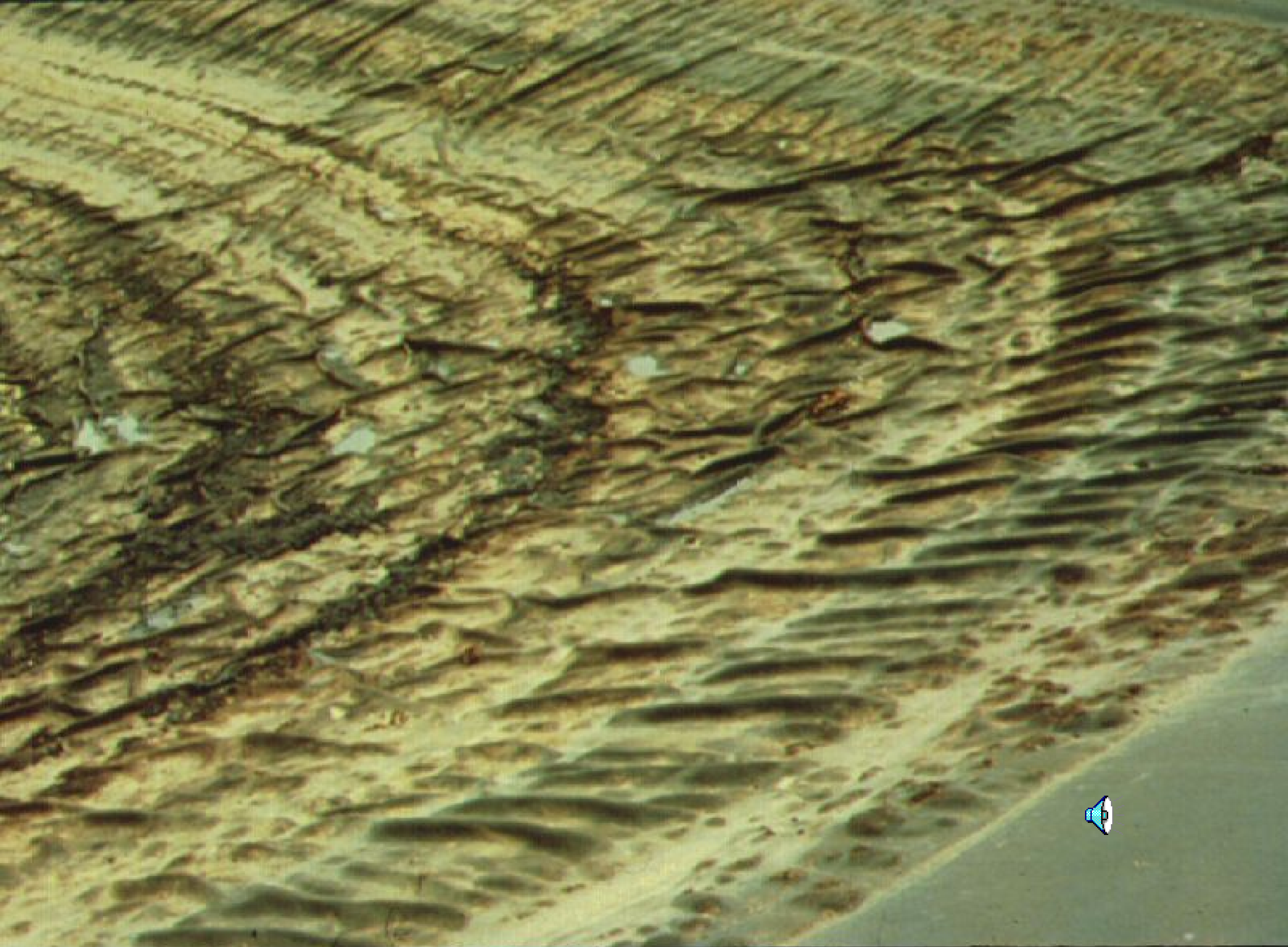
5.0 Concerns and Summary

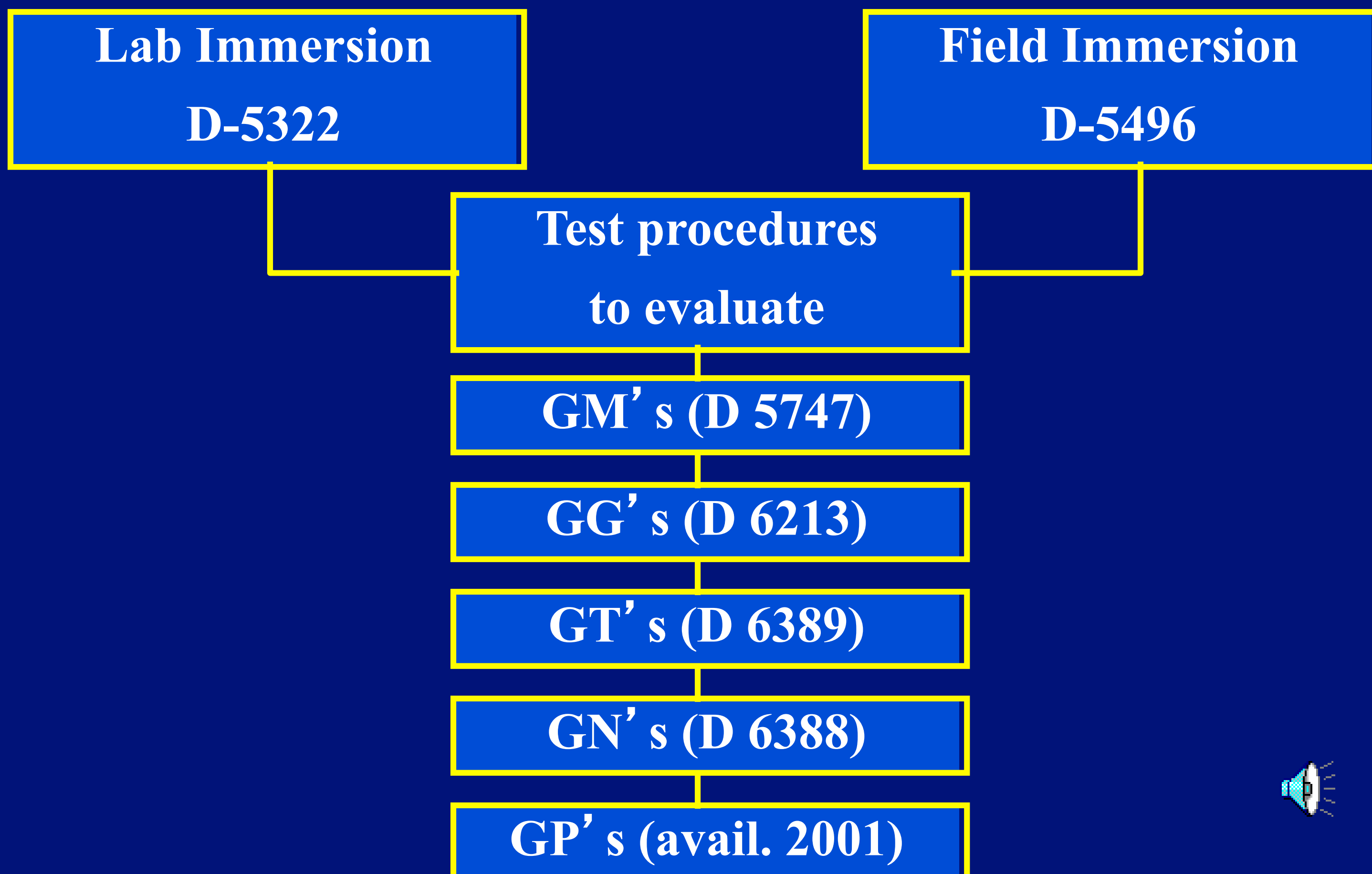
5.1 Chemical Resistance
5.2 Geosynthetic Lifetime
5.3 Biological Clogging
5.4 Waves (or Wrinkles) in GMs
5.5 Wind Uplift
5.6 Seams and Details
5.7 QC/QA
5.8 Summary

5.1 Chemical Resistance

- Resistance must be shown against the site-specific leachate
- EPA 9090 for GMs is depreciated
- ASTM has numerous TG's working on this topic
- Numerous examples of incompatibility are available

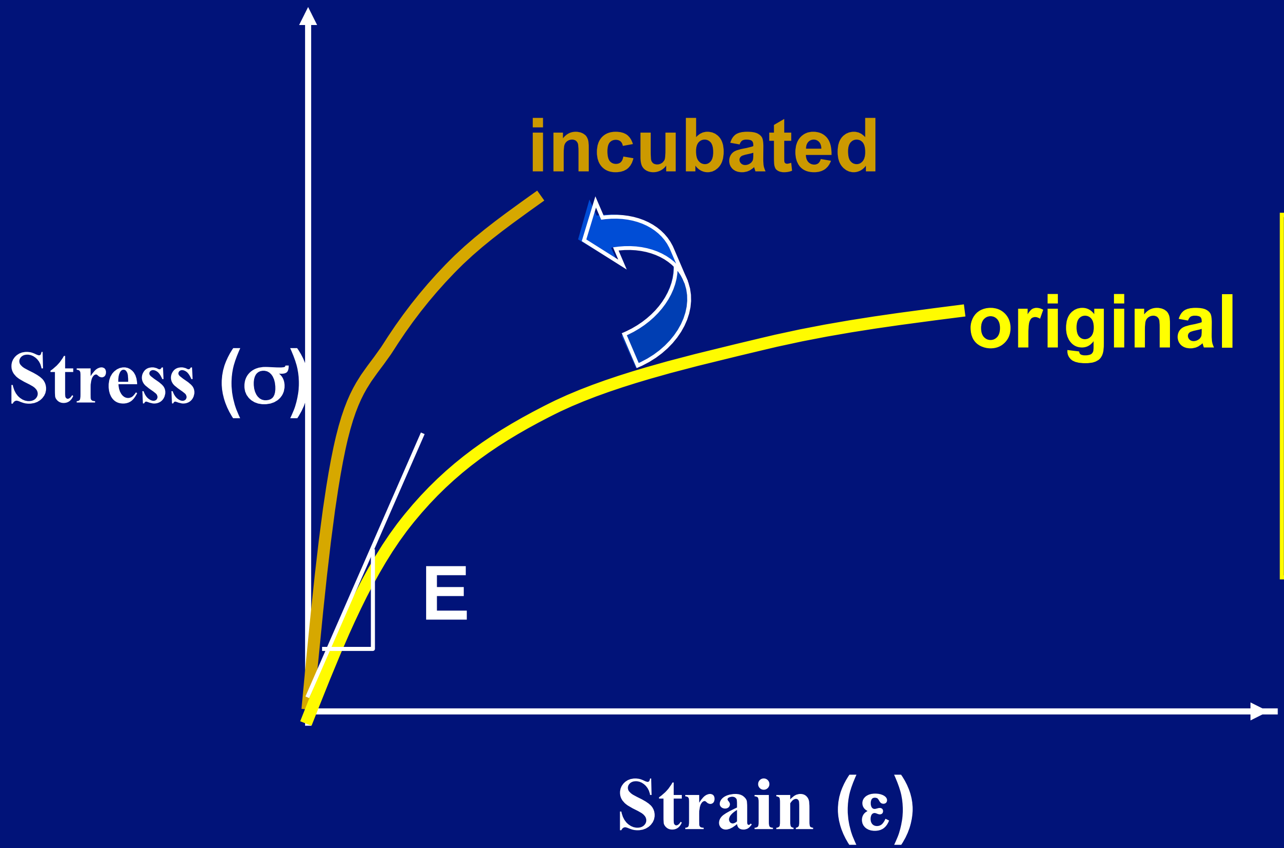


ASTM Task Groups for Chemical Resistance of Geosynthetics



In General

Reaction will cause ductile-to-brittle behavior

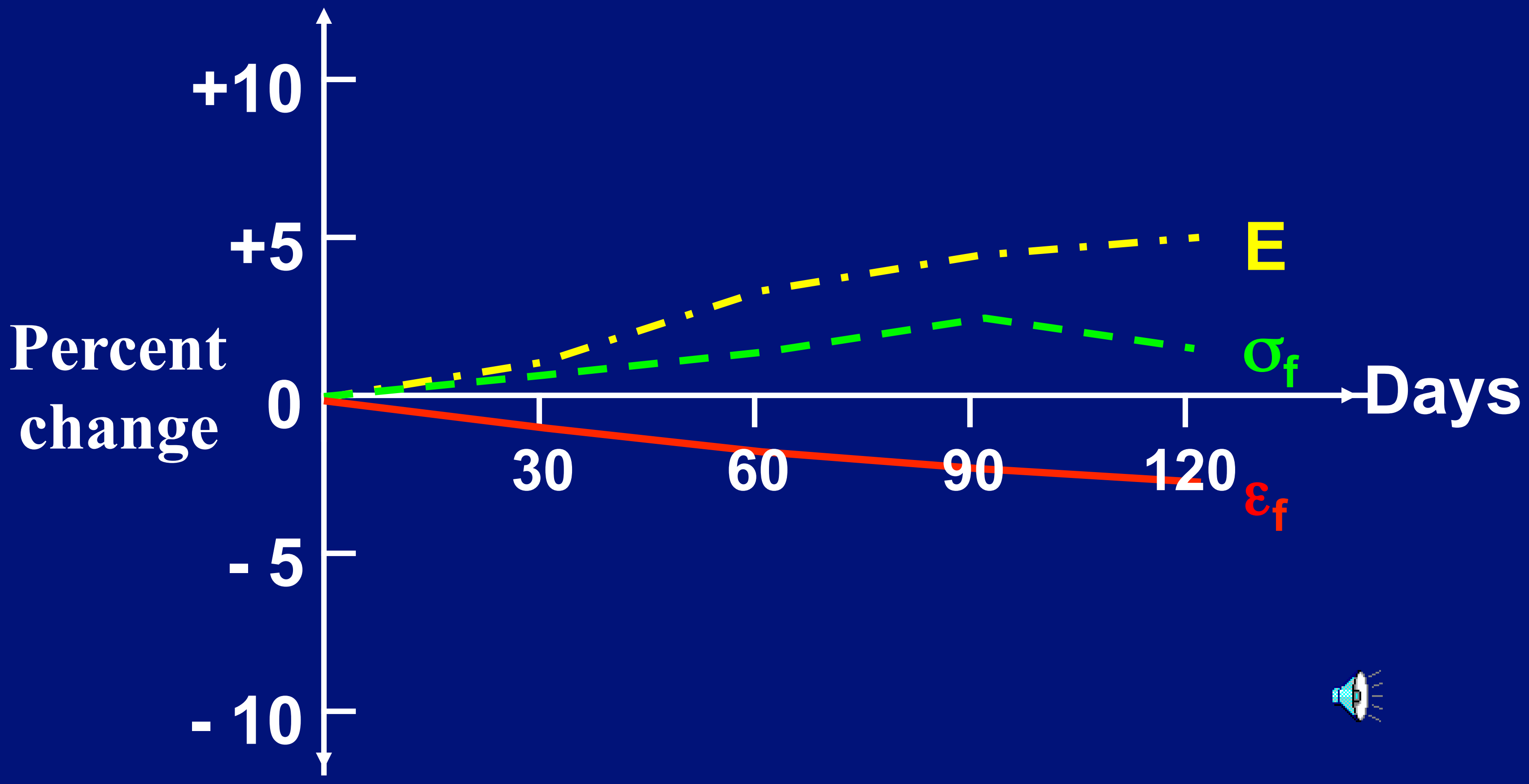


ε_f decreases

E increases

σ_f increases some then decreases

Hypothetical Response



Suggested Limits of Different Test Values for Incubated Geomembranes

Thermoset and Thermoplastic Polymers, e.g., EPDM-R, PVC, CSPE-R, EAI-R, A. D. Little Co. (also LLDPE, fPP and fPP-R)

Property	Resistant	Not Resistant
Permeation Rate	<0.9 g/m^2/hr.	>0.9 g/m^2/hr.
Change in weight (%)	<10	>10
Change in volume (%)	<10	>10
Change in tensile strength (%)	<20	>20
Change in elongation at break (%)	<30	>30
Change in 100% or 200% modulus (%)	<30	>30
Change in hardness (points)	<10	>10

Suggested Limits of Different Test Values for Incubated Geomembranes *(cont'd)*

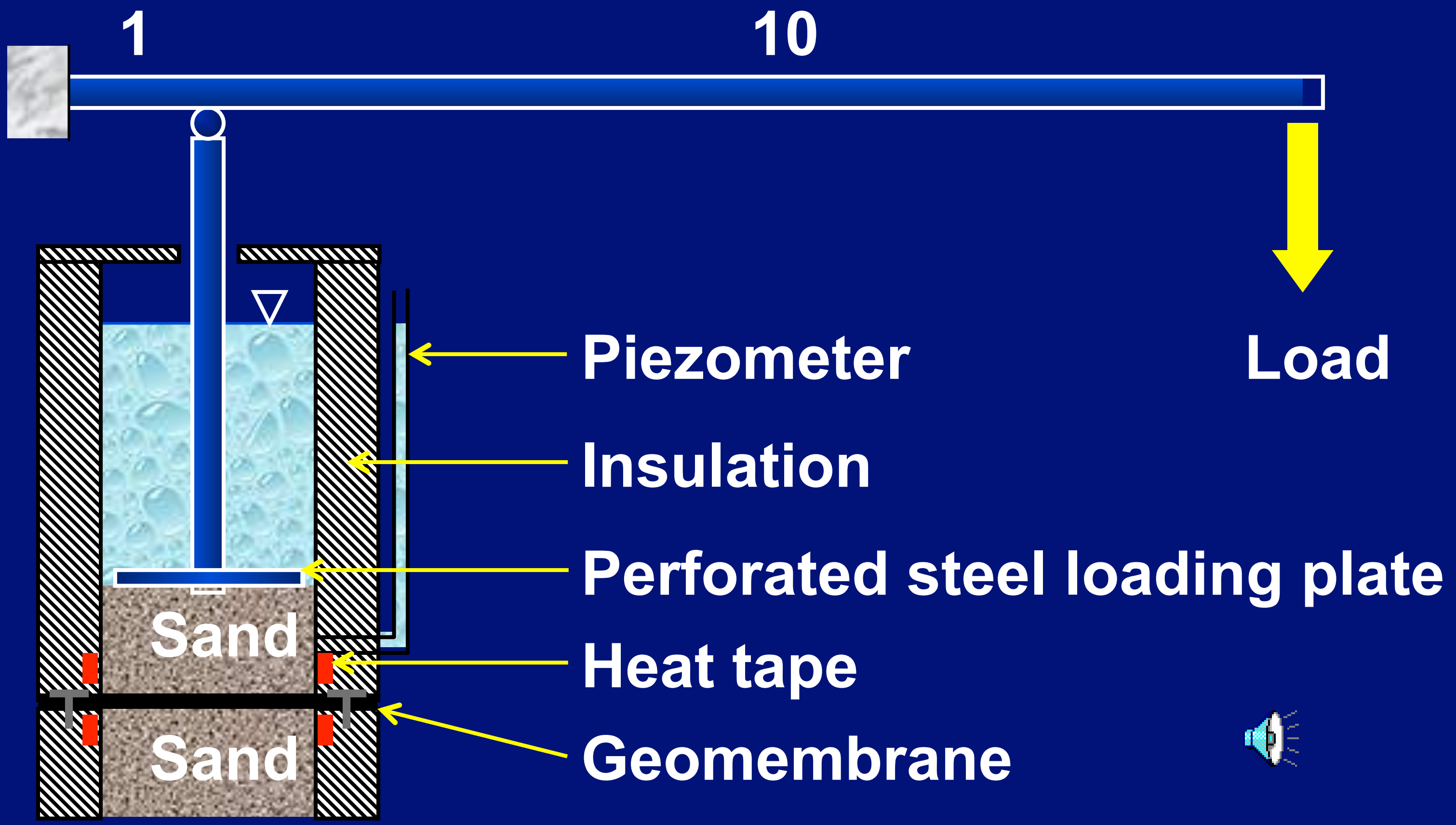
Semicrystalline Polymers (e.g., HDPE)

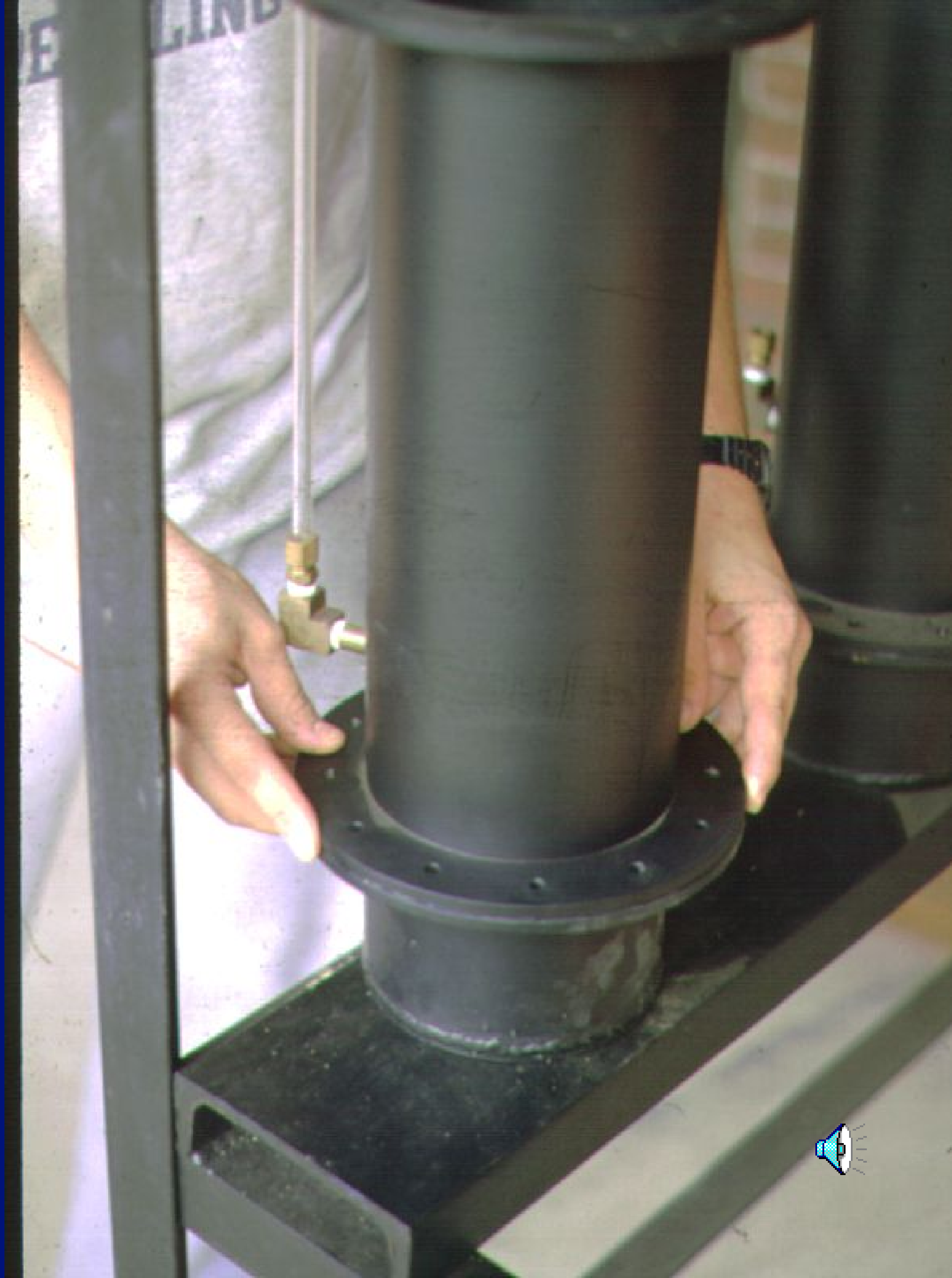
	Plastics Encyclopedia		A. D. Little Co.		Koerner (1998)	
Property	Resistant	Not Resistant	Resistant	Not Resistant	Resistant	Not Resistant
Permeation rate (g/m^2/hr.)	-	-	< 0.9	≥0.9	< 0.9	≥ 0.9
Change in weight (%)	< 0.5	> 1.0	< 3	≥ 3	< 2	≥ 2
Change in volume (%)	< 0.2	> 0.5	< 1	≥ 1	< 1	≥ 1
Change in yield strength(%)	< 10	> 20	< 20	≥ 20	< 20	≥ 20
Change in yield elongation (%)	-	-	< 20	≥ 20	< 30	≥ 30
Change in modulus (%)	-	-	-	-	< 30	≥ 30
Change in tear strength (%)	-	-	-	-	< 20	≥ 20
Change in puncture strength (%)	-	-	-	-	< 30	≥ 30

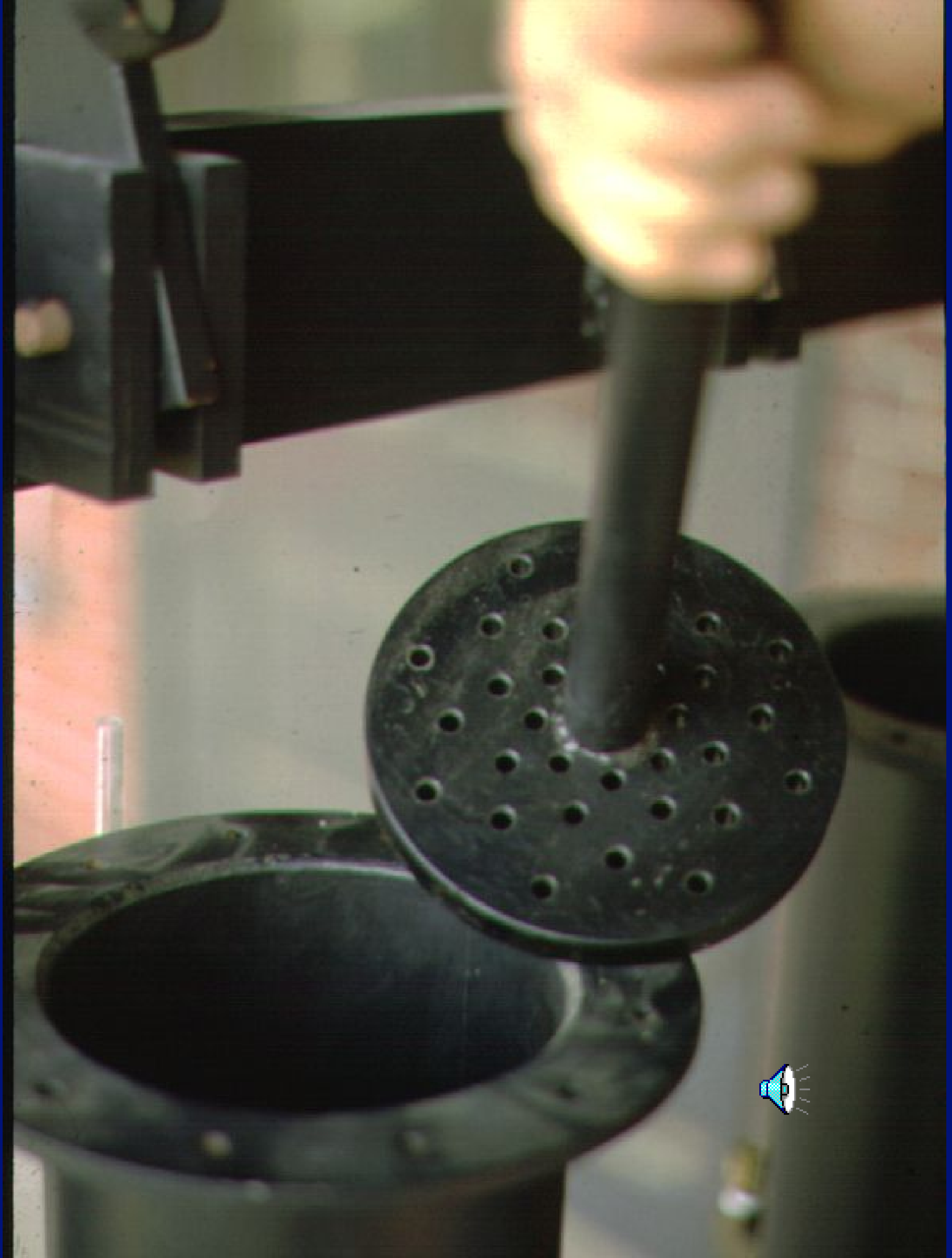
5.2 Geosynthetic Lifetime

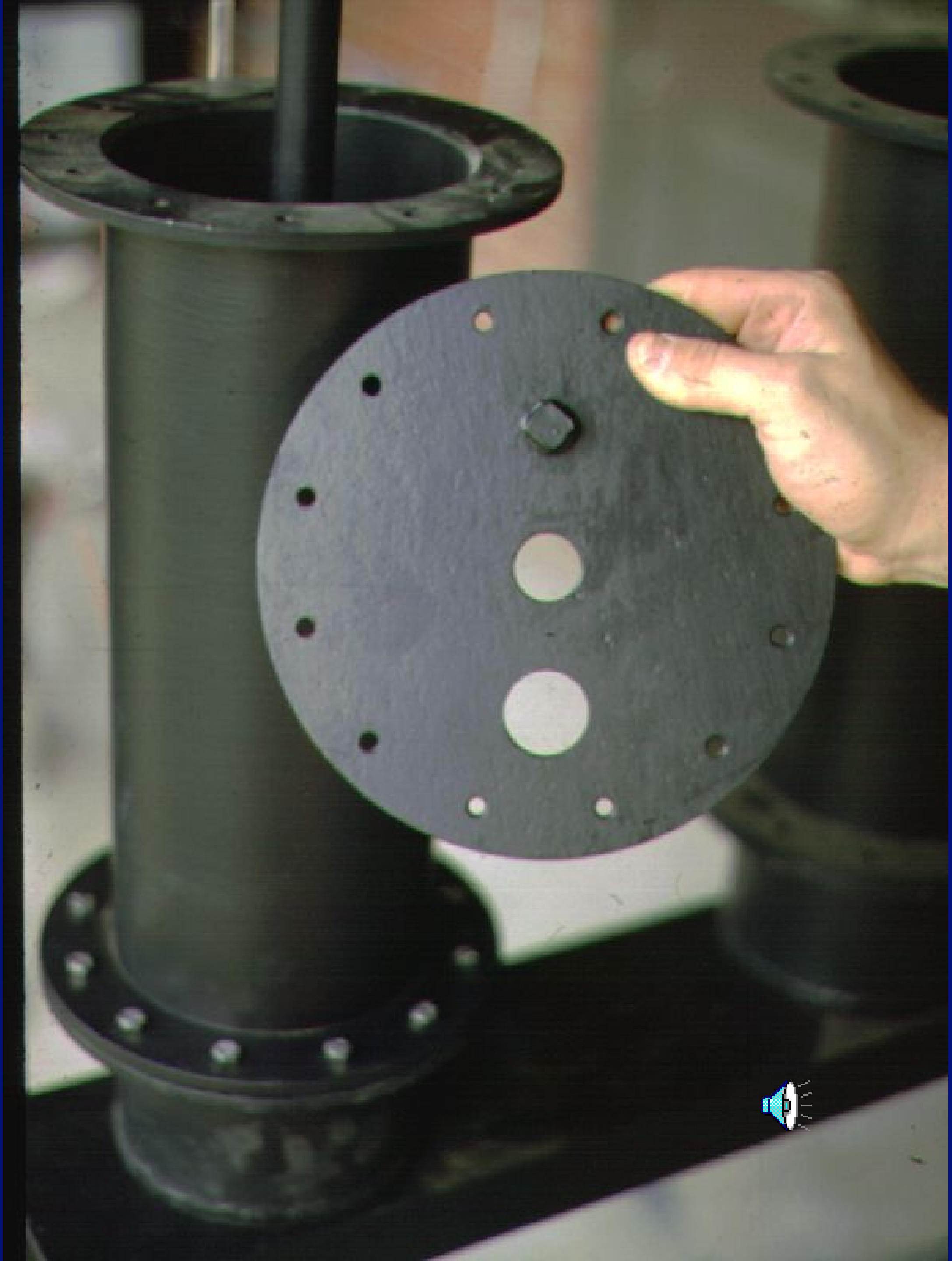
- ultraviolet
- radiation
- biological
- oxidation
- chemical (water and/or leachate)
- elevated temperature
- various types of stress

How Long Will GM's Last??







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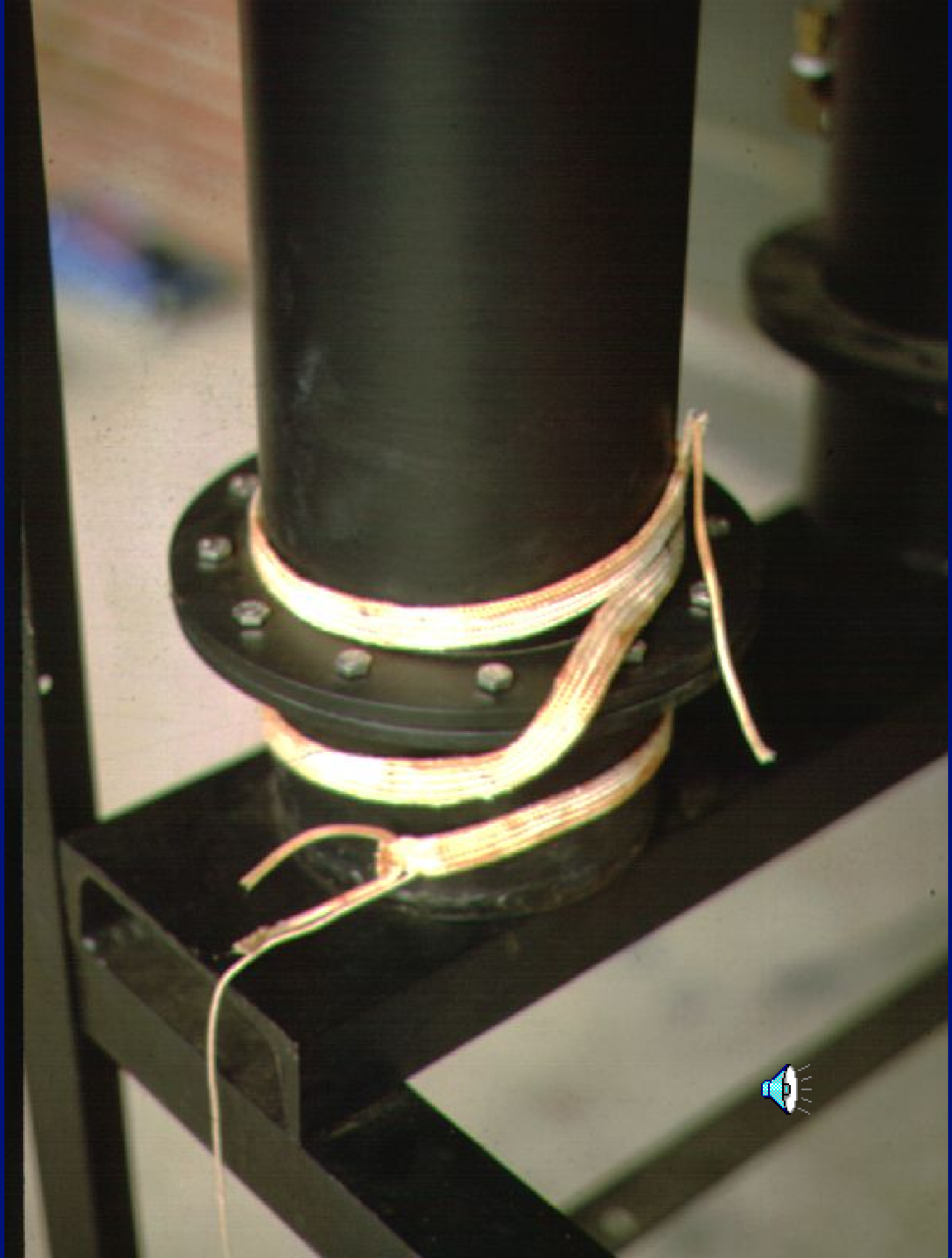
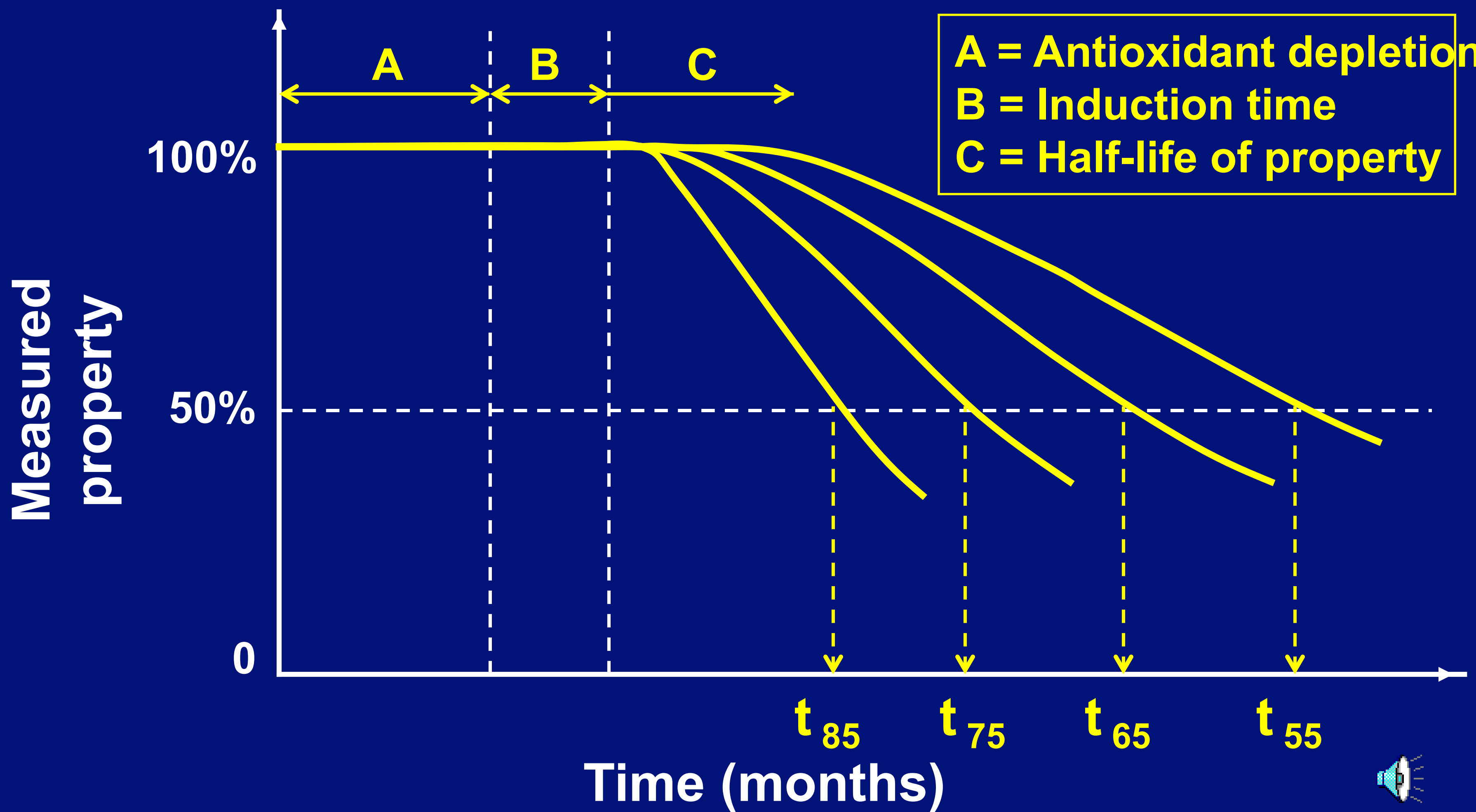
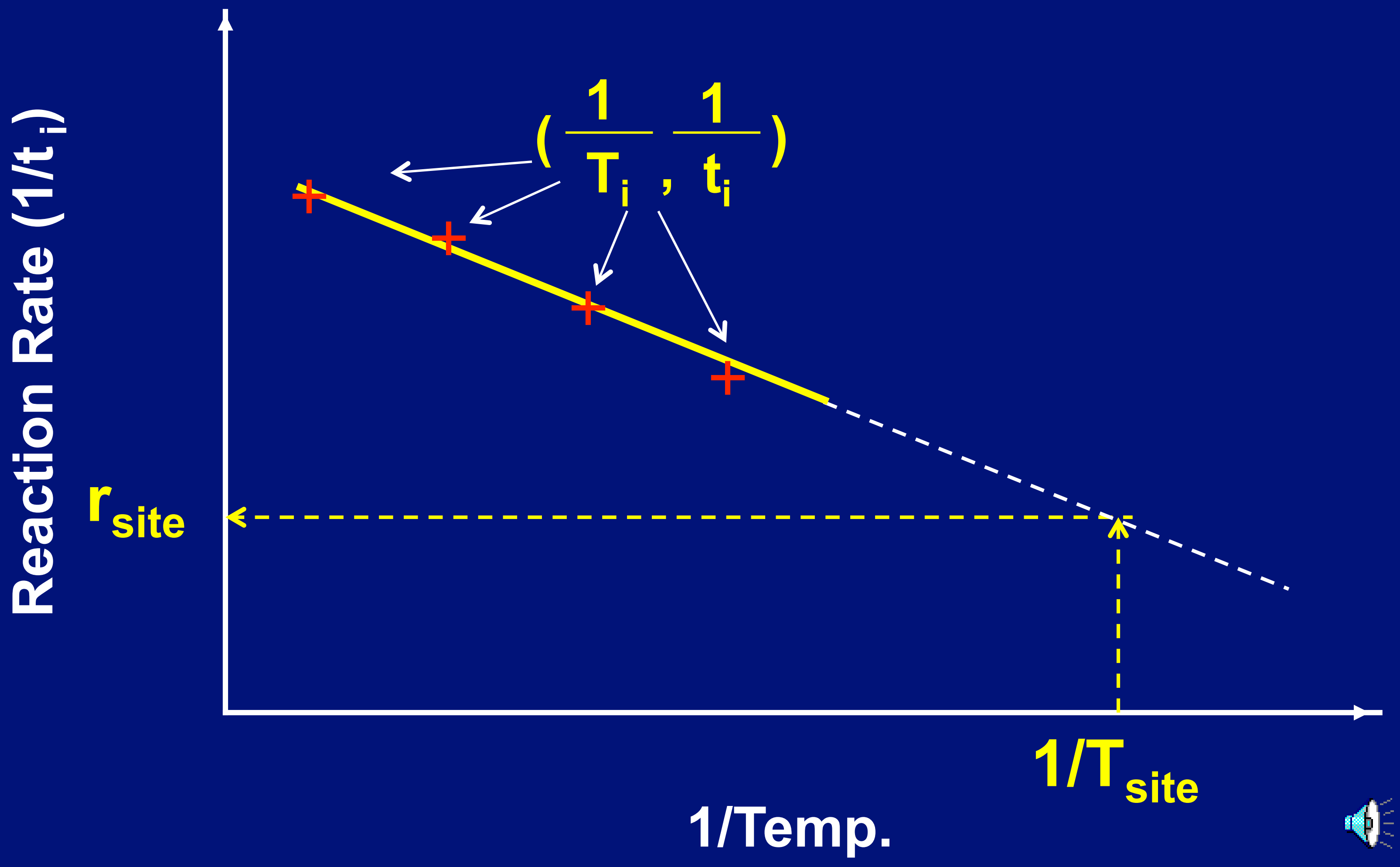


Incubated Property Behavior



Arrhenius Plot for Stage "C" (1/2 Life)



Projections: (using Arrhenius model on HDPE GMs)

$$\frac{R_{r1}}{R_{r2}} = e^{-\frac{E_{act}}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]}$$

example (a) 50% tensile strength, after Martin and Gardner, 1983 study
for Gas Research Institute (uses 90°C incubation)

$$R_{r_{at20°C}} = \mathbf{202 years}$$

example (b) 50% impact strength, after Underwriters Laboratory, 1987
study for cable shielding industry (uses 196°C incubation)

$$R_{r_{at\,20°C}} = \mathbf{752\ years}$$

HDPE Lifetime Estimate

A - Antioxidant Depletion = 50 to 150 years

B - Induction Time = 20 to 30 years

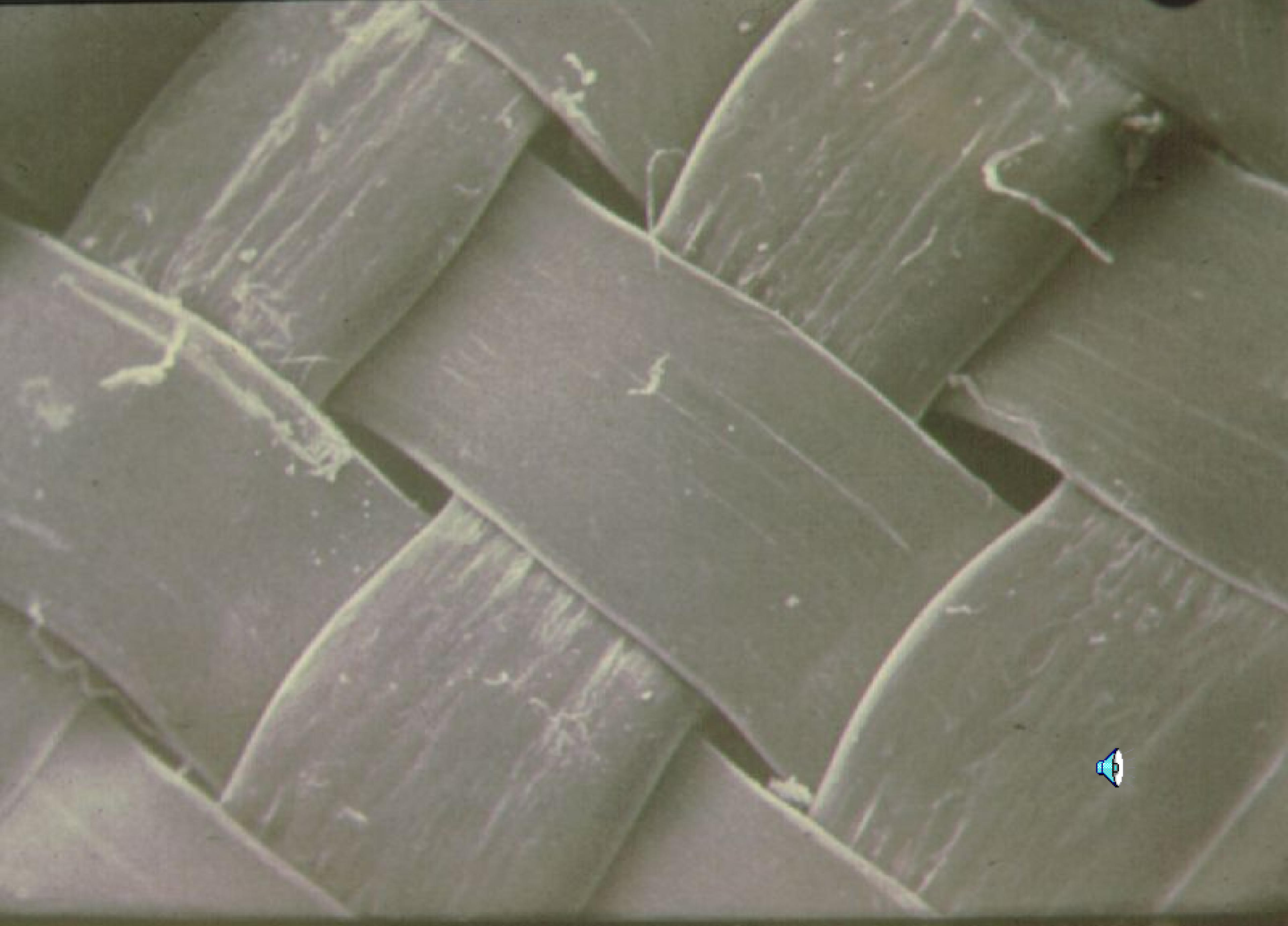
C - Half-life Estimates (from literature)

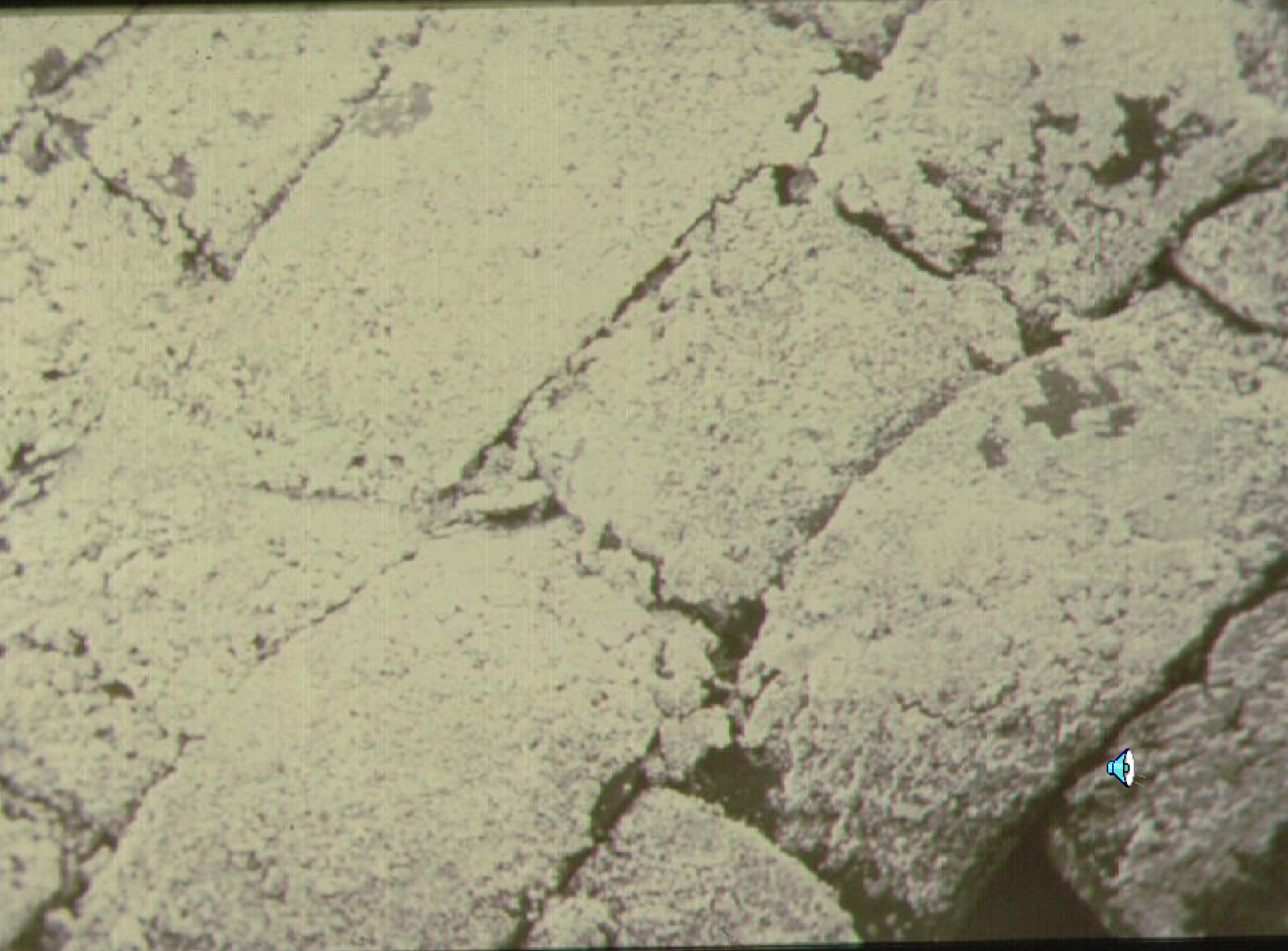
- **gas pipe = 200 years**
- **cable shielding = 750 years**

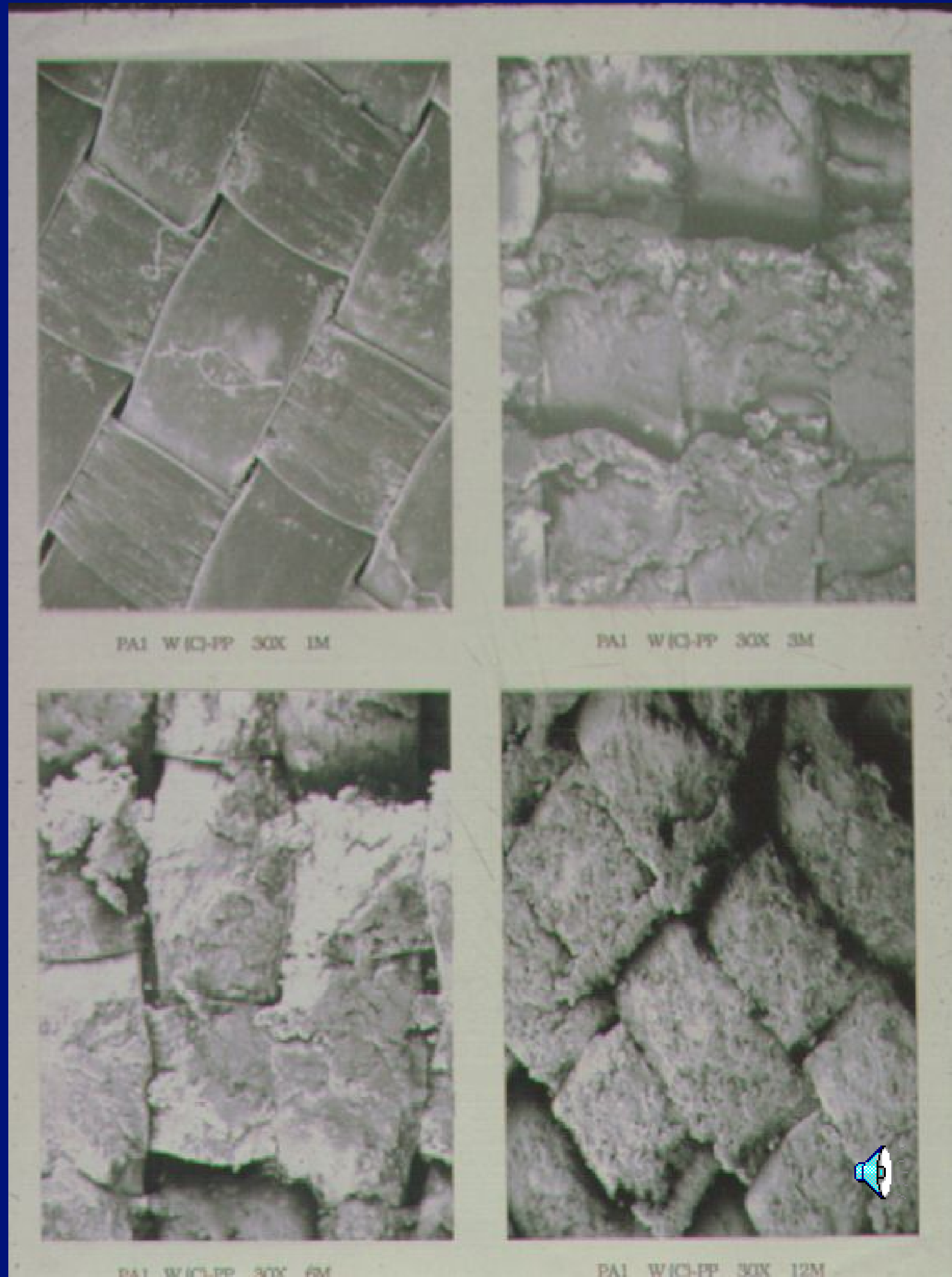
Total (est.) = 270 to $\underline{\sim}$ 1000 years

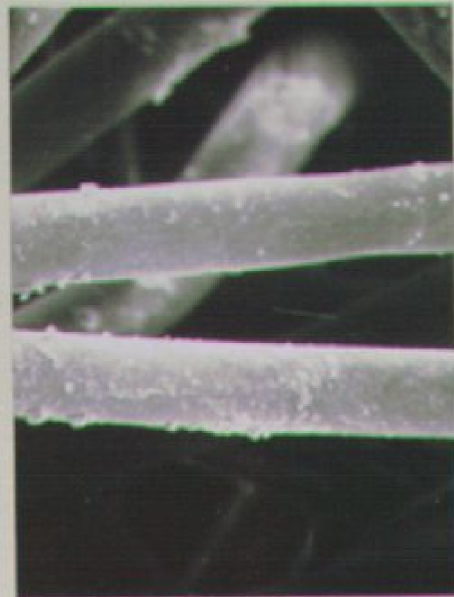
5.3 Biological Clogging

- concern is with leachate collection system
- filter (GT or soil) is probably effected before drain
- HELP indicates at 10^{-5} cm/sec filter begins "starving" drainage layer
- Mechanisms are combination of fine sediment clogging and microorganism growth
- Geo Koerner thesis of interest






PA1 W(C)-PP 30X 1M
PA1 W(C)-PP 30X 3M
PA1 W(C)-PP 30X 6M
PA1 W(C)-PP 30X 12M



PA1 NW (N)-PP1 400X 1M

PA1 NW (N)-PP1 400X 3M

PA1 NW (N)-PP1 400X 6M

PA1 NW (N)-PP1 400X 12M

Laboratory Study

(a) Four different permeants
- water (for control)
- light leachate (low TS, low BOD)
- high TS leachate (low BOD)
- high BOD leachate (low TS)

(b) Ten geotextiles
- four needle punched nonwovens
- four woven monofilaments
- one heatbonded nonwoven
- one special

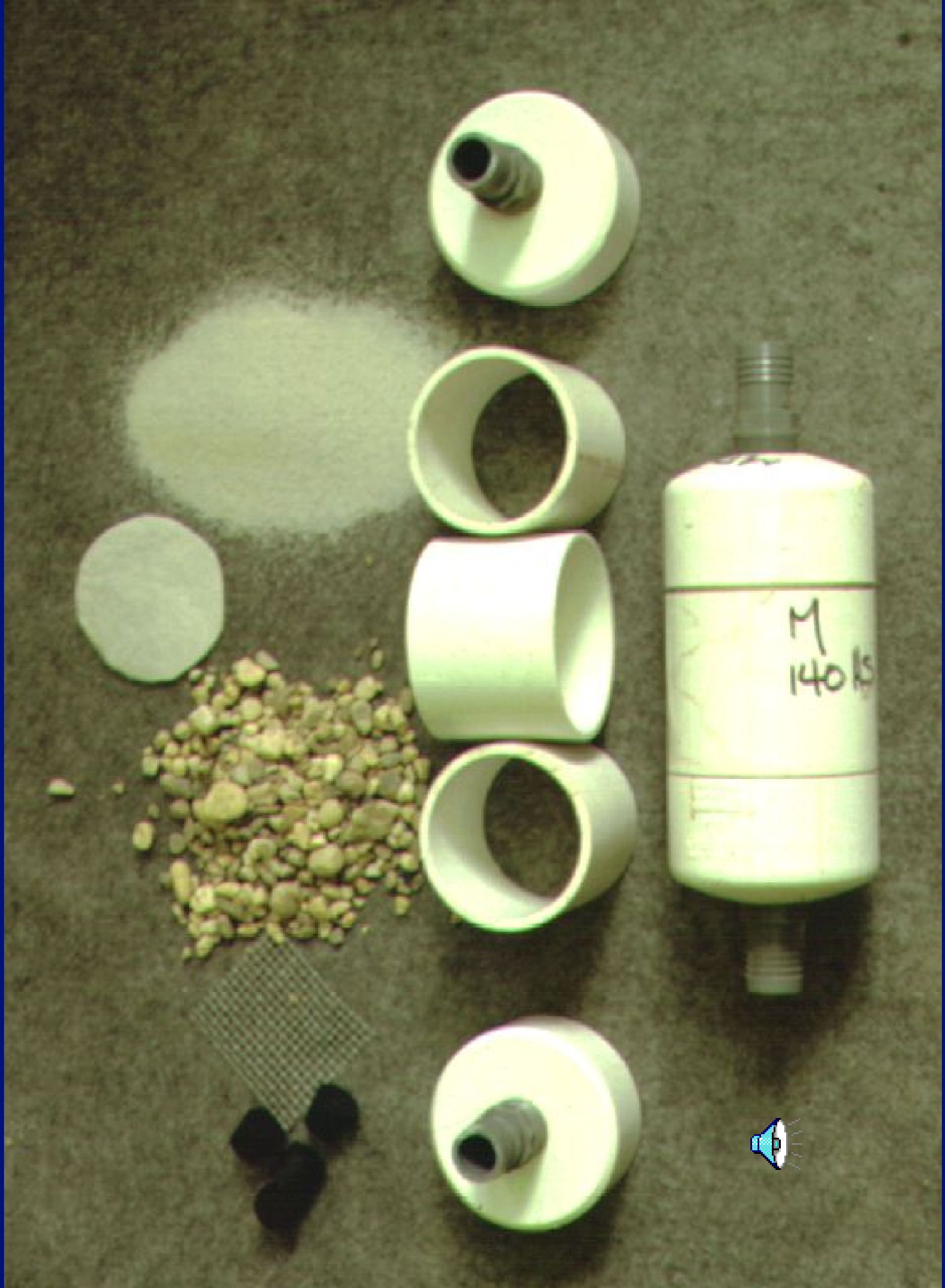
(c) Two soils
- poorly graded
- well graded sand

(d) Total head maintained at 300 mm throughout test project, i.e., for 1 to 3 yrs.

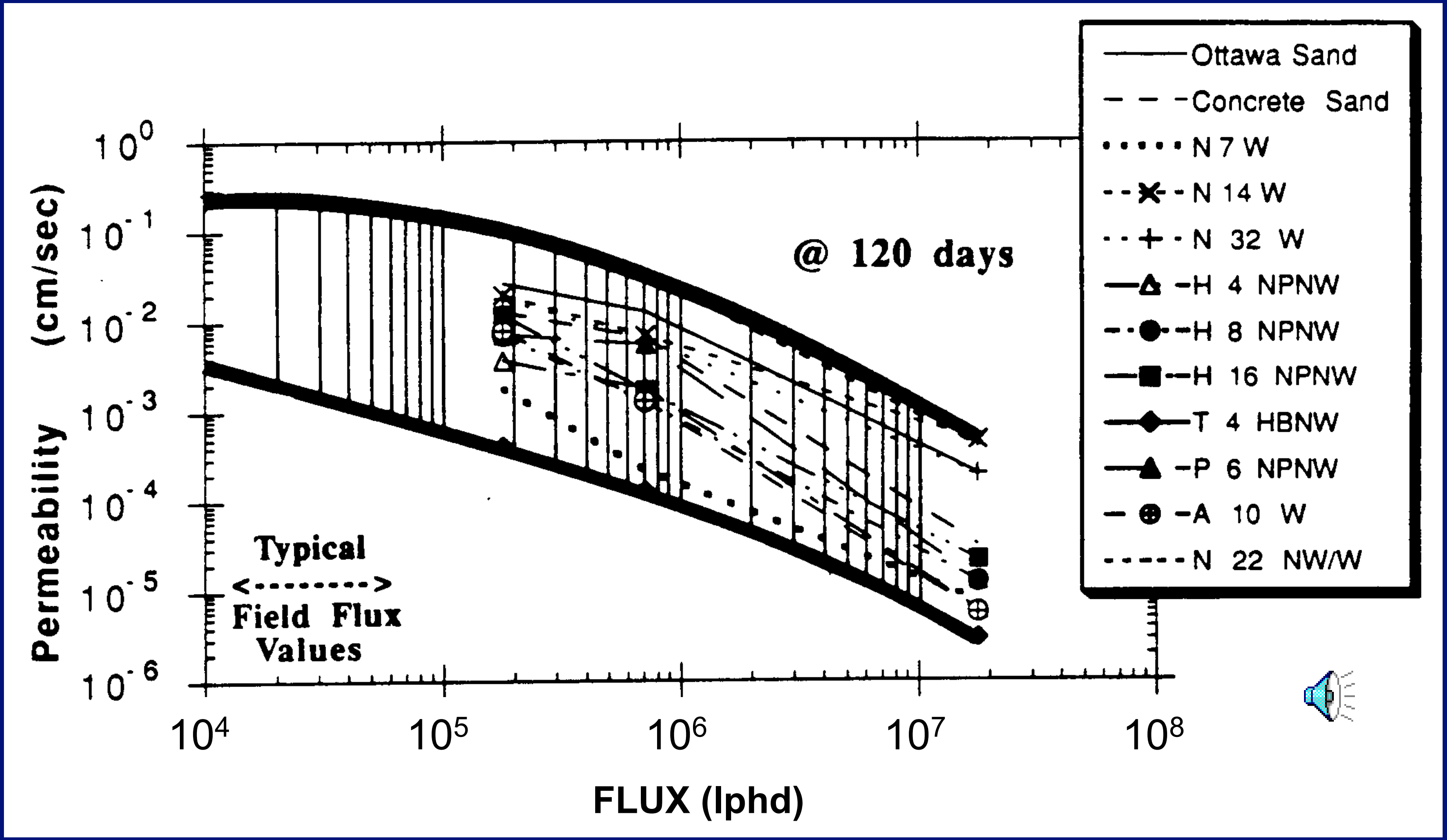
(e) Periodic constant head tests at 50 mm initially, then variable head tests as flow rates decrease

(f) Search is for equilibrium or terminal permeability for all 48 geotextile/sand cross sections

(g) Report for fast, medium and slow flow rates to develop trends


M

Mater Curve for all 12 Filters



Proposed FS equation for GT filters

$$FS = \frac{k_{allow}}{k_{reqd}\left(DCF\right)}$$

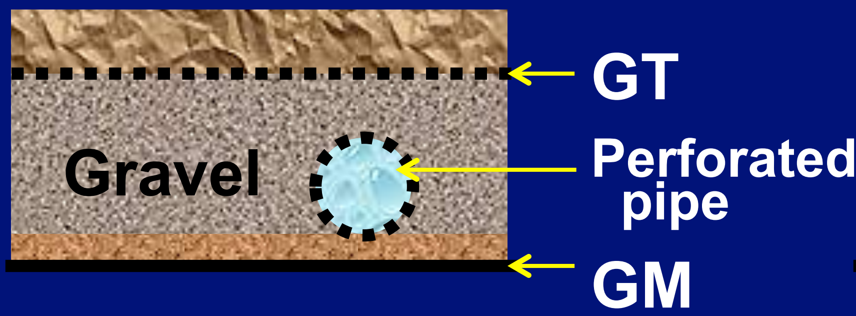
- or -

$$FS = \frac{\psi_{allow}}{\psi_{reqd}\left(DCF\right)}$$

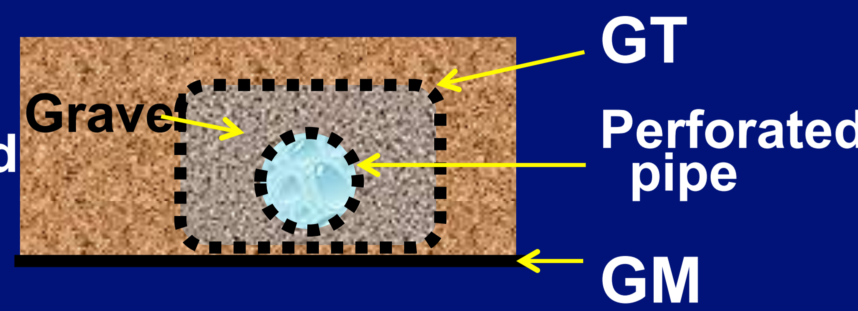
DCF = **D**rain **C**orrection **F**actor

= (footprint area/avail. flow area)

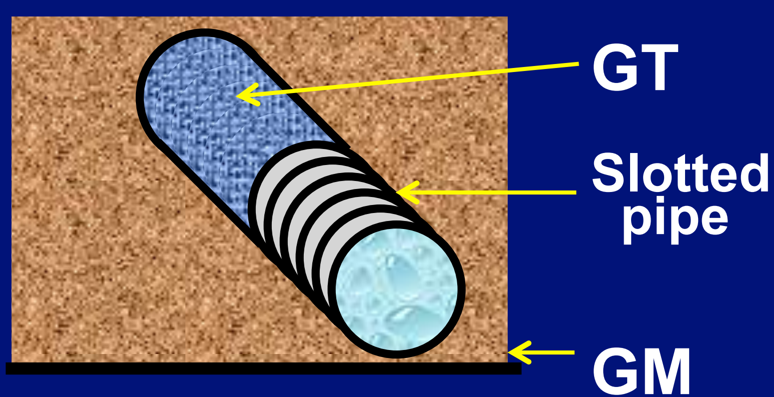
Typical DCFs



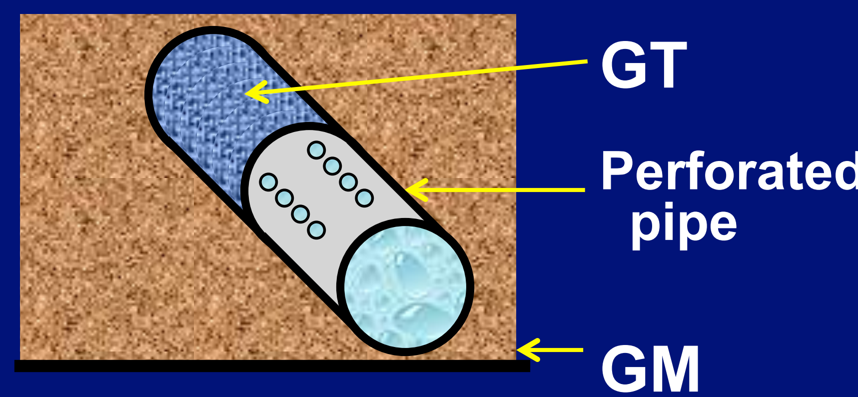
(a) Entire cell filter (DCF = 1)



(b) GT wrapped drain (DCF = 10-40)



(c) Socked corrugated pipe (DCF = 60-260)



(d) Socked smooth perforated pipe (DCF = 7,500-24,000)

Forensic analysis of the performance of four field exhumed sites using the DCF concept


100LBS.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Results

Site	$k_{allowable}$ (cm/sec	$k_{required}$ (cm/sec	DCF	FS	Predicted Performance	Actual Performance
1	2×10^{-3}	1×10^{-5}	240,000	0.0008	terrible	failure
2	3×10^{-2}	1×10^{-5}	140	21.0	good	acceptable
3	2×10^{-2}	5×10^{-5}	990	0.40	poor	failure
4	2×10^{-2}	5×10^{-5}	1,700	0.24	poor	failure

The Bottom Line:

- There exists many geotextile filters which meet or exceed the most severe field conditions witnessed to date (providing the DCF is not too high)
- The design geometry of the leachate collection system is critical to the long term performance of the system
- Do not use GT socked perforated smooth wall pipe for removal systems (DCF is simply too large)
- Keep filter as far away from the drain inlet openings as possible
- The "no-filter" strategy of select waste directly on drainage stone appears to be viable…

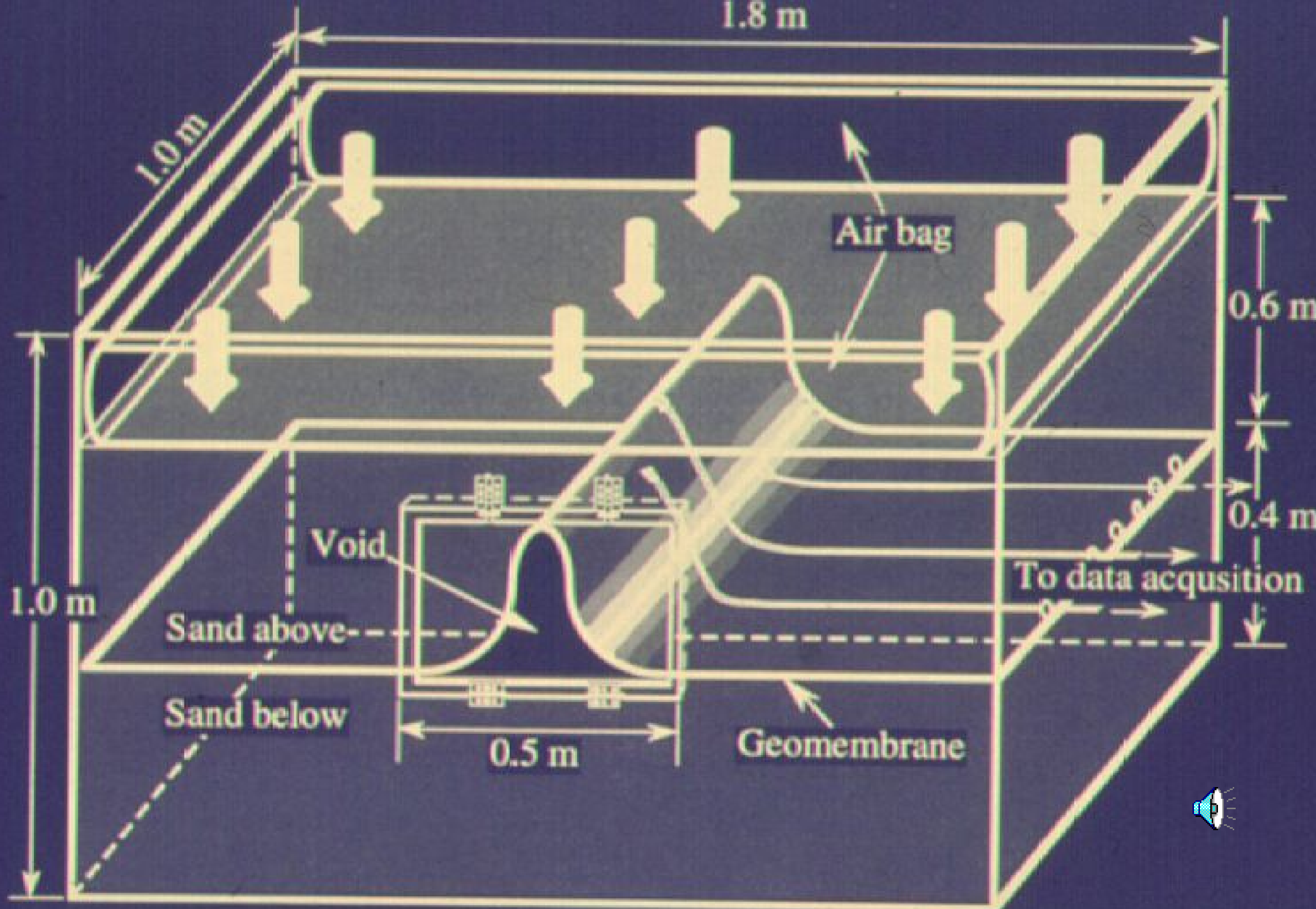
5.4 Waves in GMs
(also called Wrinkles)

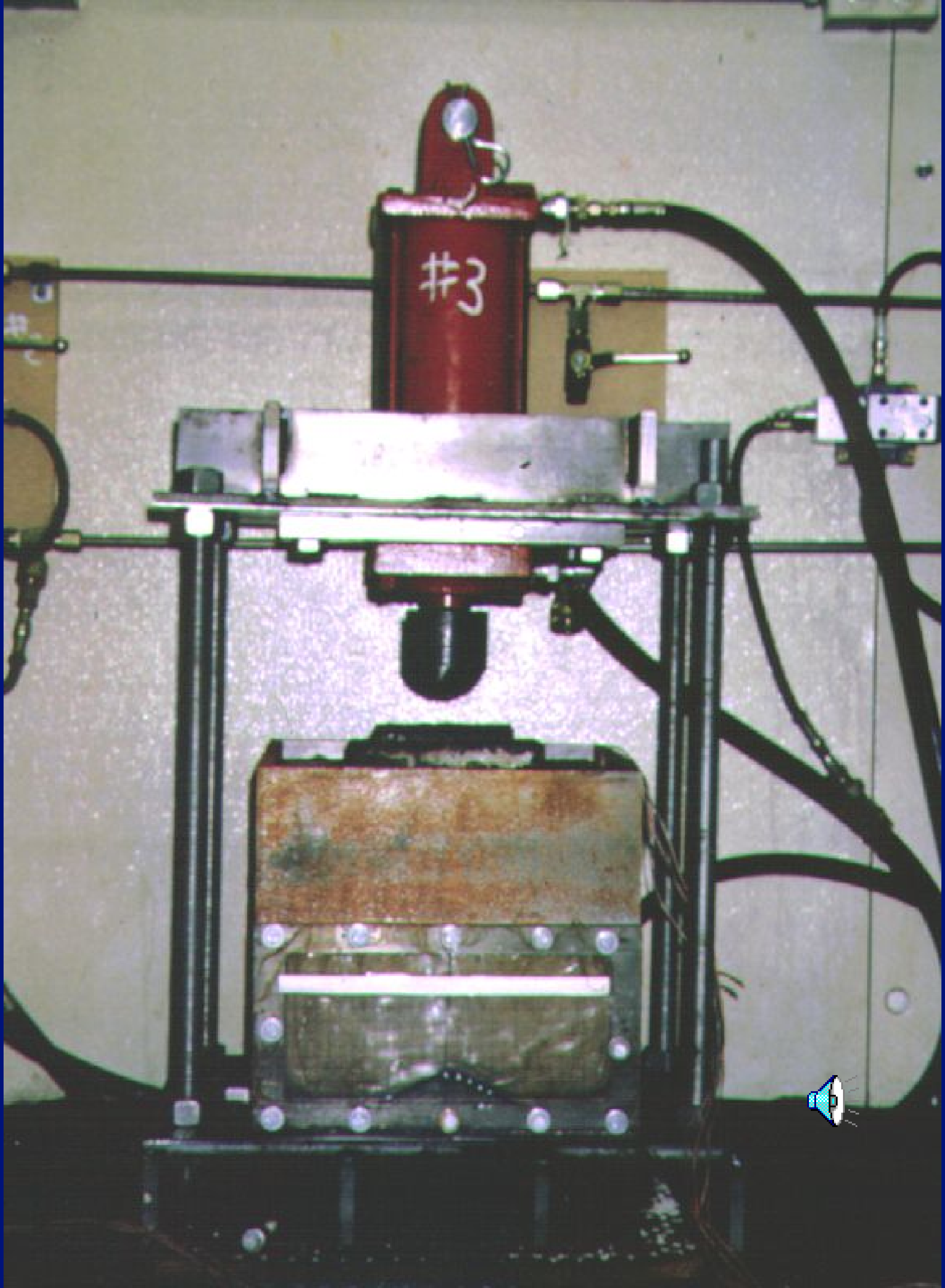
Concerns

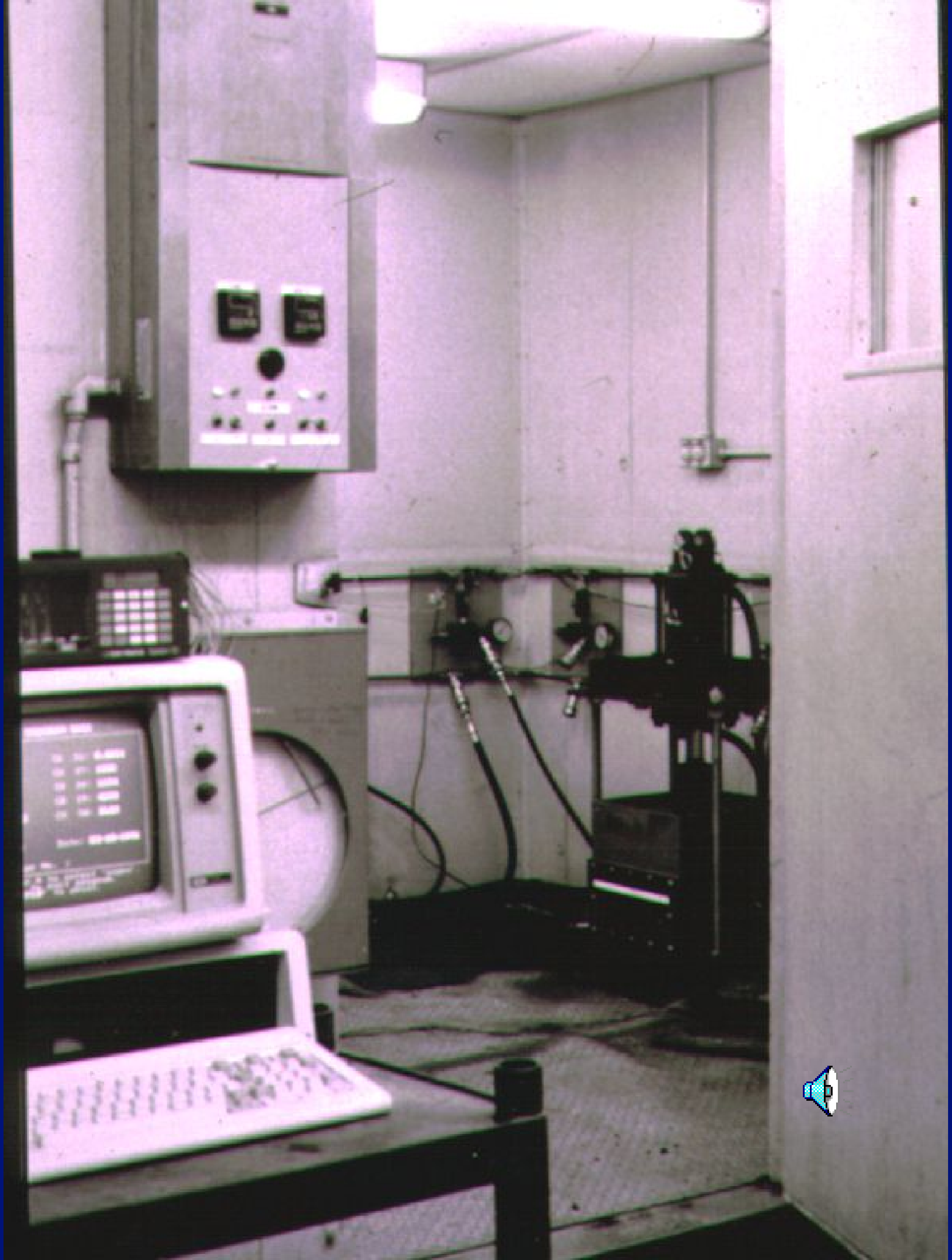
- **lack of intimate contact**
- **formation of mini-dams**
- **induced residual stresses**
- **possible (?) shorter lifetime**

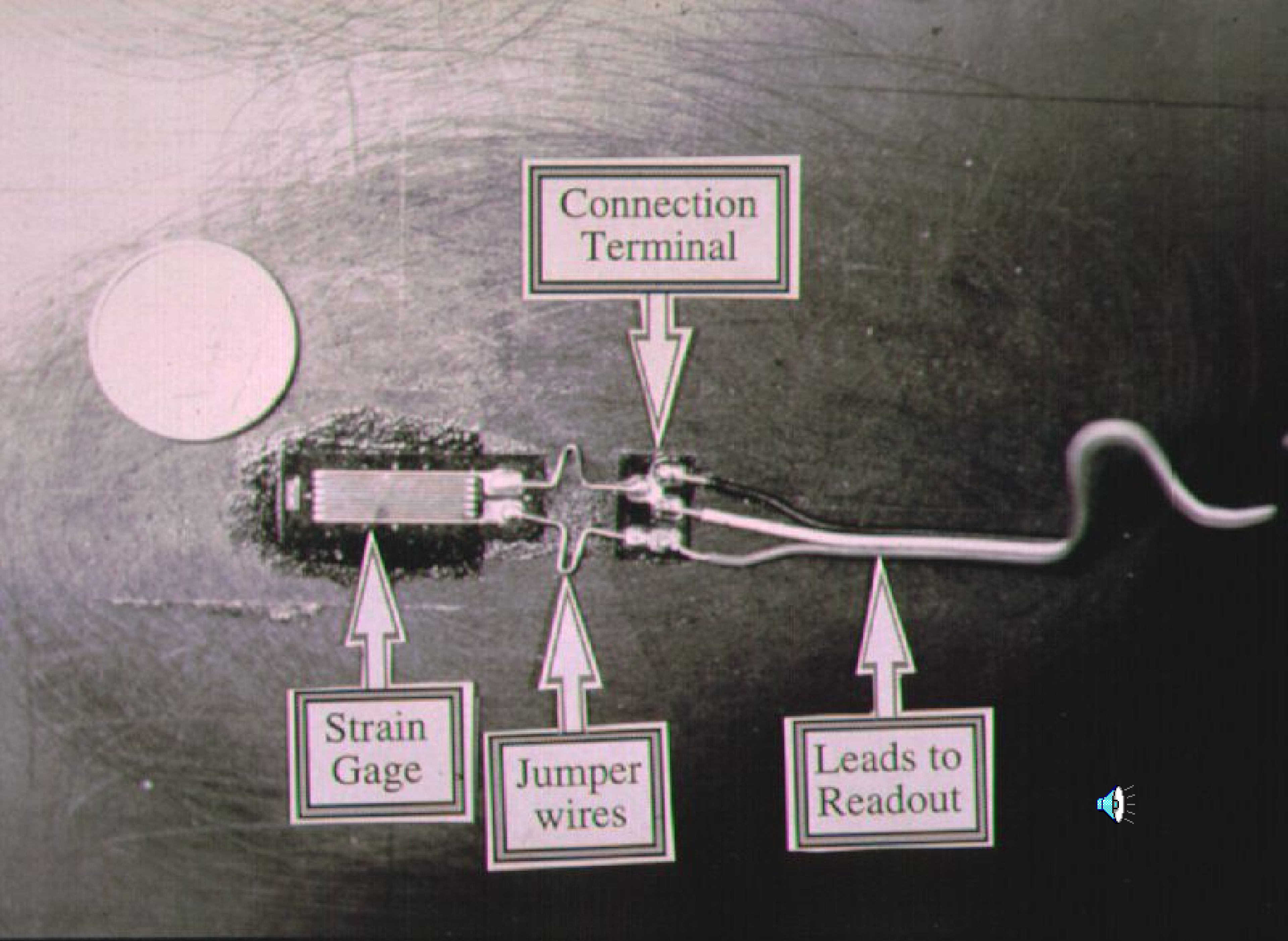
Laboratory study (T.-Y. Soong, 1996)

- applied stress - 180 to 1100 kPa
- wave height - 14 to 80 mm
- GM thickness - 1.0 to 2.5 mm
- testing temperature - 23 to 55°C


1.8 m
1.0 m
Air bag
0.6 m
0.4 m
Void
To data acqusition
1.0 m
Sand above
Sand below
0.5 m
Geomembrane


#3




Connection Terminal
Strain Gage
Jumper wires
Leads to Readout

Conclusions of Lab Study*

- Even the smallest wave at 14 mm did not disappear
- The H/W ratio of the waves greatly increase when backfilled
- Residual stresses in curved areas are as high as 22% of yield
- This accounts for both creep and stress relaxation

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* Papers available in 6IGS Conf. Atlanta, 1998

Field data is sparse:

- some exhumed sites show waves but no loss of properties (8-yrs.)
- leakage data does not indicate a problem in spite of waves
- recall previous data of EPA study
- German method of flat installation shown on following slides


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Implications of Requiring "No Waves"

- requires major change in field deployment methods
- suggests backfill only until mid-morning, e.g., ± 10:00 AM
- may require backfilling at night (with many implications)
- white co-extruded GM's mitigate waves greatly (approximately 1/2-wave height compared to black)
- rough estimate of requiring flat-GMs is 2 to 5-times current installation cost
- if GM is installed tight, the influence of induced thermal contraction stresses is unclear

5.5 Wind Uplift

- many field problems
- scenarios must be clearly stated in pre-construction meeting and QA document
- installation contractor must be aware of intent before bidding project
- replacement GM may not be readily available (or readily approved)
- CQA must document creases, patches, capstrips, replacement panels, etc., very carefully

Next File