

Flexible Liner Applications to Geophysical Measurements

by

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Flexible Liners are useful for augmentation of logging:

1. Sealing of boreholes against flow during logging runs in the interior of the liner (an environmental advantage).
2. Determination of hydraulic conductivity profiles in the hole by measurement of the liner installation/removal rate.
3. Towing of logging tools into long and tortuous holes, even vertically upward.
4. The displacement/replacement of normal, or special, borehole fluids to aid the logging procedure.
5. Protection of expensive sondes against collapse of the borehole wall.
6. The emplacement of electrical contacts against borehole walls.

Topics to be covered

- the mechanics of flexible liners
- the characteristics of liners
- transport of tools with liners
- sealing the borehole
- displacement of borehole fluids
- hydrologic characterization of holes

Some liners are installed by just adding water

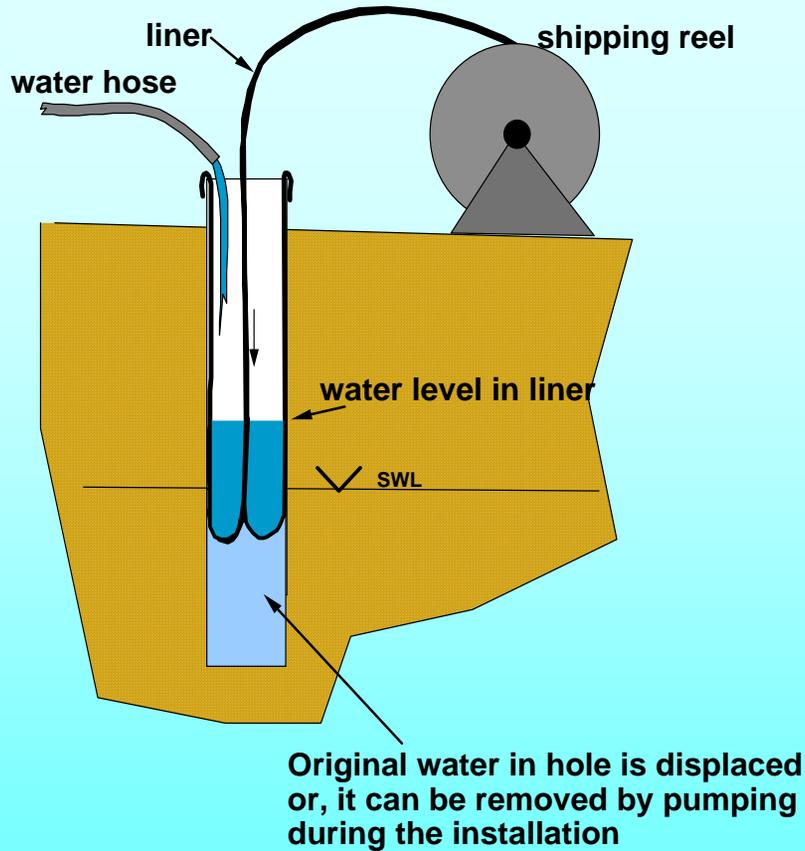
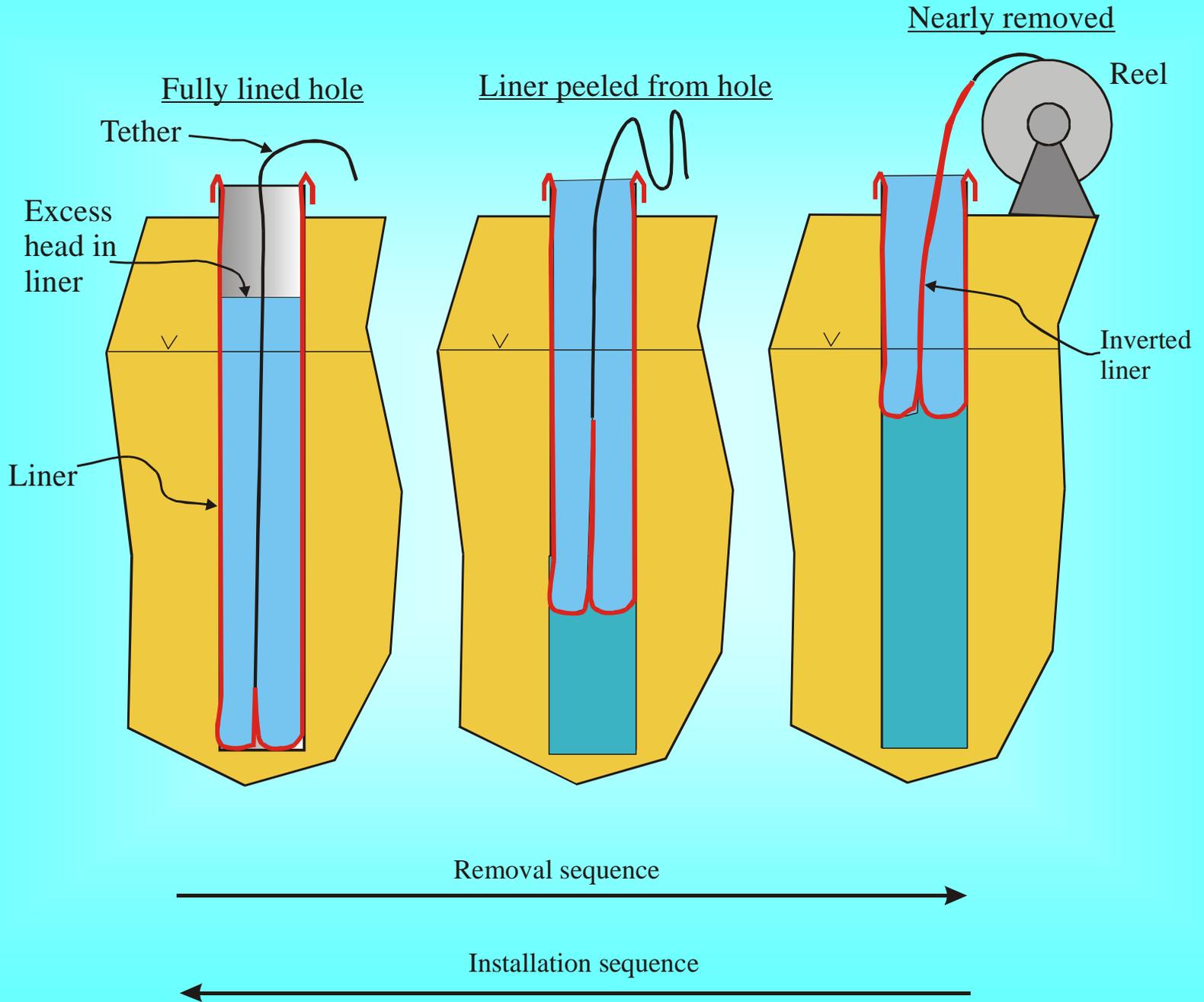
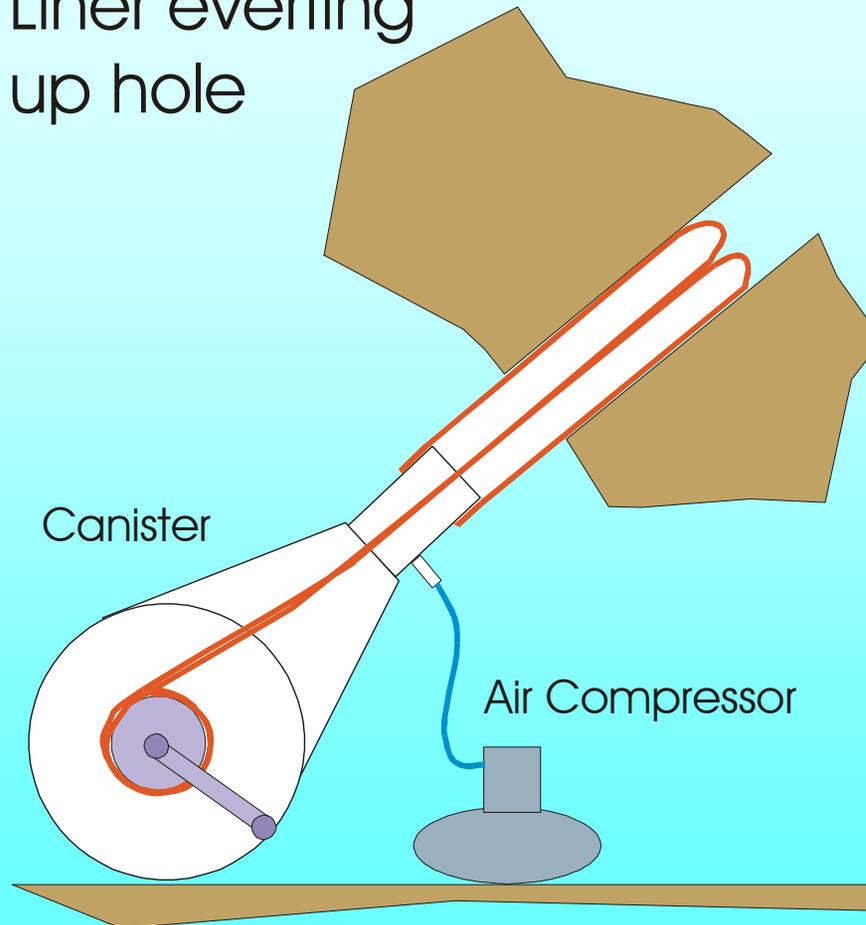


Fig. 1. Flexible Liner Installation and Removal Mechanism



Other liners are air driven

Liner everting
up hole



Mockup of liner extending into hole in back of tunnel



This liner can tow sondes for hundreds of meters



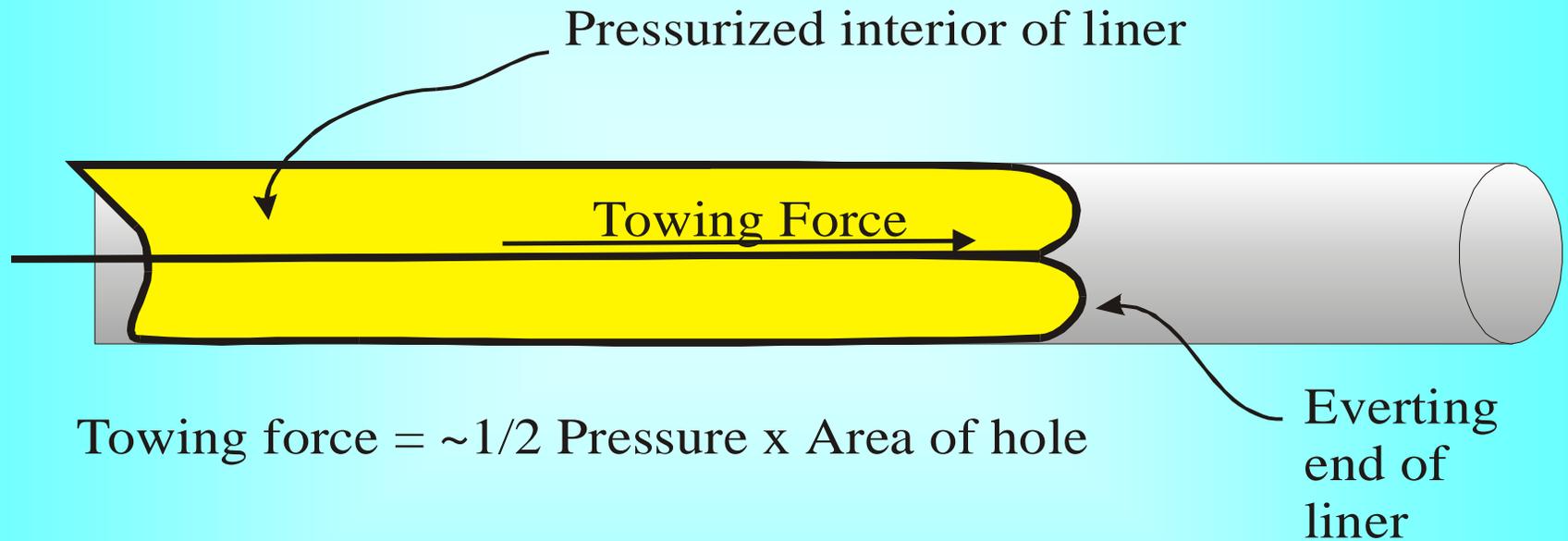
Towing neutron moisture sonde under Texas landfill



Air/Water install under landfill for 400 ft.



Fig. 3. Towing force of everting liner



Some interesting numbers for a 2" liner

- The drag of the liner against the wall = 72 lb/psi/ft
- The drag of the inverted liner within itself is 0.01 lb/ft. (or 0.03 lb/ft. upwards)
- The towing force of the liner is 1.5 lb/psi
- force required to collapse the liner is 24 lb/psi/ft
- Burst pressure of 210 denier is 350 psi (~100 psi practically)

Liner attributes are useful

1. require very little labor to deploy (the pressure does the work),
2. can be stored on reels for easy transport,
3. conform to the hole wall very well,
4. seal and support boreholes,
5. provide large towing capabilities at higher pressures and larger diameters,
6. provide a transport vehicle for many items attached to the inside or outside of the liner,

Attributes (cont.)

7. are relatively light weight and compact compared to push rods or piping,
8. contain all the hole fluids within the liner,
9. occupy very little of the hole volume,
10. are very gentle as they move against the hole wall, and,
11. propagate equally well horizontally, vertically upward, and around curves.

For mining, one advantage is the transport of sondes in holes

- An 18” canister can hold 300 ft. of 2” liner
- 20 psi can transport the sonde and cable to the end of a 300’ hole.
- A sonde can be attached to the liner at any point on the liner to adapt to different hole lengths.

The seal of the hole is very useful

- In many environmental measurement situations, the hole should not be left open to the flow of contaminants.
- Liners are used to seal holes after drilling, and then removed, or not removed, for the logging operations
- Holes are sealed with a liner to prevent fracture fluids flowing into the hole during high resolution temperature measurements.
- Many tools can look through the liner (e.g., sonic, gamma, induction coupled elec., radar)

The displacement of borehole fluids is an advantage

- John Lane, of the USGS, displaces a brine into the fractures, with a liner filled with low conductivity water. The brine filled fractures are more easily mapped with radar if the hole is not brine filled.
- A transparent liner allows video mapping of the walls by emplacing the liner with clear water. Any turbid water/mud is displaced by the transparent liner. Videos in opaque liners also show a lot of fracture and vug detail.

Liner installation can be the measurement of conductivity

As the liner is emplaced, it pushes the borehole water into the formation. The initial liner descent velocity is highest.

As the liner descends, it covers the flow paths, and therefore slows its descent.

By measuring the liner descent rate, one can calculate the distribution of the flow paths out of the hole.

Figure 7. Velocity of liner in uniform medium

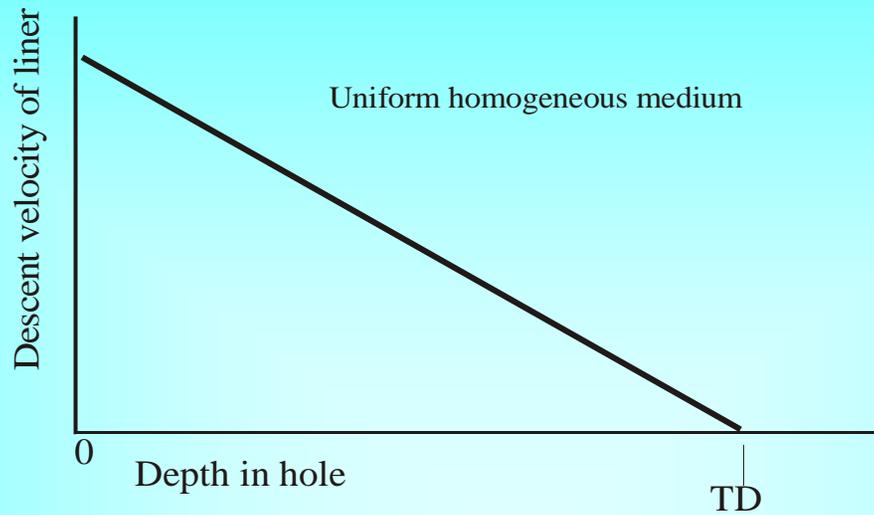
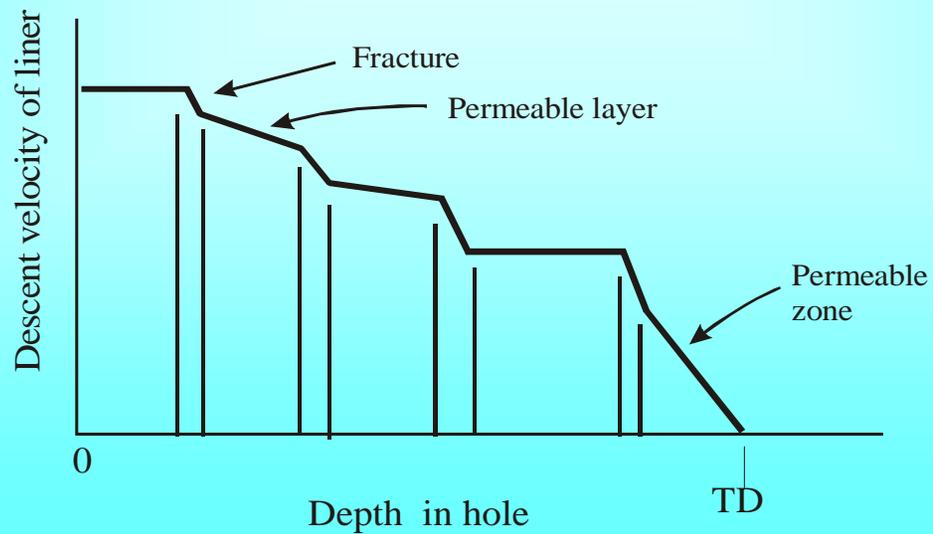


Figure 8. Possible velocity profile in fractured medium



Conclusion

There are a wide variety of applications of flexible liners to the augmentation of traditional measurements and in the measurement of flow paths directly.

The state of the art of liner fabrication and the experience/science developed make many of these applications practical. Many are already in practice.

Thanks for your attention