

Performance Assessment of Corrosion Prevention Compounds Using Laboratory Tests

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History of CPC

- Started as *temporary, cheap* field protection measure
- Escalation of performance requirements
- Inhibition capabilities vs those of primer
 - Leachability, solubility, potency
- Critical, shorter term reapplication needs

Objectives

- Develop test suite to assess CPC characteristics
 - Protective film formation/retention
 - Active Inhibition
 - Water Displacement/Wicking Ability
- Compare characteristics to performance
 - Boldly exposed vs. Occluded geometry (lap joint)
 - Constant Immersion vs. Wet/Dry

Experimental Methods

- Protective film formation/retention
 - Electrochemical Impedance in LJSS
- Water Displacement/Wicking Ability
 - Surface thermodynamic properties
 - Wicking rates into simulated lap joints
- Visual Assessment

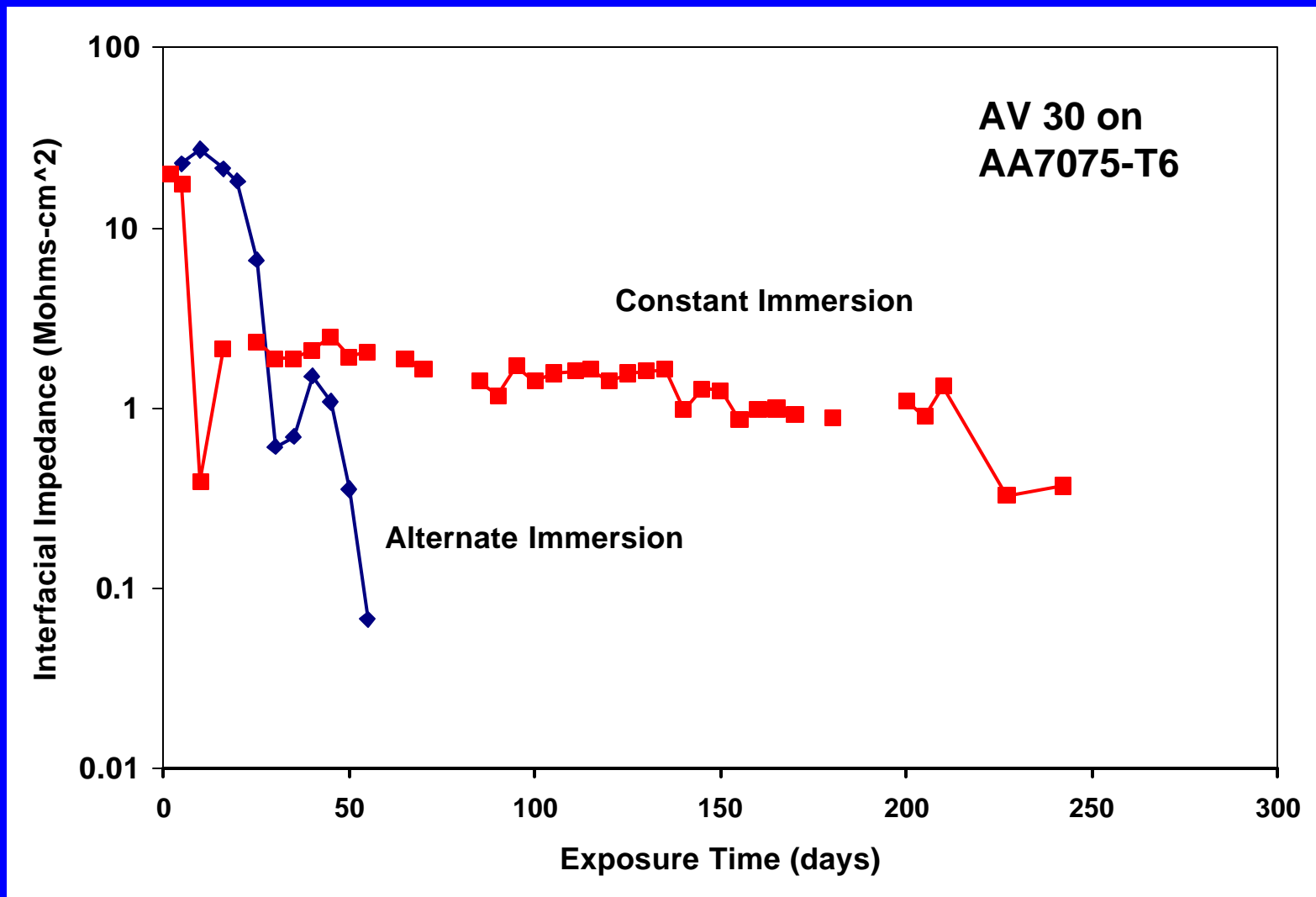
* *LJSS = 20 mM Cl⁻, 4 mM NO₂⁻, 4 mM HCO₃⁻, 2 mM F⁻, pH_i 9*

CPC Tested

CPC	Specifications	Color of liquid	Description	Film Type
Amlguard	Mil-C-85054	Dark Blue/Green	general purpose, heavy duty, durable, hard film forming CPC	WDHF (hard, dry film)
LPS 3	BMS 3-23 BMS 3-29	Dark yellow	Self-healing, anti-sling lubricant; High VOC	WDSF (waxy, very thin film)
Dinitrol® AV8	BMS 3-23 BMS 3-29	Dark Brown	high penetration, corrosion inhibiting	WDSF (non-tacky flim)
Dinitrol® AV30	none	Light Brown	Penetrating, corrosion inhibiting	WDSF (waxy)

Protective Film Formation

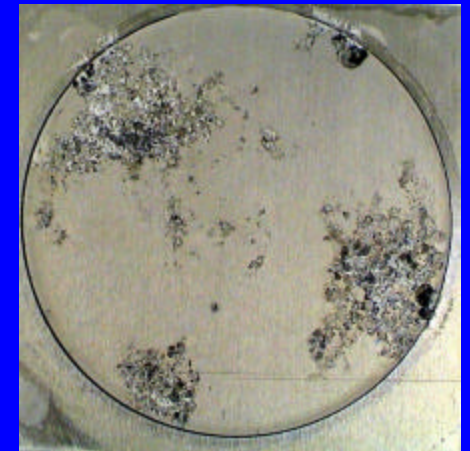
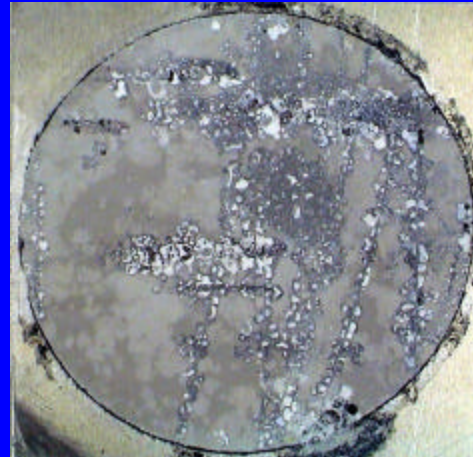
Constant vs. Alternate Immersion



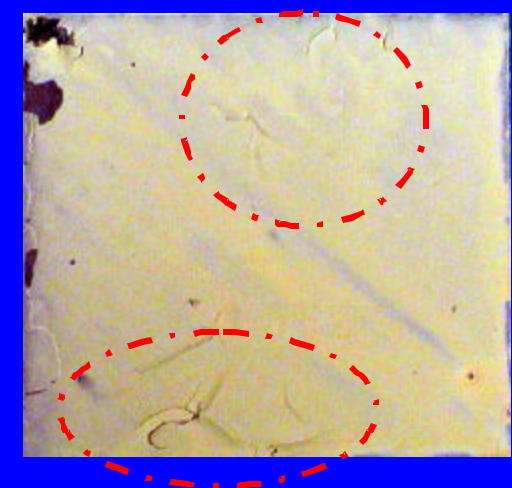
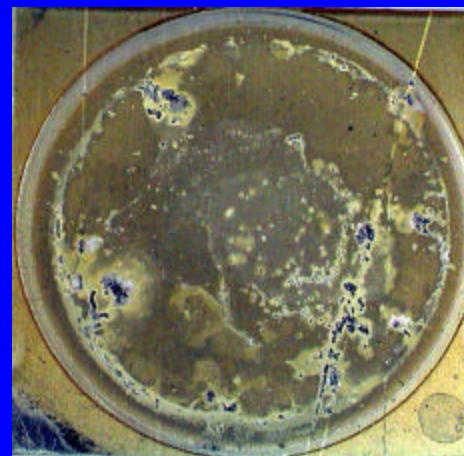
Visual Assessment

Main Failure Modes

Breaching of Film

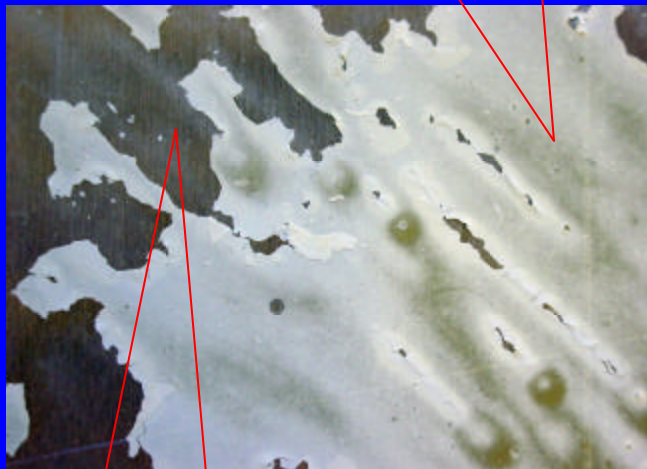


Blistering of Film

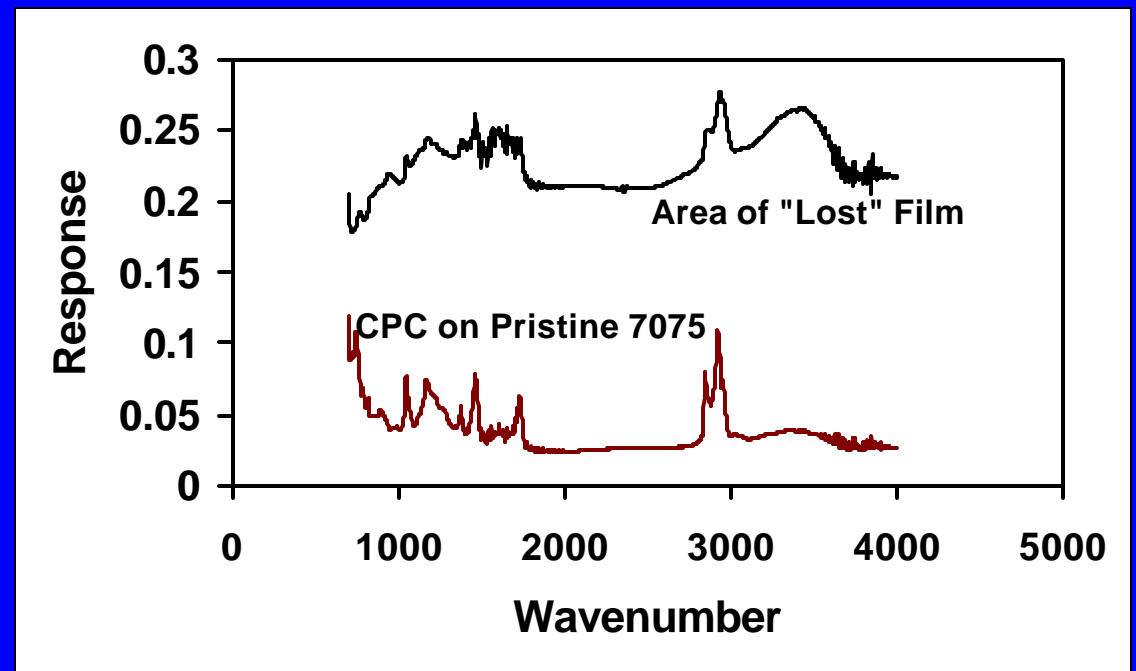


Bulk Film Loss Sometimes Observed

Intact CPC Film(AV30)



Area of Film Loss



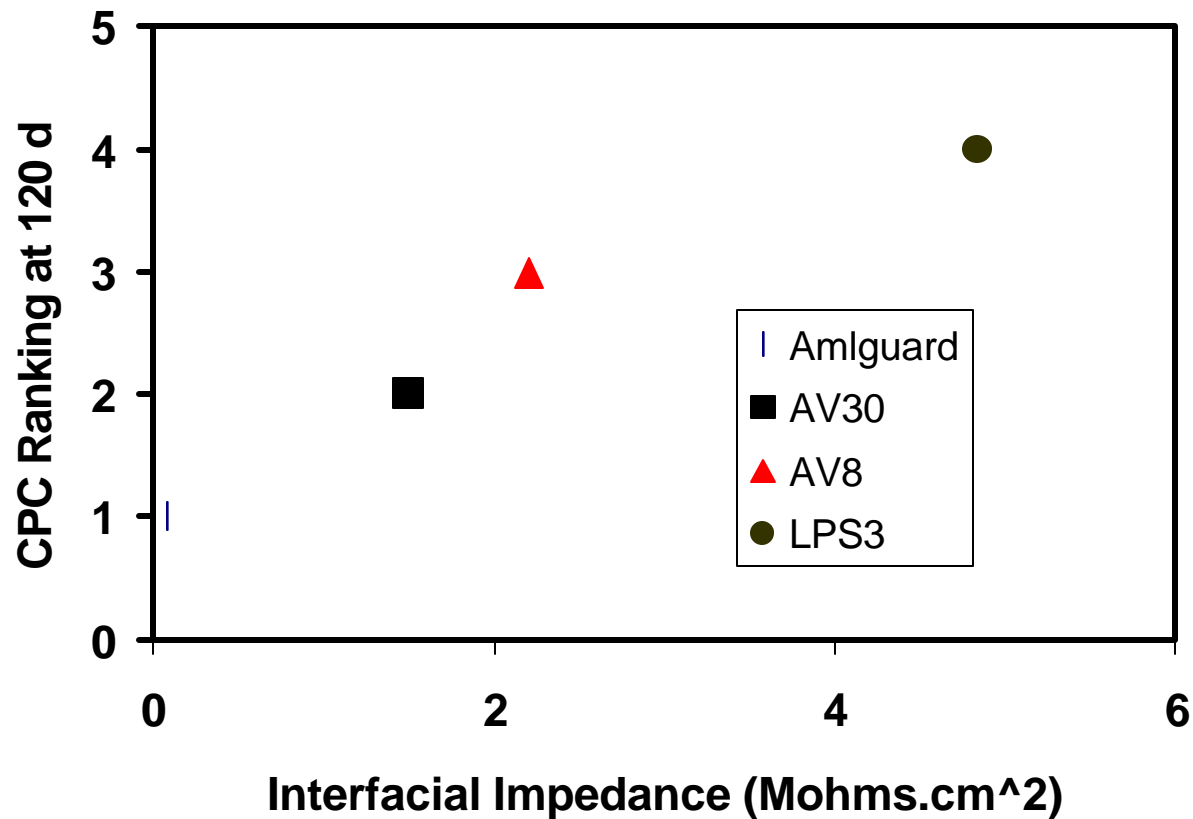
Remnant Protective Film After Bulk Film Loss

CPC Performance Ranking (AI Exposure to LJSS)

	Amlguard	AV30	AV8	LPS3
Time-to-Failure (days)	55	55	120	85*
% area corroded	25	3	5	0*
No. failed/Total Exposed	3/3	3/3	0/3	0/3
Ordinal Ranking	1	2	3	4 (best)

Prediction of 120 d Possible After 40 d Exposure

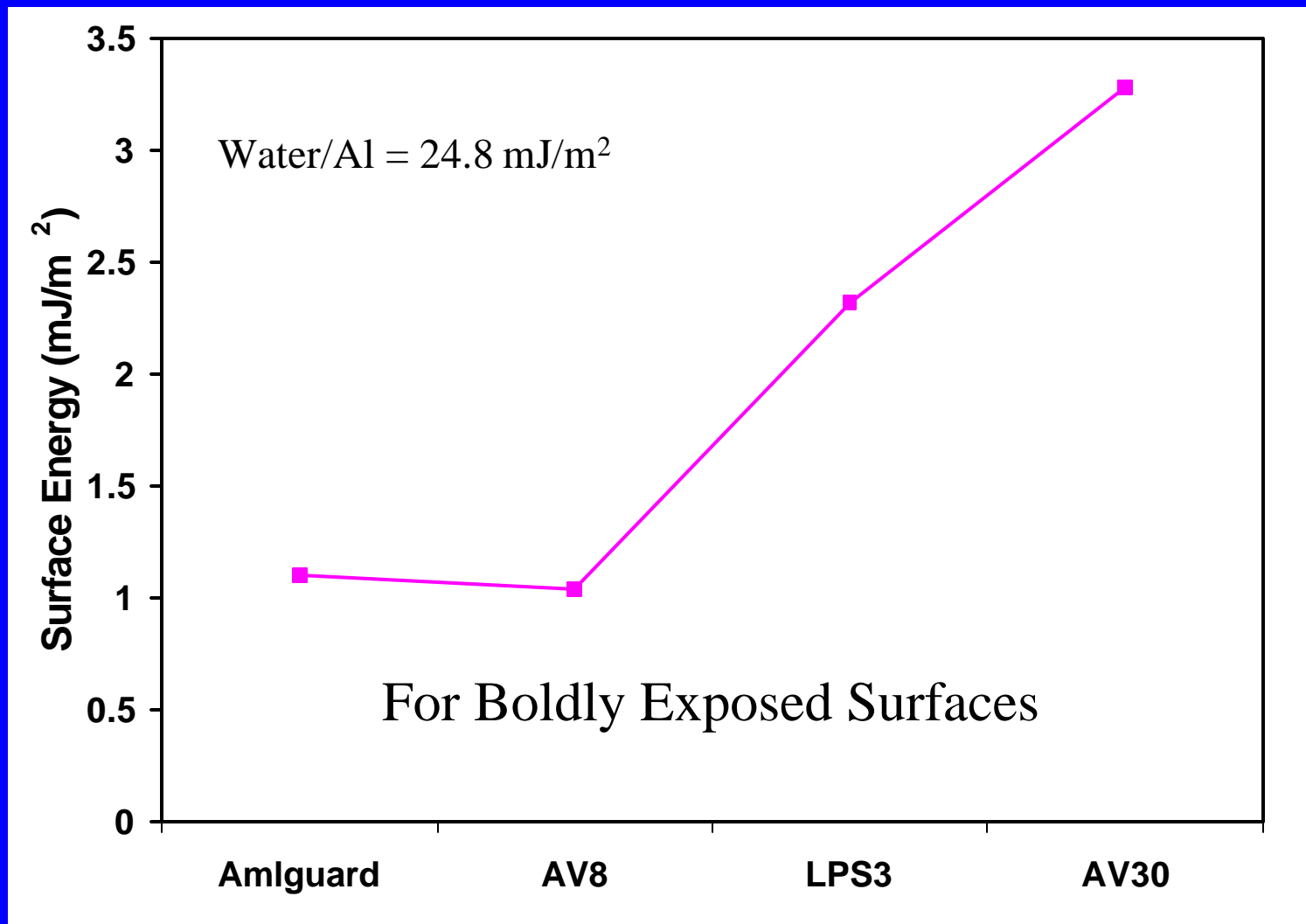
CPC Ranking vs. Interfacial Impedance (40 Days)



Lap Joint Studies

- Surface thermodynamics
- Wicking into lap joints
 - Joint initially dry
 - Joint initially wet

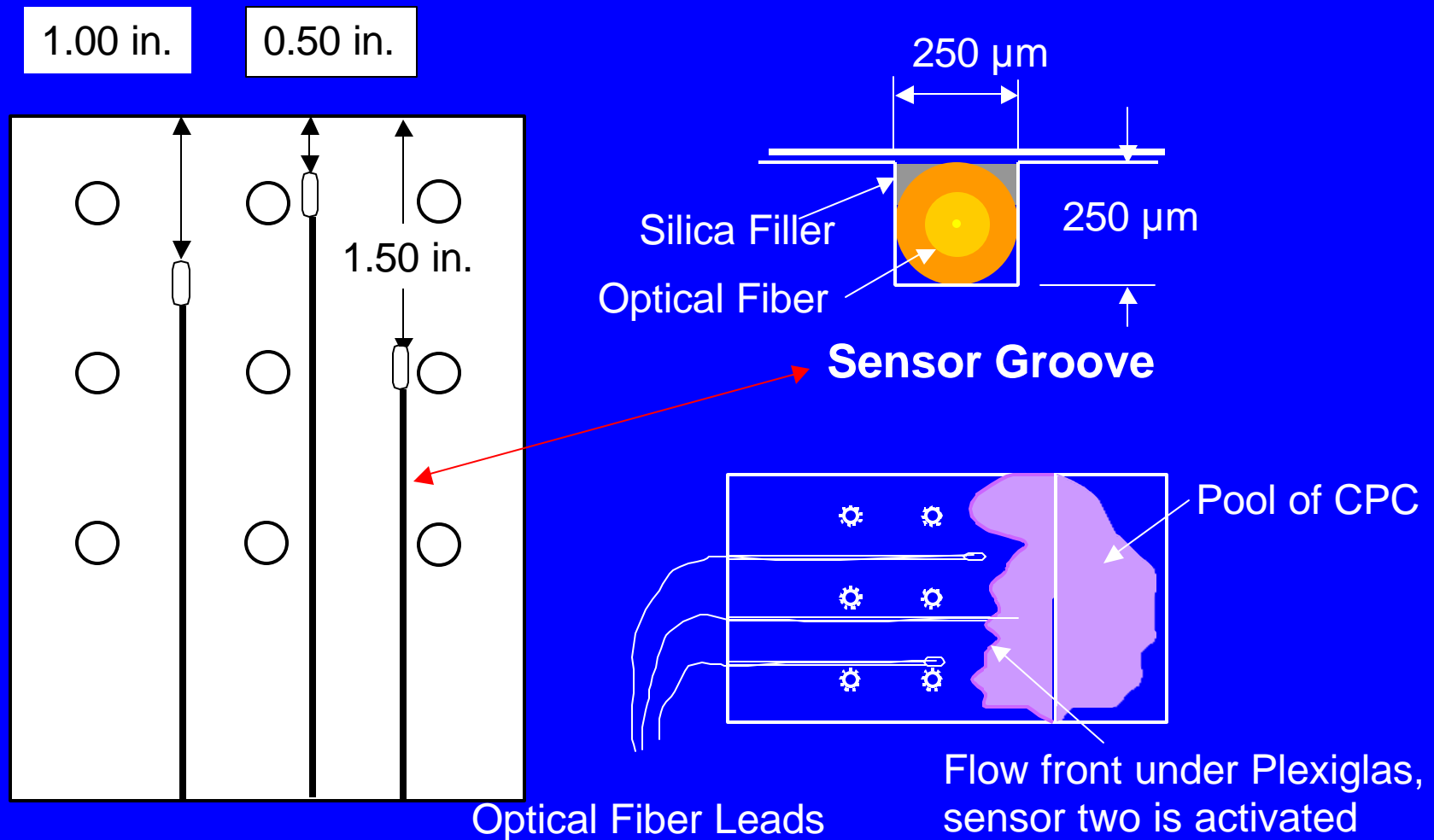
Surface Energies of Interfaces Shows Water Displacement Favorable for All CPC Studied



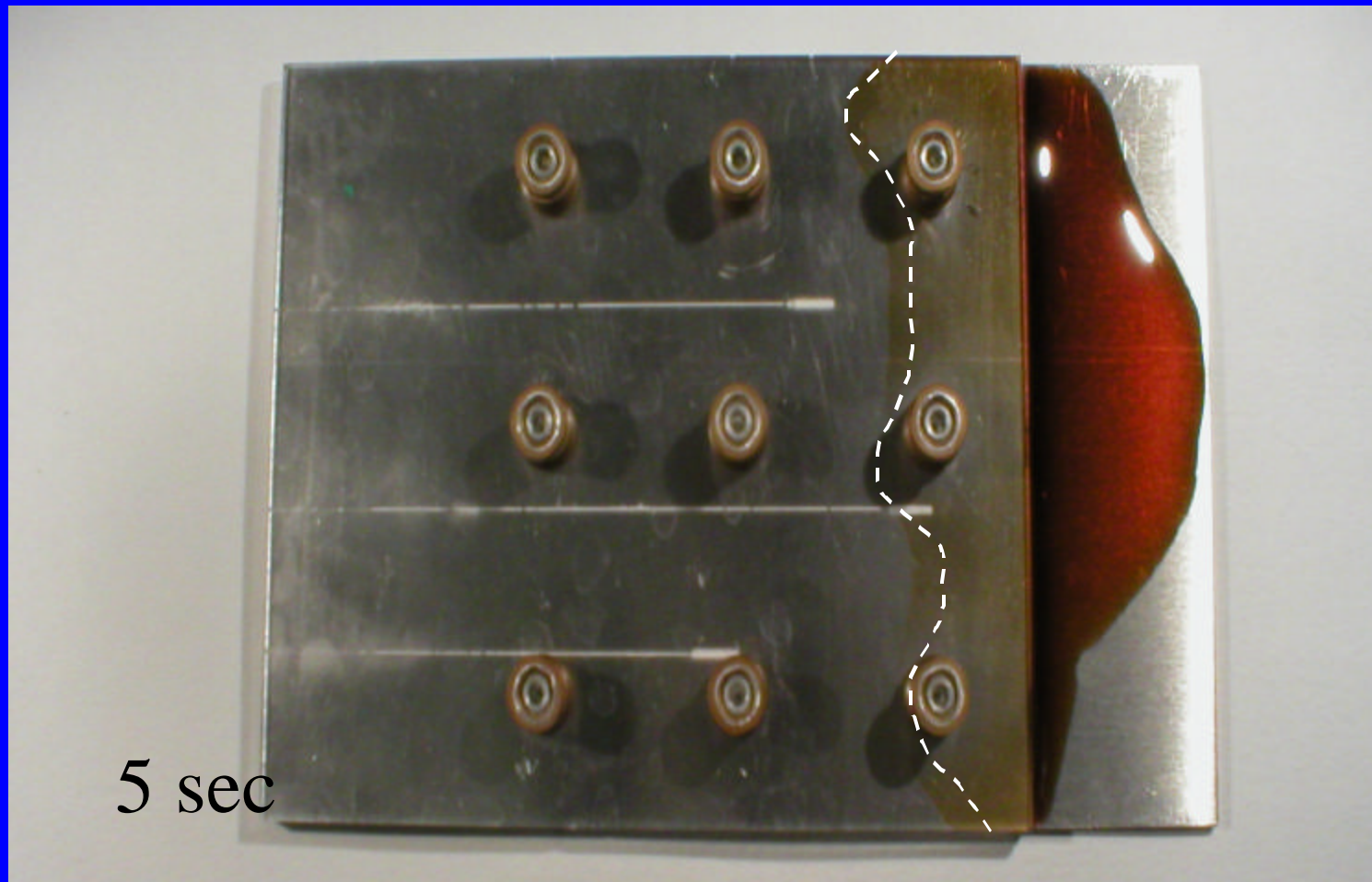
Wicking Rates

- Joint Initially Dry
 - CPC to be drawn in by capillary action
- Joint Initially Wet
 - Capillary action offset by need to displace water

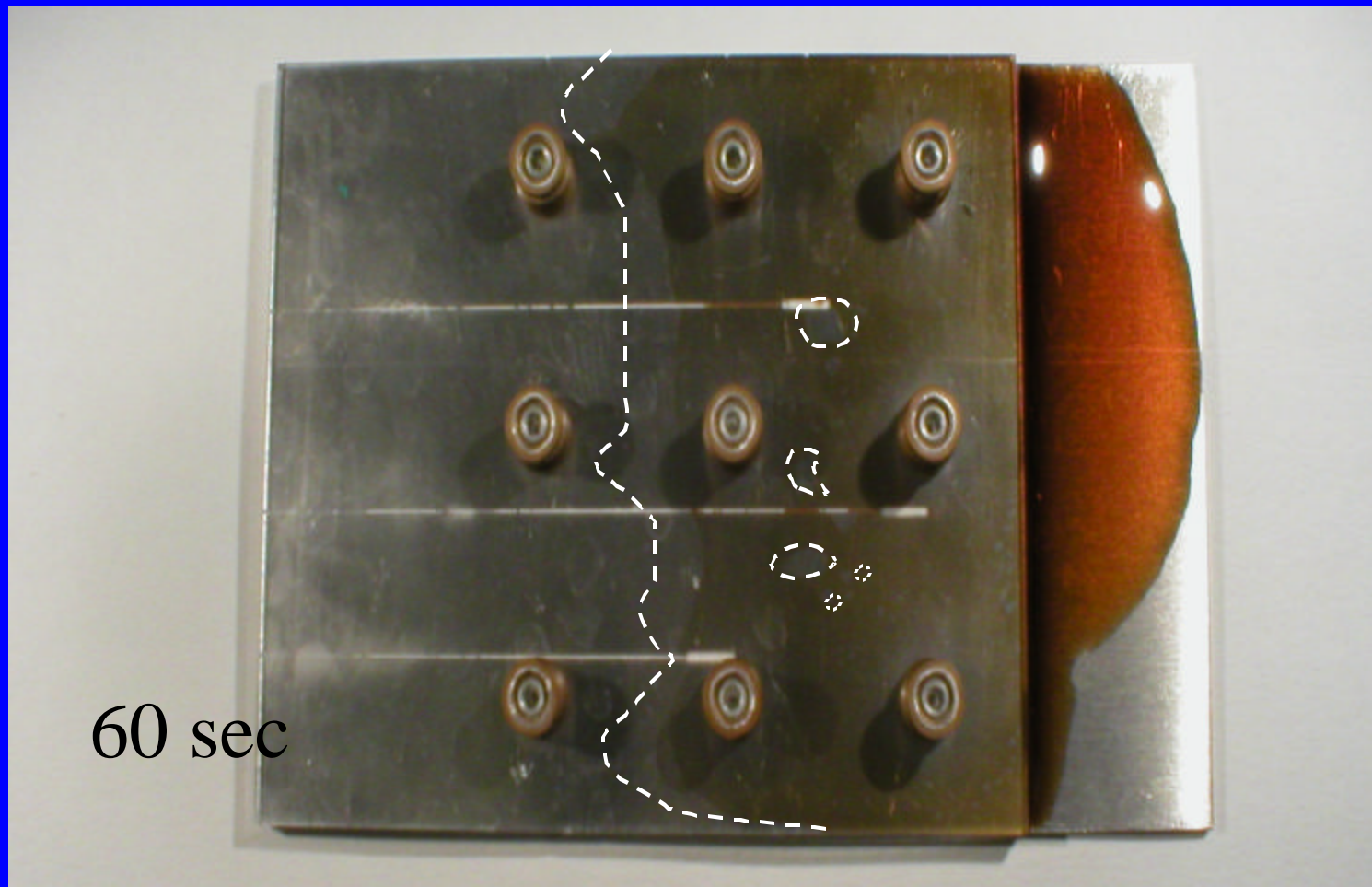
CPC Introduction into Joint



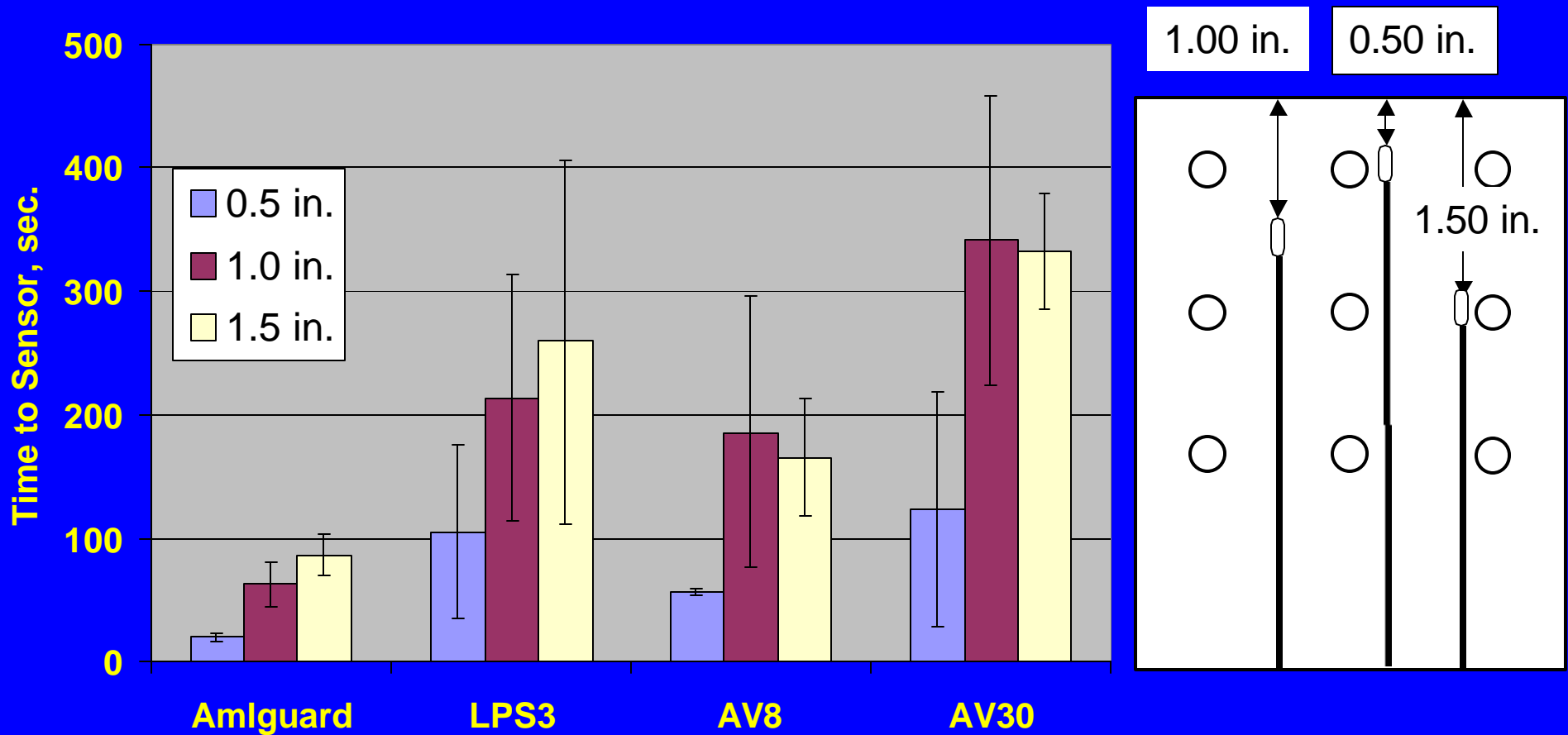
Wicking into Dry Joints is Fast



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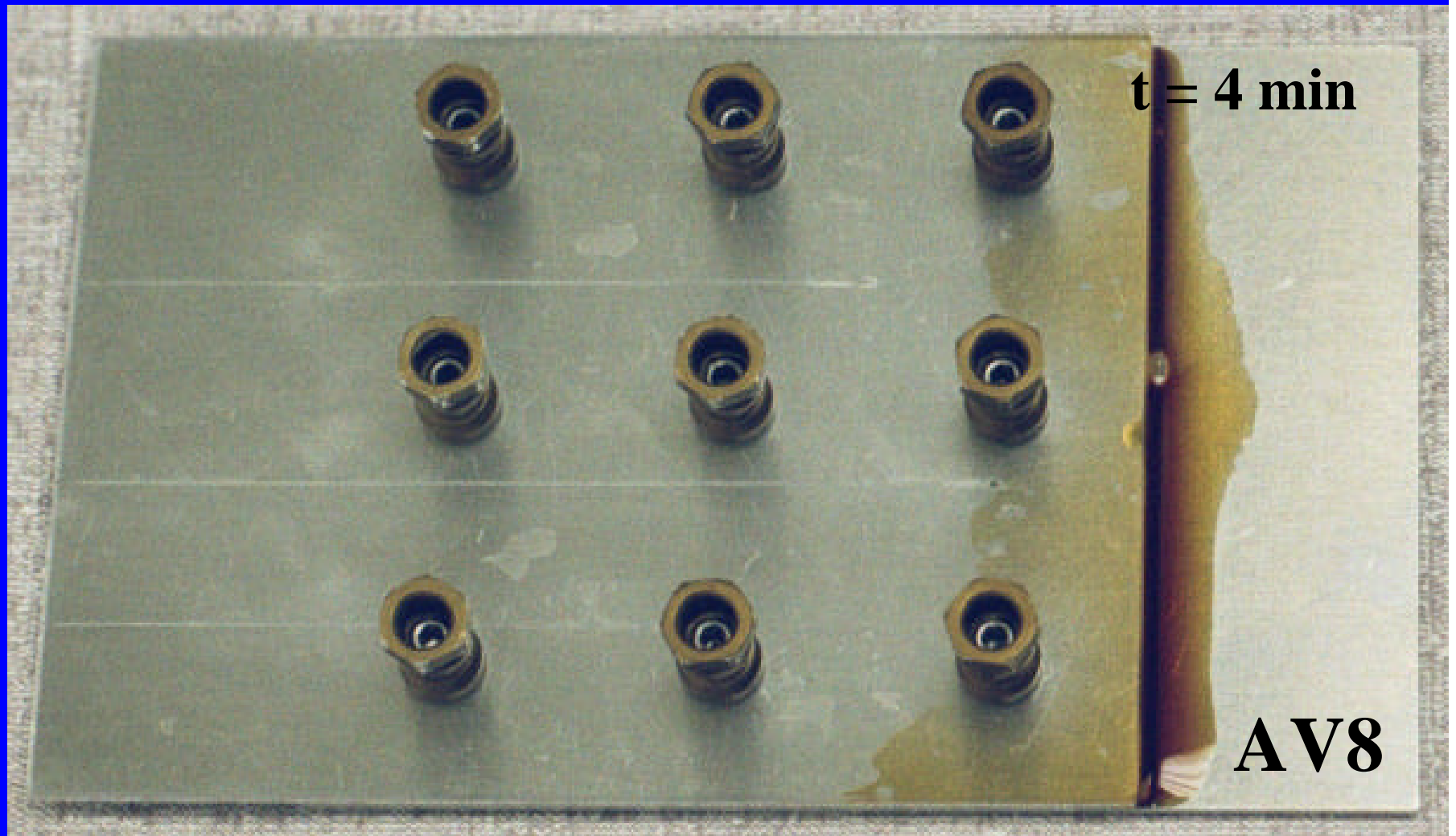
Wicking Into a Dry Joint



Wicking Capability: Amlguard > AV8 & LPS3 > AV30

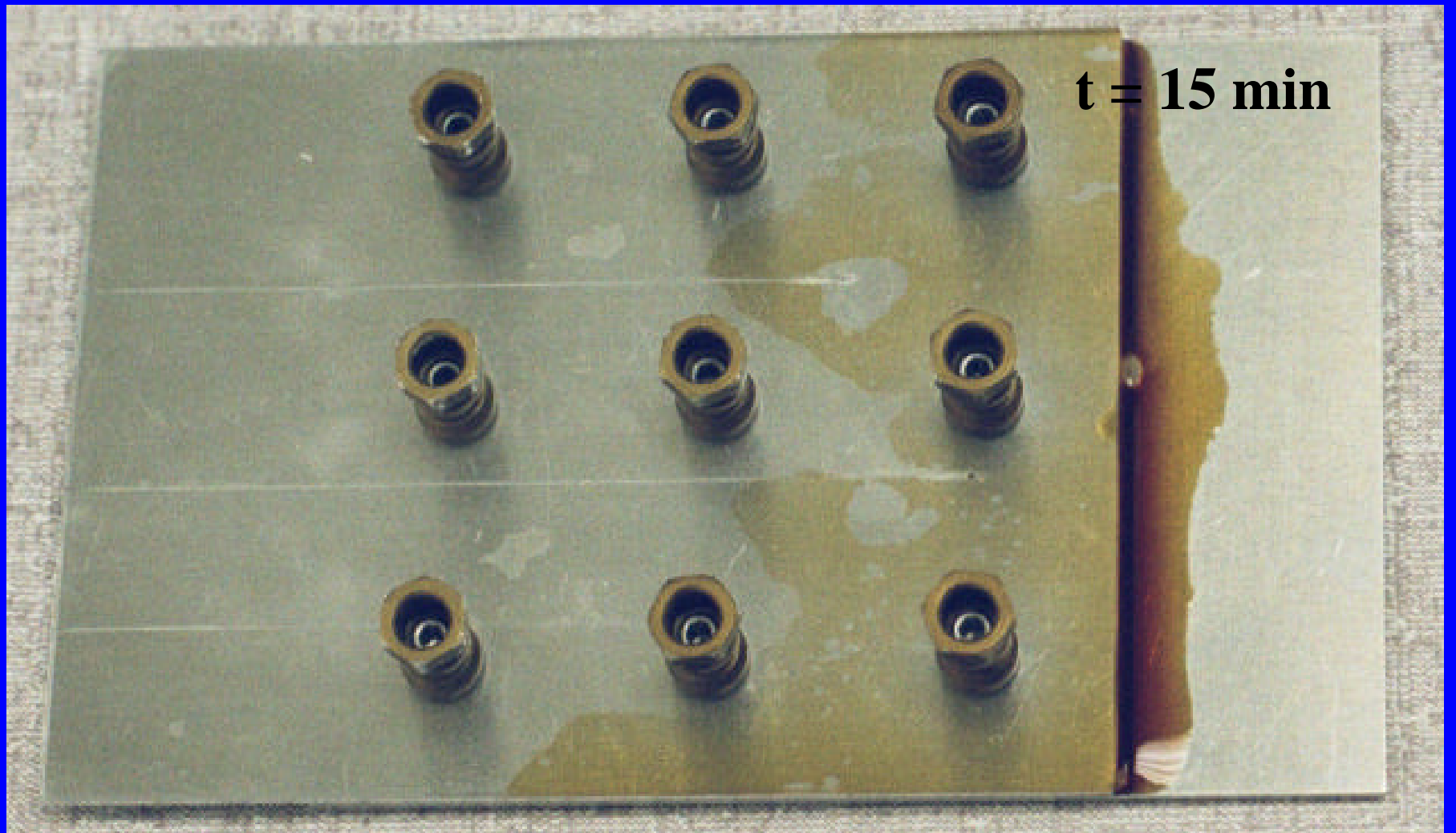
CPC Wicking into Wet Joint

Slow, Non-uniform



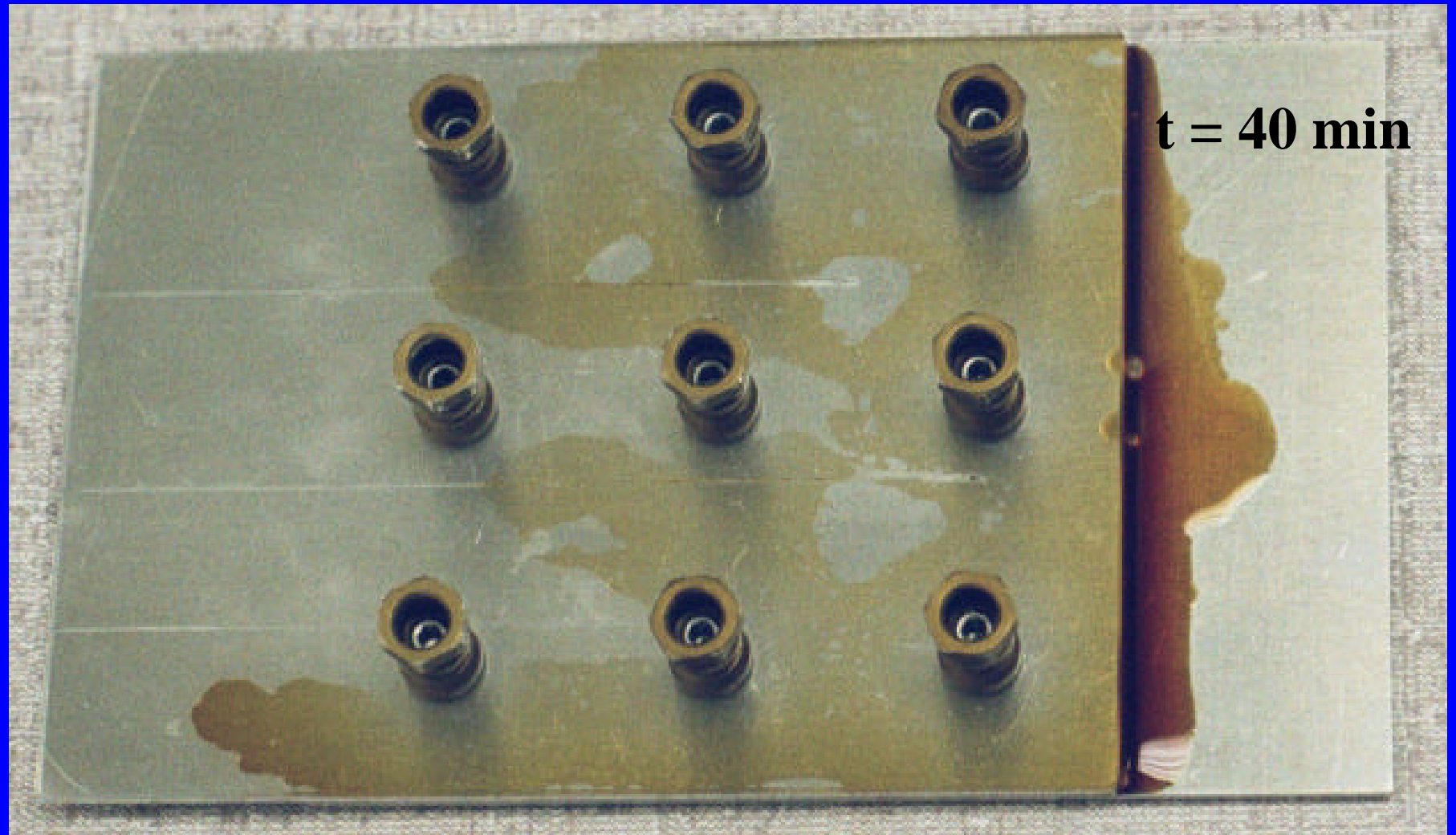
CPC Wicking into Wet Joint

Slow, Non-uniform



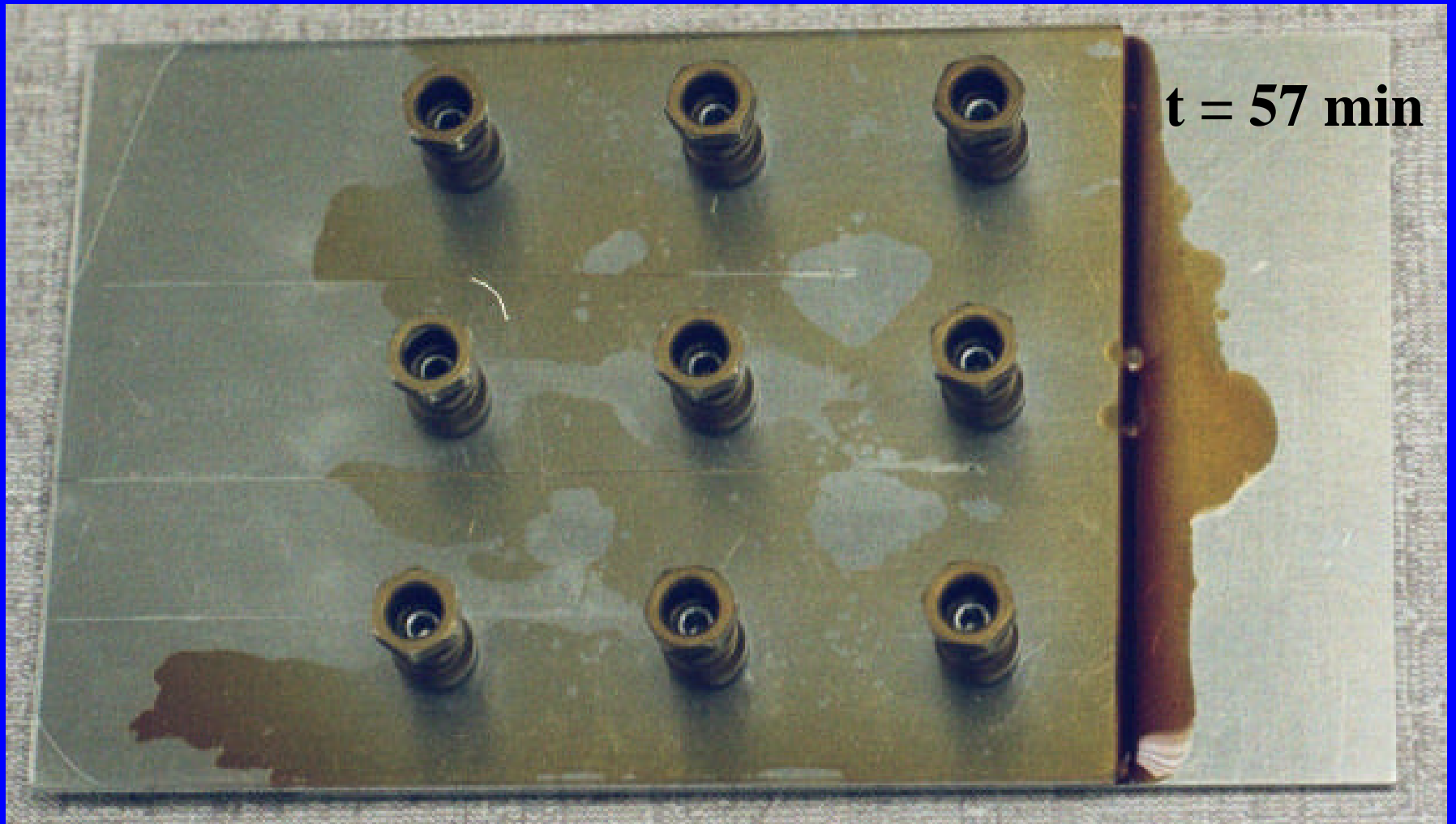
CPC Wicking into Wet Joint

Slow, Non-uniform

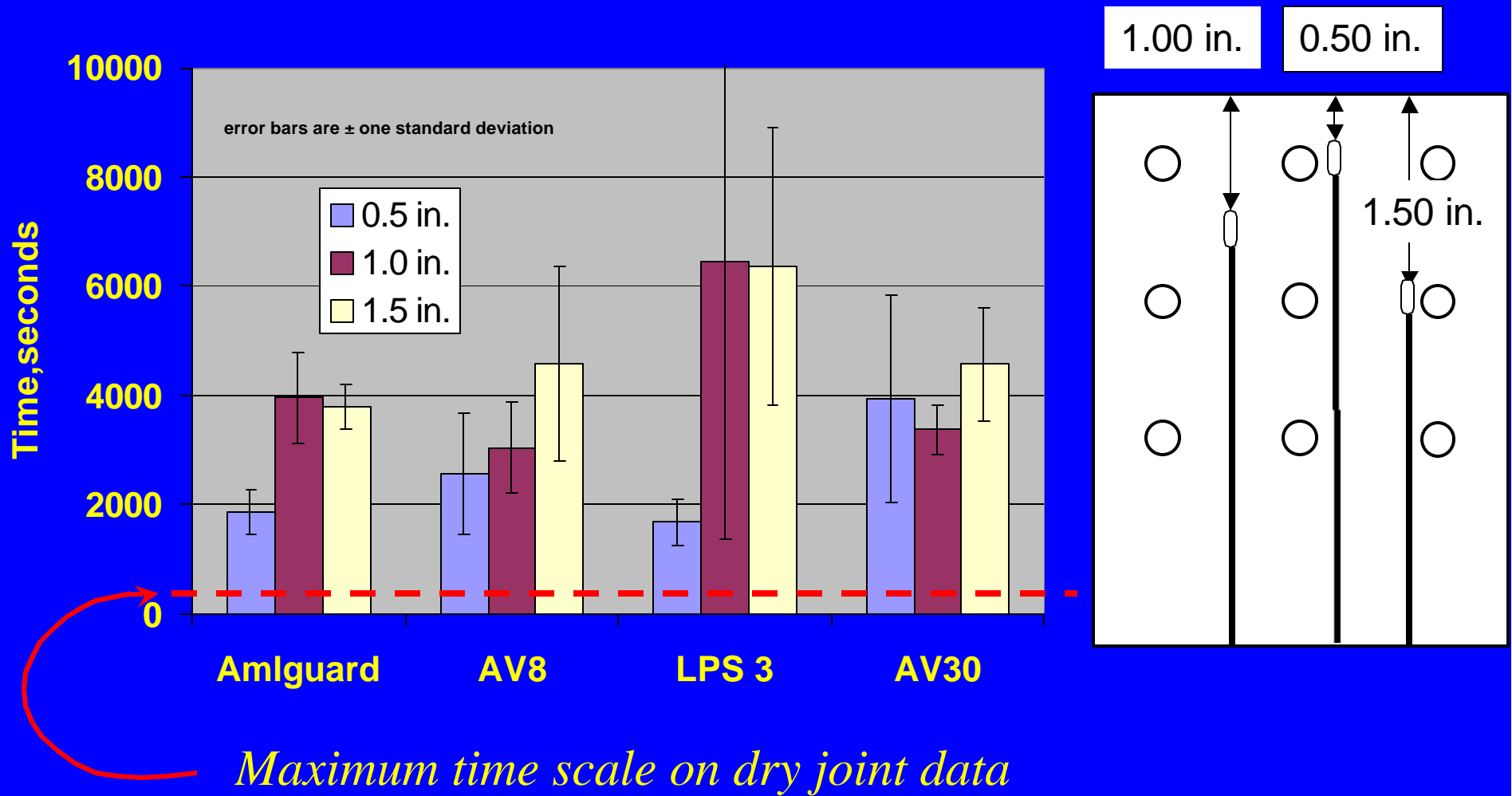


CPC Wicking into Wet Joint

Slow, Non-uniform



Wicking Into a Wet Joint is Slow



Conclusions I

Test Method Development

- AI in LJSS provides more rapid degradation than CI in LJSS
- Interfacial impedance can be used to assess CPC performance
- Interfacial impedance has more limited ability to predict CPC performance
 - Can correlate impedance to ordinal ranking

Conclusions II

Water Displacement/Wicking

- Water displacement from boldly exposed surfaces by CPC is predicted by surface thermodynamics measurements
- Complication of capillary forces make lap joint wicking predictions more difficult
 - But rates of wicking can be measured

Conclusions III

CPC Wicking Rates into Lap Joints

- CPC ingress in dry joints very fast
 - 6 to 60 mm/min
- CPC ingress in wet joints is much slower
 - 1 to 5 mm/min
- Ingress is highly variable both spatially & temporally