Fine Pore Aeration Systems Testing

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Fine Pore Diffusers

- Fine pore aeration systems are the most energy conserving alternative we have for the activated sludge process, and may other applications
- Well established technology and design principles
- Nevertheless, we have had many technology failures
- Proper utilization of the technology requires a commitment to maintenance

Outline

- Terminology
- Off-gas testing
- Materials testing
- Some conclusions

Terminology

- **Efficiency**
  - **Standard oxygen transfer efficiency (SOTE) (percent oxygen transferred)**
  - **Standard oxygen transfer rate (SOTR) (mass transferred per unit time)**
  - **Standard aeration efficiency (SAE) (mass transferred per unit time per unit power)**

Terminology Cont.

- SOTE - percent
- SOTR – lb O2/hr or kg O2/hr
- SAE – lb O2/hp-hr or kg O2/kW-hr
- All above at standard conditions (e.g. 20^{o}C, clean water, etc.)
- OTE, OTR, AE – at process conditions

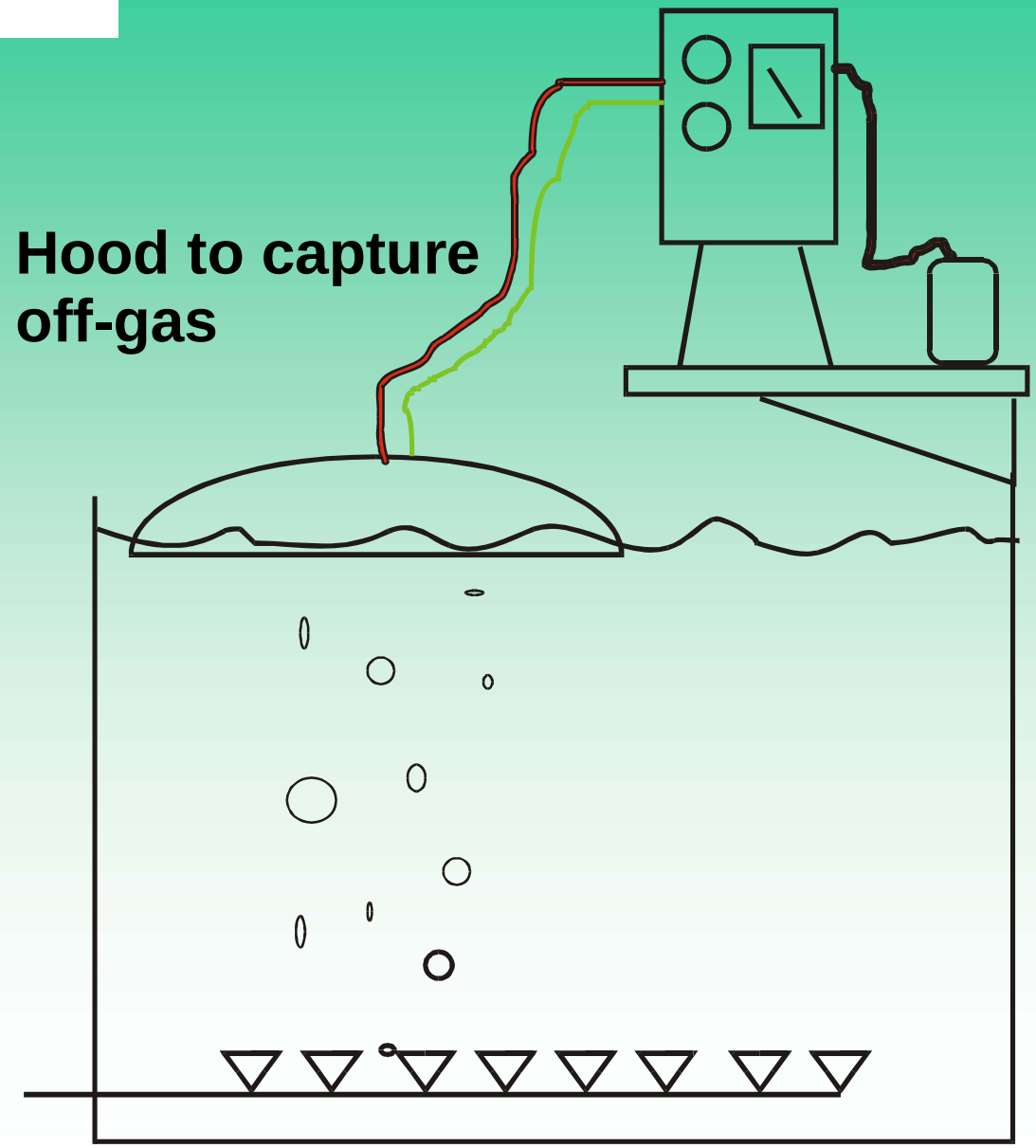
Standard and Process Conditions

- Correction formulas based upon driving force, temperature, barometric pressure, water quality, saturation concentration, etc
- Driving force and water quality the most significant
- Driving force = $(DO_S - DO)/DO_S$
- Water quality – alpha factor, 0 to 1
- Total correction can result in process water transfer of only 30 to 80% of clean water transfer

Off-Gas Testing

- Accepted as the best way to do process water testing of diffused aeration systems
- Used to the exclusion of almost all other methods for diffused systems
- Provides reliable indication of aeration efficiency, air flow distribution, wastewater flow splits among parallel aeration tanks, diffuser aging
- Reliable in underloaded, critically loaded and overloaded treatment plants

Off-Gas Technique



The Mathematics

$$OTE = \frac{\text{mass } O_2 \text{ in} - \text{mass } O_2 \text{ out}}{\text{mass } O_2 \text{ in}}$$

$$= \frac{G_i(M_o / M_i)MR_{o/i} - G_i(M_o / M_i)MR_{og/i}}{G_i(M_o / M_i)MR_{o/i}}$$

$$= \frac{MR_{o/i} - MR_{og/i}}{MR_{o/i}}$$

Use the ratio of oxygen to inerts to remove gas flow rate from the calculation

Off-Gas Measurement

- Use a simple fuel cell to measure oxygen partial pressure
- Ambient air for calibration of mole ratio
- Remove moisture and CO_2 to simplify the procedure
- Measure off-gas and compare to ambient air

Measuring Air Flow Rate

- Not needed for OTE measurement
- Useful to create an average of a large basin
- Needed to calculate the oxygen uptake rate, or total mass transferred
- Measure discharge from hood by establishing a stable pressure under the hood

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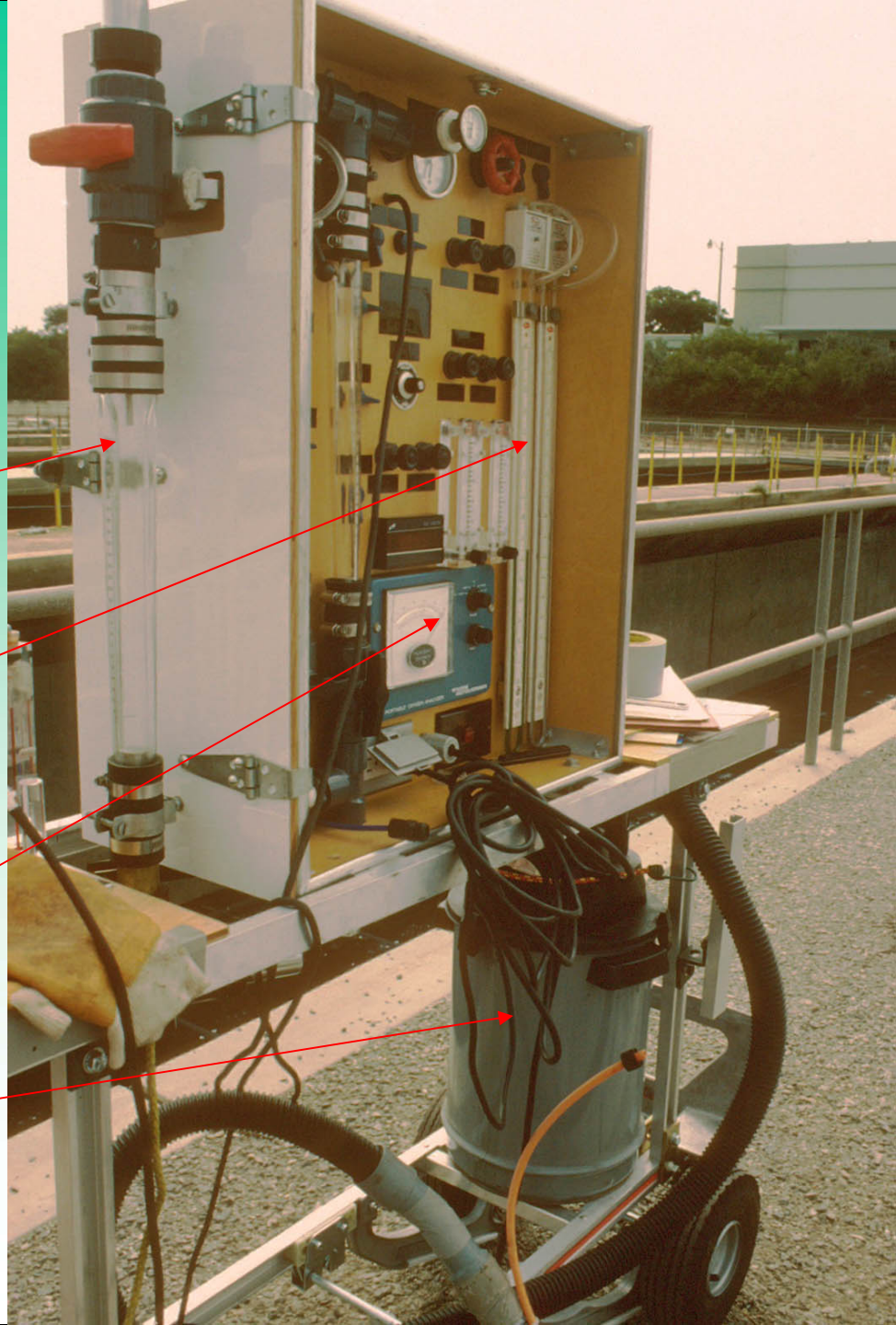
Off-Gas Analyzer

Rotometer

Manometers

Fuel Cell

Vacuum Cleaner



Off-Gas Hood

Analyzer in Action

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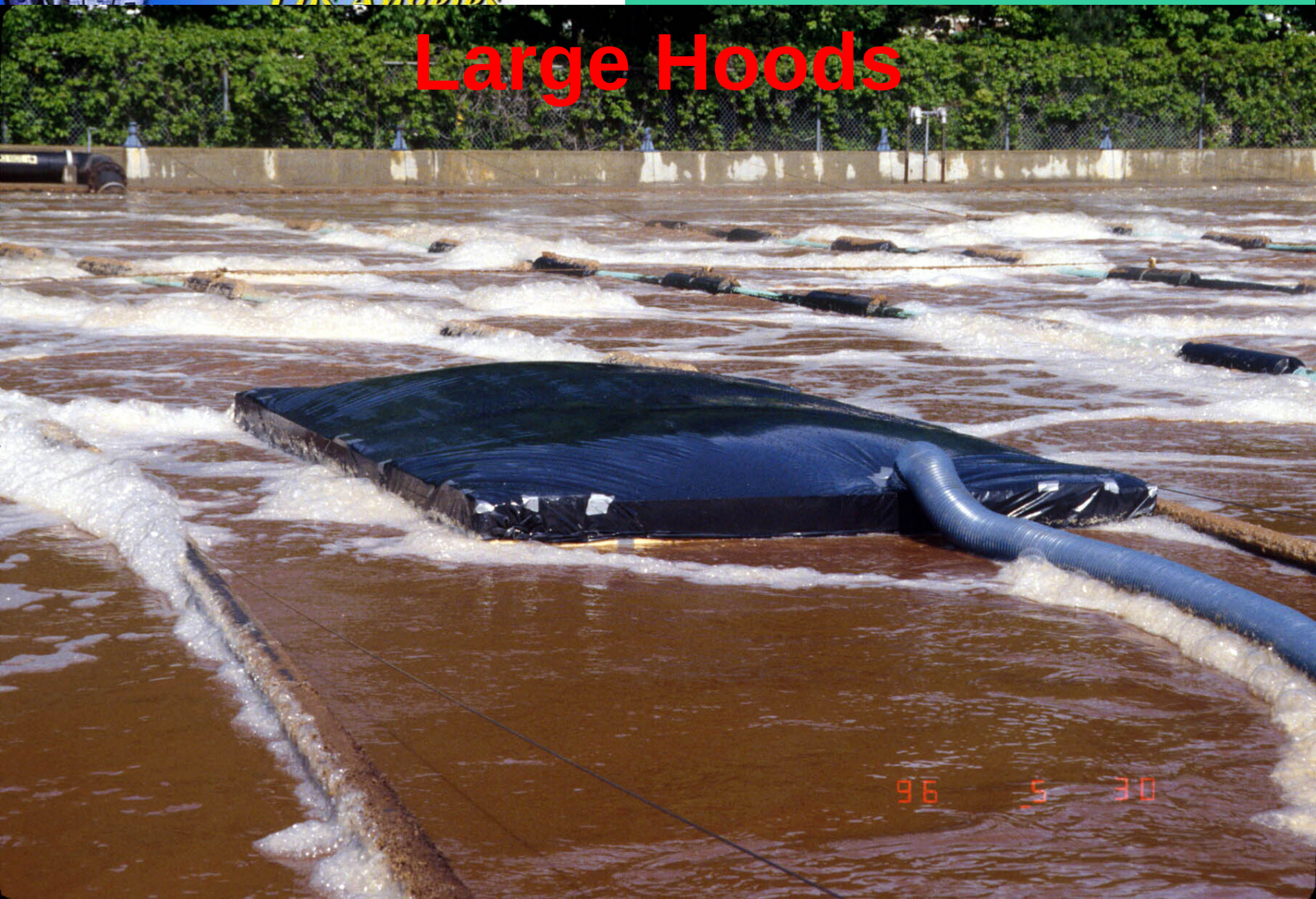
Small Hoods

Large Hoods



Really Large Hoods

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Coarse Bubble Hoods

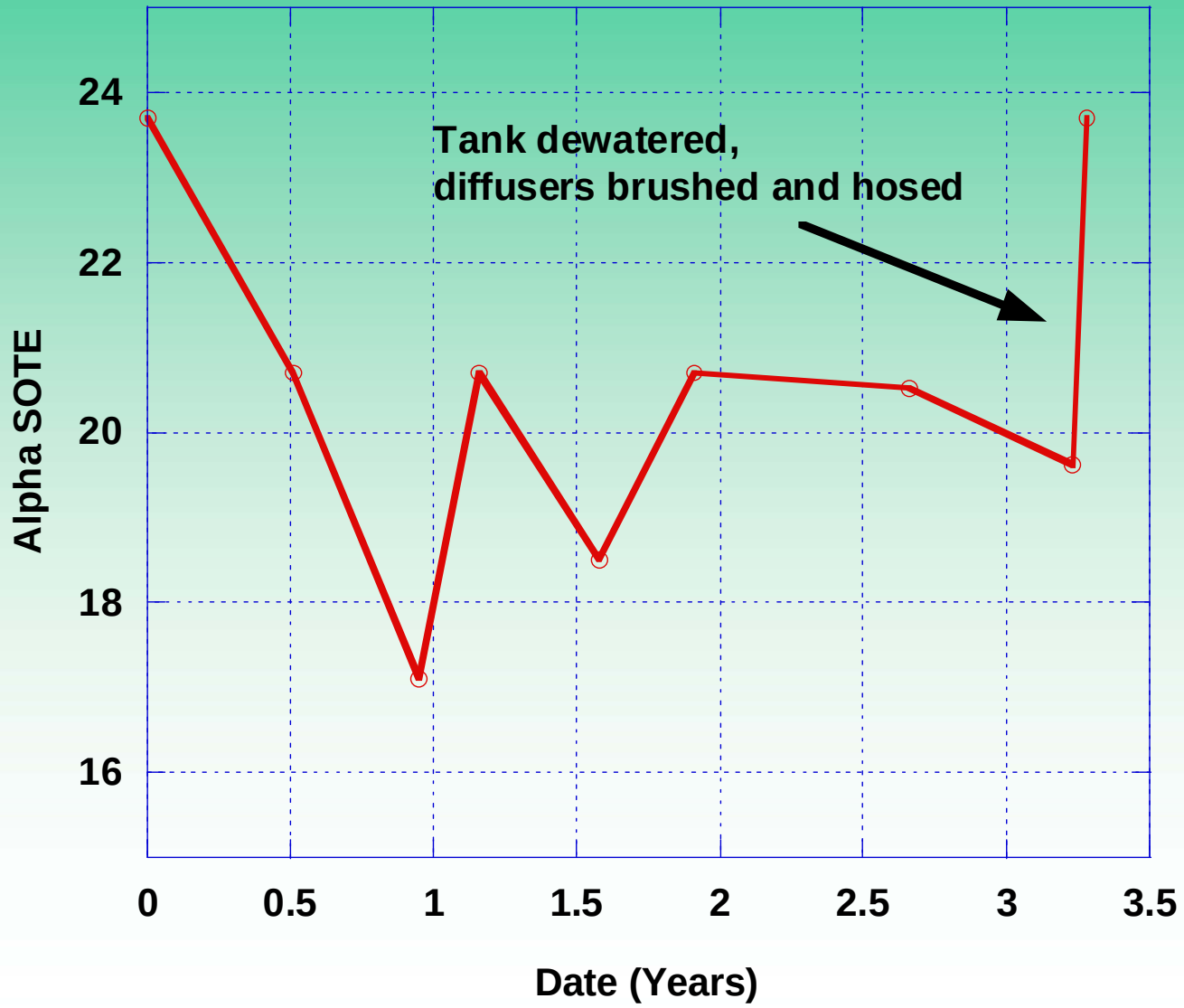
Sand Bags

Testing in a turbulent spiral roll system requires a heavy hood and weights

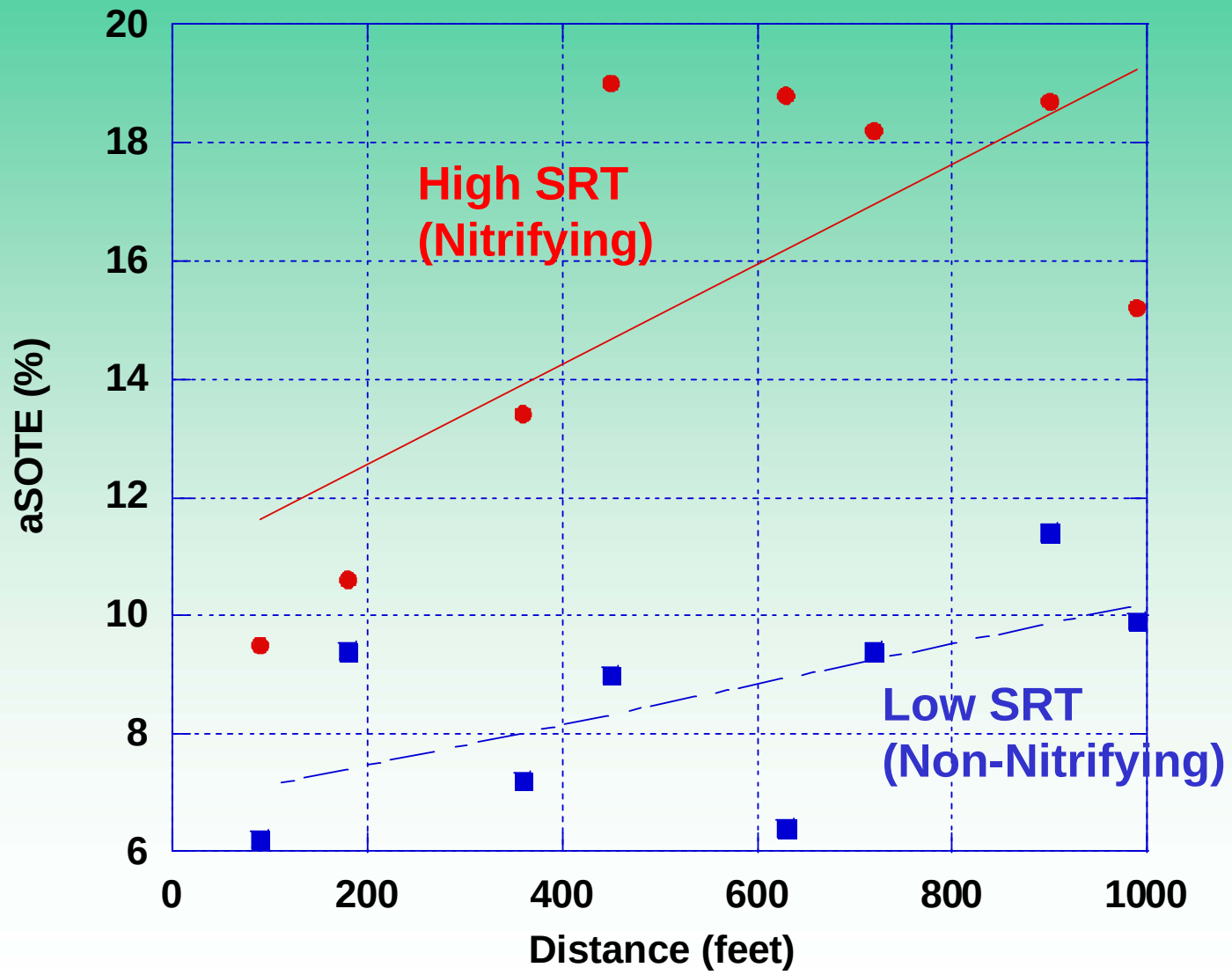
Off-Gas Results

- Define aeration capacity
- Track aerator performance and “health”
- Better understand process conditions
- Define key process parameters for expansion
- Warranty Opportunities

Typical Results

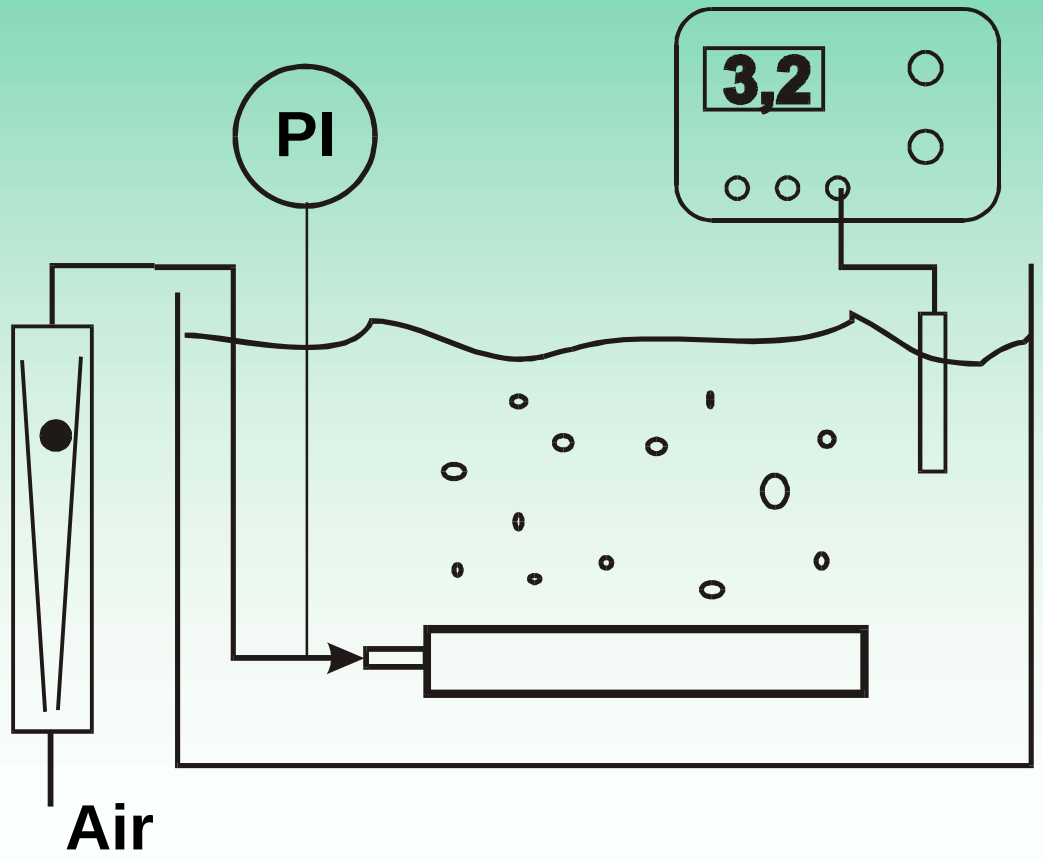


A Tale of Two Tanks

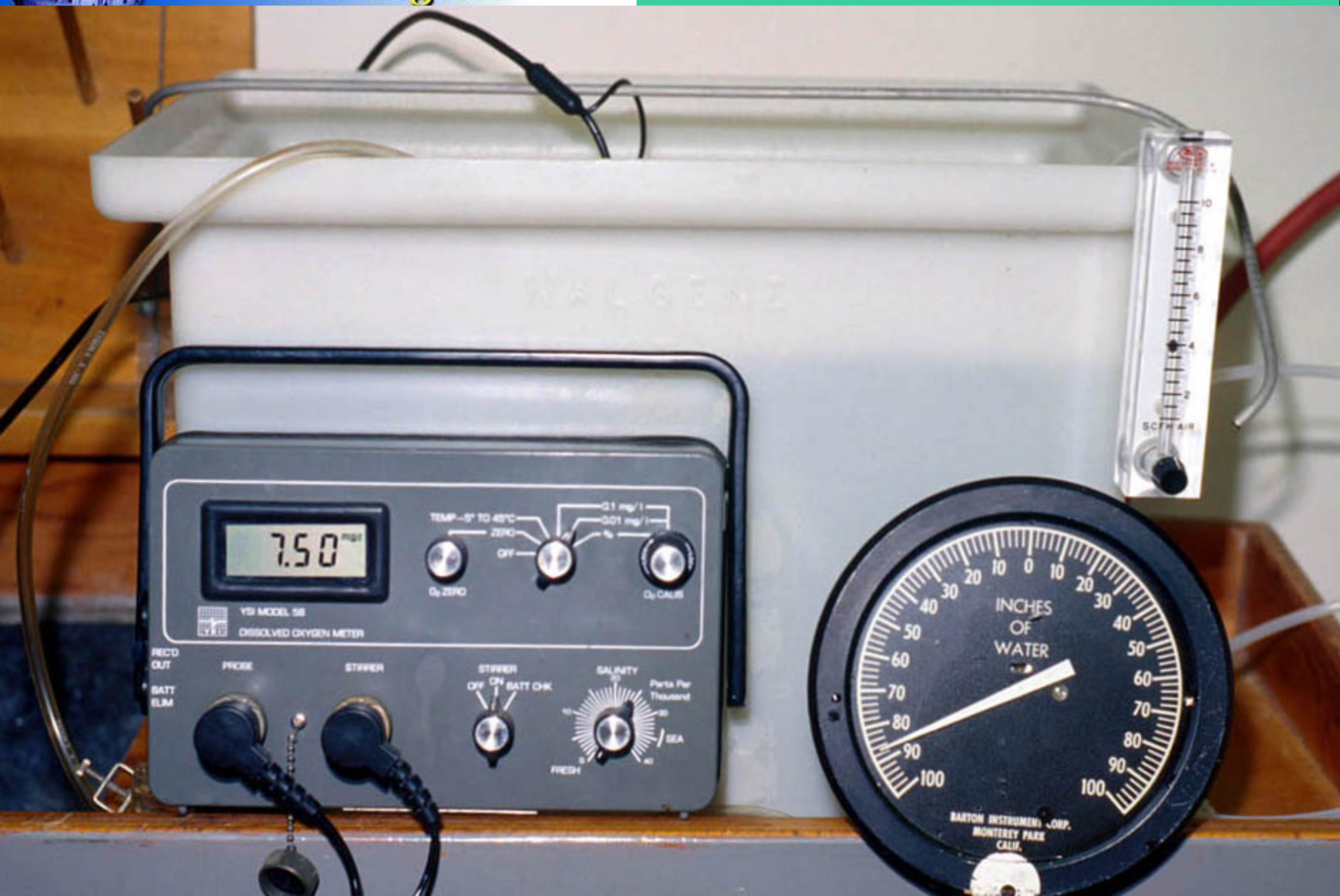


Transfer Efficiency and Pressure Drop

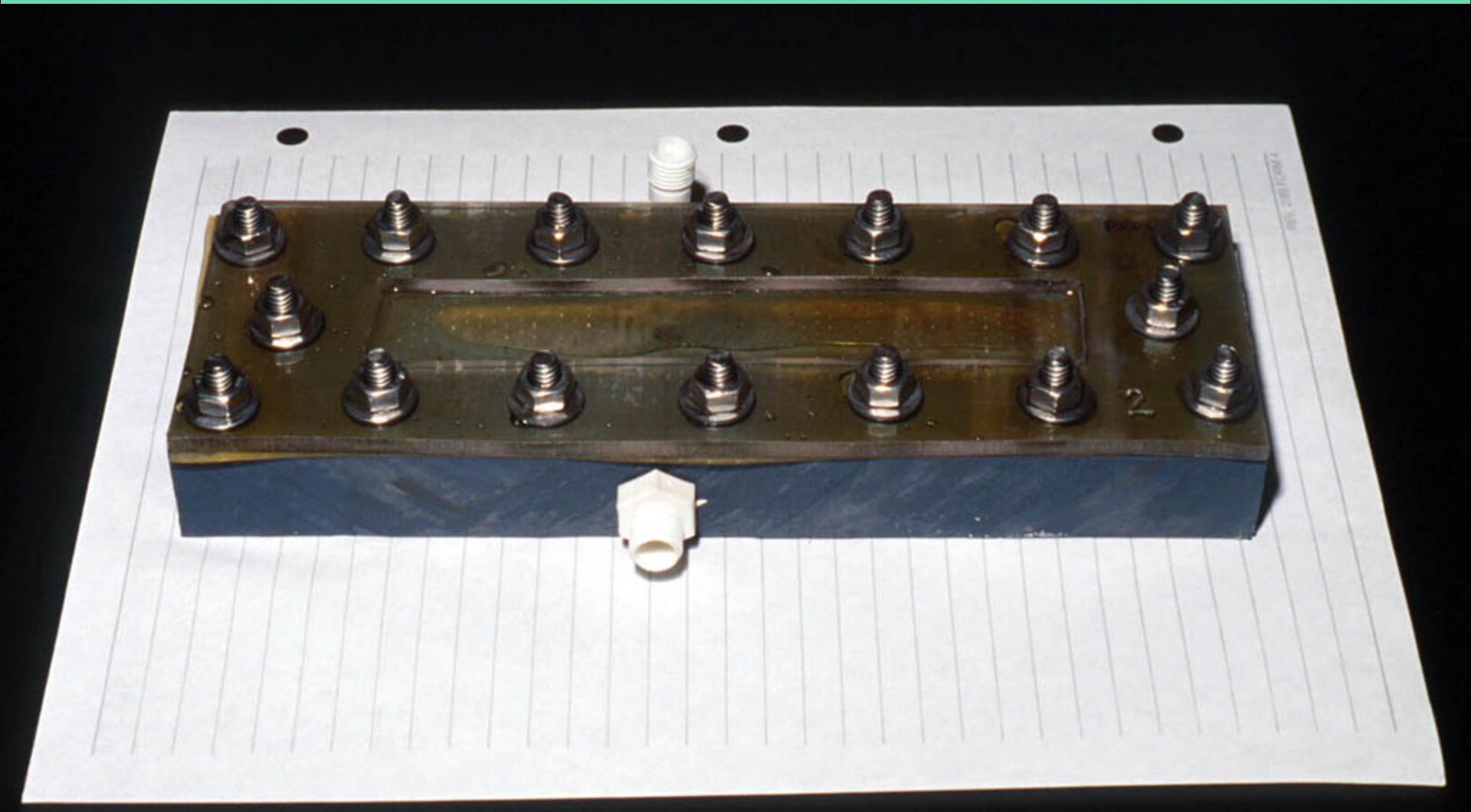
In a small tank, one can test pressure drop, oxygen transfer efficiency and observe flow patterns



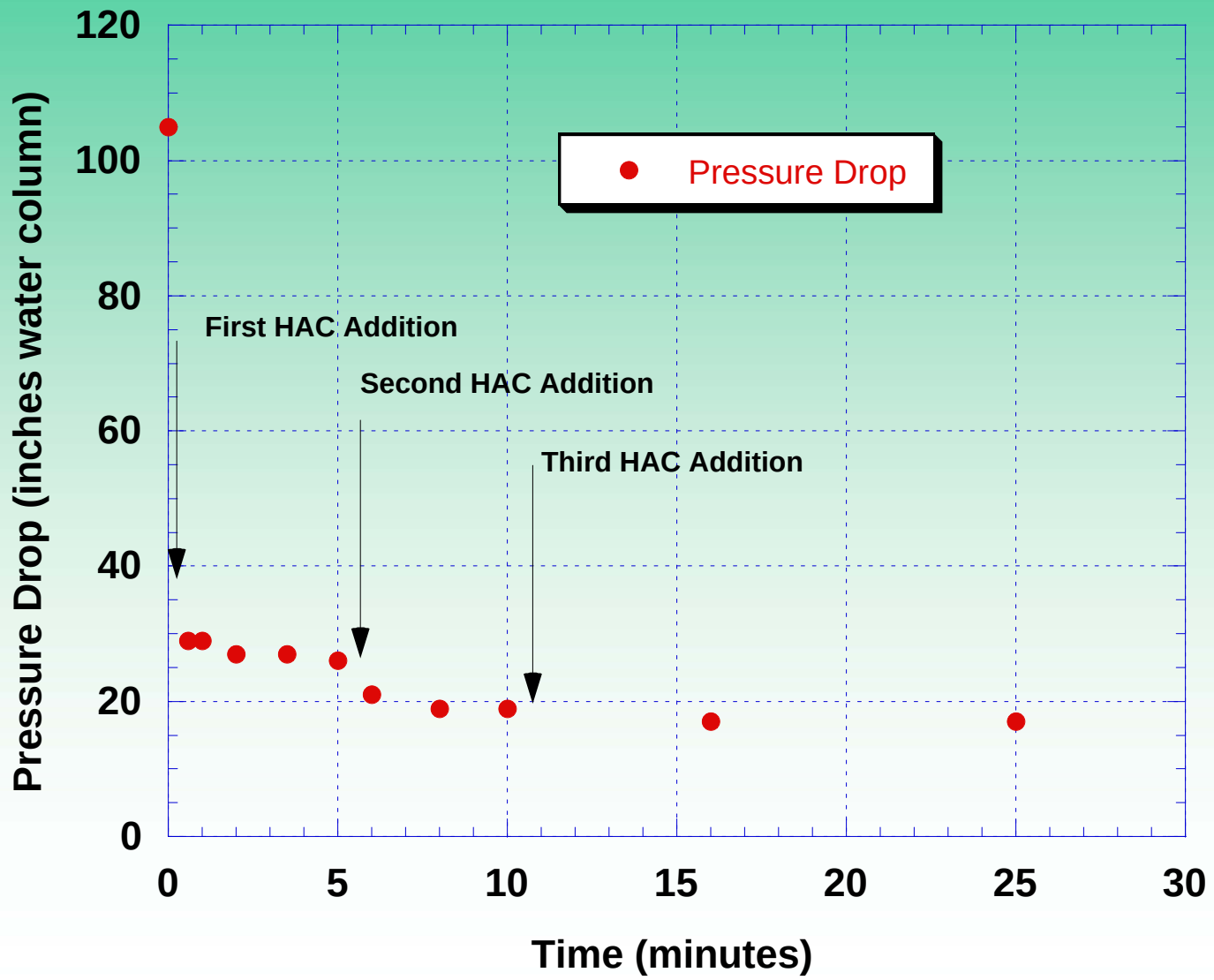
Materials Testing in the Lab



Special Holders for Membranes



Decrease in Pressure Drop With Acid Cleaning



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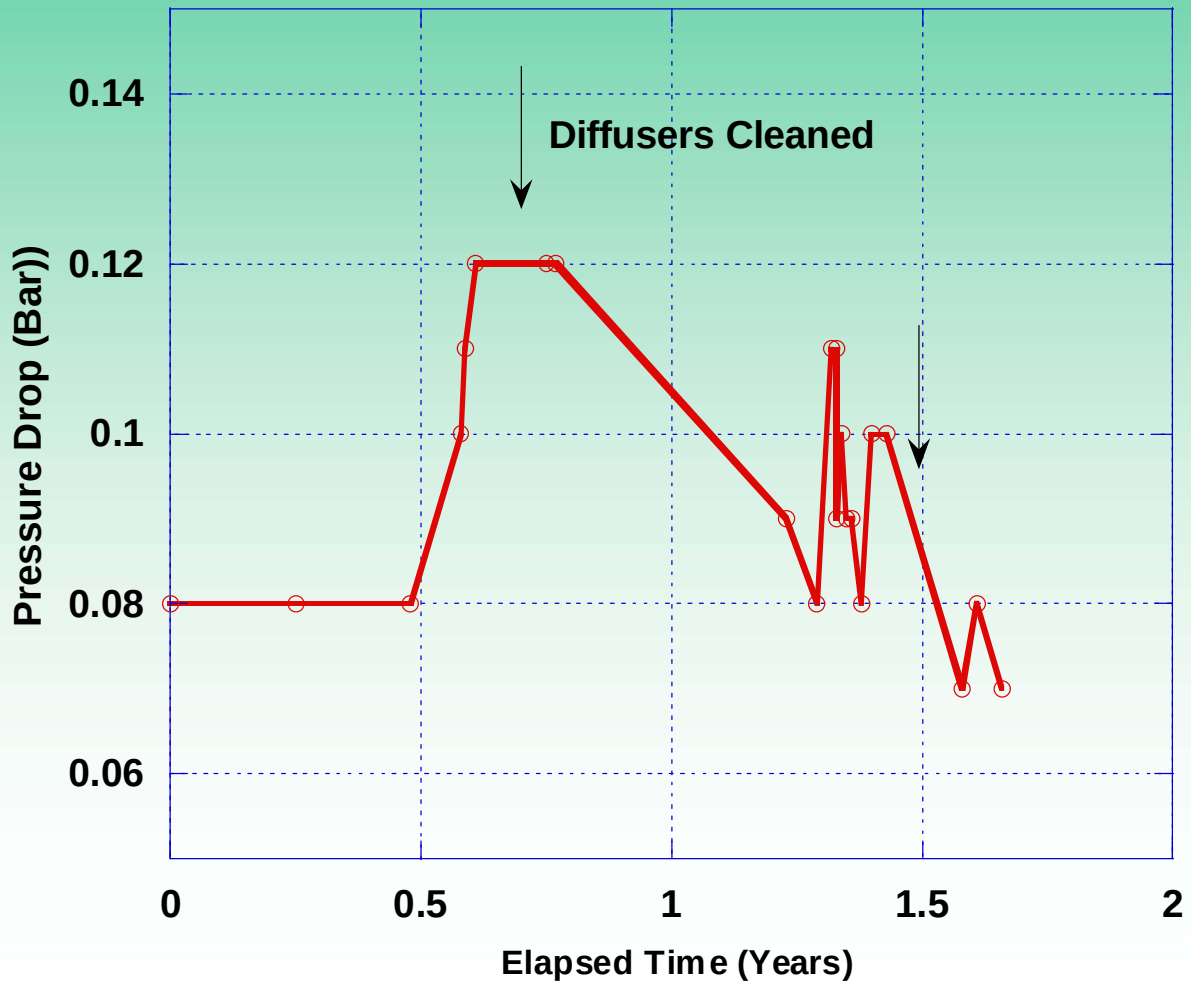
Field Pressure Drop Device

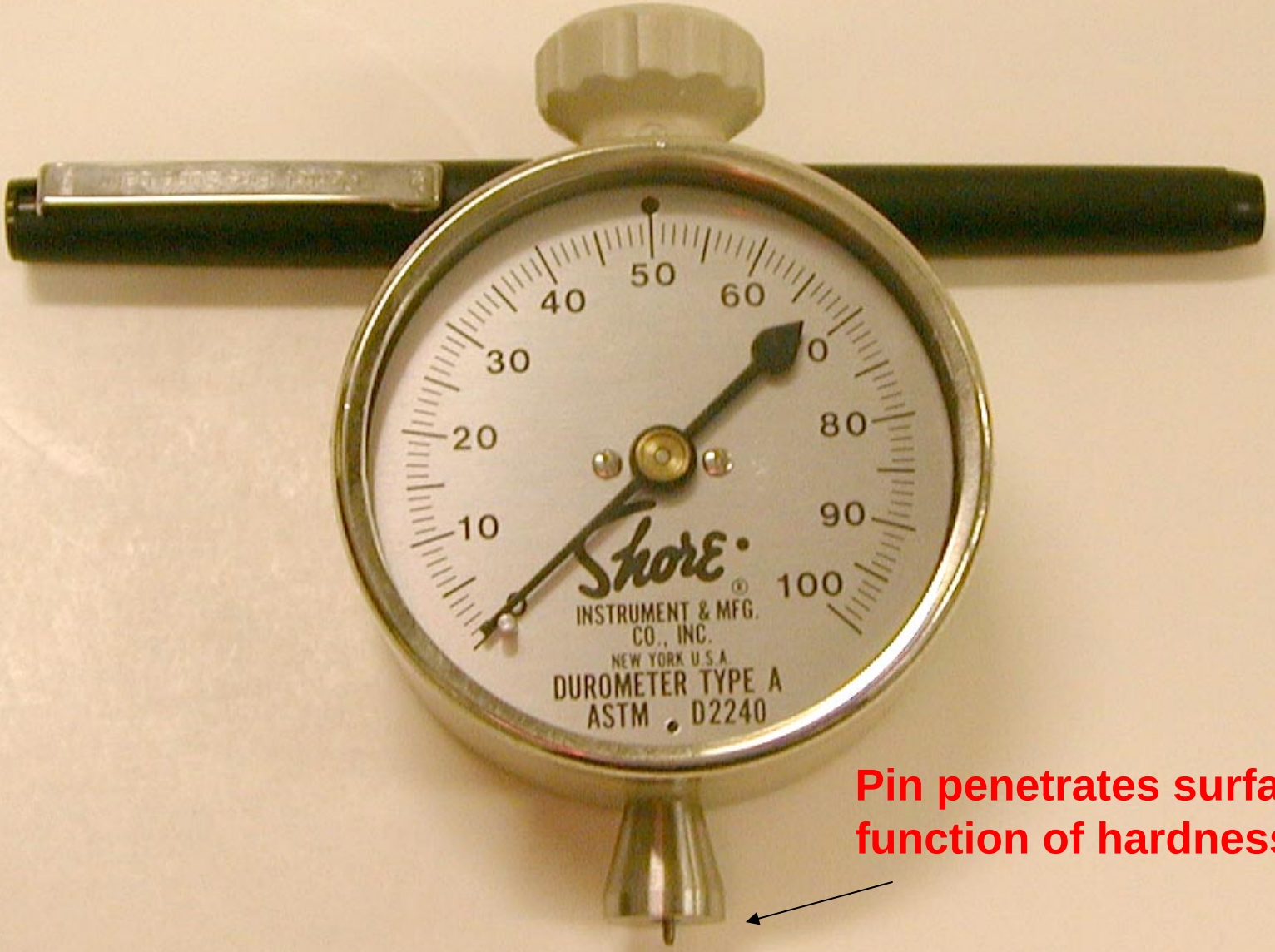
Typical Results Pressure Drop



Poor Flow Distribution

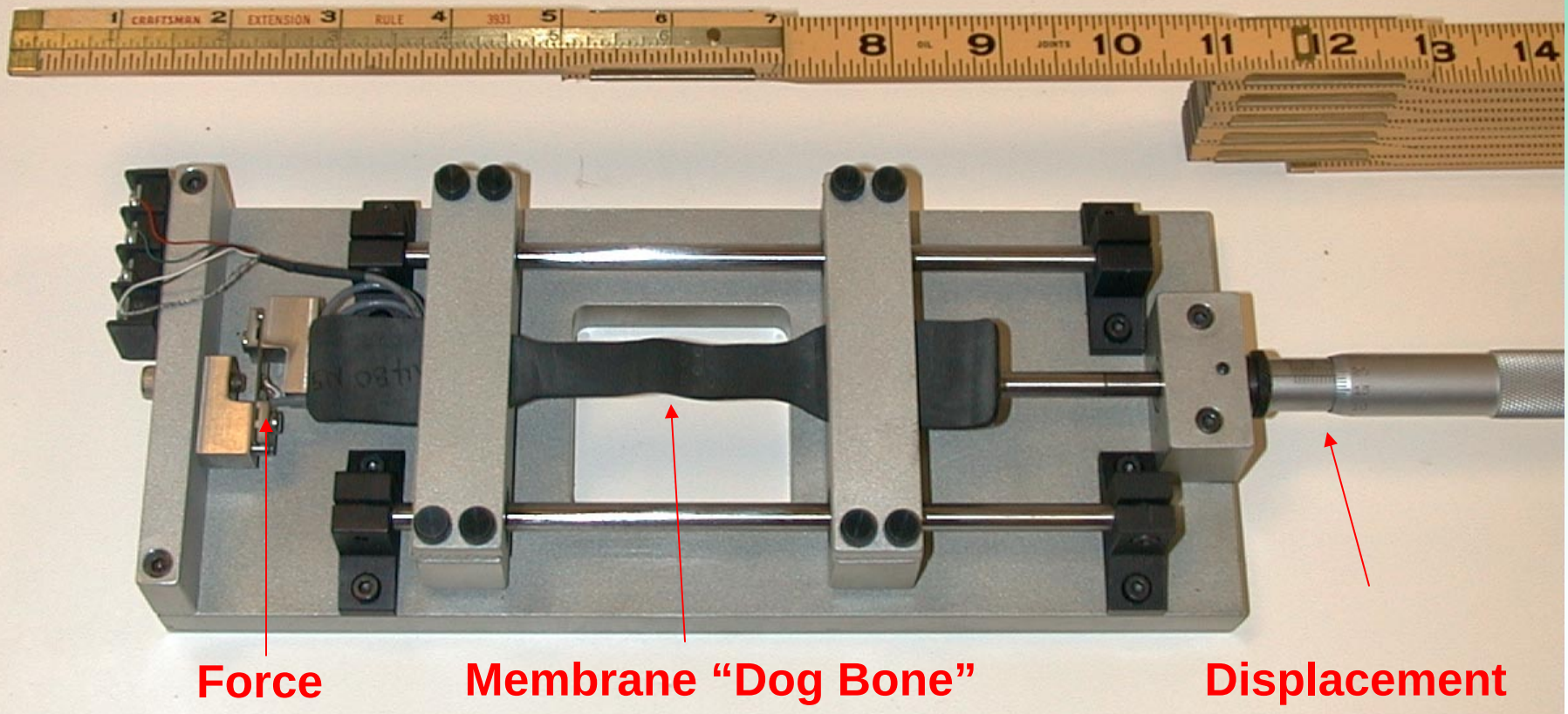
Evaluating Membrane Hardness and Strength

Durometer

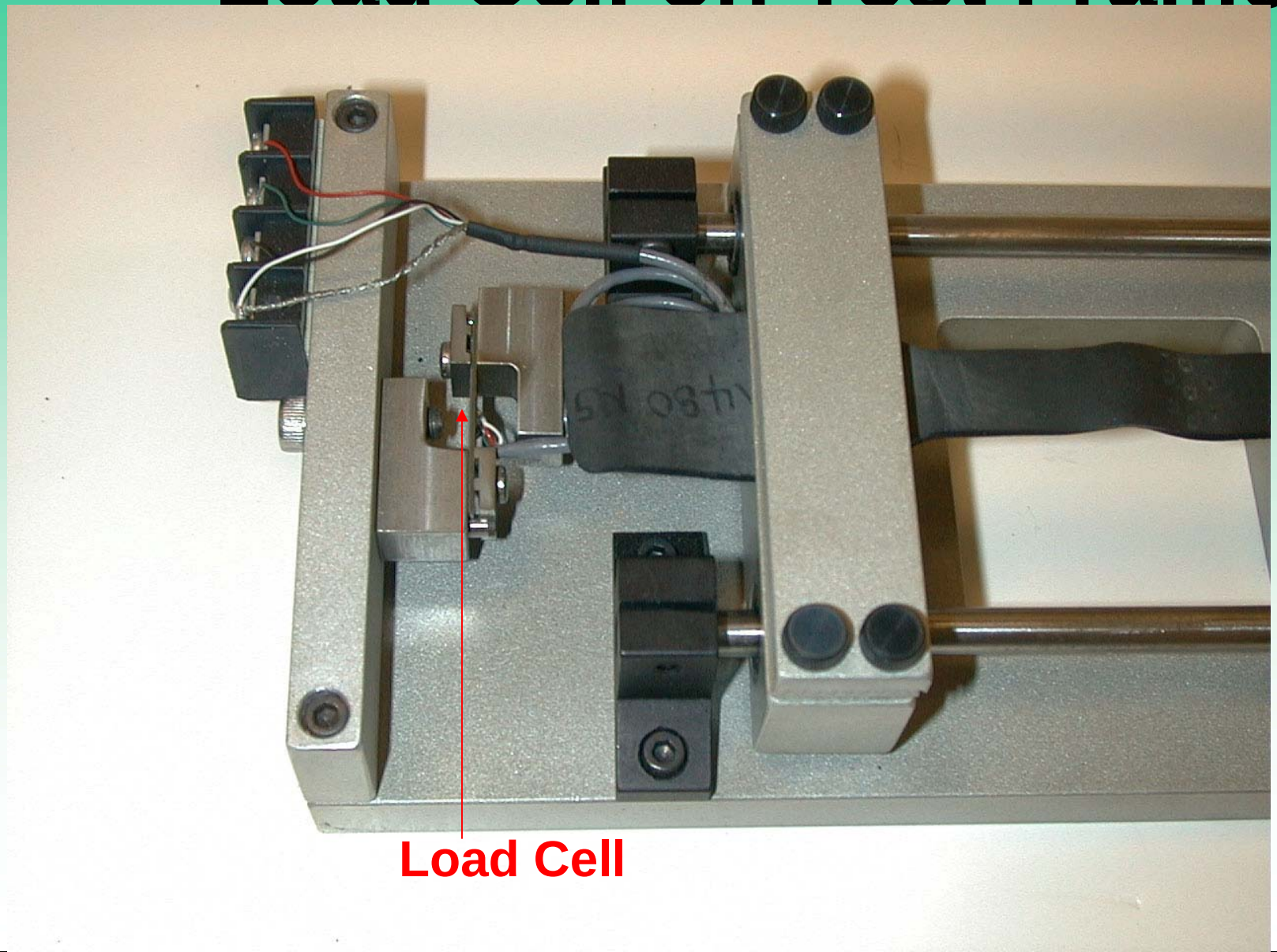


Pin penetrates surface as a function of hardness

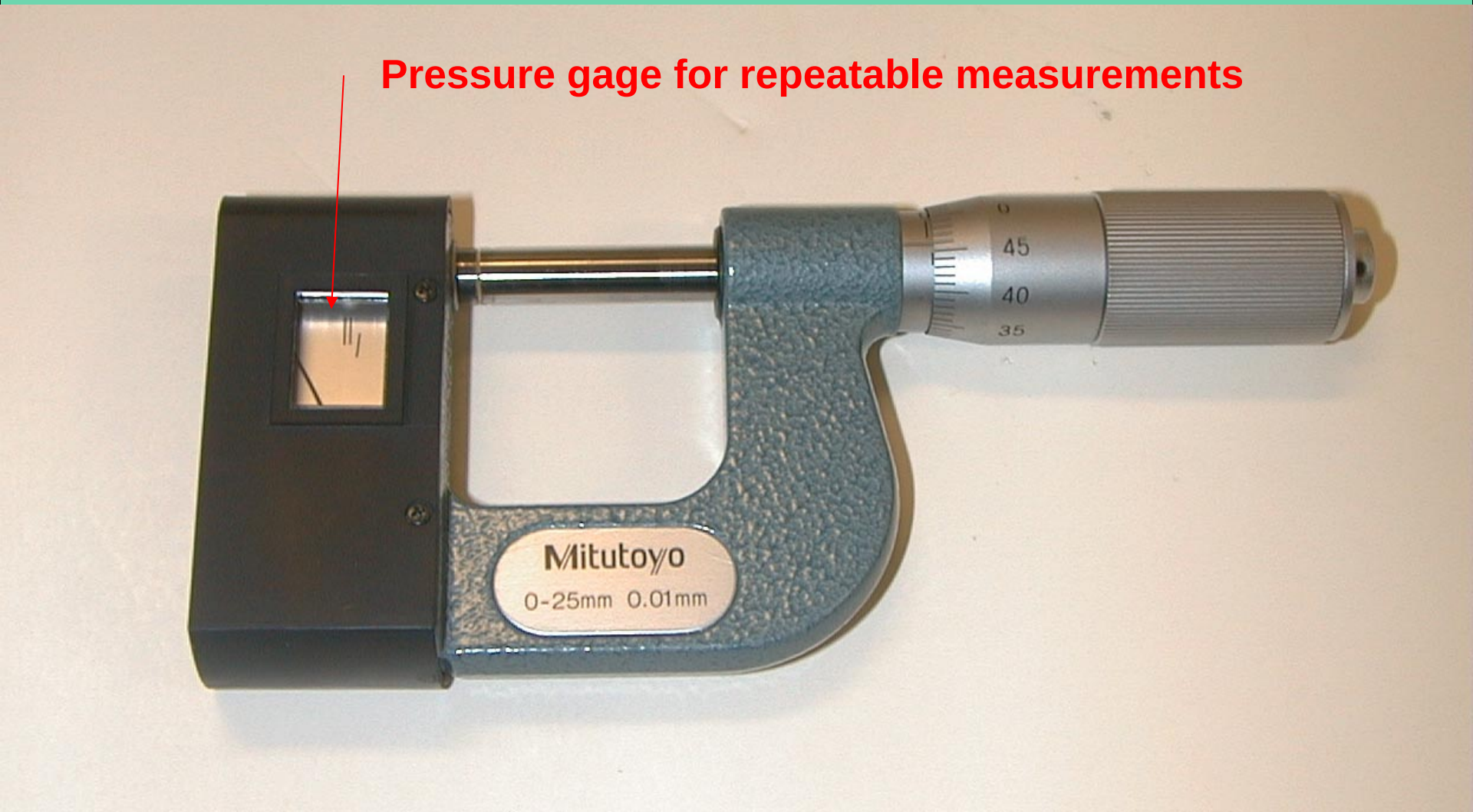
Small Test Frame



Load Cell on Test Frame



Thickness



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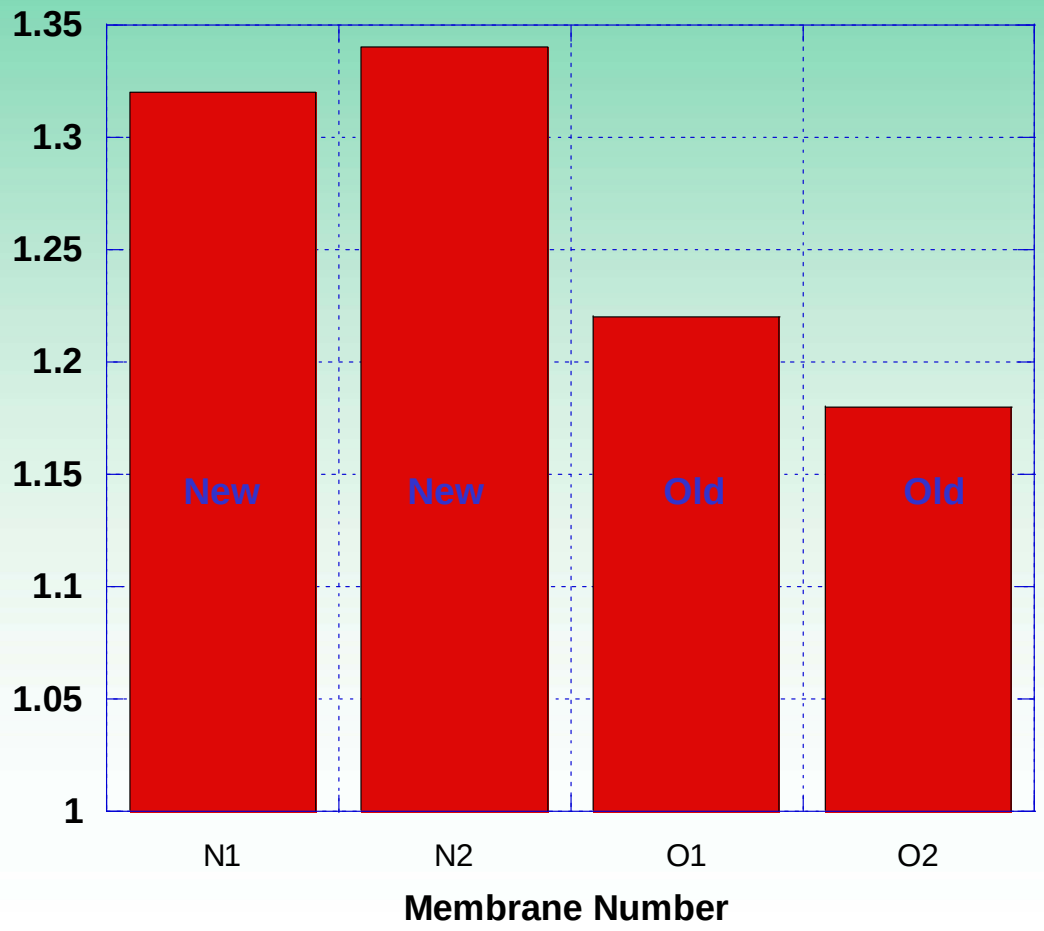
Measuring Orifice Diameters

Pin inserts into an orifice a fixed distance as a function of its diameter

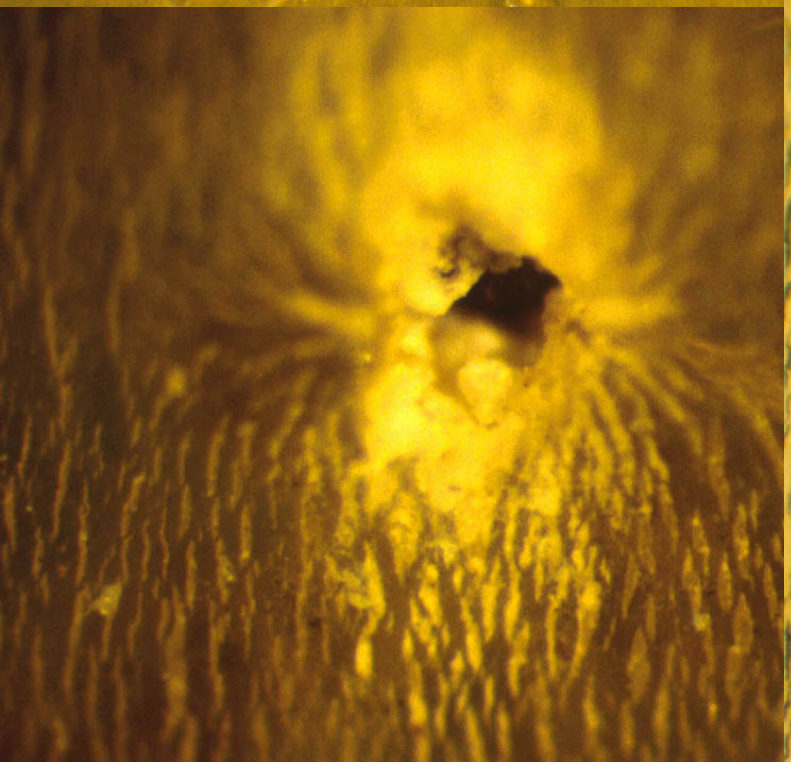
Change in Modulus

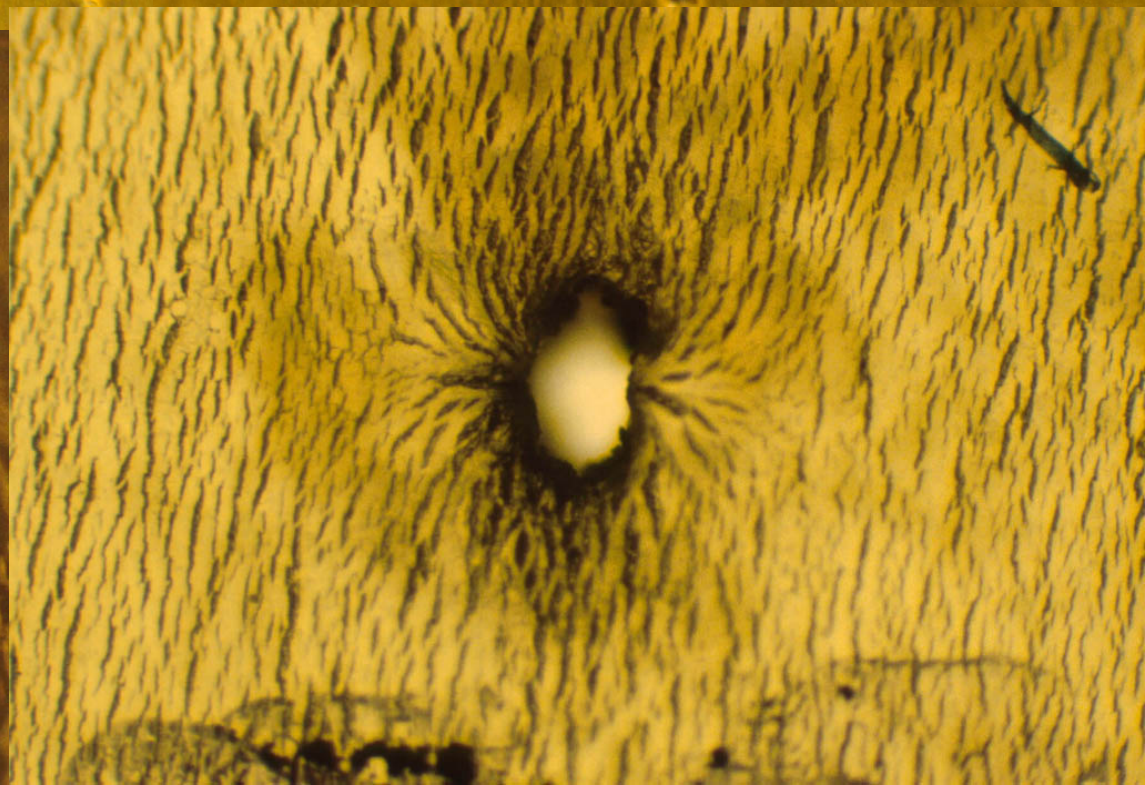
weakening with age

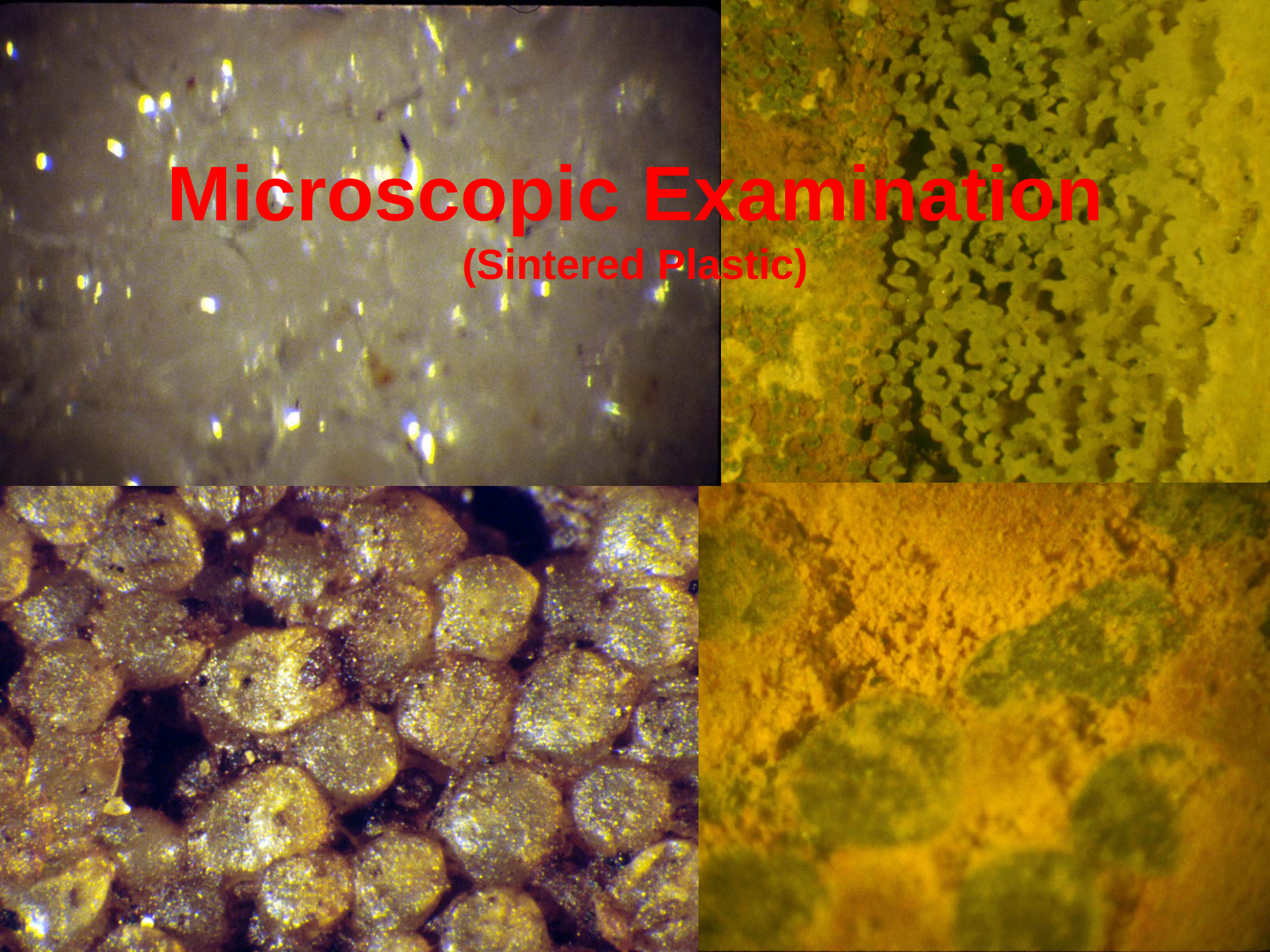


Microscopic Examination

(Polyurethane Membrane)






Microscopic Examination
(Sintered Plastic)

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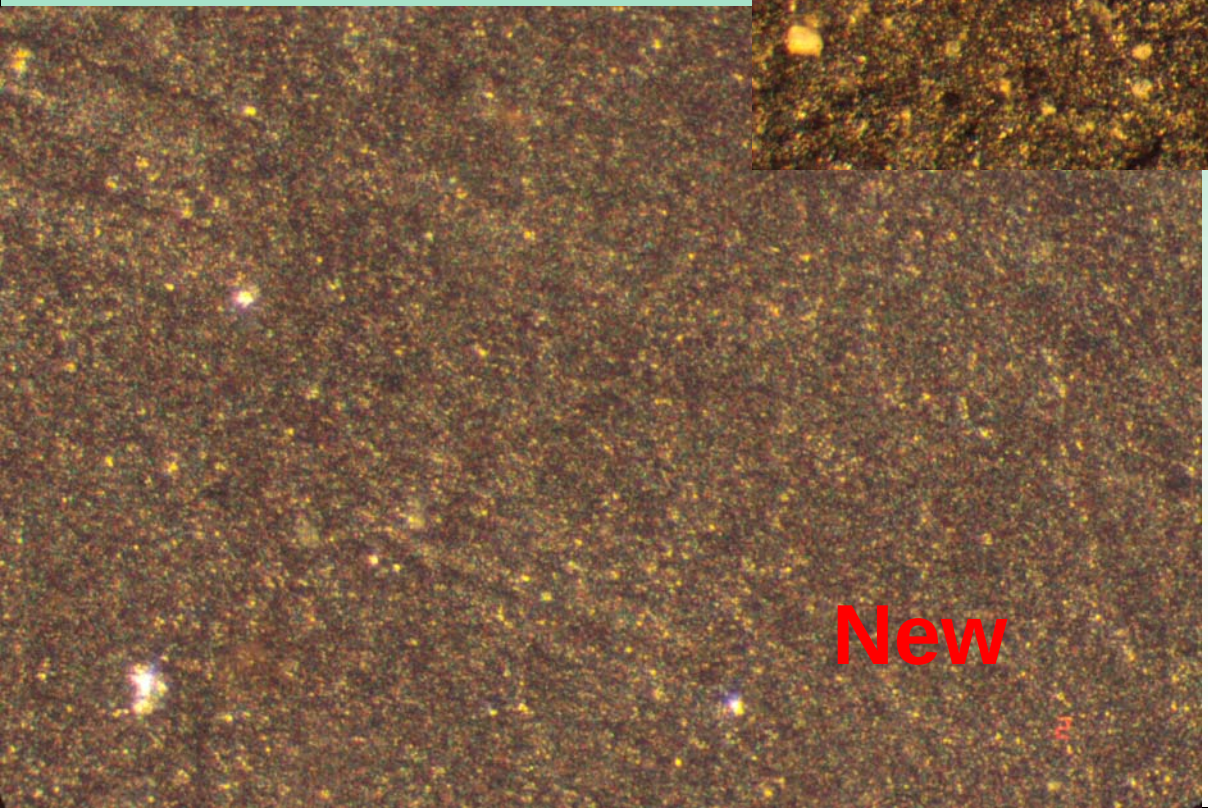
Microscopic Examination

(EPDM Membrane)



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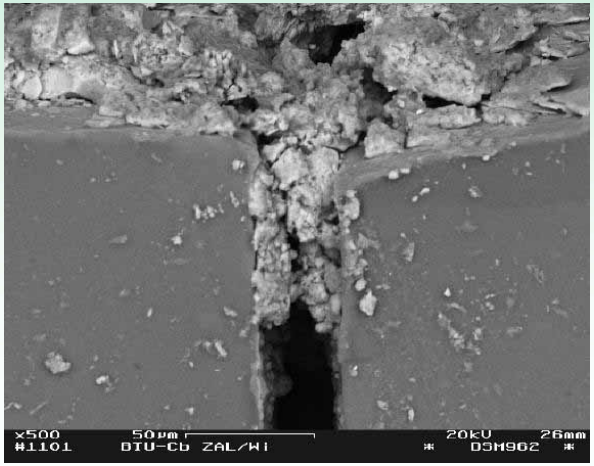
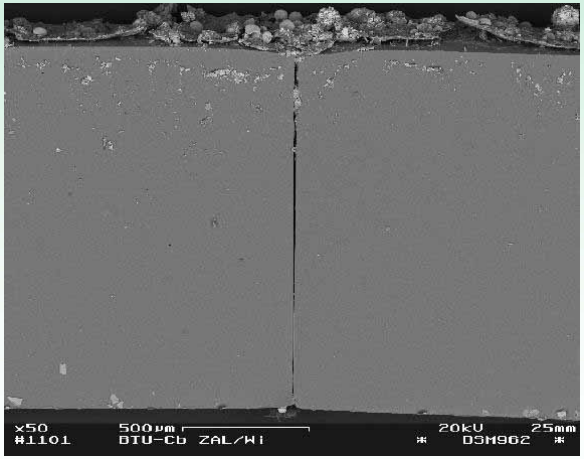
Silicone Membranes

Membrane Surface



Pore Close Up



Pore Side View

From Wiehe and Libra (2004)

Conclusions

- It is easy to track fine pore aeration system performance with off-gas testing
- One or two days every few months gives a "health" report of the aeration system. Initial and periodic testing give good information for design
- Lab-scale testing for material properties and sources of fouling can predict failures or help you understand why membranes failed
- A small, but routine investment in testing is needed
- Must plan – cannot just decide to go out and test. Diffusers must be observed over time to detect changes in efficiency or properties