



Salt Contamination Testing: Integrated Extract & Analyze Strip

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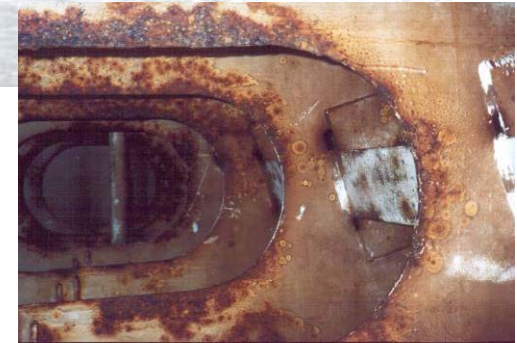
Tank Coatings Service Life

- Navy corrosion control costs \$2.4B/yr
- Represervation of tanks #1 maintenance cost



- Potential 20 year tank coatings
- High solids epoxies
- Rigorous QA/QC

- Paint over salt contaminated steel
- Premature coating failure
 - Osmotic blistering
 - Rust under coating



NAVSEA Standard Item 009-32: “Cleaning and Painting Requirements”

	Chlorides	Conductivity
Immersed applications	3 $\mu\text{g}/\text{cm}^2$ (30 mg/m^2)	30 $\mu\text{S}/\text{cm}$
Non-immersed applications	5 $\mu\text{g}/\text{cm}^2$ (50 mg/m^2)	70 $\mu\text{S}/\text{cm}$

- 3.10.7. Conductivity or Chloride Measurement
- Critical coated surfaces
- Test freshly prepared surface
- Use Bresle Method (or approved equivalent)
- 5 readings per 1000 sq.ft.

Overview

- Bresle Method review
- Other field analytical technology
- A new approach

The Bresle Method Standards

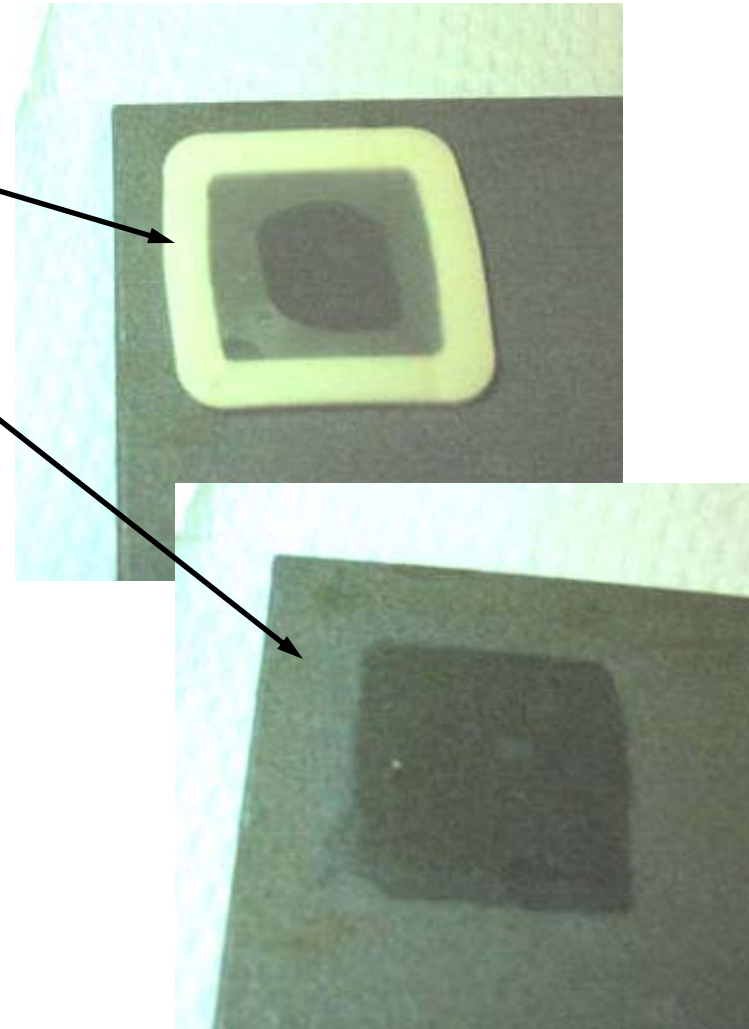
- ISO 8502-6: Extraction of soluble contaminants for analysis — The Bresle method
- ISO 8502-9: Field method for the conductometric determination of water-soluble salts
- SSPC TG-15: Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates

The Bresle Method (ISO 8502-9)

Analytical Goal	Test Method
Extract salt from substrate area (A) ...	Affix patch to substrate (area A)
... into water volume (V)	<ul style="list-style-type: none">• Inject water (Total Volume V)• Mix• Extract water• Repeat (Optional)
Measure salt in water volume (V)	Conductivity Meter
Compute salt in area (A) (Optional in 009-32)	$\rho_A = c \times \frac{V}{A} \times \gamma$

Bresle Method Analytical Problems

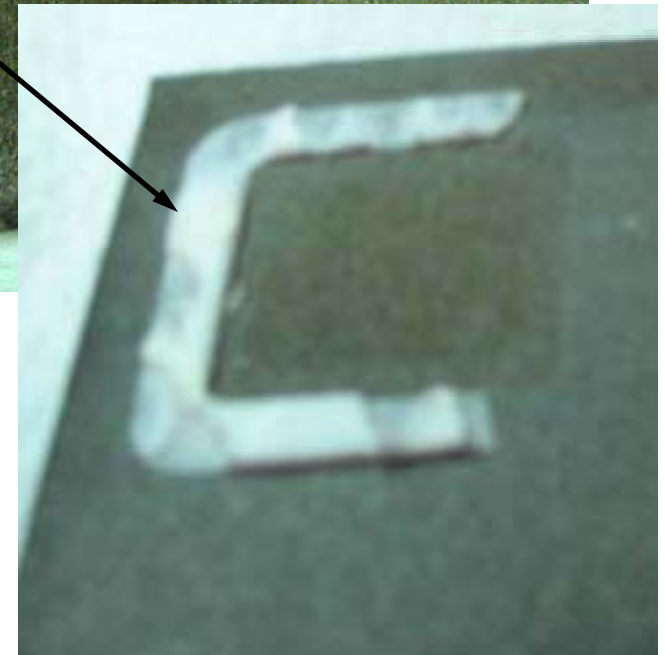
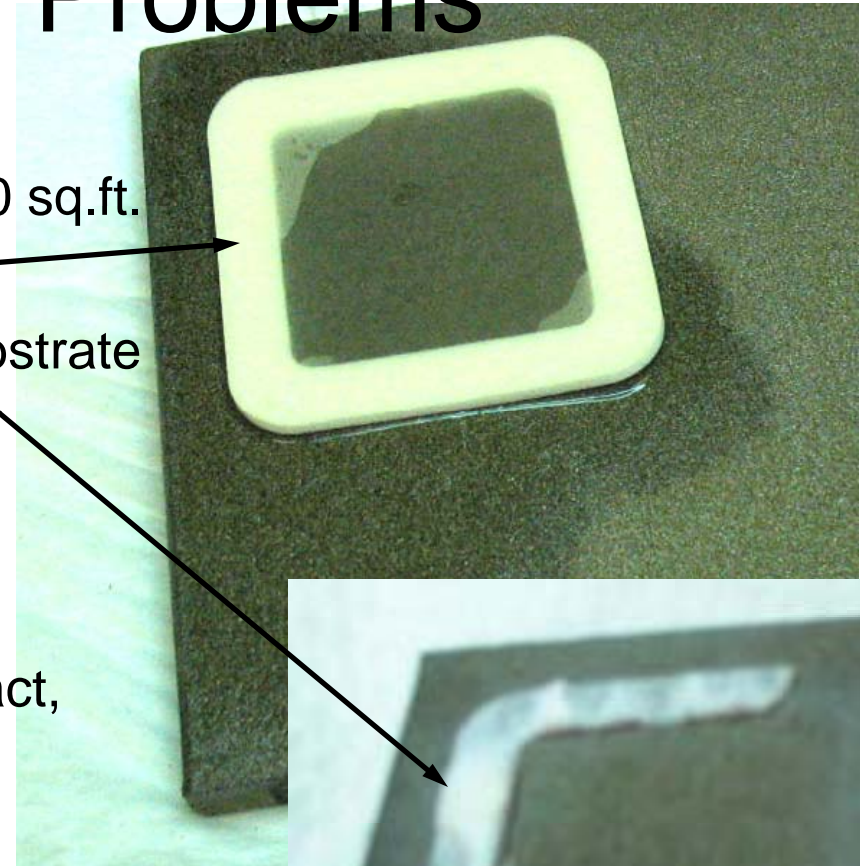
- Area reproducibility
 - Flexible foam seal: -10% to +20% of standard
 - Capillary flow under seal: seal area = cell area
- Extraction dynamics
 - No standard water volume, mixing protocol, extraction time
- Cross-contamination
 - Syringe
 - Conductivity meter
- Detection limit



Bresle Method

Field Utility Problems

- Cycle time
 - 10 min / patch = 50 min / 1000 sq.ft.
 - Longer if patches leak
 - Longer if foam seal left on substrate
- Safety
 - Syringe
 - Cumbersome
 - Bottles & cups for water, extract, solvent, waste
 - Solvent for adhesive removal



Wish List for Salt Test

Analytical	<ul style="list-style-type: none">• $\pm 5\%$ at $5.0 \mu\text{g}/\text{cm}^2$• Detection limit below $2.0 \mu\text{g}/\text{cm}^2$• No cross contamination• Insensitive to operator technique• Auditable result
Field Utility	<ul style="list-style-type: none">• Minimize cycle time• Reliable• Conforms to flat or curved surfaces• No residue on substrate• Compact, rugged, safe

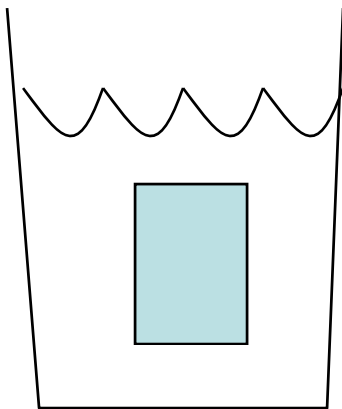
Field conductivity analyzer

- **Glucose Meter**
 - High stakes analysis
 - Low operator training
- **Disposable strip**
 - holds sample
 - integrated sensor electrodes
 - No contamination
- **Compact field reader**

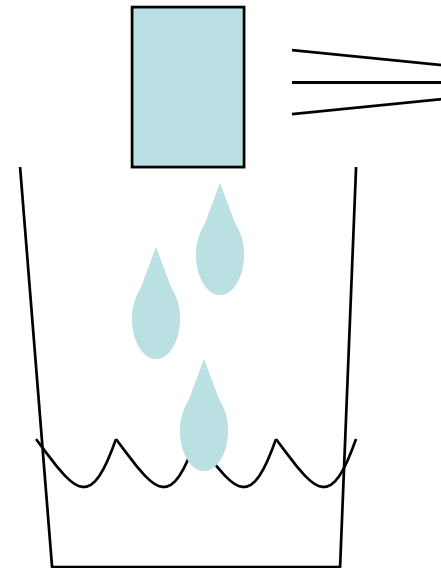


Batch vs. Flow Extraction

- Batch Extraction
- Examples
 - Bath
 - Bresle Patch



- Flow Extraction
- Examples
 - Shower
 - Water jetting



Multi-Stage Bresle Extraction

- Intermediate between Batch and Flow extraction
- ISO 8602-6:2006 Section 5.7
 - 95% in first extraction, remaining 5% with 2nd extraction
- US FHWA study (JCPL, August 2003)
 - 2 X 1.5 mL extractions
- Combine extracts, mix, measure

Number extraction stages	Volume per stage [μL]	Number 60-second stages to 99% extracted	Volume to 99% extracted [μL]
1	3000	--	--
2	1500	2	3000
10	300	4	1200
20	150	4	600

Multi-Stage Bresle Method Extraction Simulation

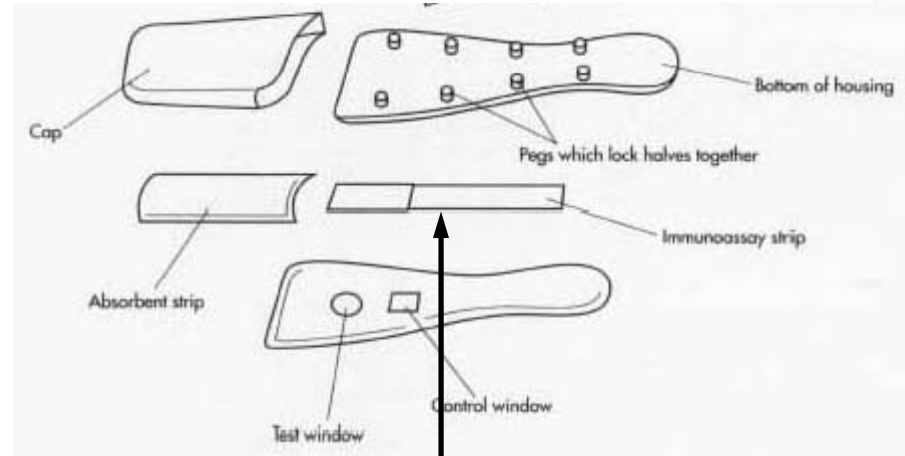
Precision fluid management

- Pregnancy Test Strip

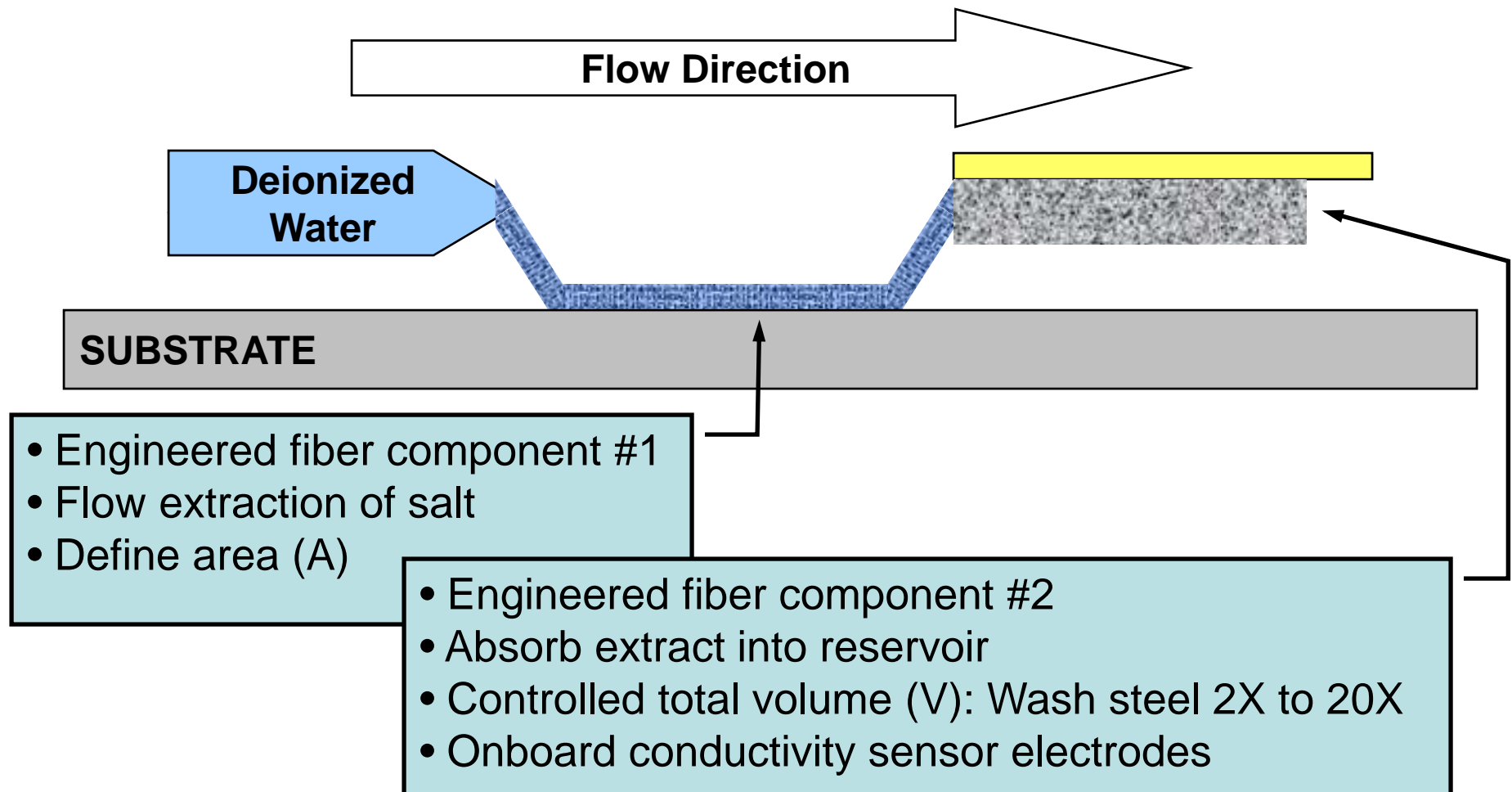
- Robust
- Reliable

- Engineered fiber membranes

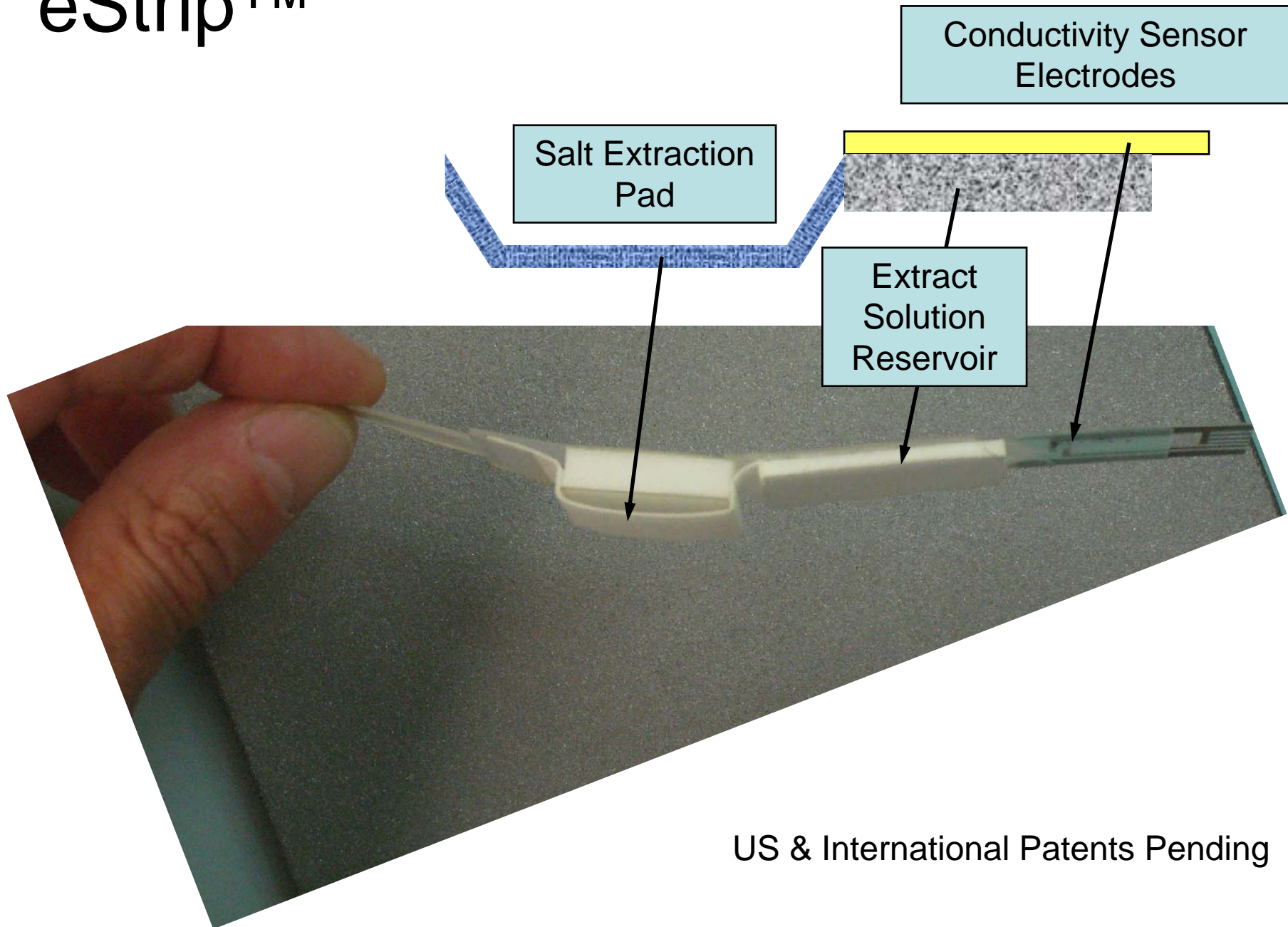
- Fluid contained
- Flow metered
- Volume controlled



Synthesis: Flow Extraction, Integrated Sensor

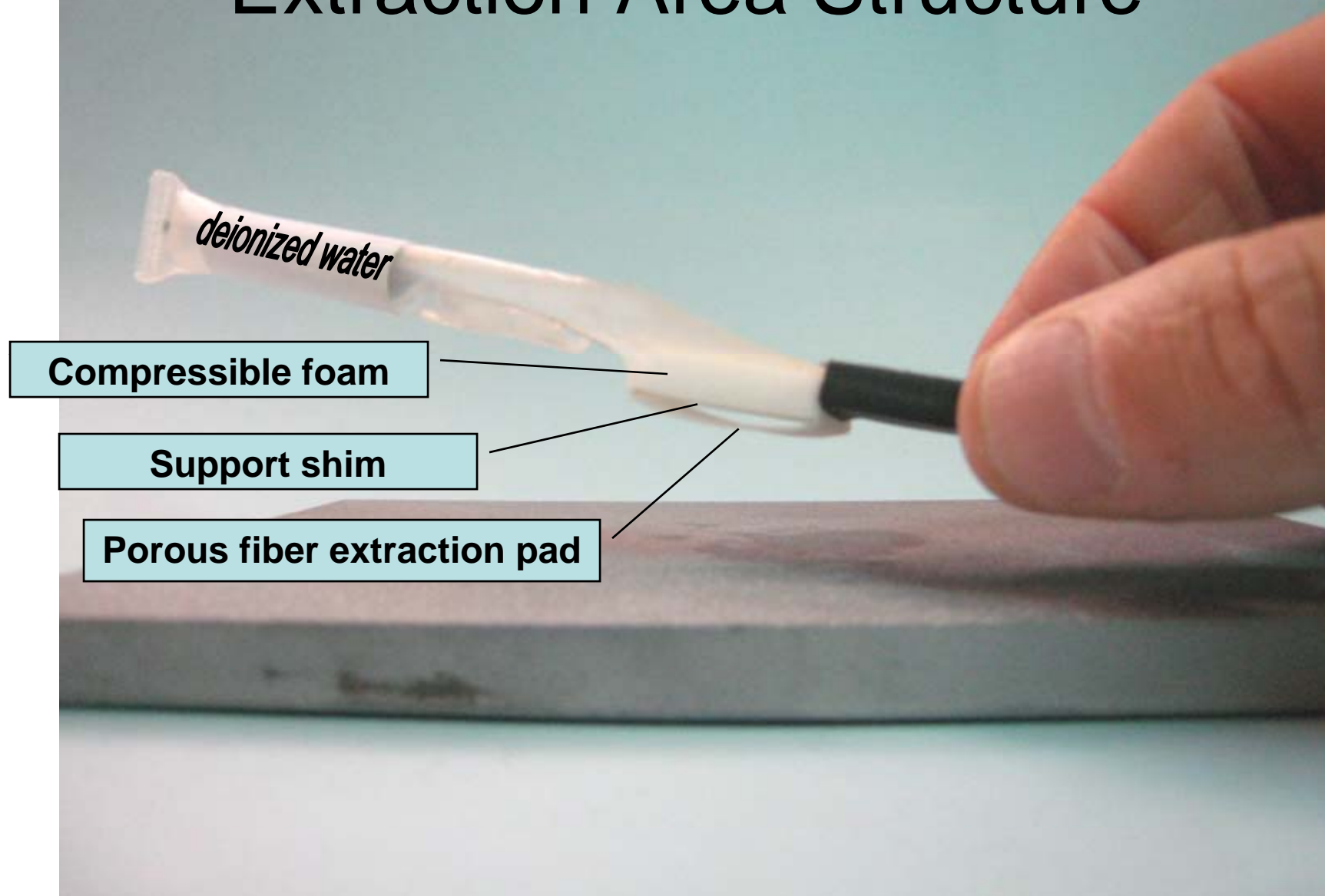


eStrip™

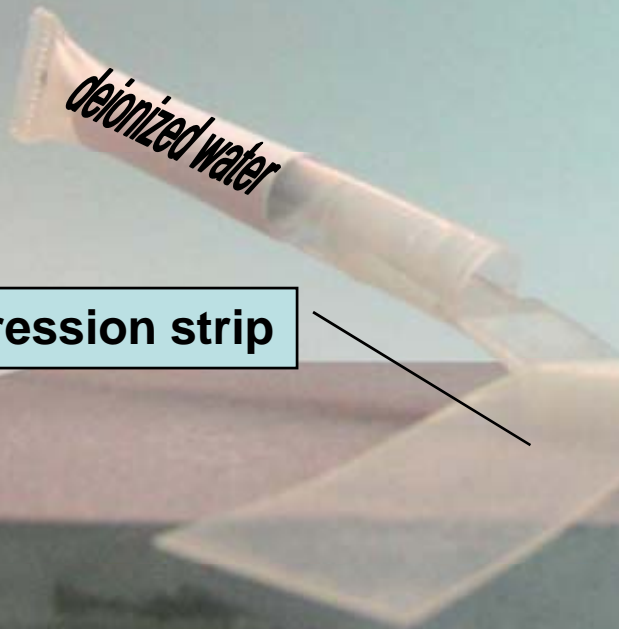


US & International Patents Pending

Extraction Area Structure



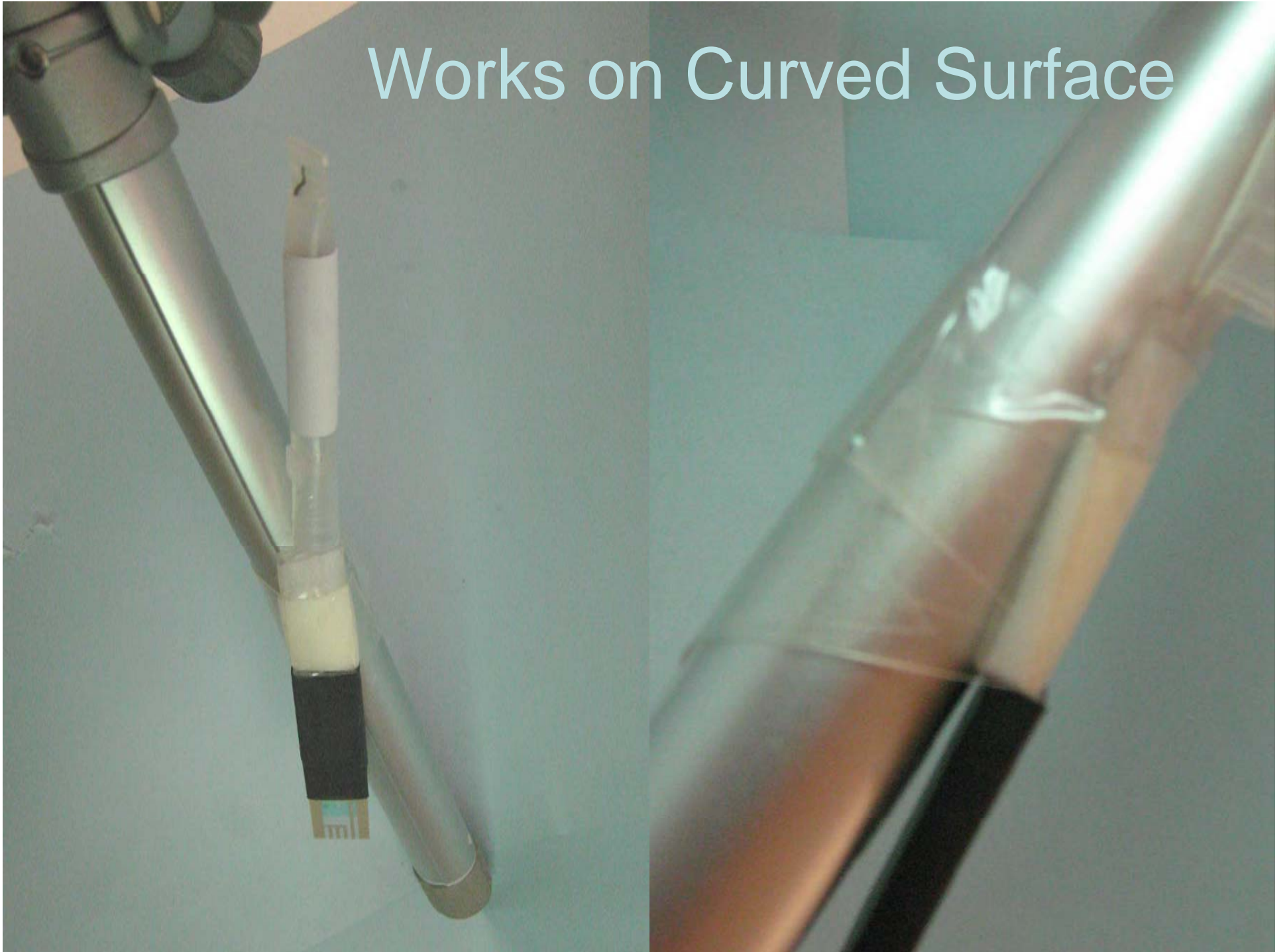
eStrip™ Extracting Salt



Adhesive compression strip

**Defined extraction pad area
compressed against steel**

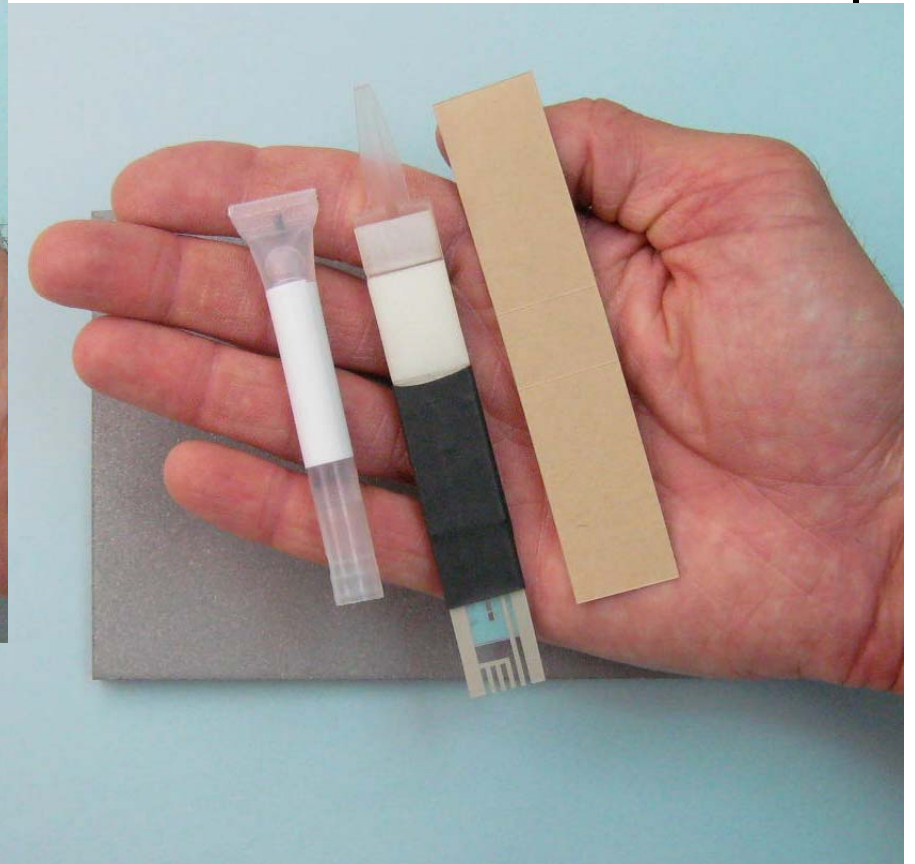
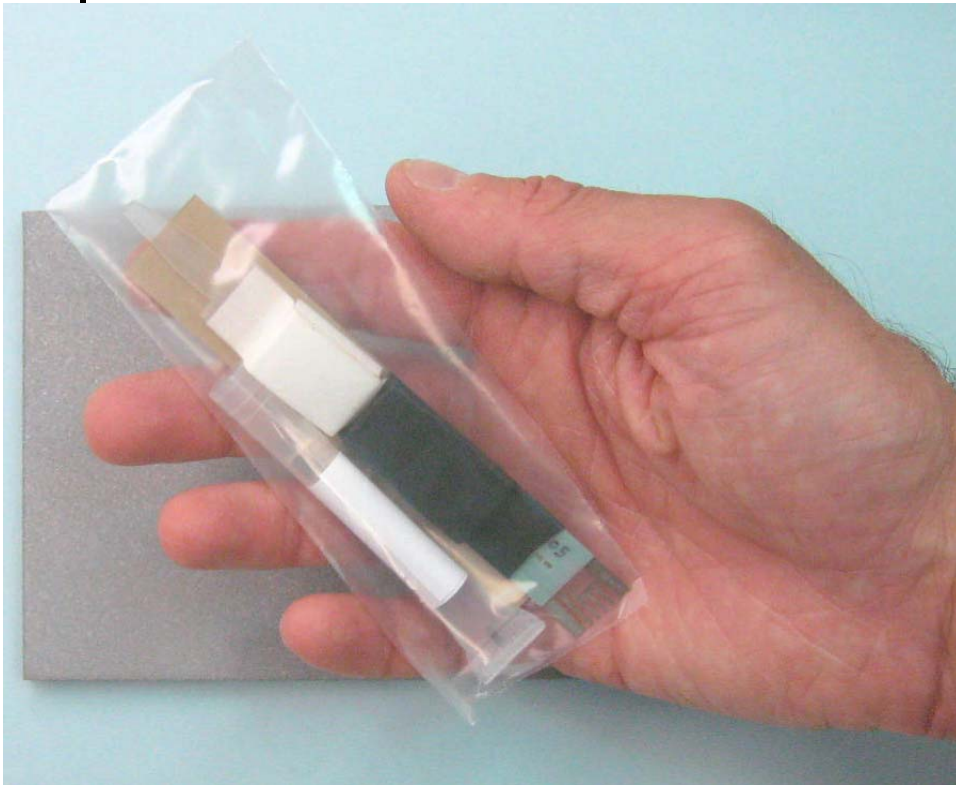
Works on Curved Surface



eStrip Work Flow

1. Unwrap Package

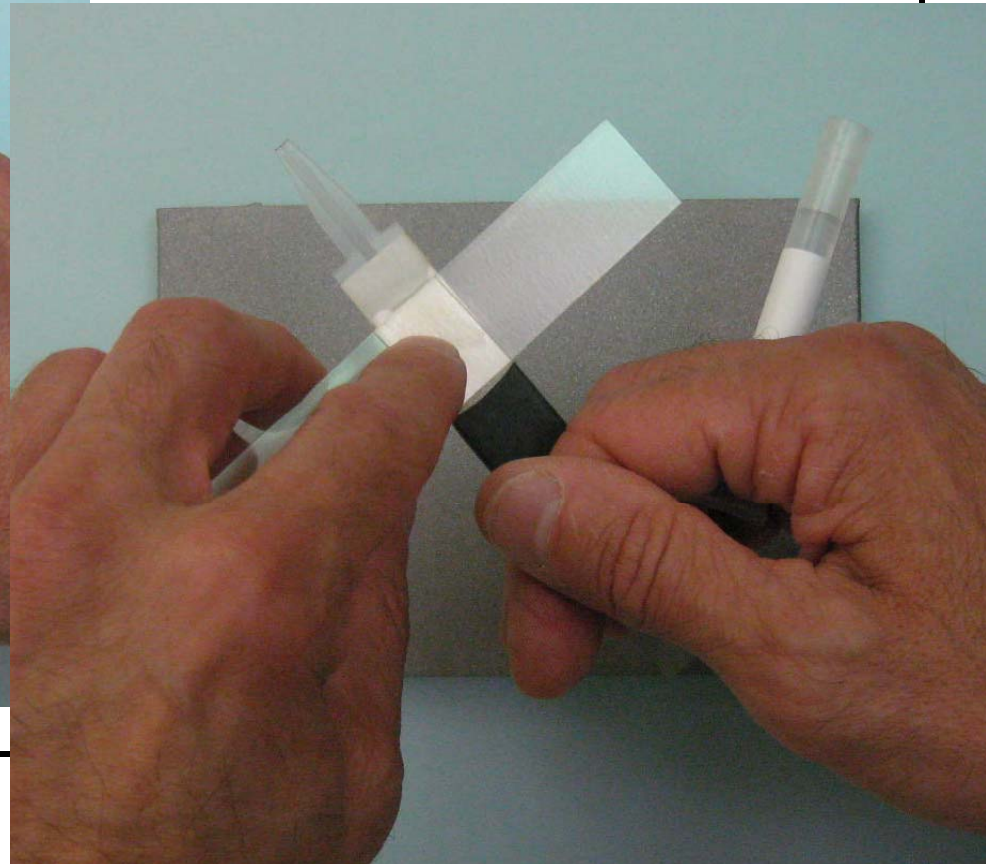
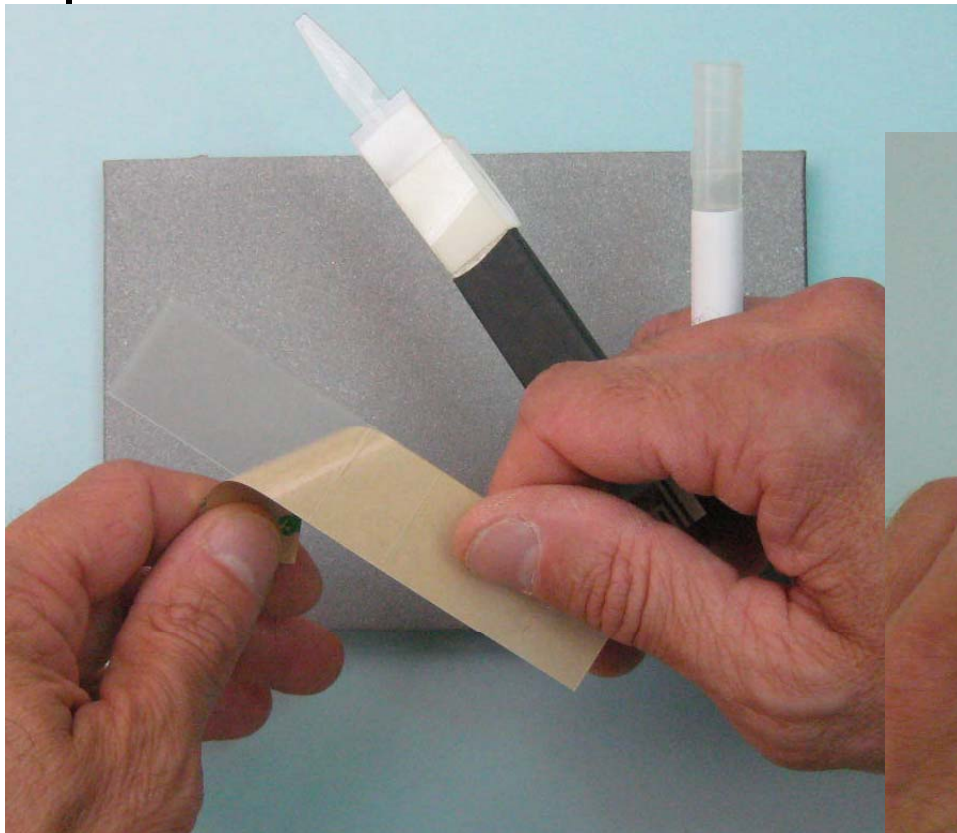
0:05



eStrip Work Flow

2. Attach Tack Strip

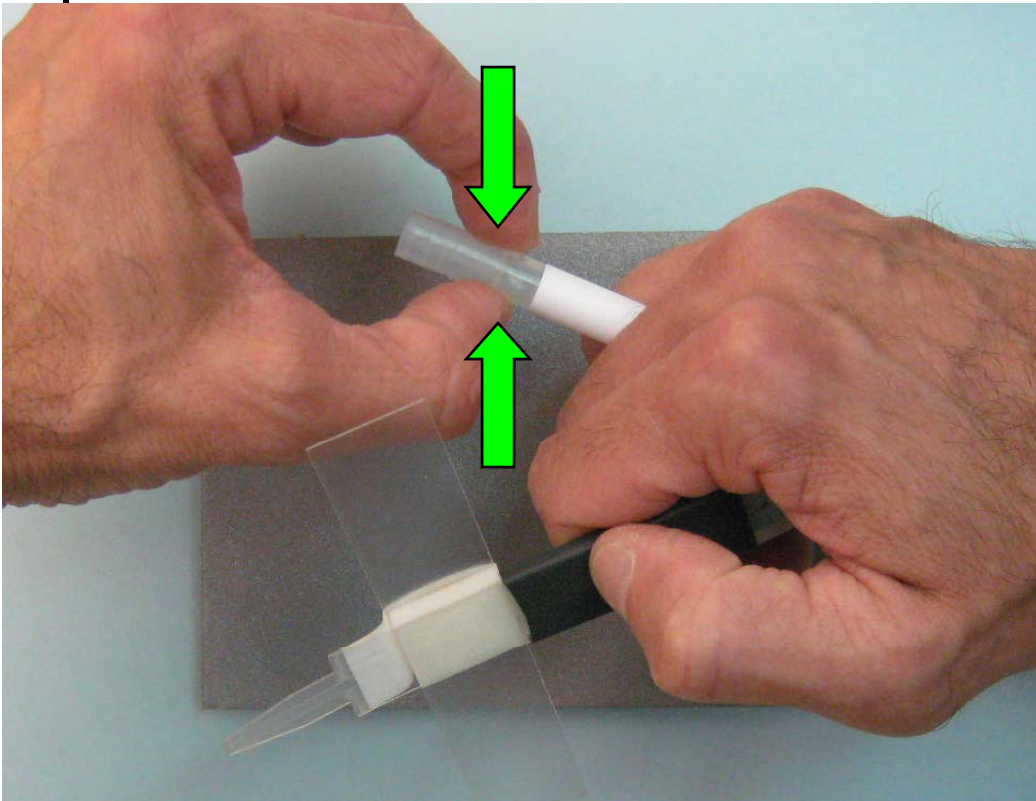
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eStrip Work Flow

3. Break seal and then insert water ampoule

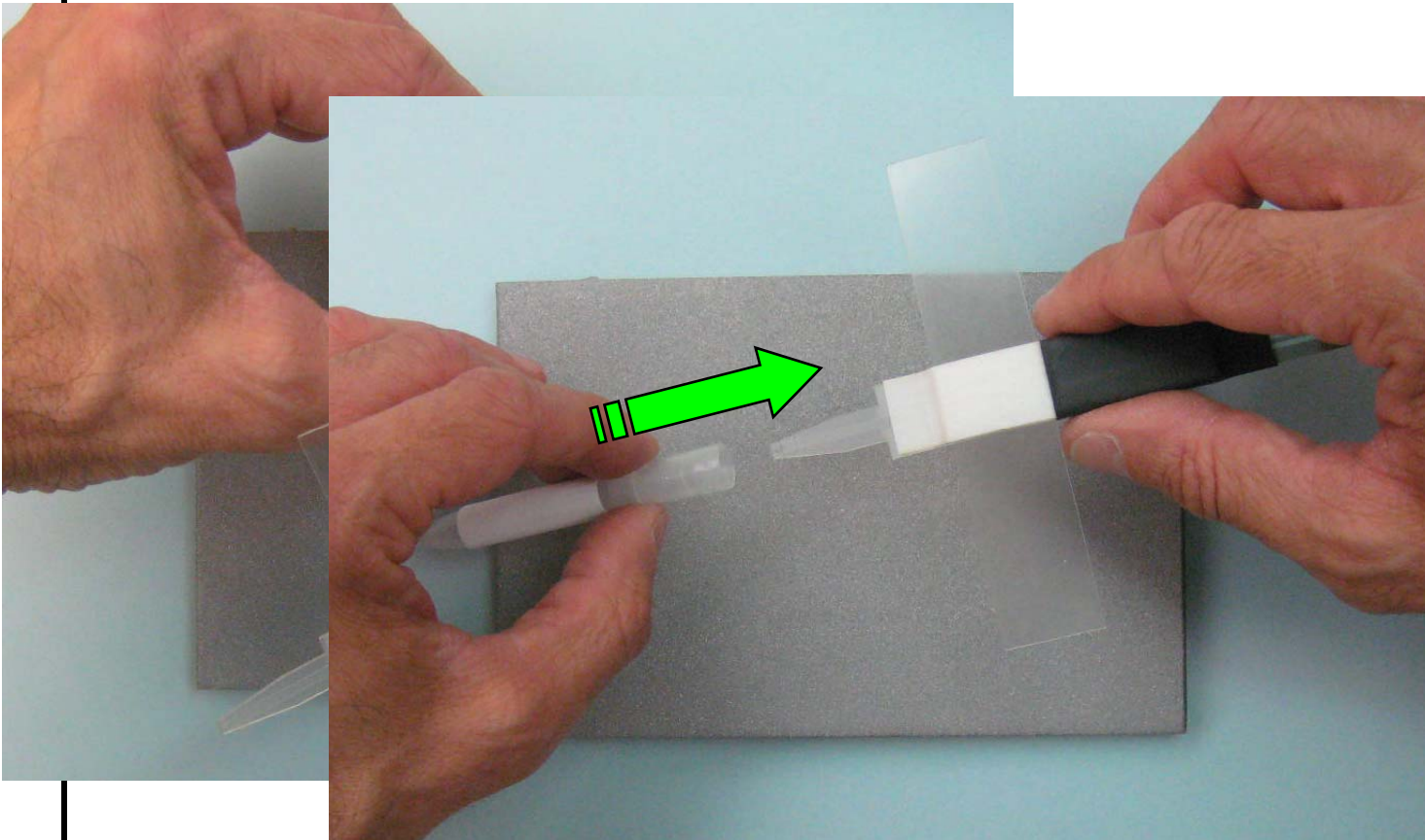
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eStrip Work Flow

3. Break seal and then insert water ampoule

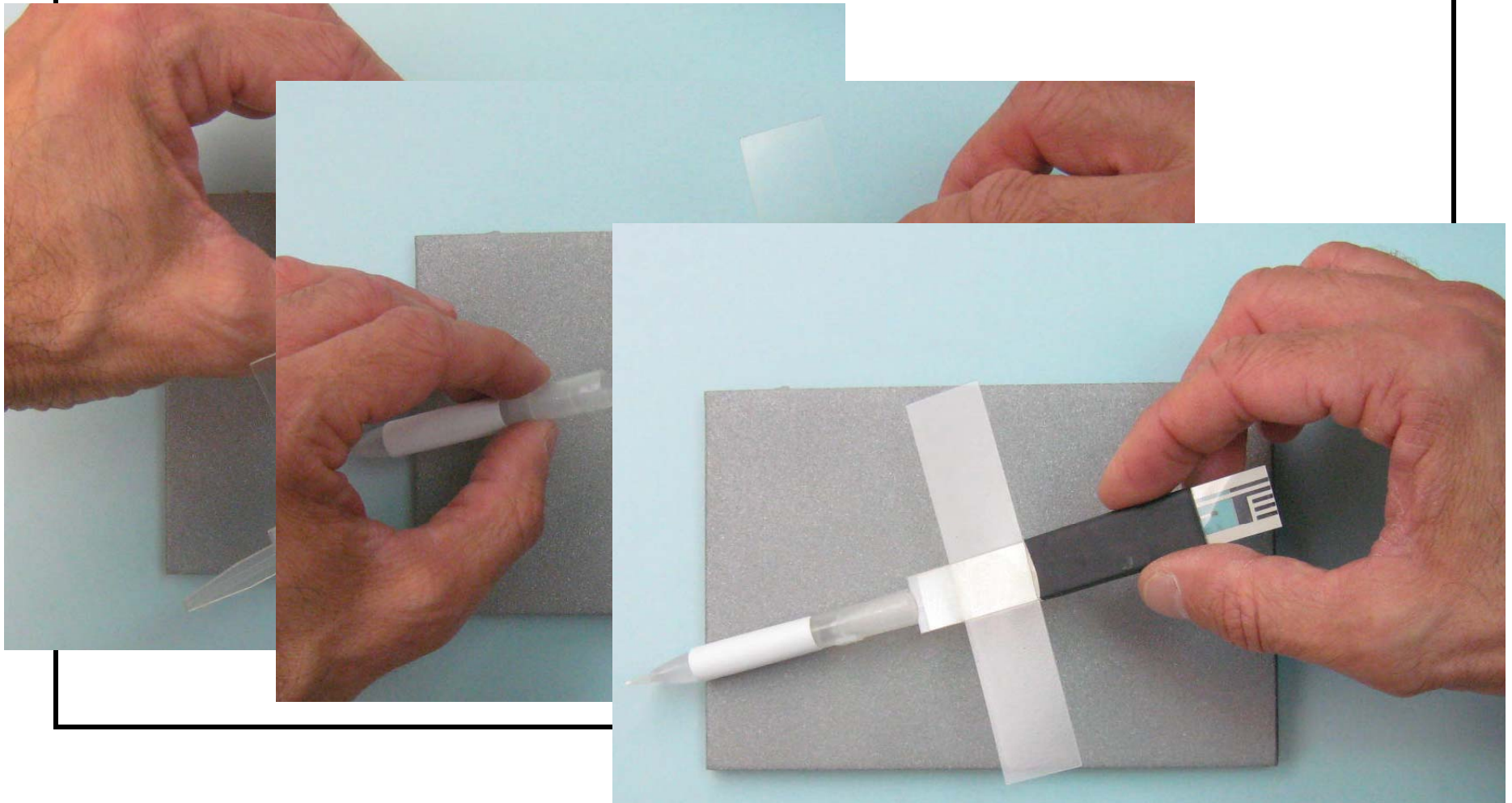
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eStrip Work Flow

3. Break seal and then insert water ampoule

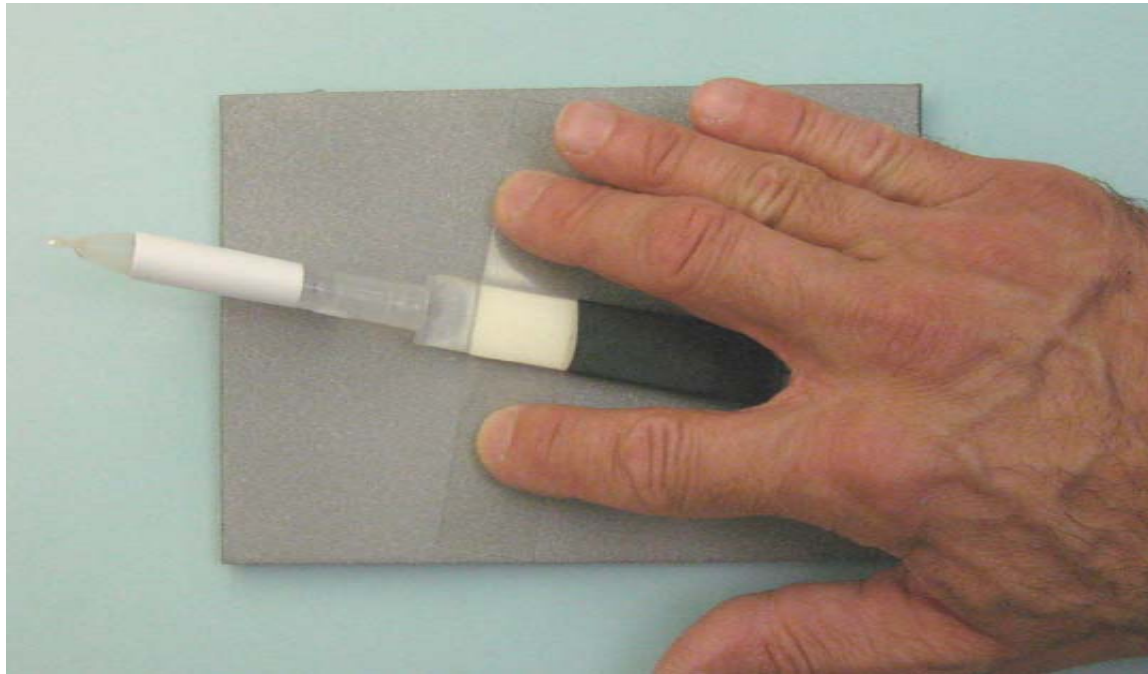
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eStrip Work Flow

4. Tack onto steel

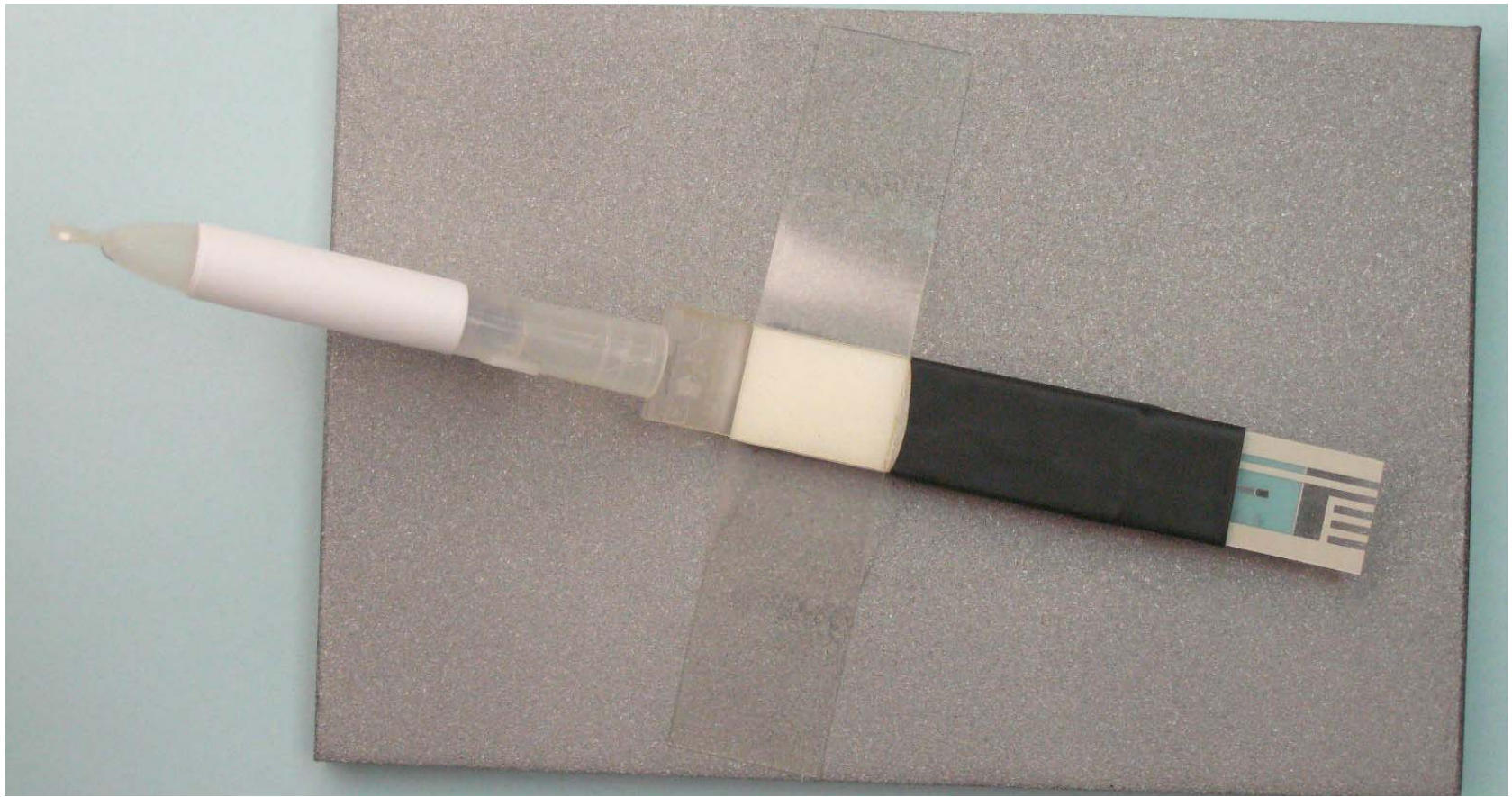
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eStrip Work Flow

5. Extract Salt into Reservoir

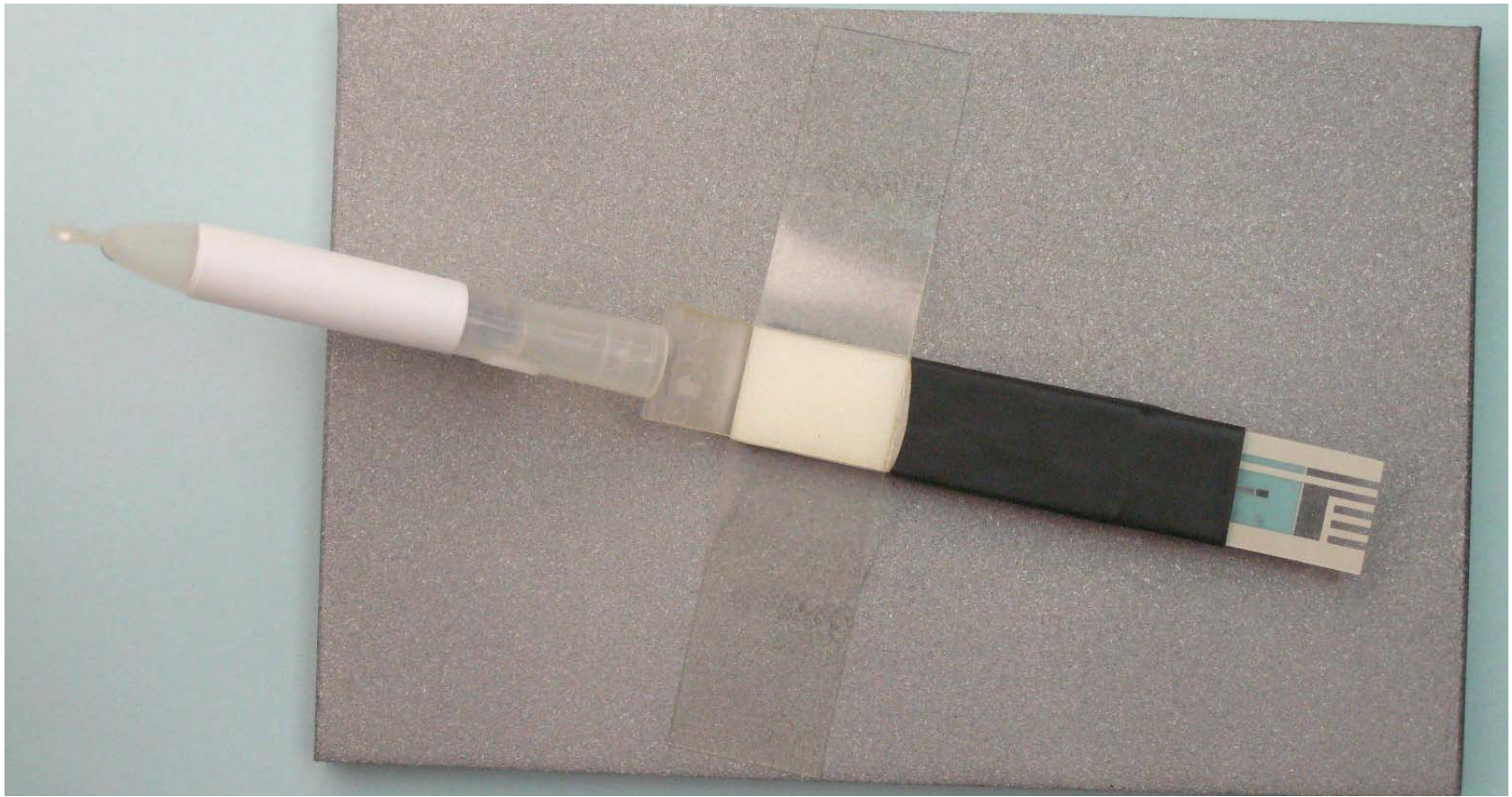
1:15



eStrip Work Flow

5. Extract Salt into Reservoir

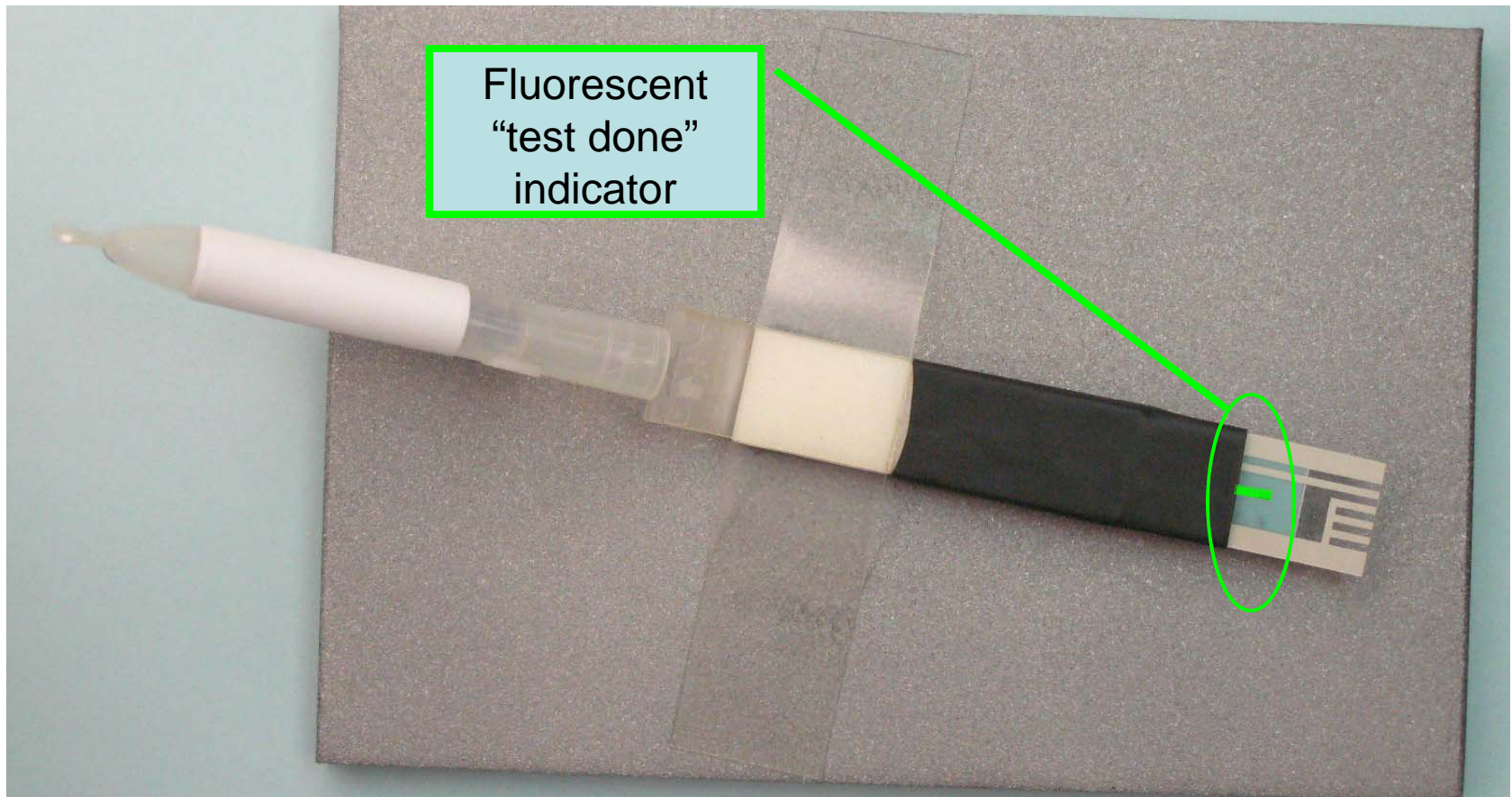
2:15



eStrip Work Flow

6. Test Done

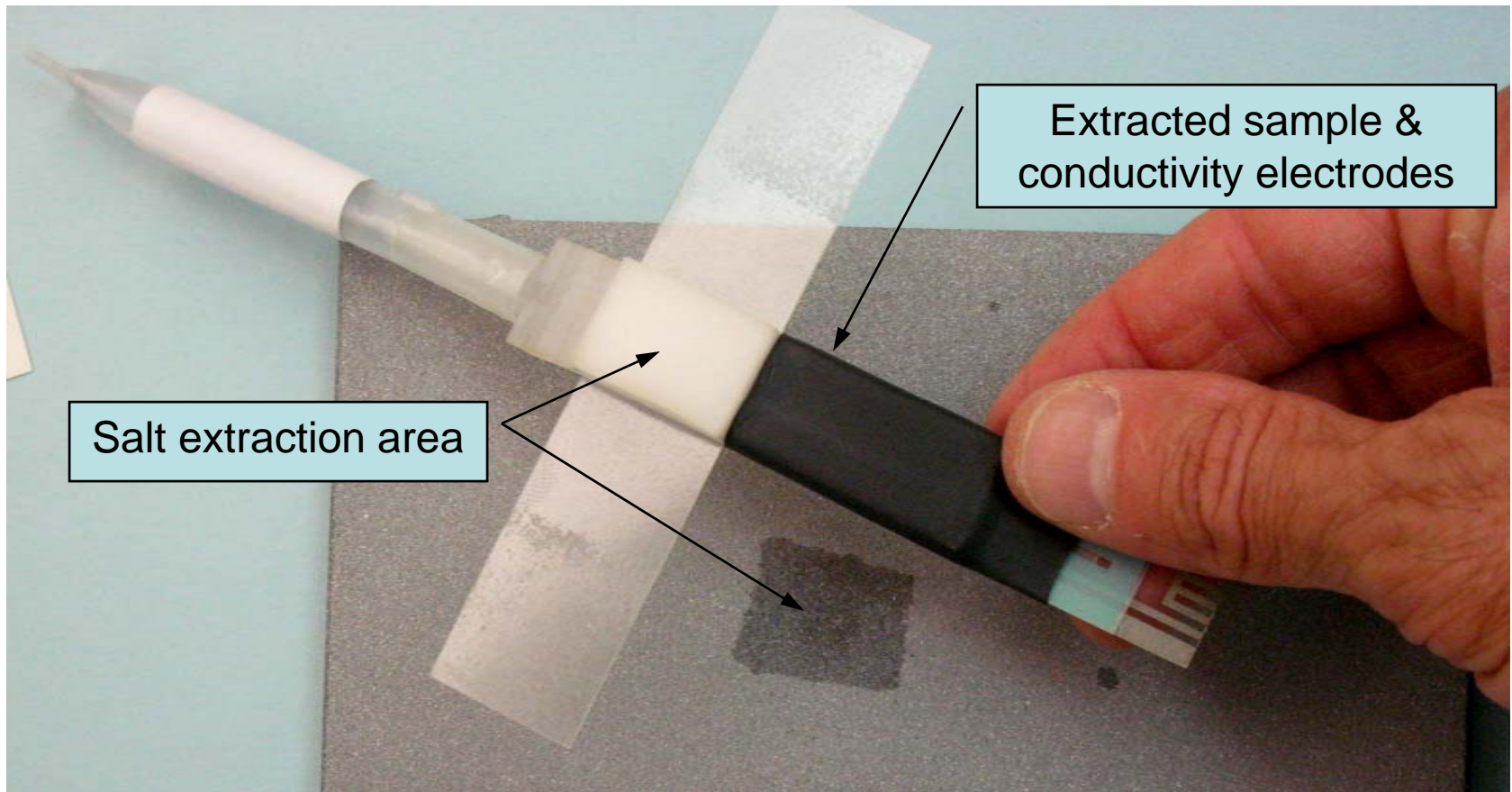
3:15



eStrip Work Flow

6. Test Done

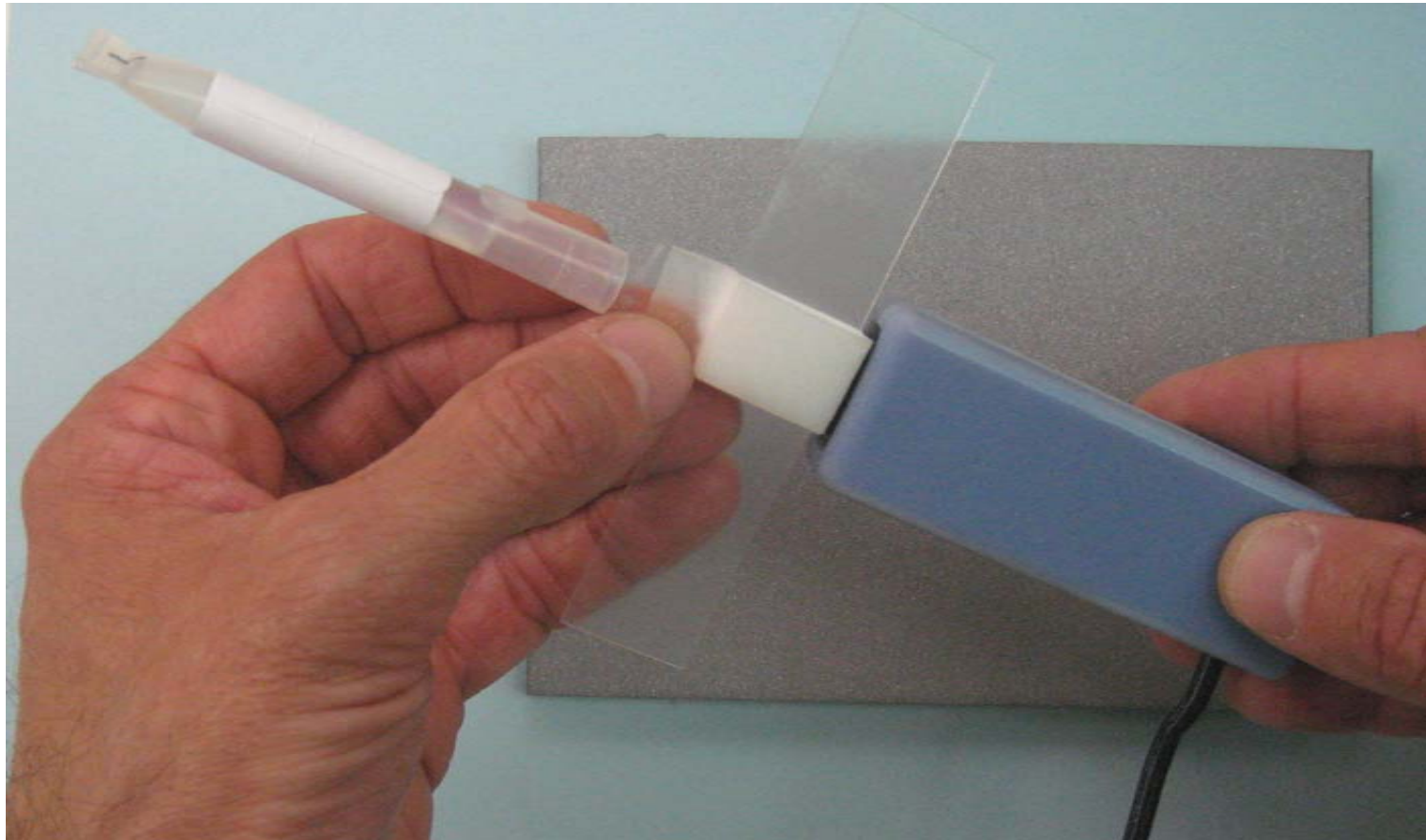
3:15



eStrip Work Flow

7. Insert eStrip into Reader

3:20



eStrip Work Flow

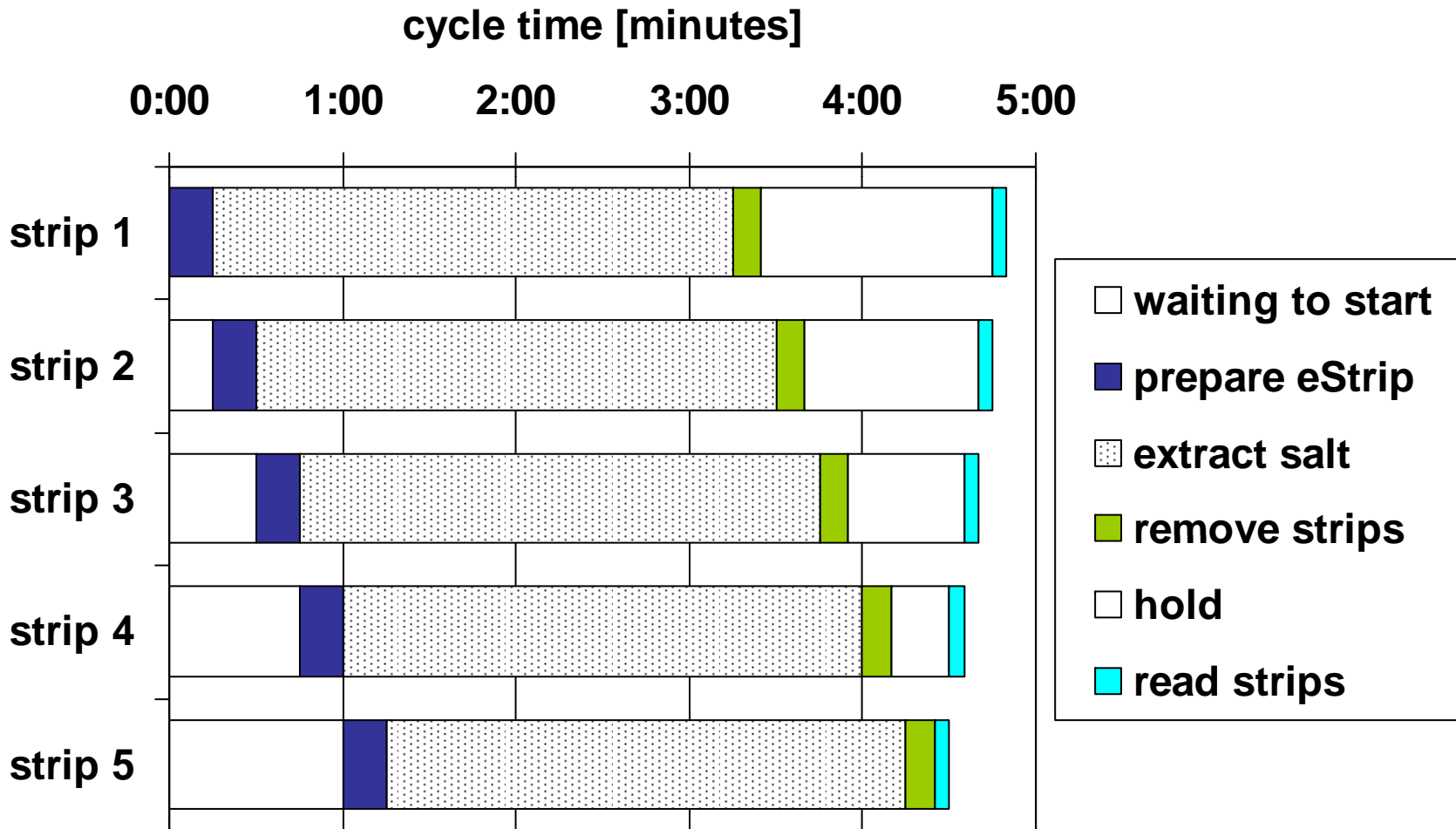
7. Read & Save Result

- Strip reader adapter
 - Replaces standard conductivity probe
 - Temperature compensated
- Fits off-the-shelf conductivity meters
- Calibrated with dry calibration strip
 - No calibration fluids



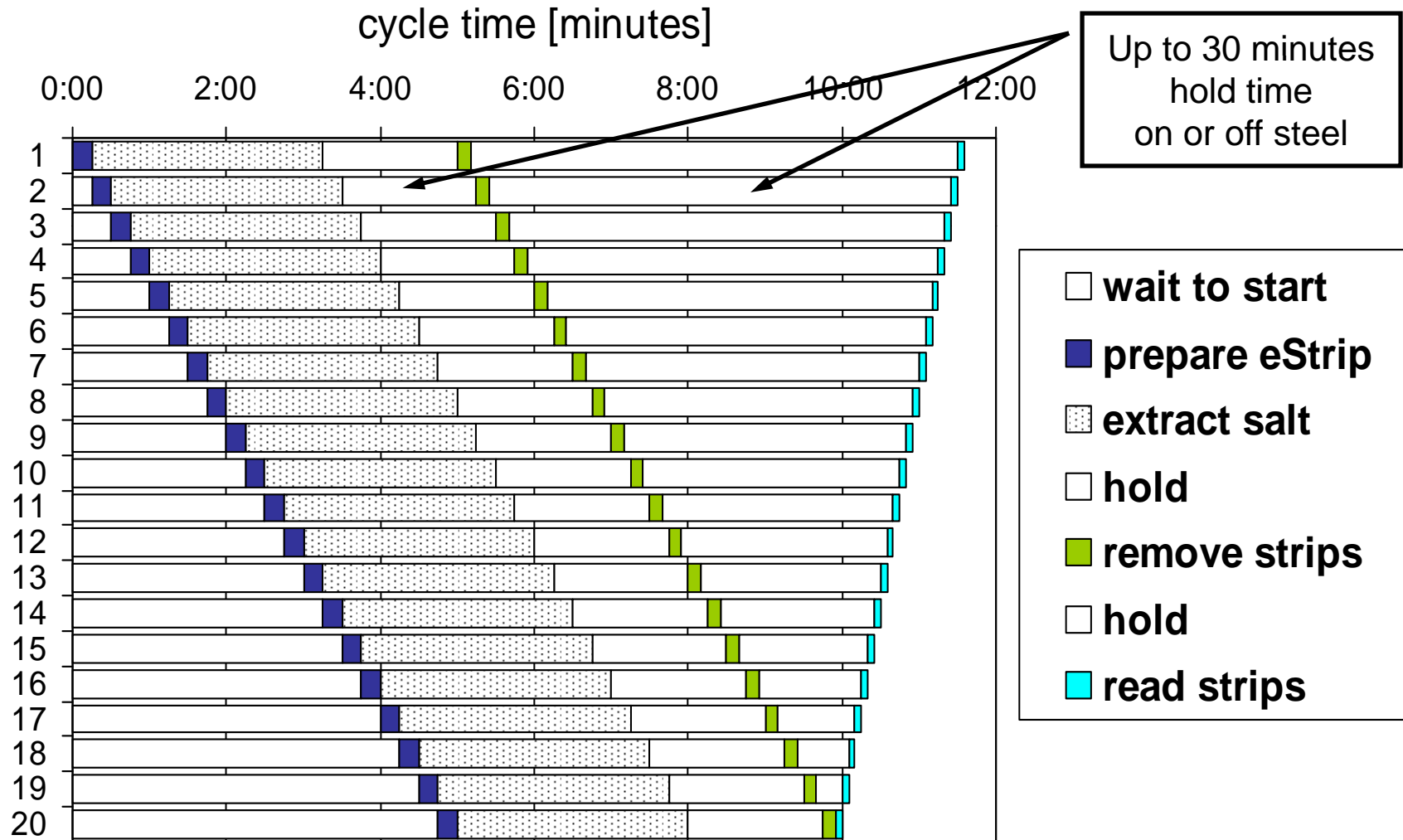
Strip Work Flow: 1000 sq. ft. tank

- 5 sample under 5 minutes



eStrip Work Flow: bigger tank

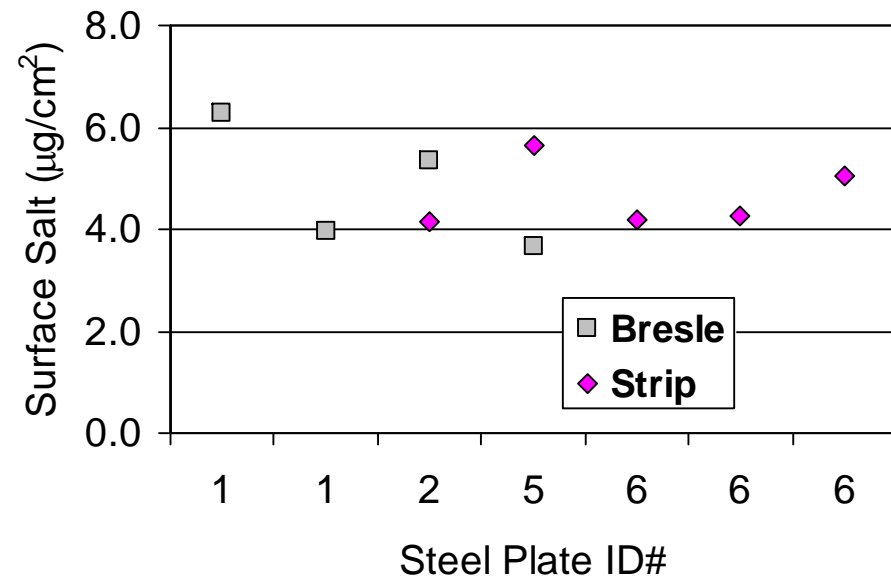
- 20 sample under 12 minutes



eStrip Measurement Performance

- Mfg Specification
 - at 5.0 $\mu\text{g}/\text{cm}^2$, $\pm 7\%$
 - at 2.0 $\mu\text{g}/\text{cm}^2$, $\pm 13\%$
 - Solvent Volume $\pm 2\%$
 - Extraction Area
 - ISO 8502-6 A-0310
 - 310 $\text{mm}^2 \pm 3\%$
 - Range 0 – 300 $\mu\text{S}/\text{cm}$

- Demonstrated
 - Small-lot manufacturing
 - On steel, match Bresle value and variability
 - No extraction failures
 - 50% Bresle Patch leak failures



eStrip Field Utility

- **Fast**
 - 5 samples < 5 minutes
 - 20 samples < 12 minutes
- **Low cost**
 - Strip cost approx Bresle Patch
 - Use off-the-shelf conductivity meters
- **Robust**
 - Substrate curvature and orientation
 - Insensitive to operator technique
 - No leaks
 - Re-wet strip to verify results
- **Safe, Clean, Easy**
 - No needles, bottles, solvents, calibration solutions
 - No residue on steel
 - Up to 30 min. hold time from extraction to analysis
 - On or off steel

eStrip Build and Test Plan

- Feasibility demonstrated in lab
- Manufacturing demonstrated
- Lab tests to match Bresle performance
 - Completed September 2008
- Available for qualification testing Nov-Dec 2008
 - Test lots from 10 to 100 strips
- Production scale orders open November 2008
 - January 2009 delivery
- Meter manufacturers
 - Contact eyates@nstcenter.com for adapter specification