

PAAMA/PENNDOT STATEWIDE CONFERENCE OCTOBER 19-21, 2022

UNCOVERING THE SCIENCE OF
PENETRATING PRIME EMULSIONS

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OVERVIEW

- INTRODUCTION TO ASPHALT PRIME COATS & KEY INDUSTRY CHALLENGES
- THE SCIENCE BEHIND PRIME COATS
- PERFORMANCE AND RELIABILITY TESTING AND RESULTS
- THE FUTURE OF ASPHALT PRIME COATS
- SUMMARY





INTRODUCTION TO ASPHALT PRIME COATS & KEY INDUSTRY CHALLENGES

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WHAT IS A PRIME COAT?

→ **A prime coat is:**

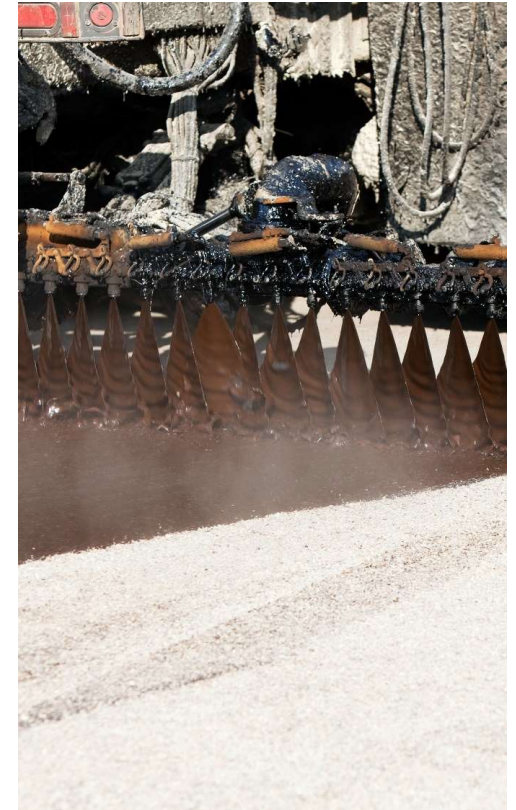
- An application of low viscosity binder to a granular base surface, or
- Mixing of low viscosity binder into the upper portion of a granular base in preparation for an initial asphalt layer or chip seal

→ **Prime coats are used to:**

- Toughen the surface for the next pavement layer
- Promote adhesion between the granular base and the next pavement layer

→ **Types of Prime Coats:**

- Cutback – asphalt, solvent
- Emulsion (Anionic or Cationic) – asphalt, emulsifier, solvent, water



PROPERTIES OF HIGH-PERFORMANCE PRIME COATS

- ❖ Emulsion absorbs quickly
 - Minimizes traffic pickup
 - Eliminates the need for sanding



- ❖ Emulsion penetrates sufficiently deep



- ❖ The primed road is ready to be paved in a short period of time



PRIME COAT APPLICATION



PREPARATION

- ❖ With dense granular bases or stabilized bases, the surface may need to be prepared



SPRAY APPLICATION

- ❖ Diluted prime coat material is sprayed
- ❖ Must avoid potential rainy days to prevent runoff prior to complete cure



SAND APPLICATION

- ❖ After 24 hours, sand is scattered onto the bed to absorb excess prime
- ❖ After absorption, the blotter sand must be removed



COMPLETE CURING

- ❖ Typically 3-5 days or longer



WEARING COURSE

- ❖ Binding Course over primed bases
- ❖ Surface is now ready for HMA or chip seal treatment

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PRIME COAT CHALLENGES

SO HOW DO WE SOLVE THESE CHALLENGES?



FOR EMULSION PRODUCERS:

- ❖ Emulsion-based prime coats may not perform as well as cutbacks
- ❖ Anionic prime coat emulsions tend to outperform cationic prime coat emulsions
- ❖ Solvents which usually contain volatile organic compounds (VOCs) are required:
 - Increasing formulation costs
 - Raising worker safety concerns



FOR PAVING CONTRACTORS:

- ❖ Increased construction time required:
 - To spread sand on the surface
 - For a full cure which typically takes 3-5 days or longer
 - To avoid unfavorable weather conditions
- ❖ Poor penetration leads to tracking away of prime coat and vehicular damage liability



FOR AGENCIES:

- ❖ Increased construction time results in slower return to traffic and added motorist delays
- ❖ Prime coats containing solvents increase the risk of community / citizen odor complaints and safety concerns
- ❖ Poor application lessens pavement durability, shortening pavement life and increasing maintenance costs
- ❖ No effective method to accurately evaluate the reliability of prime coats before applying on the road

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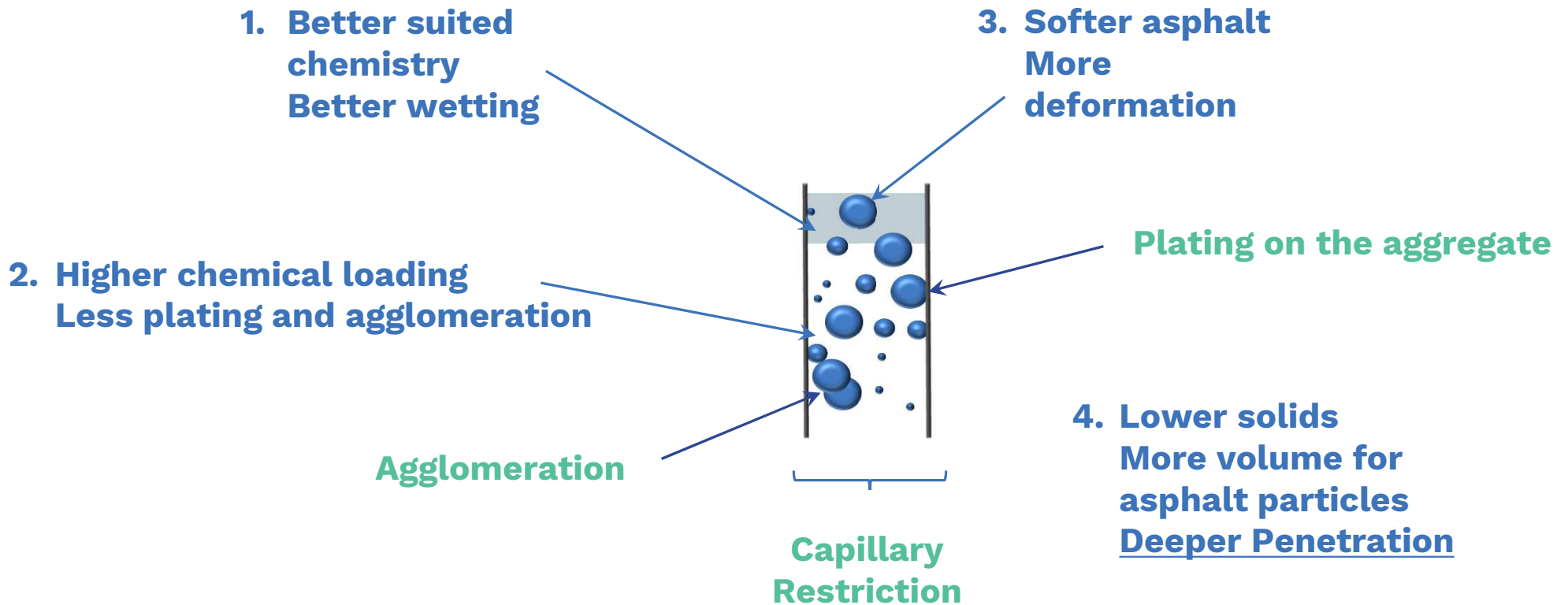
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THE SCIENCE BEHIND PRIME COATS

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CLOSER TO REALITY – VARIABLES WE CAN CONTROL



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SUMMARY OF THE SCIENCE

NOW THAT WE UNDERSTAND THE SCIENCE, HOW DO WE MEASURE RELIABILITY?



CAPILLARY RESTRICTION

- ✦ Smaller particle size asphalt emulsion is better
- ✦ Capillaries around $6.8 \mu\text{m}$ for densified soils



CONTINUOUS PHASE

- ✦ The water carries the asphalt
- ✦ Greatly impacts emulsion adsorption
- ✦ Finer particles adsorb more water



WETTING

- ✦ Surfactant type
 - Surface tension must be sufficiently low
- ✦ Surfactant quantity
 - Higher aggregate specific surface area requires more
 - Higher aggregate surface charge requires more



SUBSTRATE DEMANDS

- ✦ Granular Base
 - Consistent gradation and density
- ✦ High Clay
 - High surface charge
 - High water adsorption
- ✦ Sand
 - Low surface charge and high air voids

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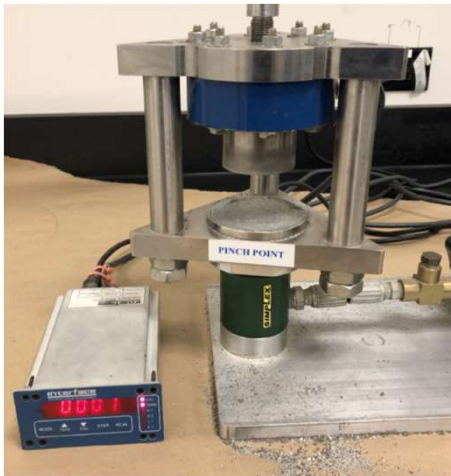
PERFORMANCE AND RELIABILITY TESTING AND RESULTS

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PERFORMANCE TEST

→ Sample Preparation

- Sieved through #8 screen
- 5% water added as lubricant
- Compressed to 100 psi (689 KPa) in a 3 oz pen cup
- Dried at 110 °C overnight
- Cooled to room temperature for testing



→ Test Method

- Asphalt emulsion diluted to 40% solids for prime, 5% to 20% for dust control
- Diluted emulsion pre-weighed to apply 1.0 L/m²
- Emulsion is poured onto the compressed soil quickly and a stopwatch is started
- The emulsion is swirled around to total coverage
- The stopwatch is stopped when all free liquid is absorbed

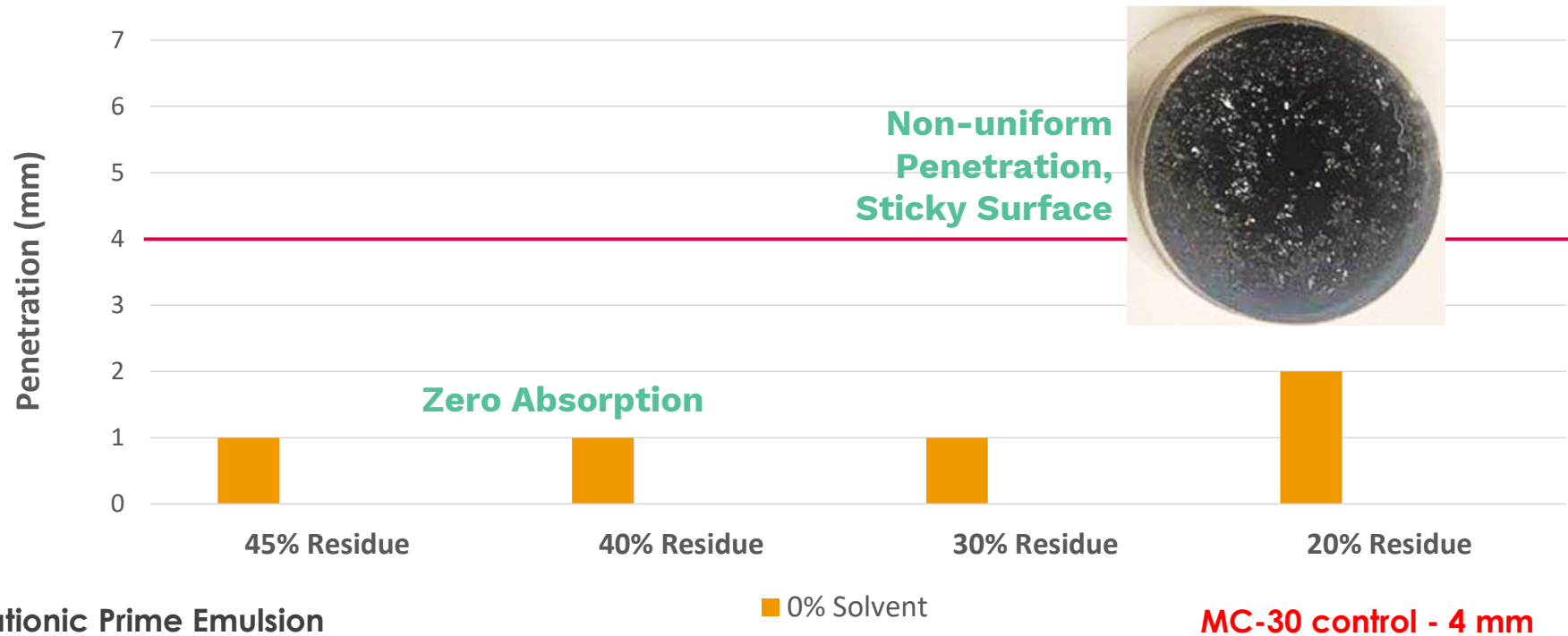


TYPICAL CATIONIC PRIME COAT EMULSION FORMULATION

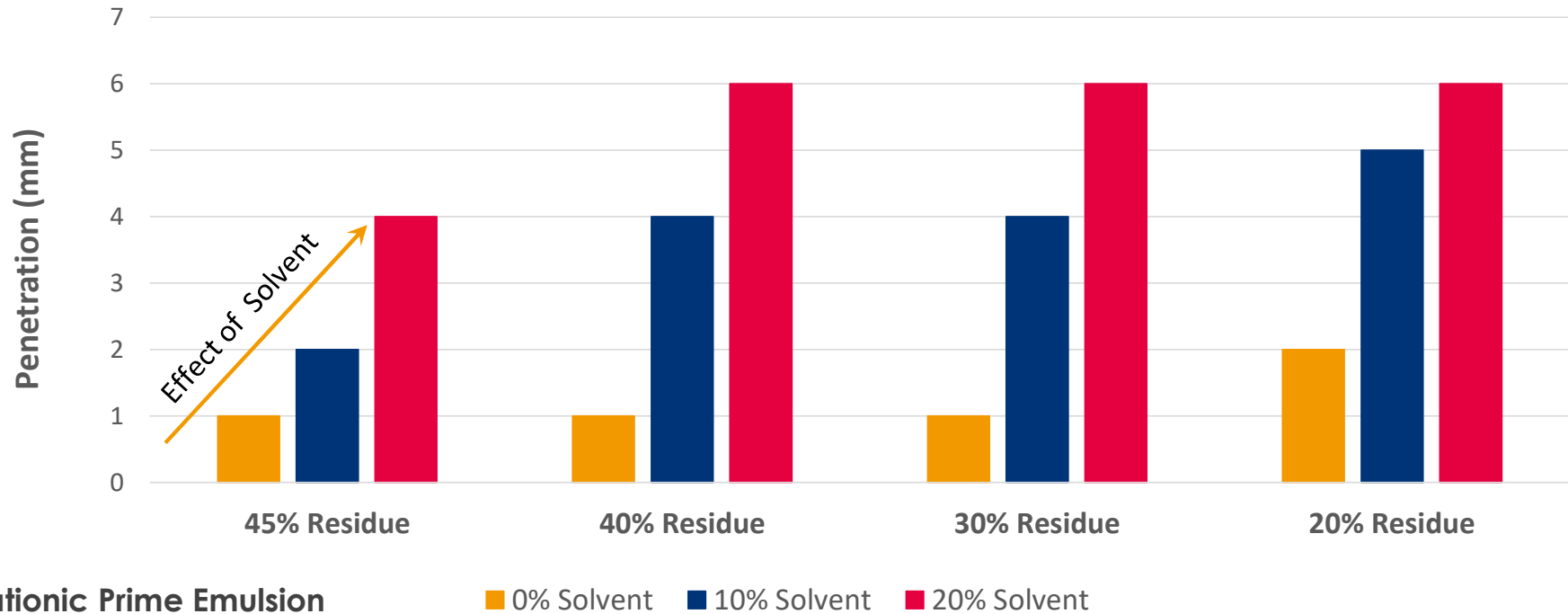
- 60 pen asphalt
- Typical emulsifier
- 15% solvent
- 40% residue



Effects of Solvent addition and Emulsion residue



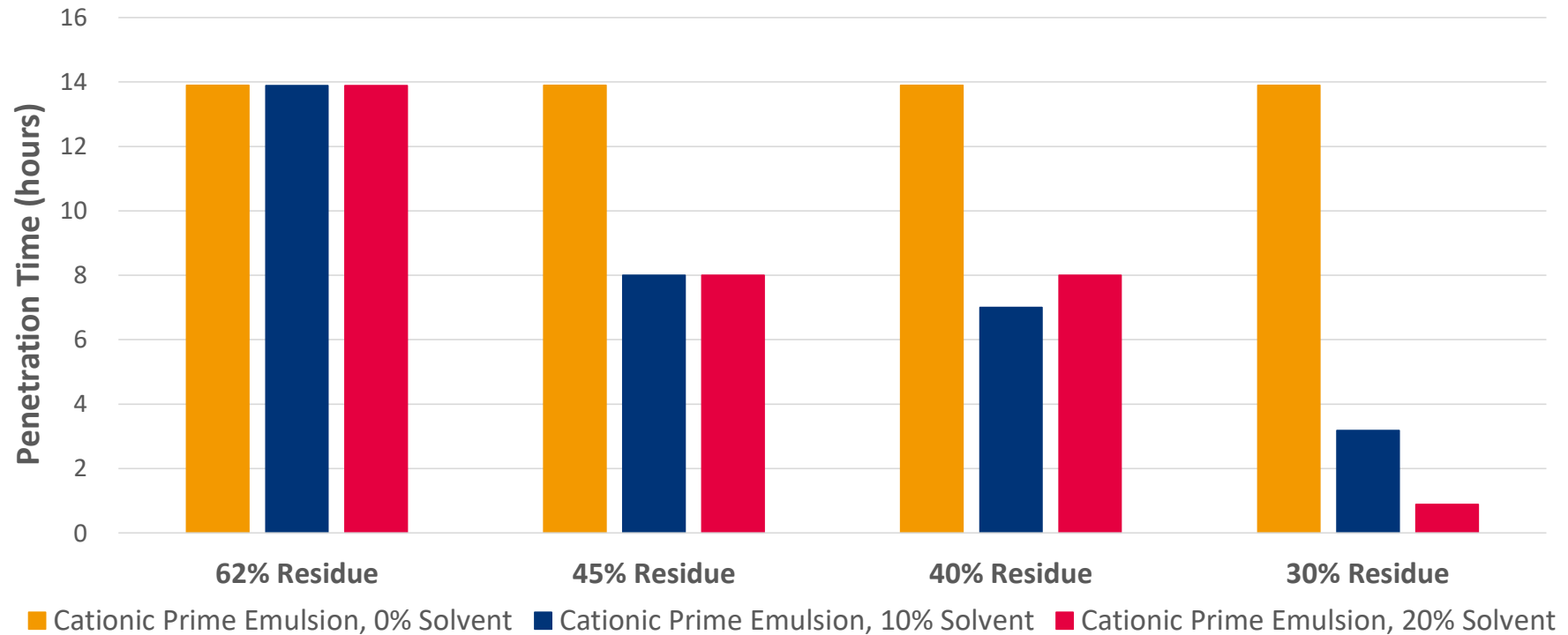
Effects of Solvent addition and Emulsion residue



✦ SOLVENT USE INCREASES PENETRATION DEPTH

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Penetration Time



✦ SOLVENT USE ALLOWS FOR QUICKER PENETRATION

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CATIONIC PRIME COAT EMULSION – 10% SOLVENT

→ 62% Residue

- **Dark black color and very shiny, extremely tacky**
- **2 mm penetration, 8+ hours**

→ 45% Residue

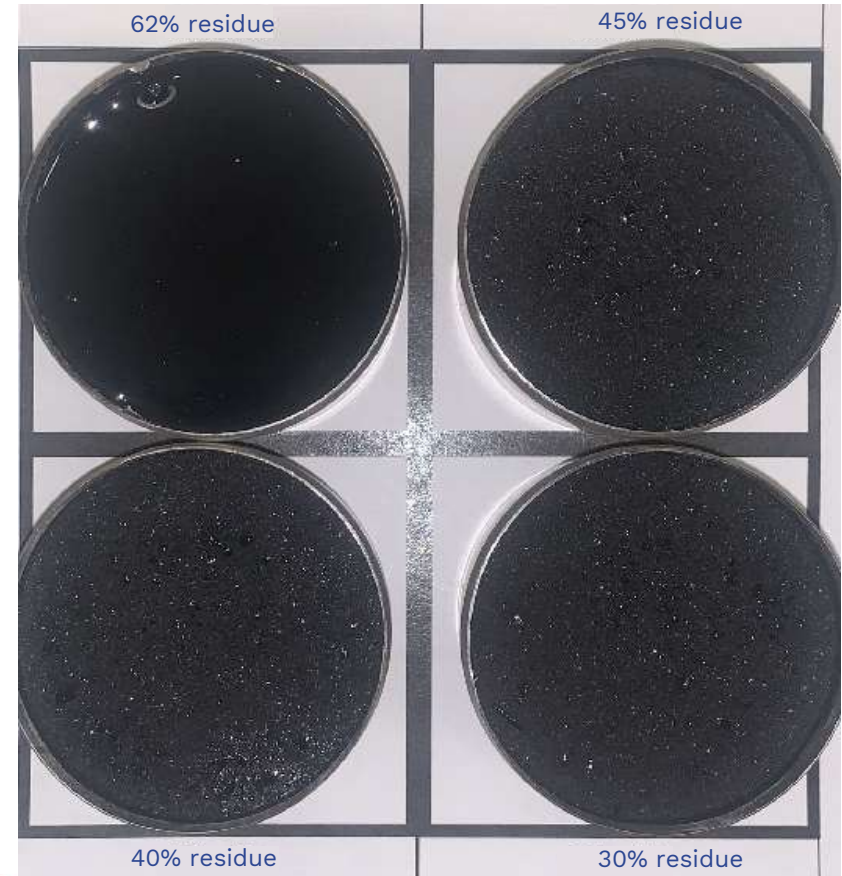
- **Dark black color, not shiny, very tacky**
- **2 mm penetration, 7 hours**

→ 40% Residue

- **Dark black color, not shiny, very tacky**
- **2 mm penetration, 3.2 hours**

→ 30% Residue

- **Dark black color, not shiny, very tacky**
- **4 mm penetration, 2.8 hours**



CATIONIC PRIME COAT EMULSION – 20% SOLVENT

→ 62% Residue

- **Dark black color, slightly shiny, slightly tacky**
- **4 mm penetration, 8+ hours**

→ 45% Residue

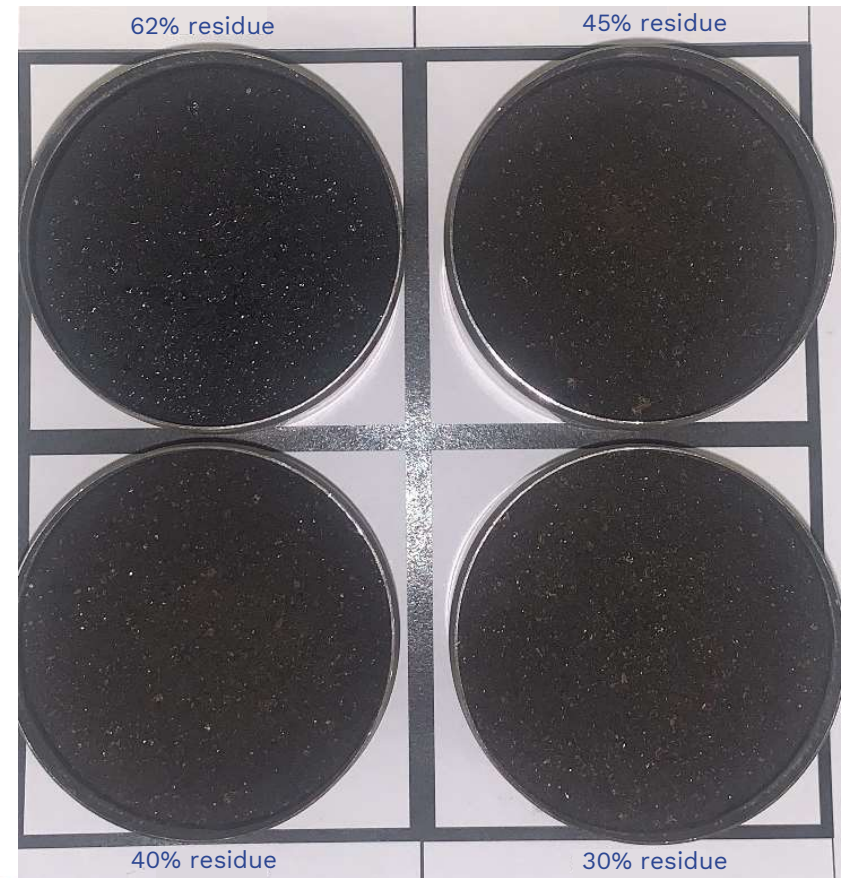
- **Dark brown color, not shiny, very slightly tacky**
- **4 mm penetration, 8 hours**

→ 40% Residue

- **Dark brown color, not shiny, very slightly tacky**
- **5 mm penetration, 8 hours**

→ 30% Residue

- **Dark brown color, not shiny, not tacky**
- **6 mm penetration, 1 hour**





THE FUTURE OF ASPHALT PRIME COATS

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NEXT-GENERATION CATIONIC TECHNOLOGY – SOLVENT-FREE APPLICATION



- Solventless formula
- PG 64-22 asphalt, ~60 pen
- 40% residue emulsion
- 1 L/m² application rate
- 14 seconds penetration time



NEXT-GENERATION CATIONIC TECHNOLOGY – EASIER & FASTER APPLICATION



→ Typically adsorbs in seconds

- **Minimal traffic delay**
- **Minimum user risk**

→ Surface Tack

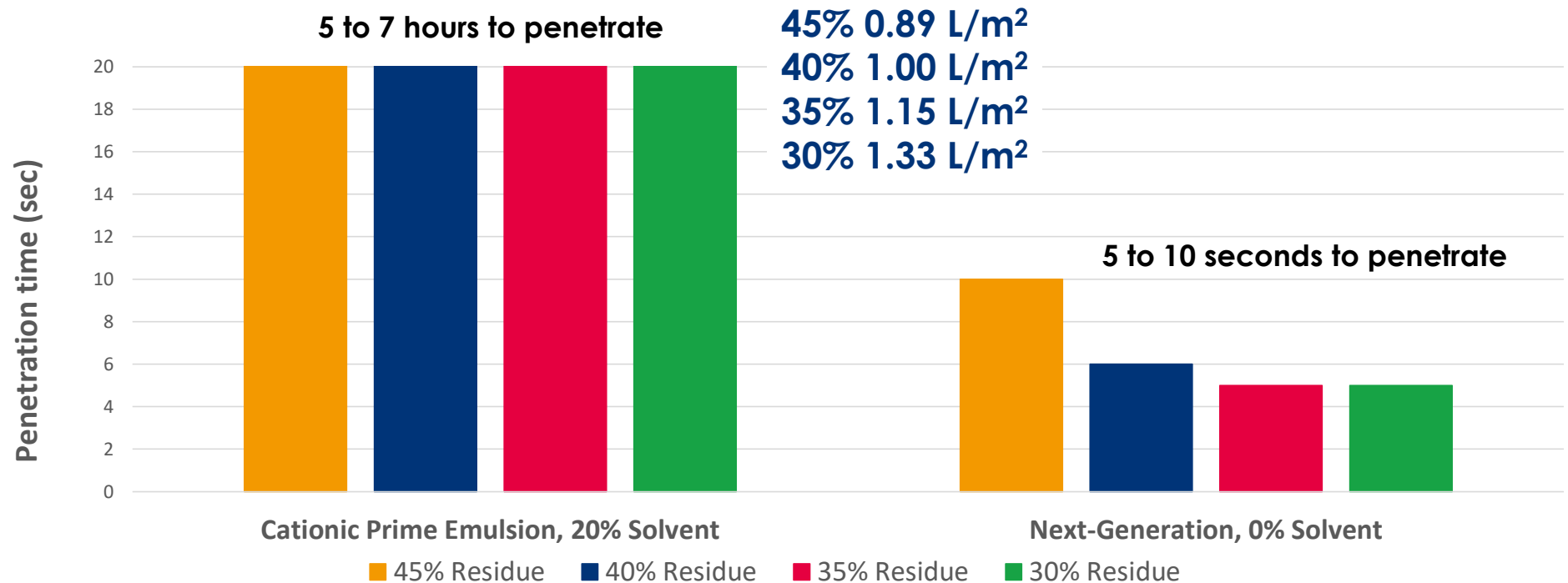
- **Minimal**
- **Little chance for tire pickup**

→ Toughening

- **Surface hardens as soon as water dries because we are not softening our binder with solvent**
- **Potential to pave in as little as 1 hour**



Equal asphalt content – Penetration Time

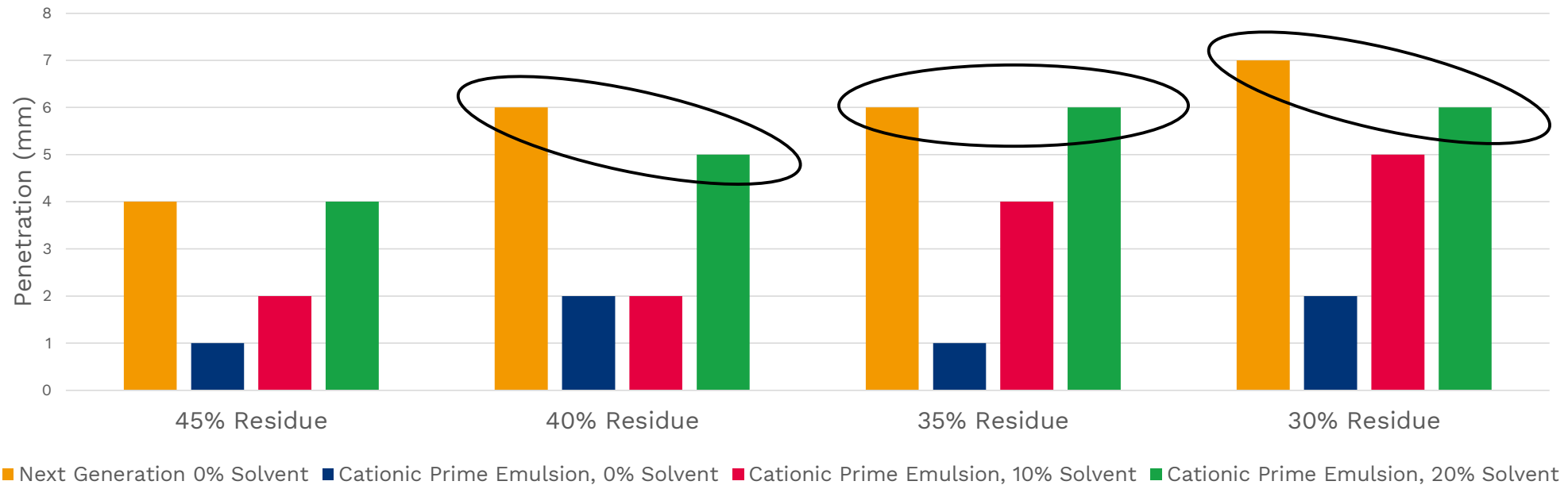


❖ THE EMULSION PENETRATES IN SECONDS NOT HOURS

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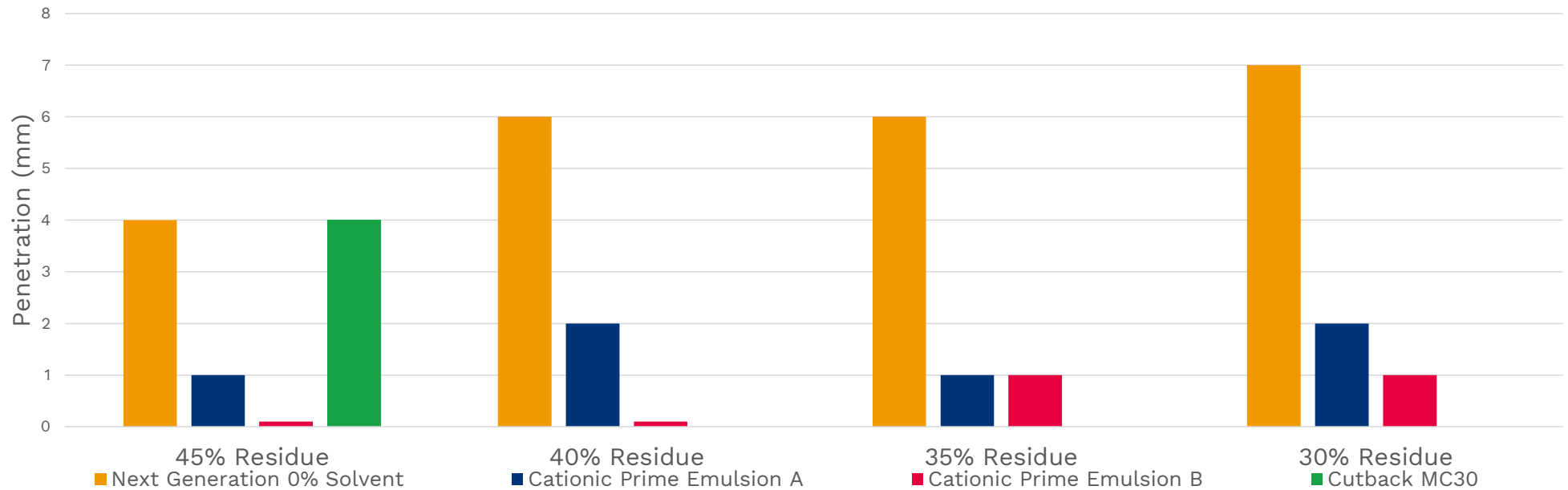
NEXT-GENERATION cationic prime COAT emulsion PERFORMANCE



✦ NEXT-GENERATION SOLVENTLESS FORMULA MEETS OR EXCEEDS 20% SOLVENT SYSTEMS

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NEXT-GENERATION cationic prime COAT emulsion vs. standard prime penetration



✦ NEXT-GENERATION SOLVENTLESS FORMULA EXCEEDS TYPICAL SOLVENT PRIME EMULSION

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SUMMARY

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WHAT WE KNOW

- Average soil capillary radius is 6.8 μm
 - **Smaller asphalt emulsion particle size is better**
 - **Deformable asphalt is helpful**
- Keep emulsion viscosity low
 - **Viscosity opposes capillary pressure**
- Maintain sufficient aqueous phase volume
 - **When the aqueous phase expands, asphalt particle penetration stops**
- Emulsifier is a critical component
 - **Provides sufficient chemical to afford wetting – aggregate dependent**
 - **Low surface tension is preferable**



THE FUTURE OF PRIME COATS – OUR NEXT-GENERATION SOLUTION

→ Potential to eliminate volatile organic compounds (VOCs)

- **Environmentally friendly with improved worker safety and comfort**

→ Fast-penetrating prime coat emulsion

→ No need to apply sand

→ Potential to pave the same day

- **No waiting for days for a complete cure**

→ Faster return to traffic

- **A few minutes vs. a few days if choosing to pave later**

→ Lower risk of vehicle damage



ARKEMA-ROAD SCIENCE'S NEXT-GENERATION PRIME COAT EMULSIFIER

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