

5.6 Seams and Details

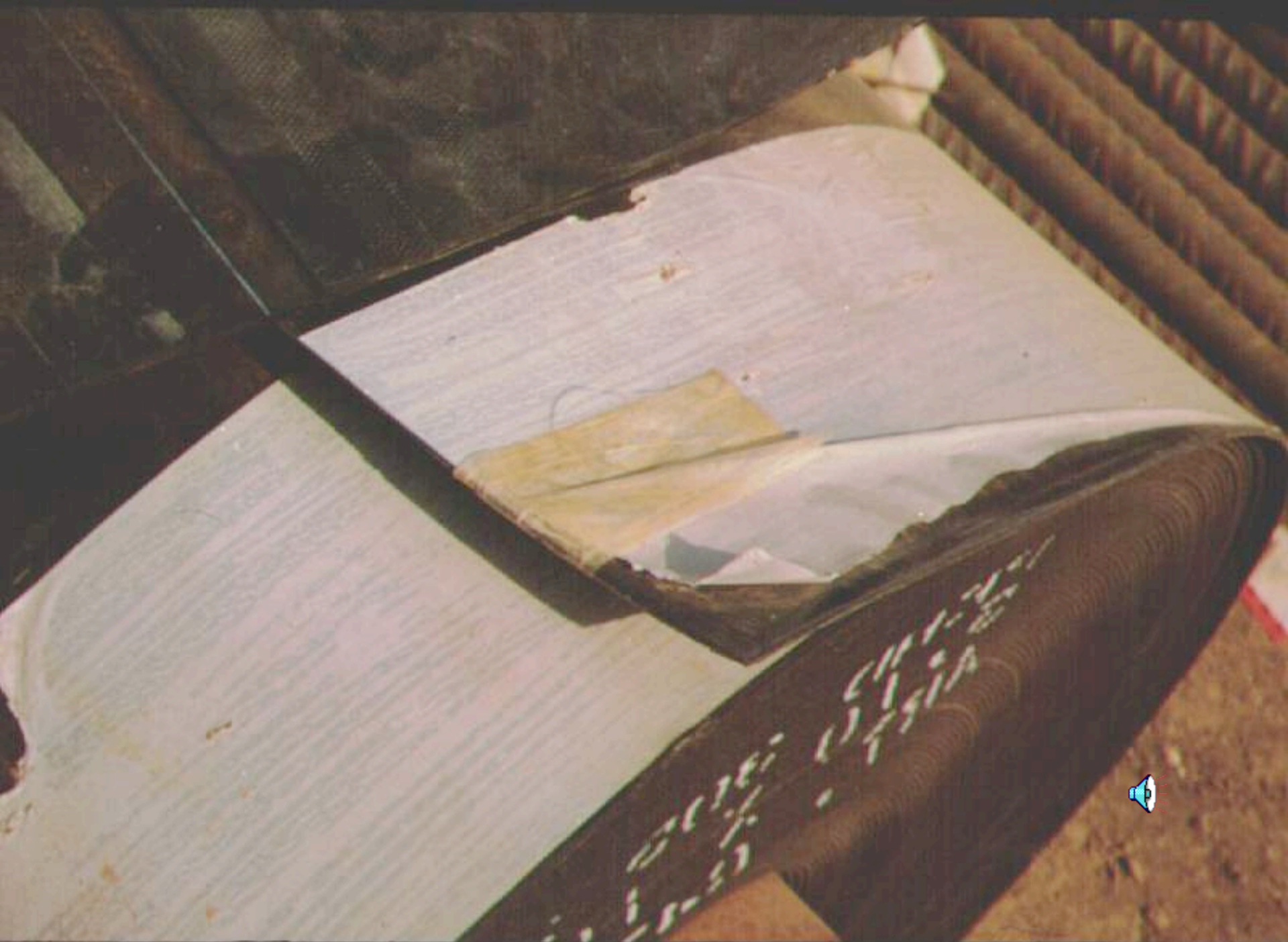
- "the" major concern with regard to leakage
- electrical field method indicates 80% of leaks are in seams and details (e.g., appurtenances)
- trial seams are important
- destructive tests (both shear and peel) are necessary
- different sampling strategies are available, e.g., method of attributes per GRI GM14
- nondestructive tests required throughout













Various Field Seaming Methods for Different Geomembranes

| Type of Seaming Method | Type of Geomembrane | | | | | | |
|---|---------------------|----------|-----|-----|--------|--------|---------|
| | HDPE | VFP E | fPP | PVC | CSPE-R | EIA -R | EPDM -R |
| extrusion (fillet) | A | A | A | n/a | n/a | n/a | n/a |
| thermal fusion (hot wedge and hot a | A | A | A | A | A | A | n/a |
| chemical (solvent and bodied solvent) | n/a | n/a | n/a | A | A | A | n/a |
| adhesive (chemical and contac | n/a | n/a | n/a | A | A | A | A |

n/a = not applicable



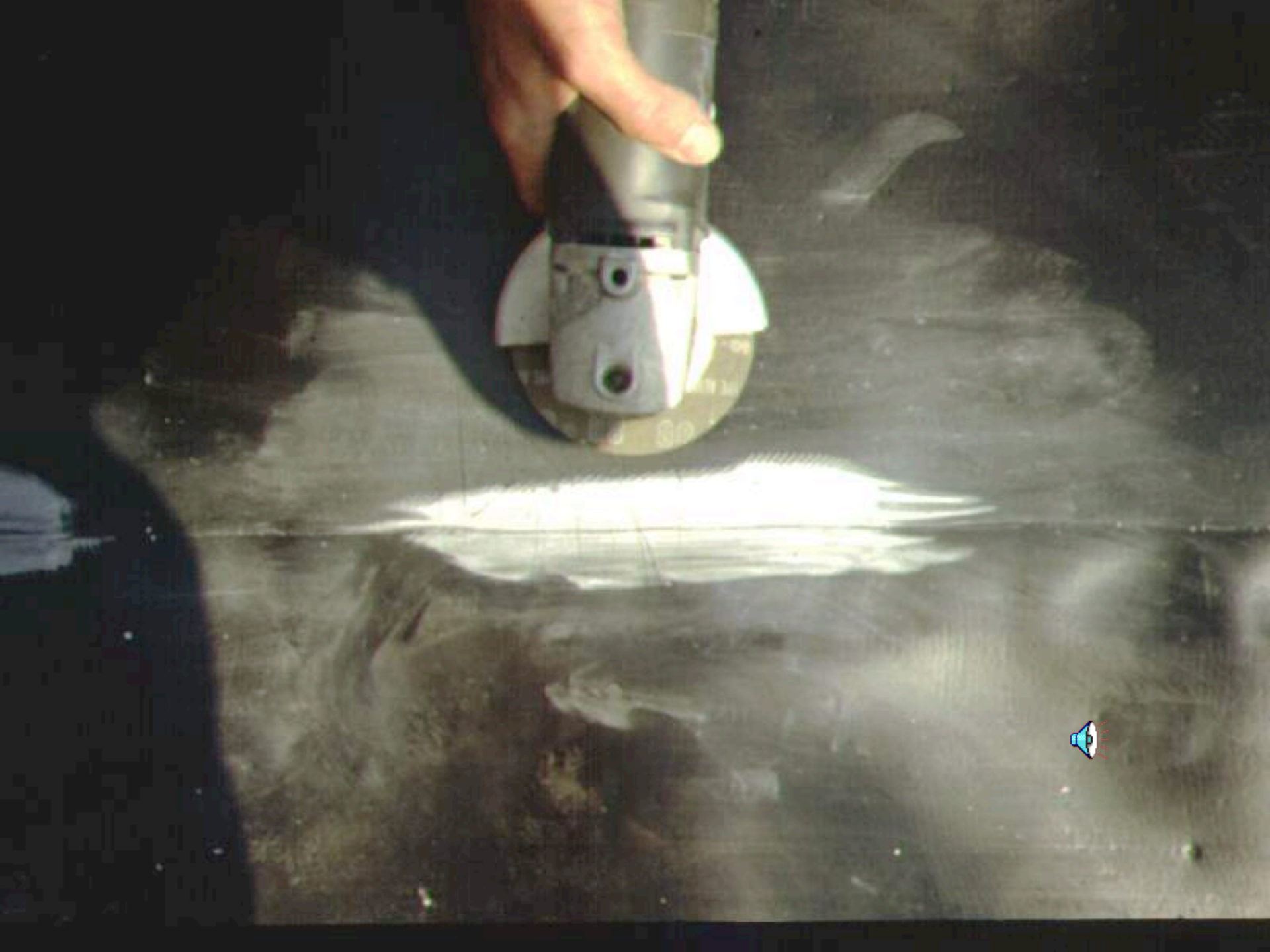
Extrusion Fillet Seaming













Extrusion Fillet Seam
(excessive flashing) 

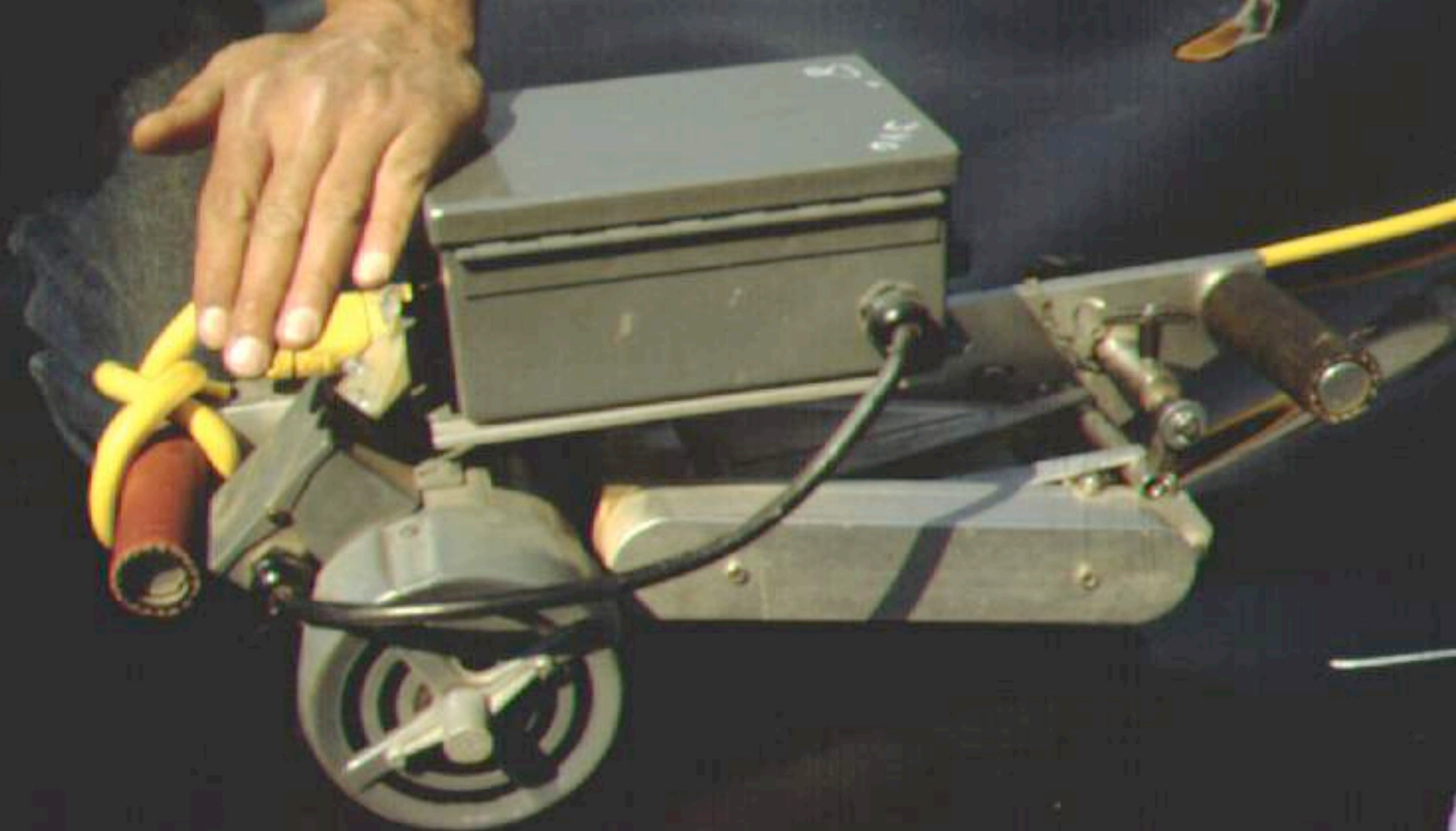


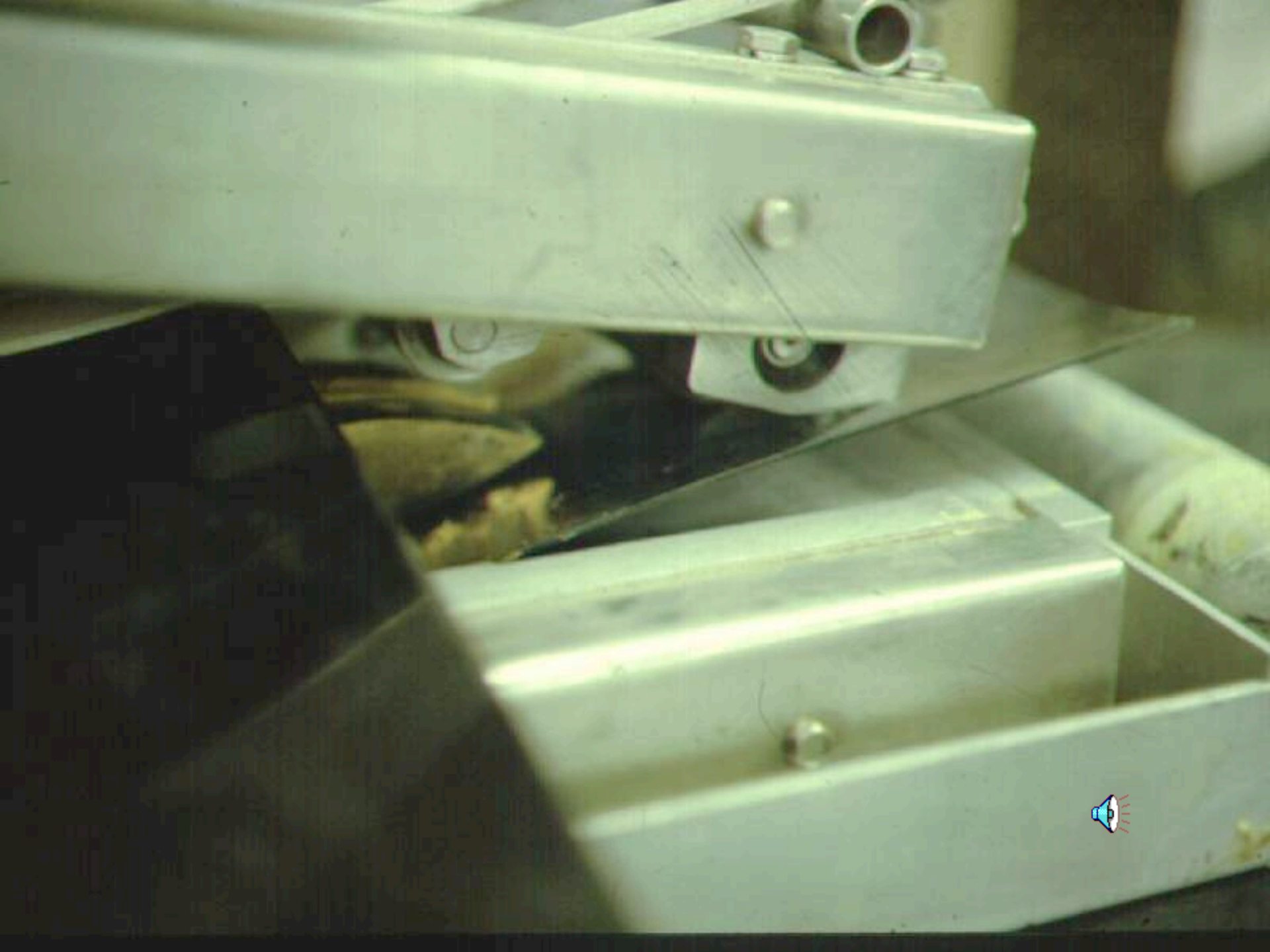
Extrusion Fillet Seam
(excessive heat-puckered)




Thermal Fusion (Hot Wedge)



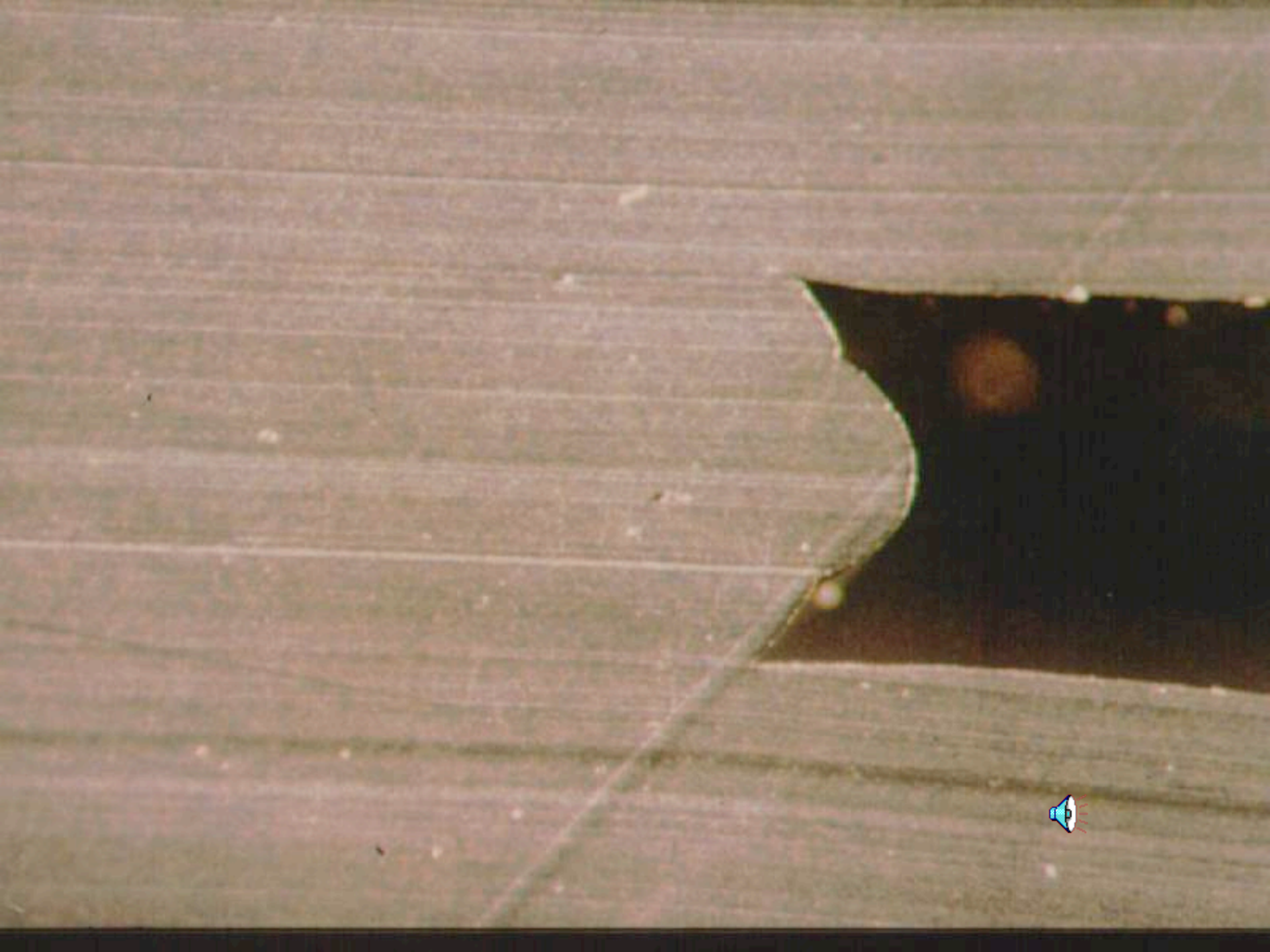






Dual Hot Wedge Seam
excessive squeeze-out







Dual Hot Wedge Seam
roughened sheet - acceptable







Dual Hot Wedge Seam
(roughened sheet - poor)



Thermal Fusion (Hot Air)









Single Hot Air

good example - 1.0 mm



Chemical
(Solvent and
Bodied Solvent)









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Geomembrane Test Strips

- Prequalifies personnel, equipment and procedures
- Typically on 2-3 m long strips of excess GM
- Made before AM-work; before PM-work, and changes in weather conditions
- Shear and peel tests via field tensiometer
- Seams pass → go to production seams
- Seams fail → try again
- Seams fail → retain crew or modify equipment
- CQA document must be specific







Recommended Test Method Details for Geomembrane Seams in Shear and in Peel and for Unseamed Sheet in Tension

| Type of Test | HDPE | LLDPE | PVC | CSPE-R | EIA-R |
|------------------------------|----------------|----------------|----------------|---------------|---------------|
| Shear Test on Seams | | | | | |
| ASTM Test Method | D6392 | D6392 | D3083/D6392 | D751 | D751 |
| Specimen Shape | Strip | Strip | Strip | Grab | Grab |
| Specimen Width (mm) | 25 | 25 | 25 | 100 (25 grab) | 100 (25 grab) |
| Specimen Length (mm) | 150 + seam | 150 + seam | 150 + seam | 225 + seam | 225 + seam |
| Gage Length (mm) | 100 + seam | 100 + seam | 100 + seam | 150 + seam | 150 + seam |
| Strain Rate (mm/min.) | 50 | 500 | 500 | 300 | 300 |
| Strength (kPa) or (kN) | Force/(25 × t) | Force/(25 × t) | Force/(25 × t) | Force | Force |
| Peel Test on Seams | | | | | |
| ASTM Test Method | D6392 | D6392 | D413/D6392 | D413 | D751 |
| Specimen Shape | Strip | Strip | Strip | Strip | Strip |
| Specimen Width (mm) | 25 | 25 | 25 | 25 | 25 |
| Specimen Length (mm) | 100 | 100 | 100 | 100 | 100 |
| Gage Length (mm) | n/a | n/a | n/a | n/a | n/a |
| Strain Rate (mm/min.) | 50 | 500 | 50 | 50 | 50 |
| Strength (kPa) or (kN) | Force/(25 × t) | Force/(25 × t) | Force/25 | Force/25 | Force/25 |
| Tensile Test on Sheet | | | | | |
| ASTM Test Method | D638 | D638 | D882 | D751 | D751 |
| Specimen Shape | Dumbbell | Dumbbell | Strip | Grab | Grab |
| Specimen Width (mm) | 6.3 | 6.3 | 25 | 100 (25 Grab) | 100 (25 Grab) |
| Specimen Length (mm) | 115 | 115 | 150 | 150 | 150 |
| Gage Length (mm) | 33 | 33 | 50 | 75 | 75 |
| Strain Rate (mm/min) | 50 | 500 | 500 | 300 | 300 |
| Strength (kPa) or (kN) | Force/(wt) | Force/(wt) | Force/(wt) | Force | Force |
| Strain (mm/min.) | Elong/33 | Elong/33 | Elong/50 | Elong/75 | Elong/75 |
| Modulus (kPa) | From Graph | From Graph | From Graph | n/a | n/a |

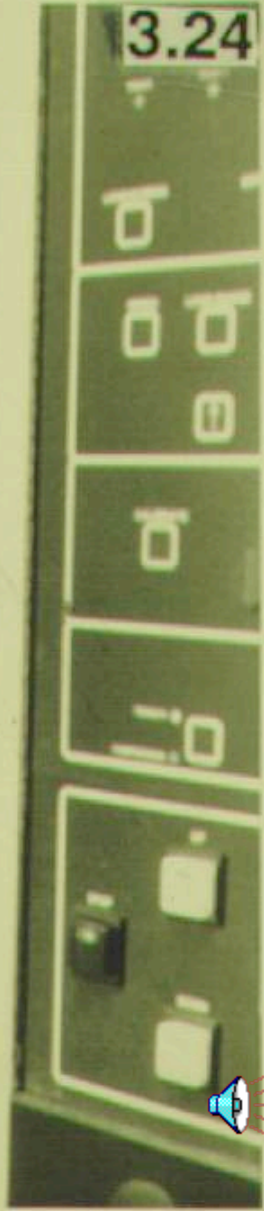
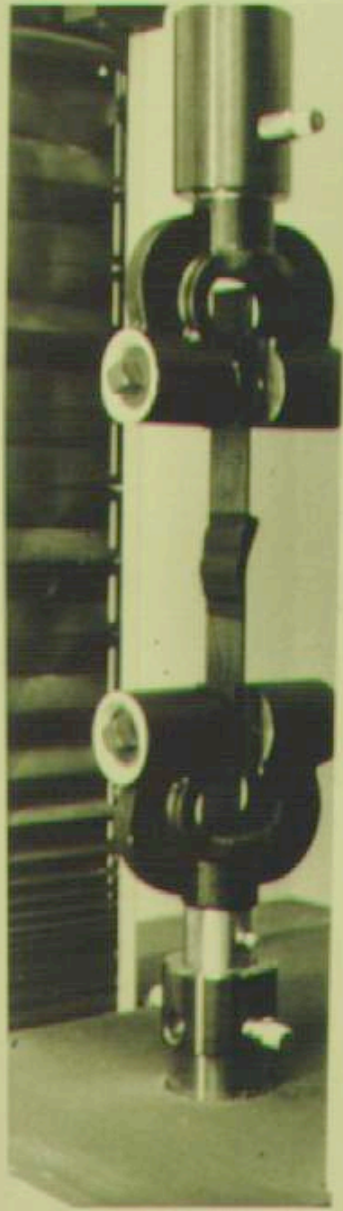
where n/a = not applicable, t = geomembrane thickness, w = specimen width



Destructive Seam Tests

- Typically 1 per 150 m seam
- From 0.5 to 1.5 m long sample
- Distribute as per CQA plan
- Typically 5 shear and 5 peel from each 300 mm long sample
- CQA plan must be specific regarding pass/fail criteria
- If failure, take 2 new samples 3 m on each side of failure
- Repeat until bad section bounded
- Cap strip accordingly







3.25





Nondestructive Seam Tests

| NDT Method | Seam Types* | Geomembrane Types |
|----------------------------|--------------------------------------|---------------------|
| 1. air lance | C, BC, Chem. A., Cont. A | all, except HDPE |
| 2. mechanical point stress | all | all |
| 3. dual seam | HW, HA | all |
| 4. vacuum chamber | all | all |
| 5. electric wire | all | all |
| 6. electric current | all | all |
| 7. ultrasonic pulse echo | HW, HA C, BC, Chem. A, Cont. A | HDPE, VLDPE, PVC |
| 8. ultrasonic impedanc | HW, HA C, BC, Chem. A, Cont. A | HDPE, VLDPE, PVC |
| 9. ultrasonic shadow | E Fil., HW, HA | HDPE, VLDPE |

*E Fil. = extrusion fillet
 HW = hot wedge
 HA = hot air
 C = chemical (solvent)

BC = bodied chemical (solvent)
 Chem. A = chemical adhesive
 Cont. A = contact adhesive



5.7 QA/QC

- **Both quality in manufacturing and in construction are necessary for geosynthetics**
- **MQC/MQA (in factory) in tandem with CQC/CQA (in field) is ideal**
- **Leakage rates are directly related to good CQC, followed by good CQA**
- **Numerous reports/papers are currently available**
- **Costs of CQA are 2-10% of completed facility**



Recommended U. S. EPA Implementation Programs

Implementation Program for CQA (i.e., field inspectors/monitors)

| No. of Field Crews* At Each Site | No. of Certified Personnel |
|-------------------------------------|--|
| 1-2 | 1 - Level III** |
| 3-4 | 1 - Level III** 1 - Level I |
| ≥ 5 | 1 - Level III** 1 - Level II 1 - Level I |

*Performing a Critical Operation; Typically 4 to 6
People/Crew

**Or PE with applicable experience



Recommended U. S. EPA Implementation Programs (*cont'd*)

Implementation Program for CQC (i.e., field installers/contractors)

| No. of Field Crews* At Each Site | No. of Certified Personnel |
|-------------------------------------|--------------------------------|
| 1-4 | 1 - Level III** |
| ≥ 5 | 1 - Level III** 1 - Level I |

*Performing a Critical Operation; Typically 4 to 6
People/Crew

**Or PE with applicable experience



Certification of CQA/CQC Field Installation Inspectors

- **NICET Certification**

- Level I (entry)
- Level II (2 yr. exp.)
- Level III (5 yr. exp.)

- **Subfields**

| | | |
|--------|-----|------|
| CSPE-R | PVC | HDPE |
| VLDPE | GCL | GN |
| GT | GG | GA |

- **Compacted Clay Liners and Soil Collection Systems to be added** 

Certification of CQA/CQC Field Installation Inspectors (*cont'd*)

- Tests began in December 1992
- Tests given in 200 locations
- Four times per year
- \$75 per test
- \$20 annual fee for registry
- multiple choice answers
- recommendations by immediate supervisor
- recommended in EPA Technical Guidance Document
- program is not a good fit for CQC (activity is ongoing by Installers Assoc., IAGI)



Geosynthetic Testing Laboratory Accreditation Program

- **not certification of results, but accreditation of laboratory equipment and infrastructure**
- **follows ISO 9003**
- **test-by-test challenge on actual performance**
- **Geosynthetic Accreditation Institute-Lab Accreditation Program (GAI-LAP) effort**



GAI-LAP

- **Applying Laboratory Must Supply:**
 - quality manual
 - SOP's of all tests
 - typ. reports of all tests
- **laboratory visit by auditor(s)**
- **each test - yes, no, or pending**
- **subsequent year's are handled by proficiency testing**
- **program began January 1, 1995**
- **contact: Dr. George Koerner/Geosynthetic Institute**



Other Possible Activities

- **Certification of Geosynthetic Testing Laboratory Technicians**
- **Certification of Geosynthetic Products per Generic Specification**
 - geomembranes (begin 1999)
 - geonets (?)
 - geotextiles (?)
 - geogrids (?)
 - geosynthetic clay liners (?)
 - geocomposites (?)
 - geopipe (?)
- **Certification of Geosynthetic Design Engineers (???)**



5.8 Summary

- **Geosynthetics are bona fide engineering materials**
- **Test methods and designs are available - challenge them accordingly**
- **Liner systems are very capable of assuring environmentally safe and secure waste facilities**
- **Basic advantage of geosynthetics is quality control of factory manufactured products**
- **Products must be accompanied by rigorous CQC/CQA**
- **Geosynthetics potential is awesome!**



**We Thank You for Your
Attendance and Best Wishes in
Your Use of Geosynthetics!**

