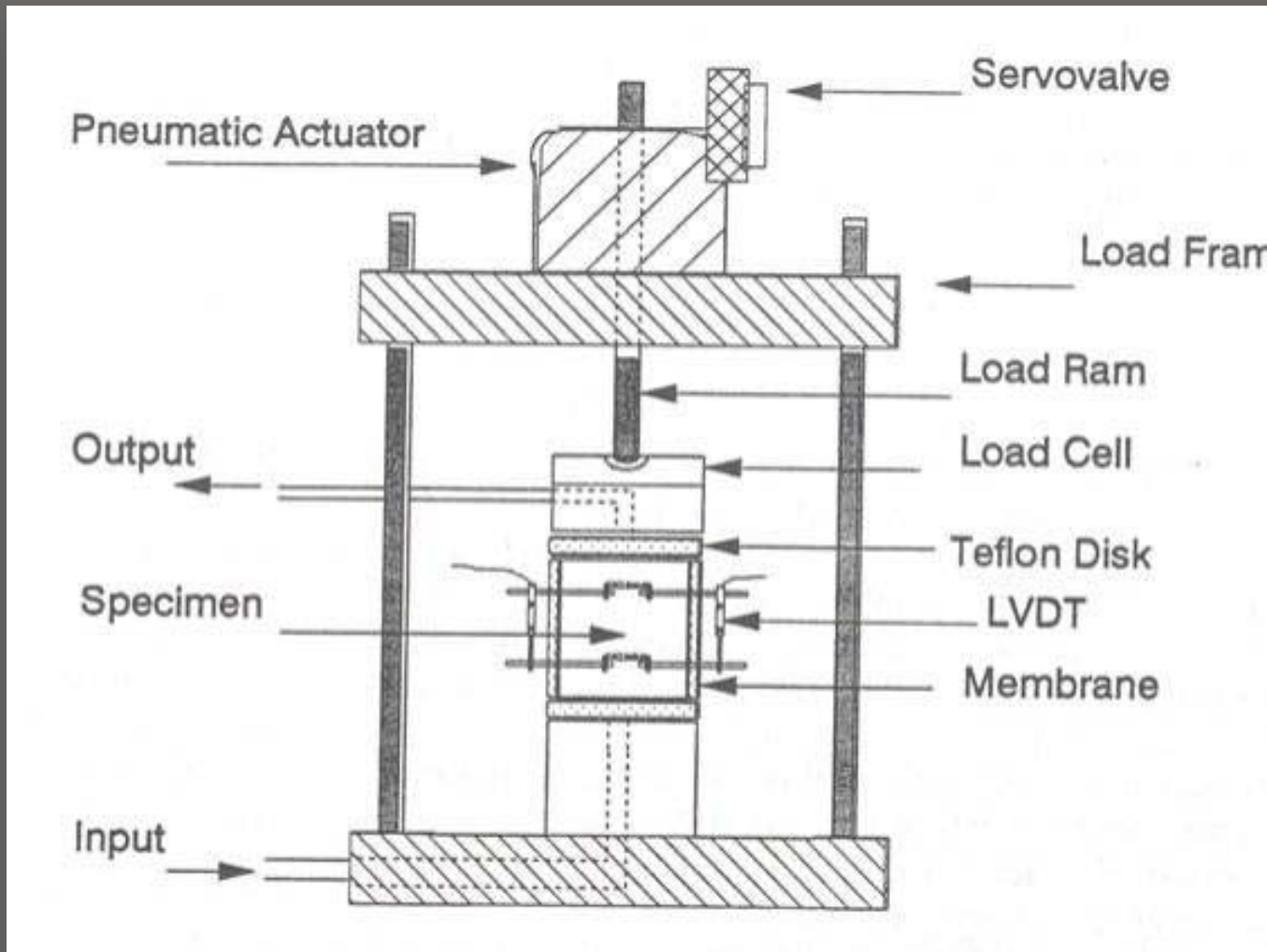
- Construction air voids



# ECS



# ECS



# ECS

## ⇒ Aging

- Loose Mix
  - 4 hours at 135C
- Compacted Specimen
  - None required (cool)



# ECS

## ⇒ Specimen Conditioning and Testing

- Initial Resilient Modulus (uniaxial)
- Thawing Cycles (1+)
  - 60C
  - Repeated loading, Mr
- Freeze Cycle
  - Optional
  - Repeated Loading, Mr



# ECS

## ⇒ Interpreting the Results

### ■ Modulus Ratio

- Multiple conditioning cycles
- Accumulation of moisture damage



# Loaded Wheel Tests

## ⇒ Test Temperature

- High Temperatures (40-60C)
- Conducted under water

## ⇒ Loading

- Repeated Wheel Passes
  - Pressurized rubber hose w/ wheel
  - Steel wheel
  - Pneumatic wheel



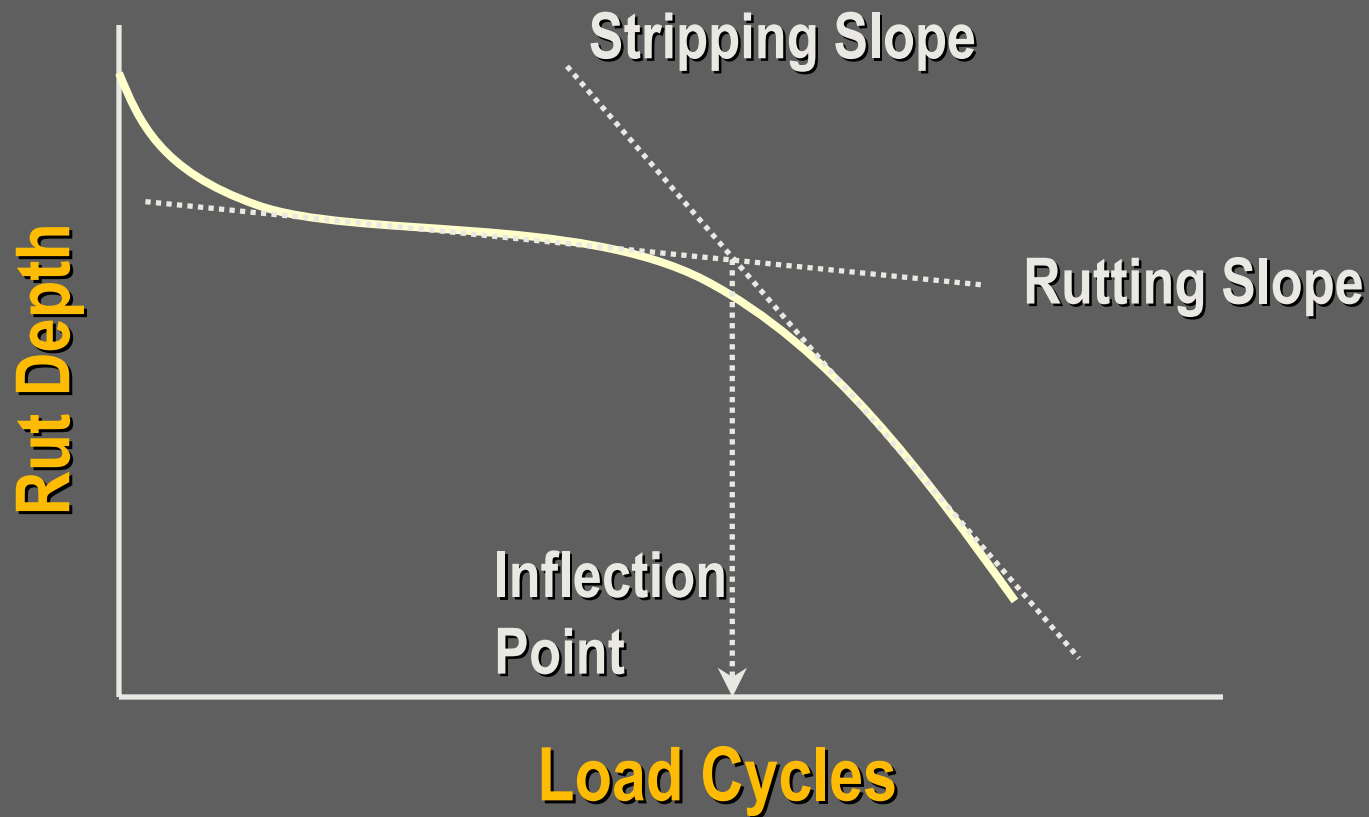
# Asphalt Pavement Analyzer



# Hamburg Wheel Tracker

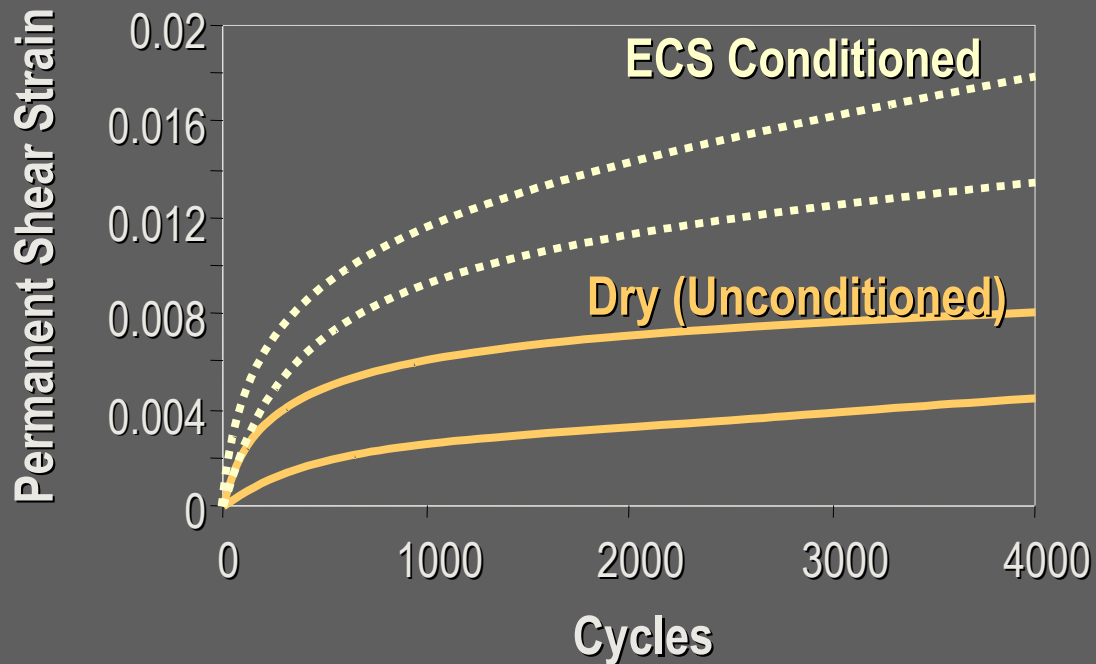


# Hamburg Wheel Tracking Test



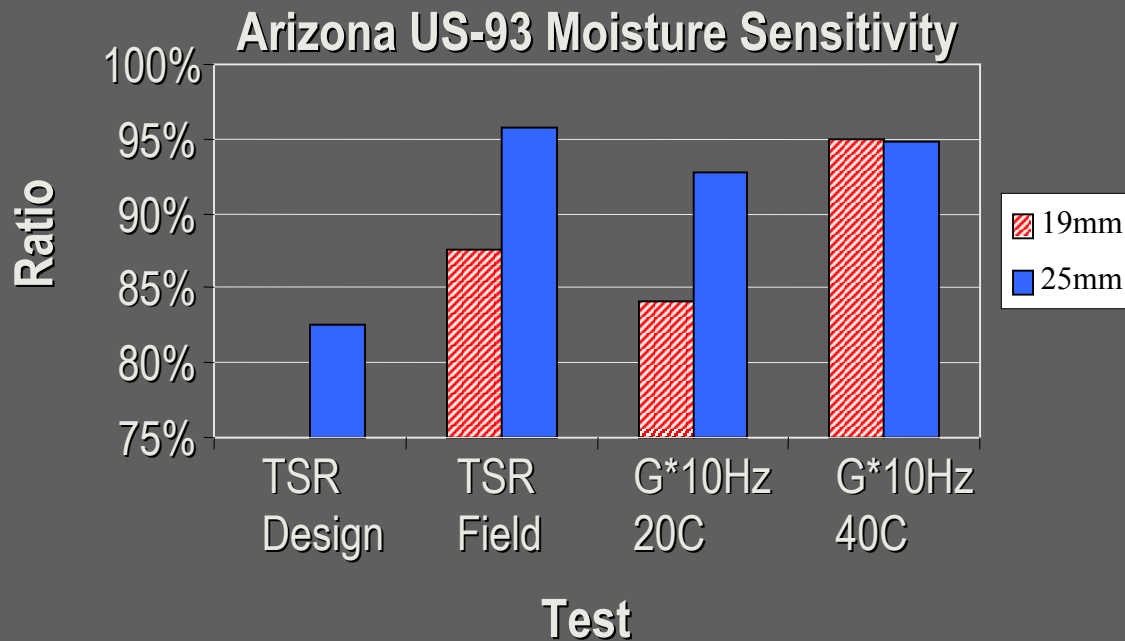
# Other Tests

➔ ECS Conditioning w/ Mechanical Property Test



# Other Tests

➔ Partial Vacuum Saturation w/ Mechanical Property Tests



**Thanks !**

