POLYGUARD RD-6

“A FAIL SAFE” PIPELINE COATING SYSTEM FOR REHABILITATION OR GIRTH WELDS ON CATHODICALLY PROTECTED PIPELINES

A large percent of corrosion failures on cathodically protected structures are associated with disbonded coatings that shield cathodic protection currents.

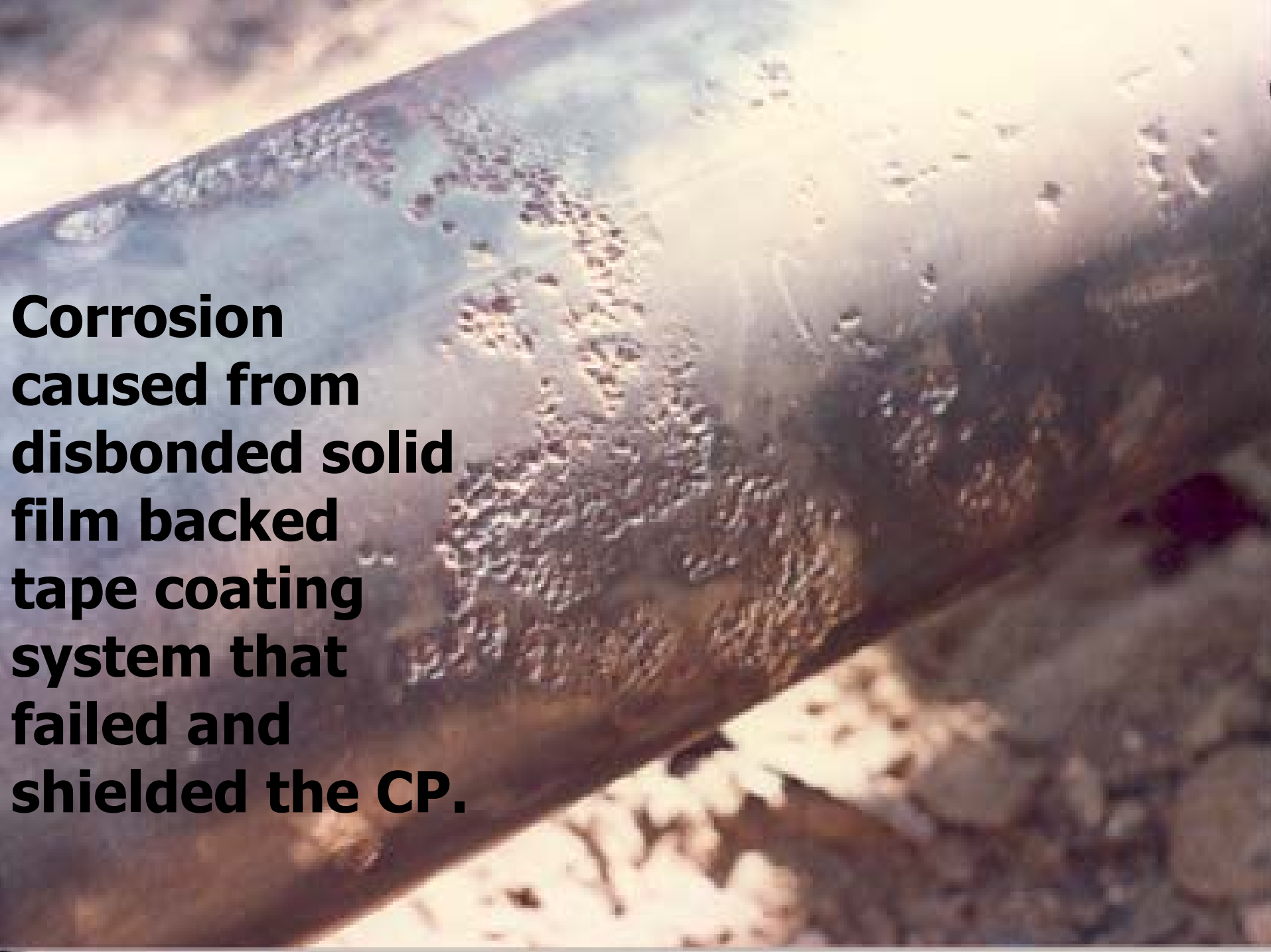
The **Polyguard RD-6** pipeline coating system has been engineered to have **"Fail Safe"** properties with a woven geo-textile fabric **backing that will not shield CP, is resistant to soil stress, has a compound that is very compatible with CP and is field and lab proven "Fail Safe" to reduce or prevent corrosion and stress corrosion cracking on pipelines if water were present between coating**

"Fail Safe" means that if the coating system fails, the metal being protected does not corrode or corrosion is significantly reduced when adequate CP is available.

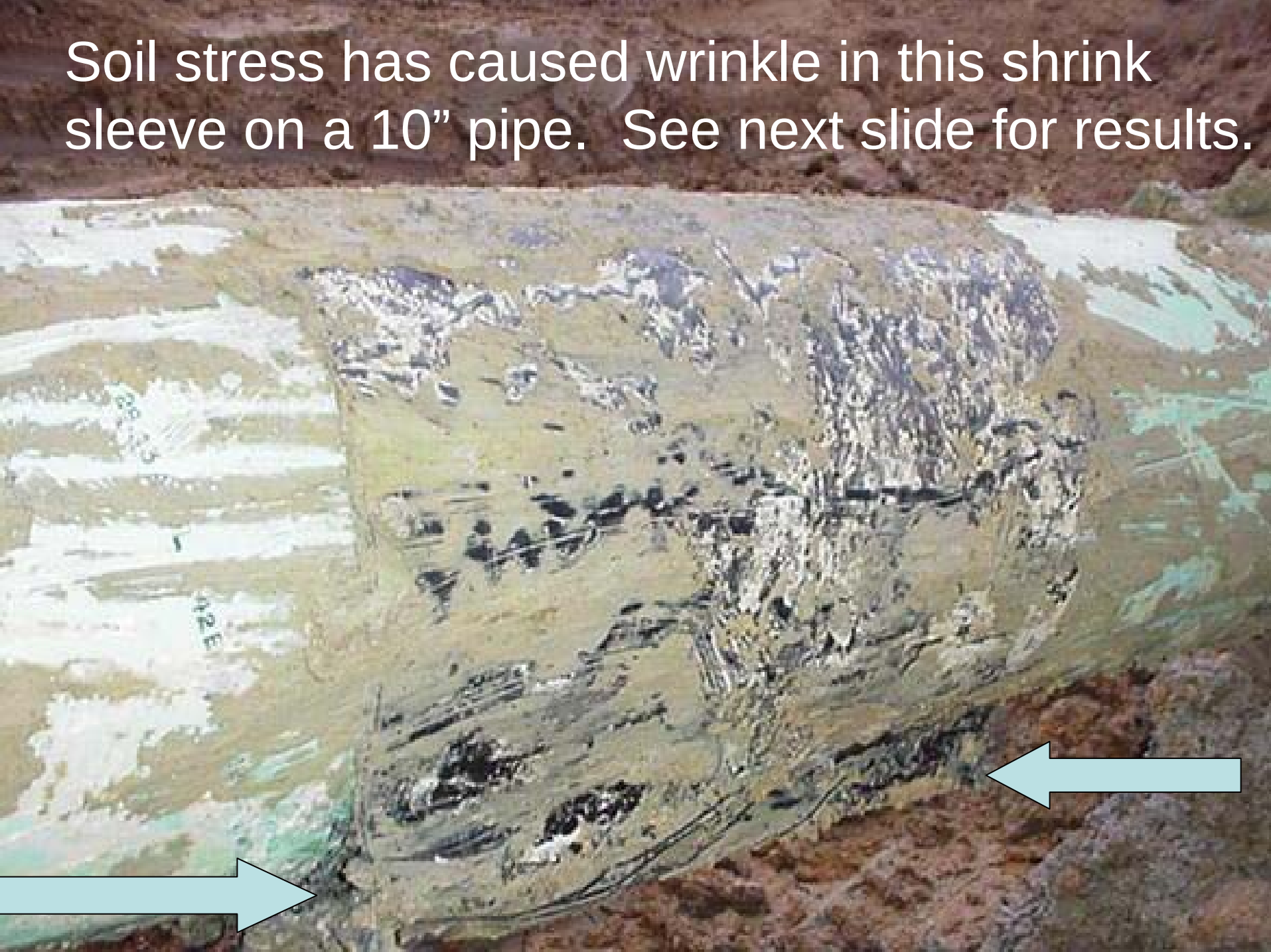
Fusion Bonded Epoxy is such a "Fail Safe" coating. Corrosion is rarely found under disbonded FBE. At this time stress corrosion cracking (SCC) has not been found under disbonded FBE or RD-6.

The **Polyguard RD-6** is another proven "Fail Safe" coating system!

At this time we can not say that **RD-6** is 100% “Fail Safe”, but we can say it provides a definite advantage over most other types of coatings, especially solid-film backed tape coatings, and shrink sleeves

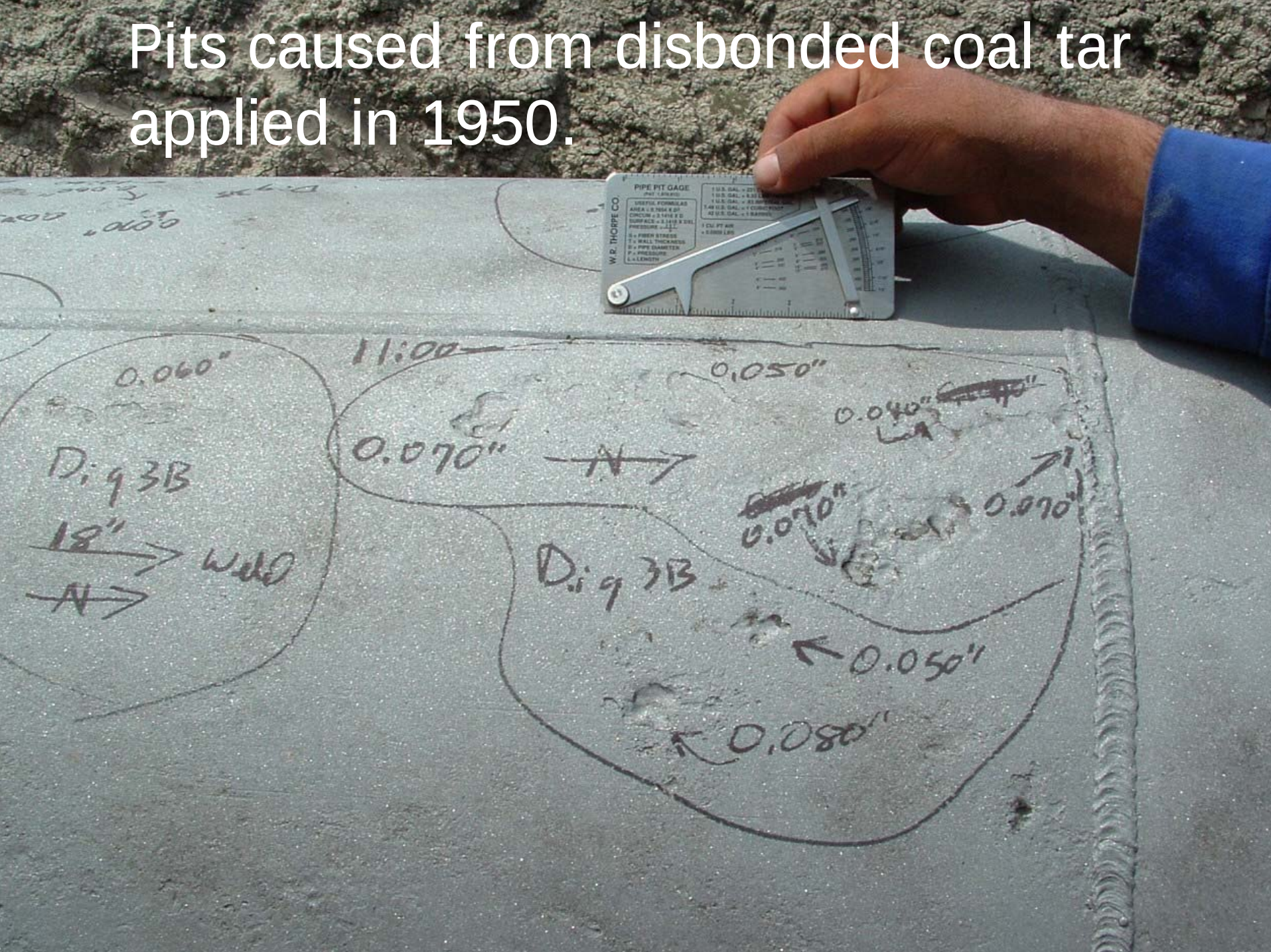

Corrosion caused from disbonded solid film backed tape coating system that failed and shielded the CP.

Soil stress has caused wrinkle in this shrink sleeve on a 10” pipe. See next slide for results.




Corrosion under shrink sleeve after eight years. No corrosion under FBE. Shrink sleeve was not “Fail Safe”!


Lack of adhesion under shrink sleeve. Corrosion is developing because of shielding effects.
Not “Fail Safe”.
17 11:49


Pits caused from disbonded coal tar applied in 1950.
PIPE PIT GAGE
W.R. THORPE CO
0.060"
11:00
0.050"
0.070"
0.040"
0.070"
0.070"
Dig 3B
18"
Dig 3B
0.050"
0.080"

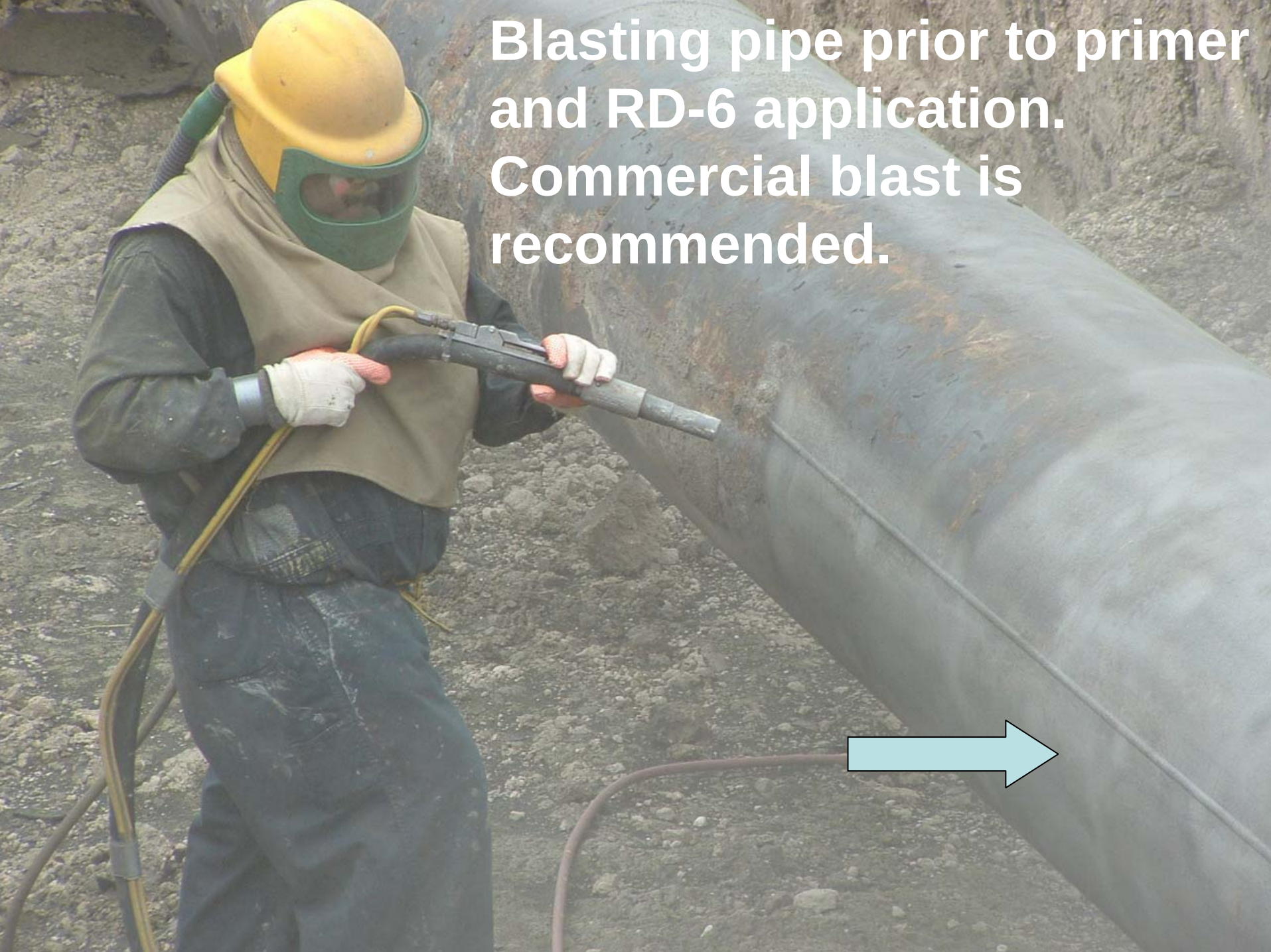

Severe soil stress caused coal tar coating to disbond. Notice dirt between the coating and pipe.
0.065"
3:00
0.020"
0.050'
0.040"
0.070
0.080'
0.055'
16'

The mechanisms by which coating systems fail are not totally understood but some are:

- Poor surface preparation
- Poor application
- Poor selection criteria
- Cathodic protection

RD-6 Surface Preparation

1. **Commercial blast recommended (Most liquid coatings require a near white blast!)**
2. **Performs well on surfaces prepared with hand or power brushes (See Charter test results).**
3. **Heating of the pipe only to remove visible moisture or to bring the temperature of the pipe surface above the dew point.**


Blasting pipe prior to primer and RD-6 application. Commercial blast is recommended.

Application Techniques

FBE requires:

Near white blast required; High heat; Expensive and complicated equipment

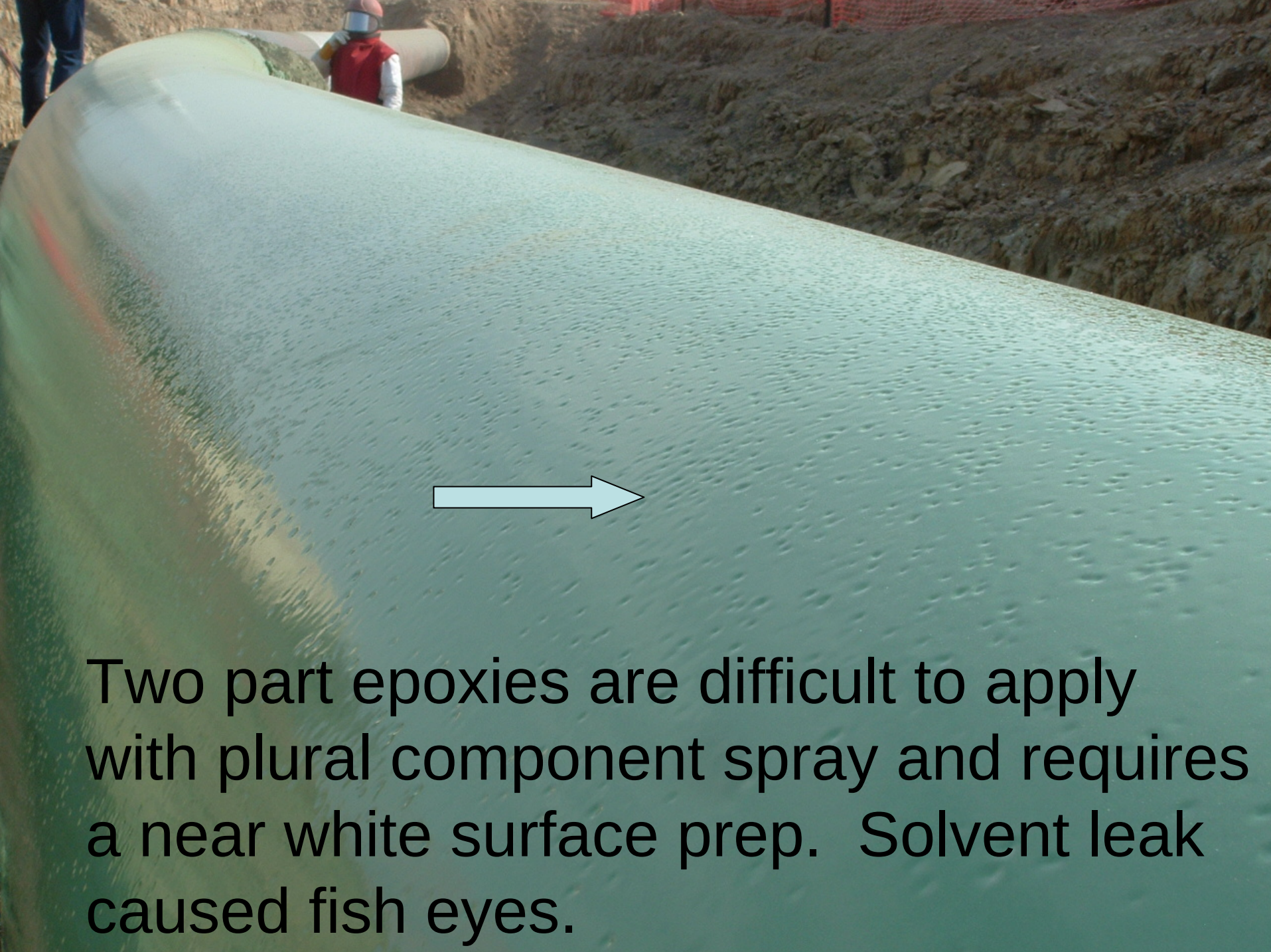
Liquid epoxies require:

Near white blast required; Subject to off ratio mixtures; Pot-life problems; Many have complicated plural component spray equipment; Cure time issues; Temperature dependent; Backfill is not immediate

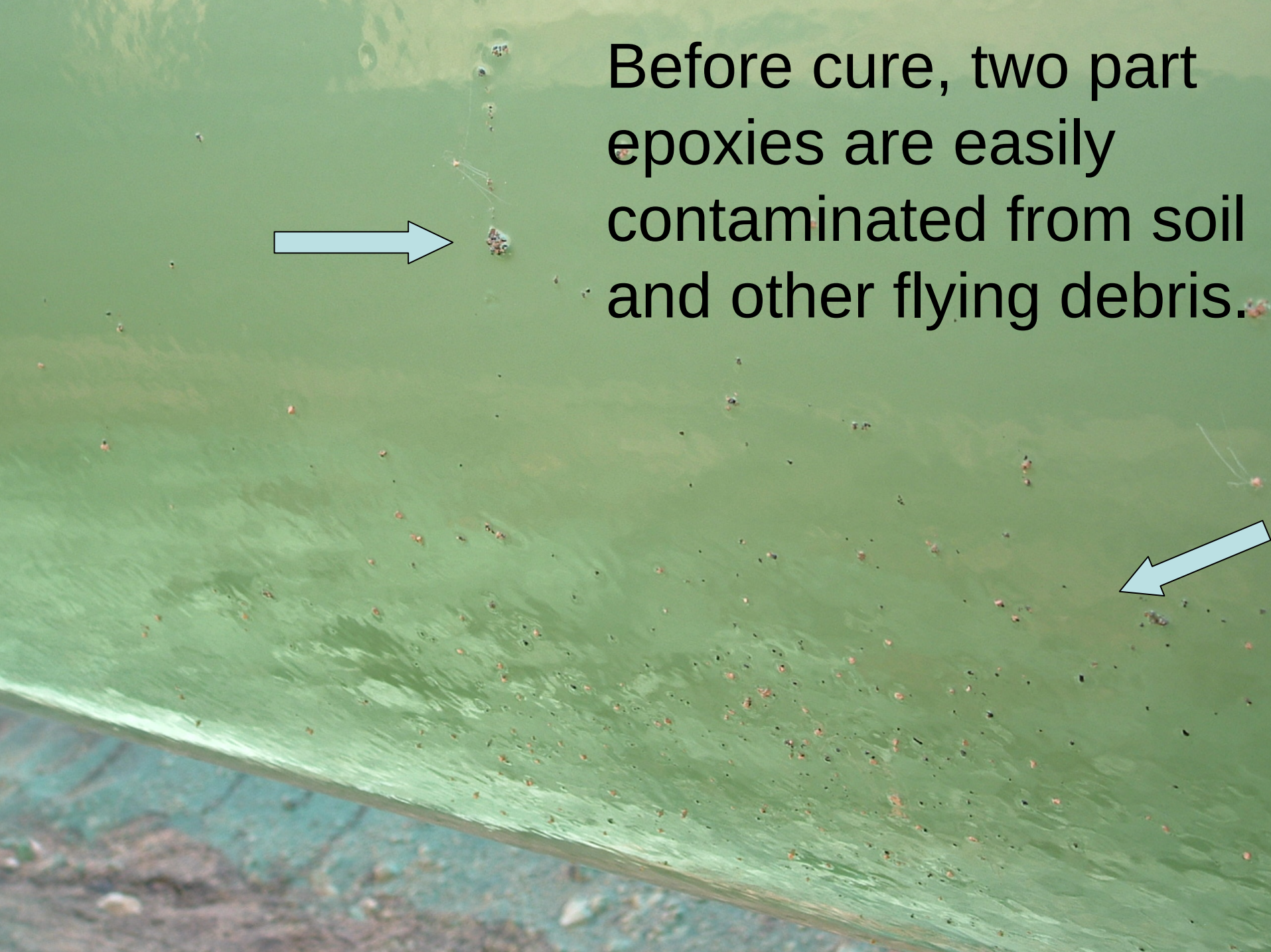
Shrink Sleeves:

Heat required; Proper heating of the pipe and sleeve; Over heating causes cracks in sleeve; Under heating of sleeve or pipe causes improper bond or air pockets; Some require primer

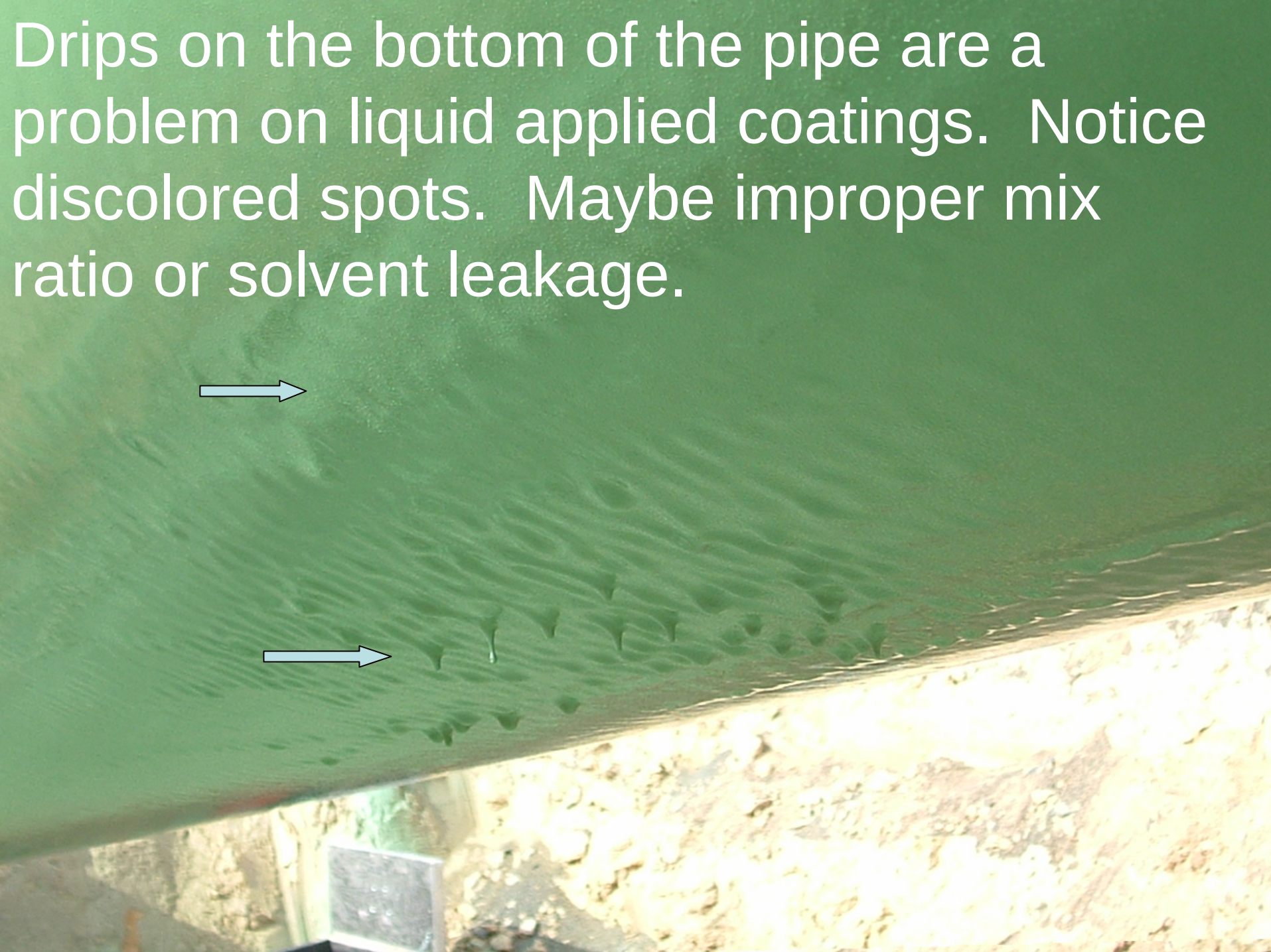
Poor application techniques.

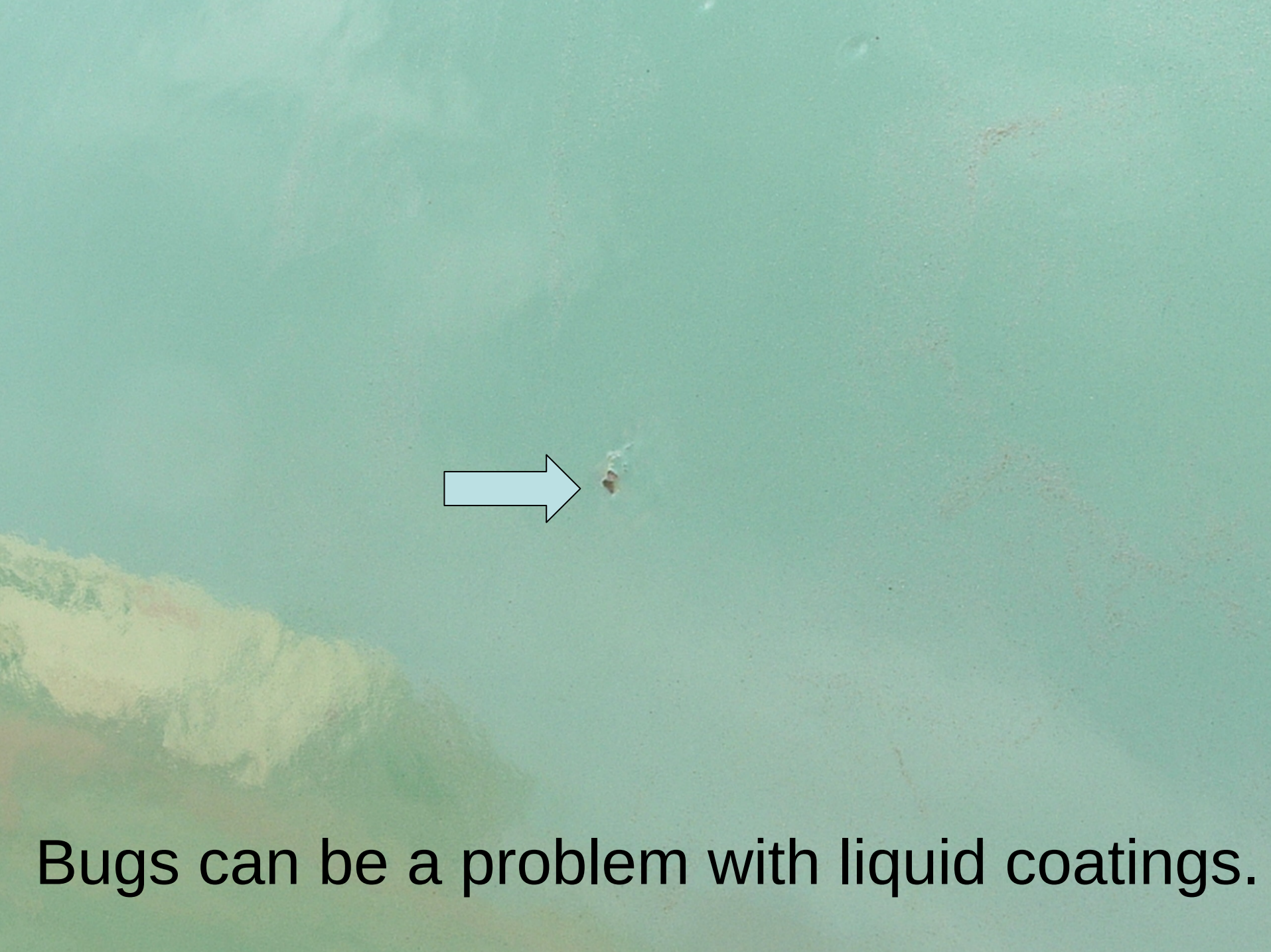


Two part epoxies are difficult to apply with plural component spray and requires a near white surface prep. Solvent leak caused fish eyes.


Before cure, two part epoxies are easily contaminated from soil and other flying debris.


Sags and runs on sprayed two part epoxy system.


Drips on the bottom of the pipe are a problem on liquid applied coatings. Notice discolored spots. Maybe improper mix ratio or solvent leakage.



Bugs can be a problem with liquid coatings.

RD-6 Application

Polyguard 600 primer:

1. Easily applied with brush or roller
2. Fills the anchor pattern in the metal
3. Cures quickly
4. Provides chemical reaction with RD-6 compound to enhance adhesion

606 filler compound:

1. Used to fill large or deep pits
2. Used to fill transition areas to other coatings
3. Not always required


Applying the Polyguard 600 primer with roller.
Unbonded outer wrap from previous application.

RD-6 Application

Proper application tension and overlap:

1. Wrap application machine is recommended to achieve proper tension and overlap.
2. If applied by hand, the unbonded outer wrap is required to assist in soil stress resistance.
3. Unbonded outer wrap is recommended for large diameter pipe (12” and above).

Proper application using a tape machine and weld seam tape. Bridging can occur at the weld seam.


Hand application may be used, but proper tension and overlap are more difficult.
Release liner to keep tape from sticking to itself in roll.
Many problems occur on the bottom of the pipe when hand applying.

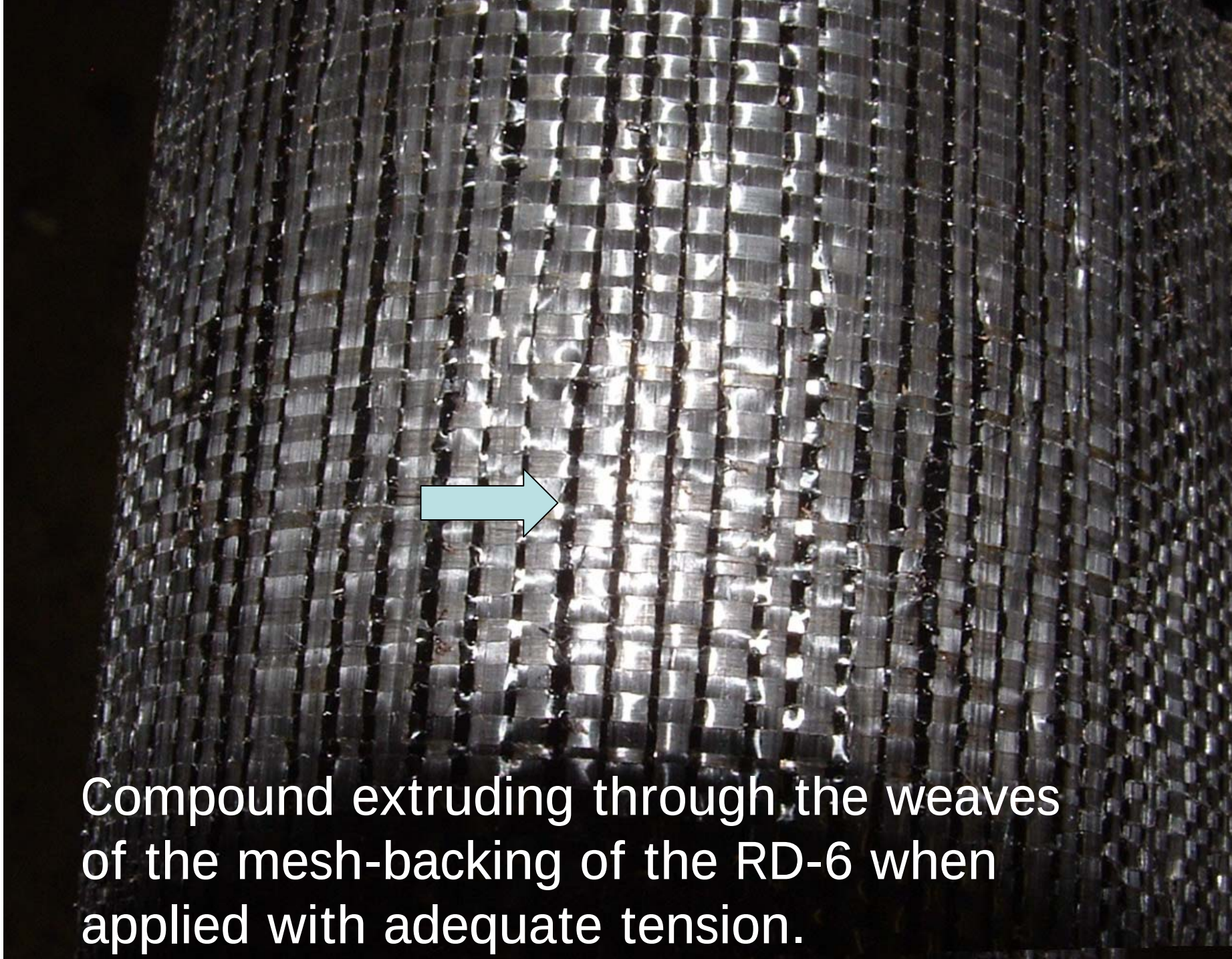
Application Techniques

RD-6 mesh-backing:

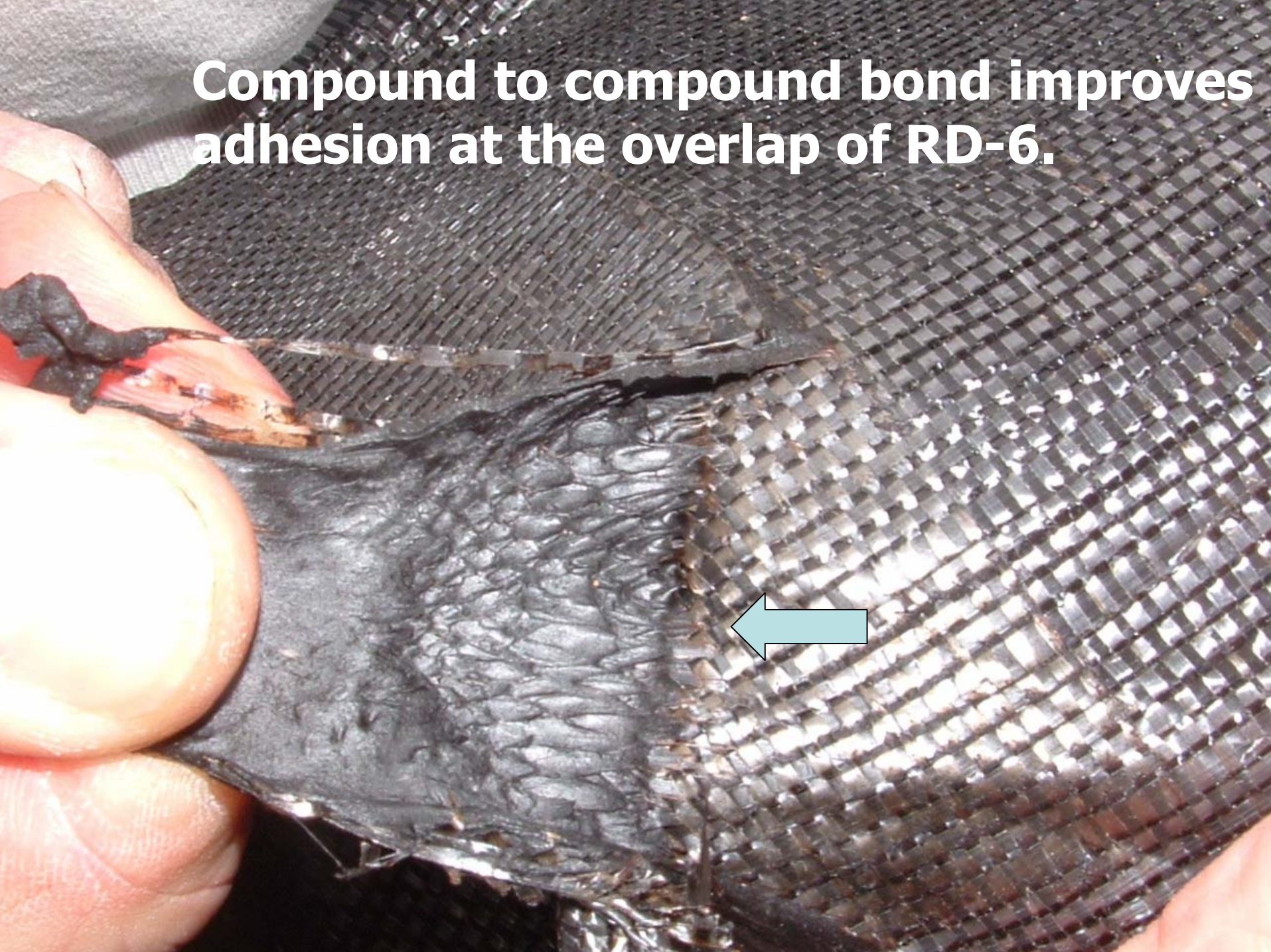
1. Very strong, with very little stretch

Basket weave design:

1. Allows the compound to extrude through openings
2. Allows compound to compound adhesion at overlaps.
3. Better overlap adhesion than compound to solid-film back tape coating systems.
4. Tapes **without** a release liner **do not bond** to the backing in the roll and **will not bond** to the backing at the **overlap**.



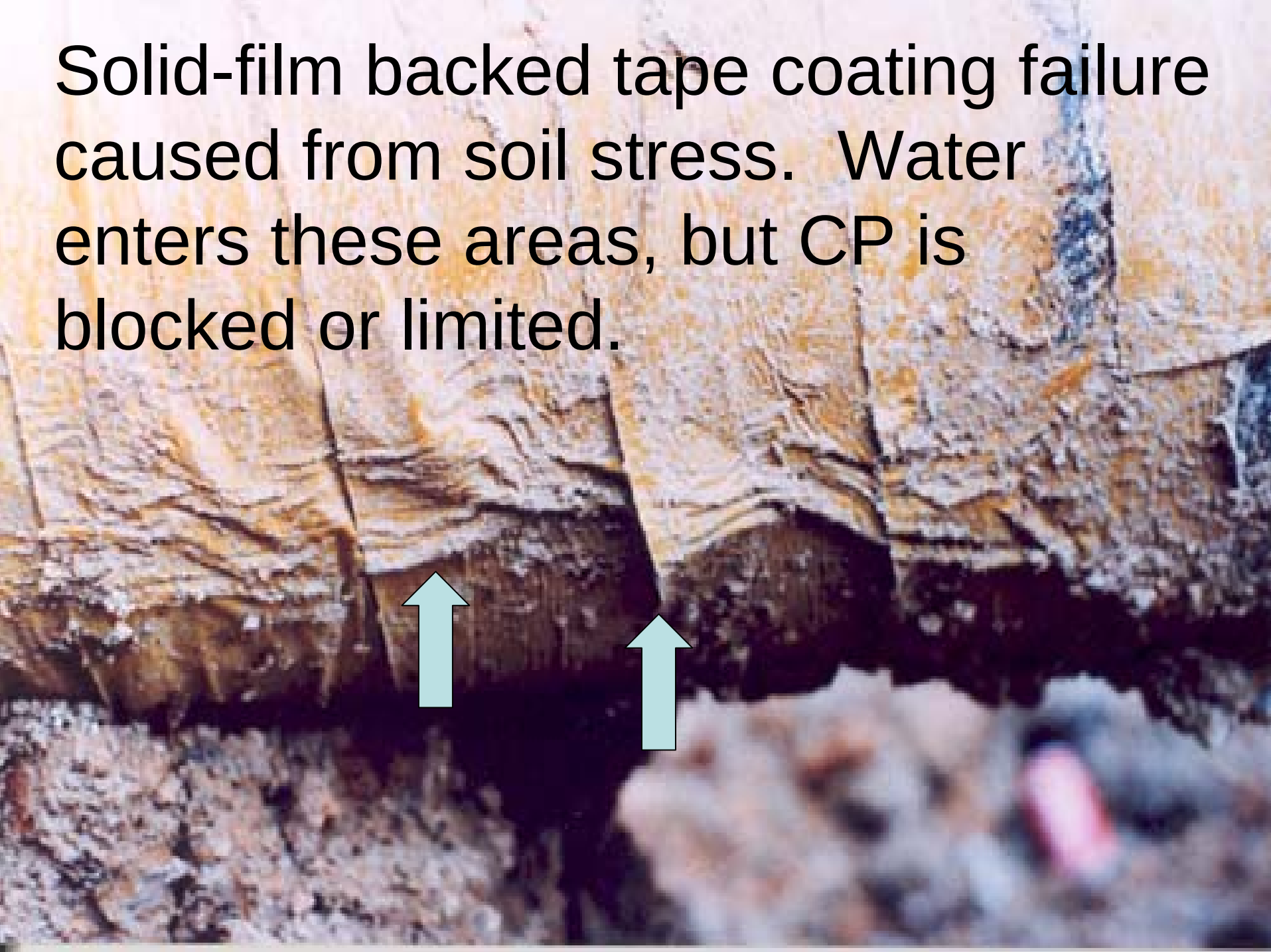
Compound extruding through the weaves of the mesh-backing of the RD-6 when applied with adequate tension.


Compound to compound bond improves adhesion at the overlap of RD-6.

RD-6 does not require heat for application.
No complicated equipment (can be hand applied).
No pot life concerns.
There is no mixing or cure time!
No problems about weather, bugs or debris after application.
Backfill can be immediate!

Coating Selection Criteria

Soil Stress must be considered when choosing a coating system. Many types of coatings are affected by soil stress, especially coatings that stretch easily (most solid-film backed tapes). Coal tar coatings can crack, separate or wrinkle. Shrink sleeves can move or wrinkle causing voids and places for water to enter. Drips and sags from liquid coatings can be areas where soils hold to and cause cracking as pipes move.


Solid-film backed tape coating failure caused from soil stress. Water enters these areas, but CP is blocked or limited.

Soil stress and disbondment on coal tar coating

The RD-6 coating system is designed to resist soil stress when properly applied.

A non-bonded outer wrap is applied over the RD-6 as the final step. This outer wrap provides a "slip plane" causing it to wrinkle instead of the actual coating. Required when RD-6 is hand applied and recommended on large diameter pipe (≥12").

Evaluation of RD-6 after three years of service in Greenville, MS. Serious soil stress area. Outer wrap wrinkled. See next slide.

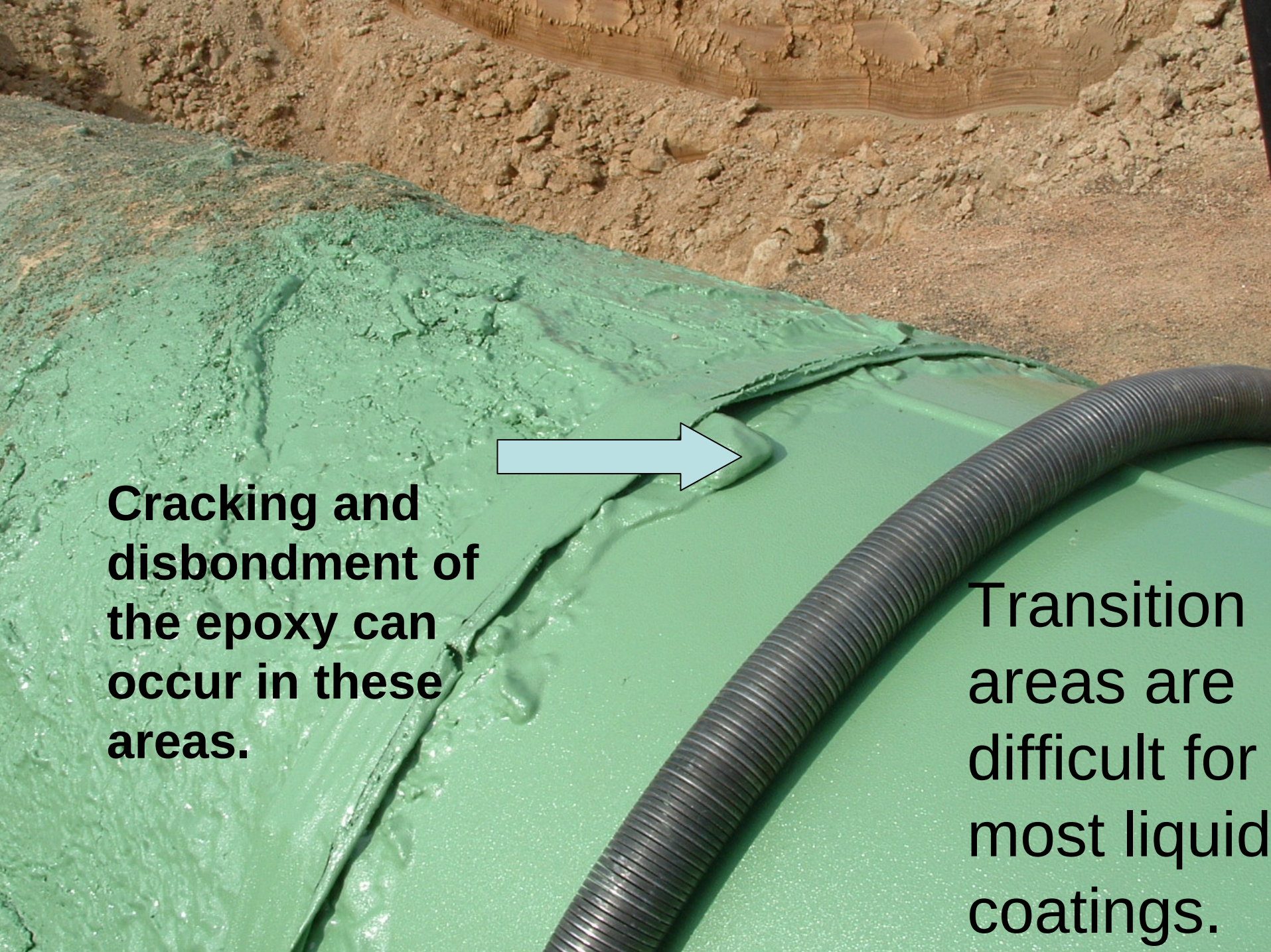

Holiday detection of coating after three years service. RD-6 coating in excellent condition! No holidays! No wrinkles in RD-6!

Stripping the Weld Seam

The weld seams should be stripped to prevent the soil pressure from moving the compound and leaving a thinner coating at the weld.


Stripping the weld seams and 606 filler compound to fill large pits and transition areas.


Cigarette wrap
at transition
from old
coating to new.


Cracking and disbondment of the epoxy can occur in these areas.
Transition areas are difficult for most liquid coatings.

The next slide shows the only known site (after over 15 yrs) that the RD-6 coating actually had wrinkles and water under the coating. The RD-6 was applied without proper tension, no outer wrap, no stripping of the weld seams and at the transition, it was applied directly over the old coal tar coating allowing water to penetrate under the RD-6. This experience provided us with opportunity to prove the "FAIL SAFE" in the field!

Poor application techniques caused this problem. No weld seam tape; No cigarette wrap on the pipe; Not enough tension during application; No outer wrap and coated over the old coating that allowed water!


The compound was displaced at weld seam because it was not stripped leaving little or no compound. Notice some flash rusting from areas not primed properly along weld seam.
Next slide shows properly applied RD-6 in the same area after one year.


Same pipe coated with RD-6 after over 12 months of service with proper outer wrap, tension and stripping of welds.

Coating Selection Criteria continued

- Internal and external operating

  RD-6 performs well at external pipe service temperature up to 150^{o} F (65^{o} C).

- Presence of bacteria and other organisms

  RD-6 has no known effects or deterioration from bacteria or other microbiological organisms.

- RD-6 compound does not dry out or crack and provides the dielectric strength of the coating system. The woven polypropylene backing will not deteriorate in most pipeline conditions.

Coating Selection Criteria
continued

- Compatibility with cathodic protection
  1. RD-6 is very compatible with CP
  2. RD-6 has minimal cathodic disbondment damage
  3. Polyguard can provide many years of CD test results from third party laboratories.

Thirty day cathodic disbondment test [CDT] on RD-6 (1.5 V & 72º F). Typical CDT results are 0 to 8 mm of disbondment.

Failed cathodic disbondment test result (shrink sleeve) after 30 days.

Failure after 3 days in CDT. (Moisture cured urethane)

Compatibility with cathodic protection, cont.

Failed coatings that shield CP (NOT Fail Safe) are the main cause of corrosion problems on cathodically protected pipeline systems, not inadequate CP.

Cathodic Protection, continued

- Higher CP requirements may cause coating damage.
- We must have coatings that resist cathodic disbondment.
- "Fail Safe" properties are important when using more stringent CP criterion.
- **When selecting a pipeline coating, the "Fail Safe" characteristics may be more important than other issues that are normally considered.**

Cathodic Protection, continued

- CP will protect exposed substrate
- May penetrate partially under disbonded coatings at opening or holiday
- CP will not protect under most disbonded coatings.
- “Fail Safe” coatings allow some CP current to protect the substrate when water is present between the coating and the substrate even if there is no opening or holiday.

How to determine if a coating is "Fail Safe"

1. Actual field data

   If a failed coating is found, take pH readings of any water or moisture between the coating and the substrate.

2. Inspect for corrosion.

   If corrosion is not present and the pH is above 8, CP is usually adequate enough to provide some protection to the substrate.

How to determine if a coating is "Fail Safe", continued

3. Corrosion is found, and the pH is > 8

   Determine if corrosion may have occurred before CP was applied or was adequate.

4. Corrosion is found and the pH is < 8

   CP may not be adequate or the coating type shields the CP current.

5. Check several areas if the disbondment is large.

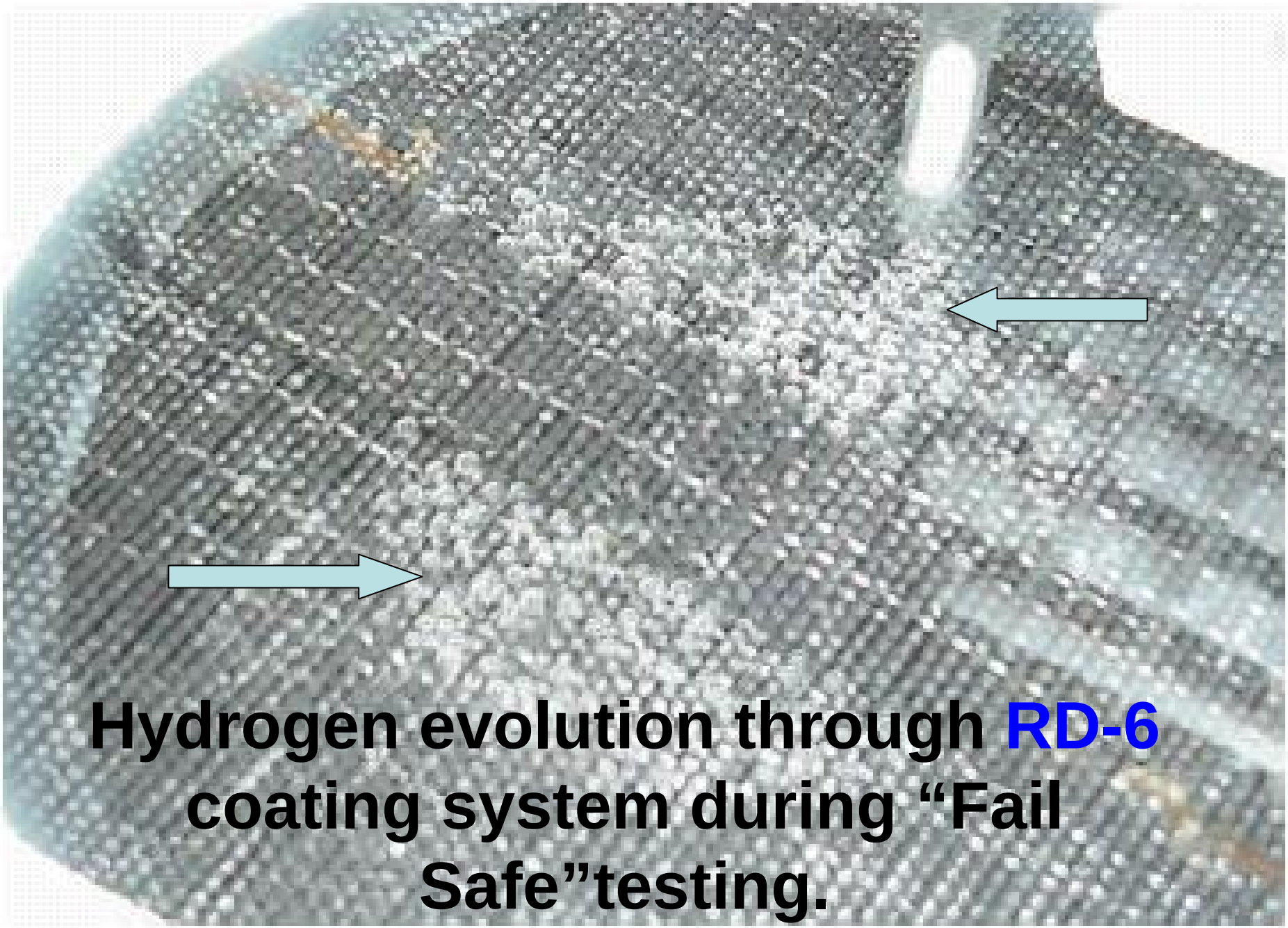
Polyguard RD-6 has been tested in the lab and field to prove it has “Fail Safe” properties.

The RD-6 compound has excellent adhesion, dielectric strength and is very water resistant.

Polyguard will furnish data of these test results upon request.

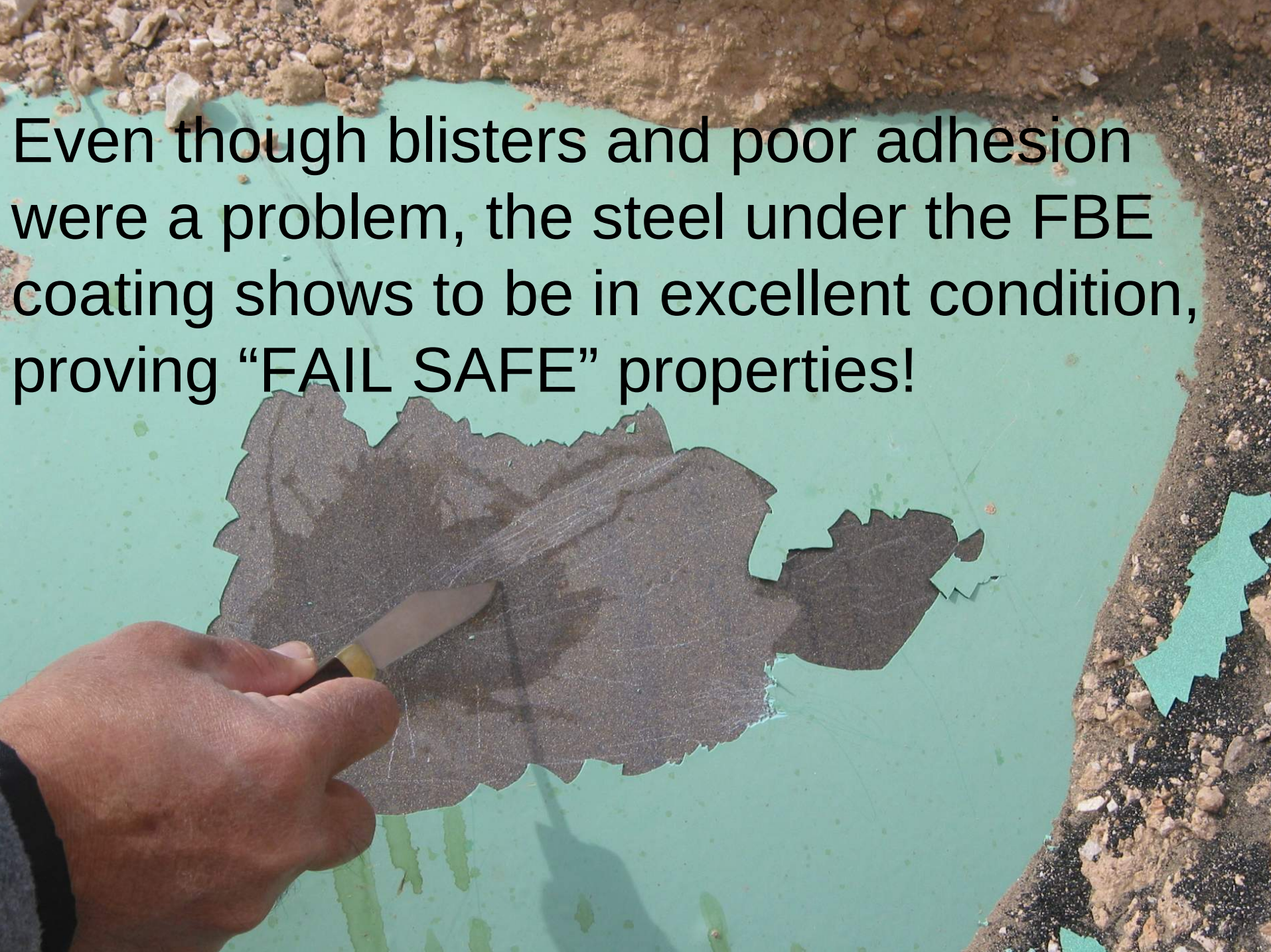
RD-6 – A “Fail Safe” Pipeline Coating System

The RD-6 is a mesh backed coating system that allows CP under the coating (similar to FBE) if water is present, and in contact with the overlap. The following photo shows the hydrogen evolution taking place during “Fail Safe” testing of the RD-6. Further proof of the “Fail Safe” properties.



Hydrogen evolution through RD-6 coating system during “Fail Safe”testing.


Water under blisters on FBE coated pipe
used for gas transmission in central USA.
Water under the blisters had a Ph of 12.


Even though blisters and poor adhesion were a problem, the steel under the FBE coating shows to be in excellent condition, proving “FAIL SAFE” properties!


Checking pH
of water
under the
improperly
applied RD-6
(Same area
as shown
before).

pH check indicates a high pH (9 to 10) in water under the improperly applied RD-6 showing it is “Fail Safe”.


Checking pH under disbonded coal tar coating with significant corrosion present. This site is only a few feet from the previous slide.


pH of 5 to 6 under disbonded coal tar coating.
3
4
6
7
8
9

Other advantages of "Fail Safe" coatings

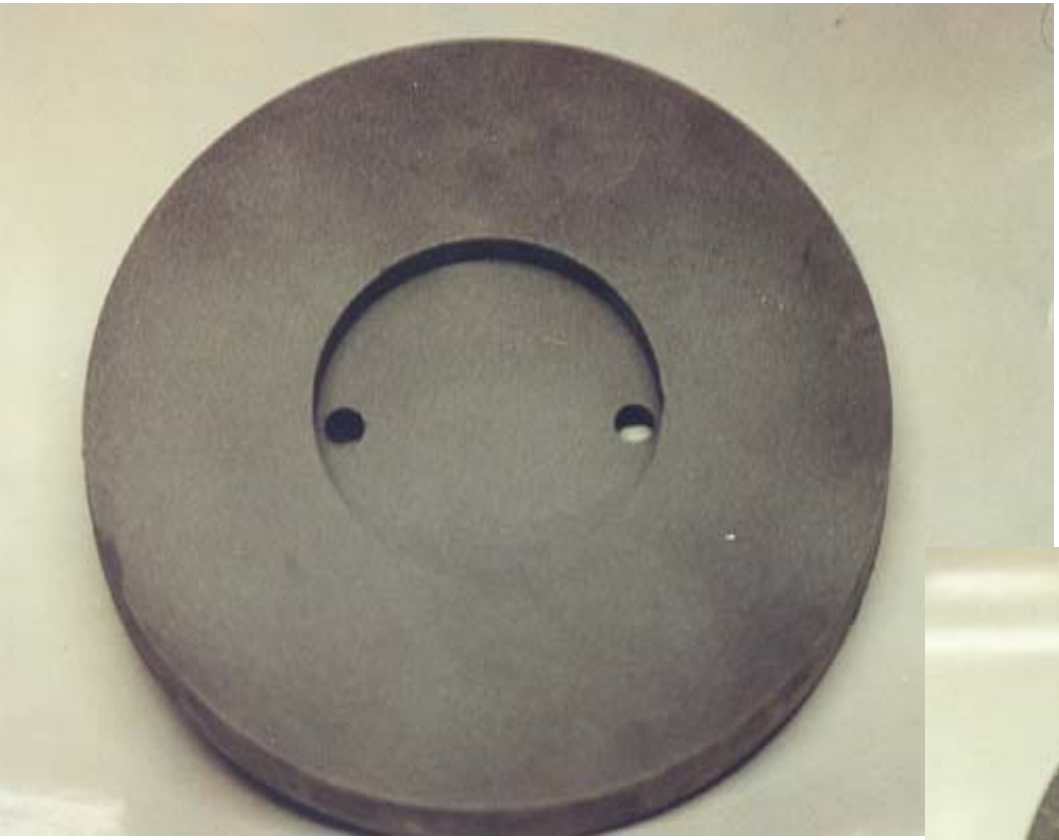
- Because FBE and RD-6 allow protective currents into most failed areas, these areas may be found by using DCVG surveys.
- Since these are "Fail Safe" coatings there is no hurry to repair. Repairs can be made if CP requirements become too high.

When properly applied, RD-6 has no reported failures!

How to determine if a coating is "Fail Safe", continued

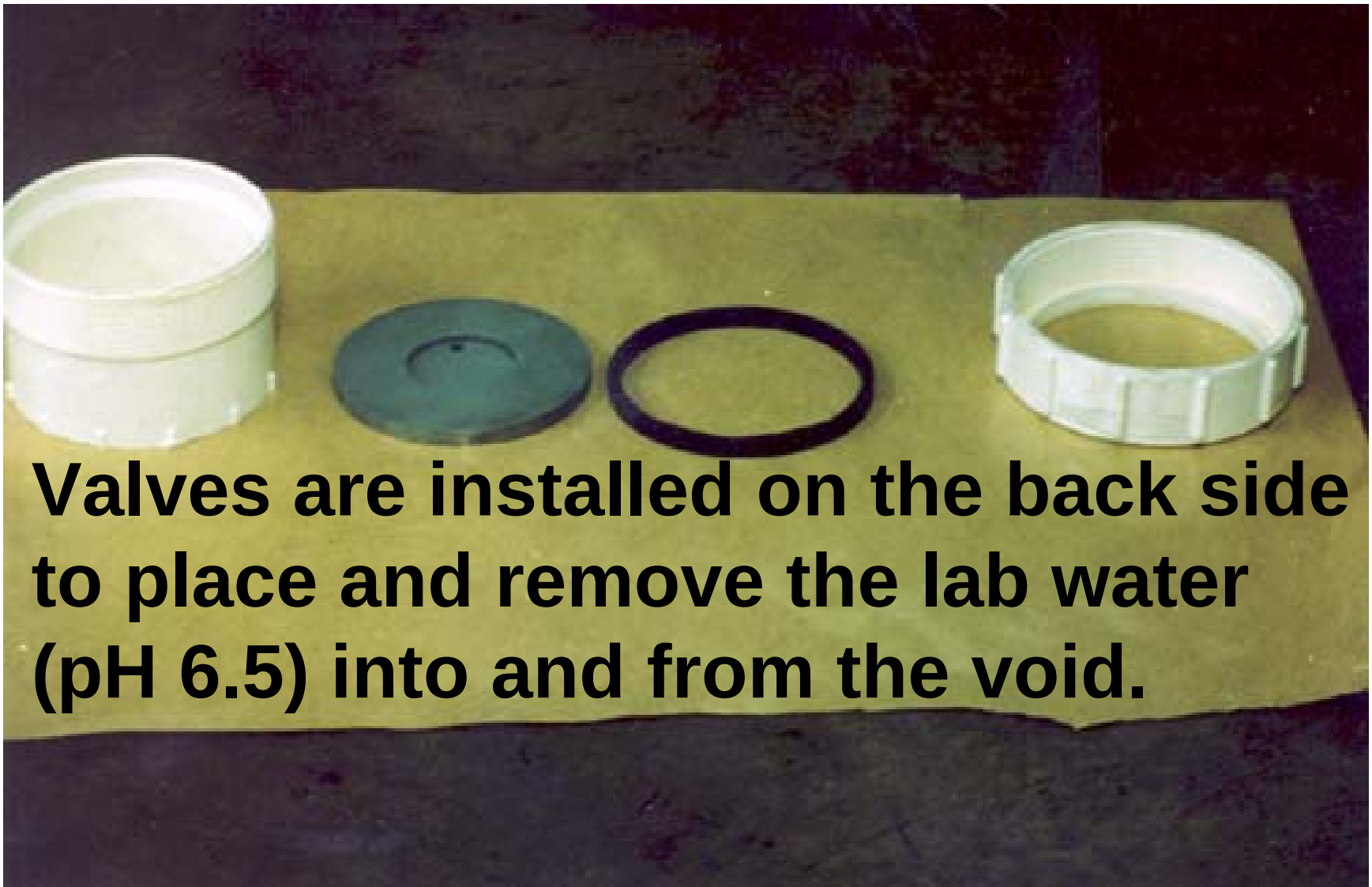
- Lab testing can be another effective method of determining if a coating will be "fail safe".
- Proper testing requires successfully duplicating the condition of disbonded coating as encountered in the field.

Test jig for determining "Fail Safe" coatings



Disc is 0.5" thick, approximately 8" in diameter with a 3" x 0.25" machined area for "Fail Safe" void under coating.

Test jig for determining "Fail Safe" coatings, continued



Test jig for determining "Fail Safe" coatings, con.

Coating is applied over the disc with void. After sealing, water is placed on top of the coating and a anode is placed in this water. Negative return is attached to the bottom plate. 1.5 to 3 volts is applied for two weeks.

How to determine if a coating is "Fail Safe", continued

- Typically, if the coating is not "fail safe", the pH of the water in the void will change less than one pH value either way.
- With a "fail safe" coating the pH of the water will typically change to between 9 and 13.
- Repeated testing is required to help eliminate possible errors.
- Test jigs may have to be adapted slightly for certain coating types.

Conclusions

- Pipeline coatings can be proven to be “fail safe” through field observations and laboratory testing.
- There must be a balance between a coatings overall performance and the cathodic protection system.
- The coating system must withstand soil stress, be easy to apply and be compatible the environment.

Conclusions, continued

- Field applied coatings for rehabilitation and girth welds such as RD-6 must be compatible with existing coating systems.
- **“Fail Safe”** coatings systems such as **RD-6** and FBE provide characteristics that are very desirable to the end user.
- **When selecting a pipeline coating, the “Fail Safe” characteristics may be more important than other issues that are normally considered.**

Some RD-6 Advantages:

1. **Proven “Fail safe” properties (similar to FBE) helping to prevent corrosion and SCC if water does penetrate.**
2. **Very resistant to soil stress; even better with unbonded outer wrap.**
3. **Compatible with most other pipeline coatings; great for rehabilitation and girth welds!**
4. **No heat required to apply, much safer!**
5. **Very compatible with CP (Over 15 years of test data and in-service life).**
6. **Limited surface preparation, easy application, no pot life problems or complicated equipment.**
7. **Resistant to microbiological attack.**
8. **Defective areas may be found by DCVG survey.**
9. **No known failures when properly applied!**
10. **Engineered to meet your pipeline coating requirements!!**