2019-03-13-Penetrator-Sectioning-Report.docx

Project: 901809.00 DeepPIV/ Deep Sea Bioinspiration

Author: Denis Klimov (EE) (sectioning), with input from Aaron Schnittger (MT); (potting; pressure testing).
Penetrator design: Jon Erickson (ME)

Description of issue:

- DeepPIV fiber optic assembly leaked in December 2018 under pressure during deployment ~ 600m depth. Several milliliters of oil intrusion into pressure housing were observed. In subsequent testing in the pressure chamber on shore, it was found that some test assemblies are leaking, and some do not.

Design:

- The integrity of the fiber optic assembly against water intrusion is provided by "Penetrator" which is a stainless steel tube with O-ring seal to underwater connector; with optical fibers potted inside of the tube (Fig 1.)
- The fiber specifications: 4 ea of SMF-28; 1550nm SM Fiber; 9 um core; 900 um PVC jacket
- Penetrator dimensions:
  - Full length 2.65 inch x Full OD 0.875 inch
  - Tube OD 0.785 inch x Tube ID: 0.605 inch
- Potting specifications:
  - Hard epoxy (applied first); diameter 0.605" x ~ 0.9" long:
    - Lok-Tite E-30CL Hysol Epoxy
    - Nominal pot life 30 min. Actual ~ 1 hour (longer than nominal).
  - Soft epoxy (applied second); diameter 0.605 x ~ 0.65" long;
    - Lok-Tite E-05CL Hysol Epoxy
    - Nominal pot life 30 min. Actual ~ 0.5 hours.

Test samples of sectioned penetrators:

- Sample 1 (Fig 1.) DID NOT leak during pressure testing. Difference from Sample 2 highlighted in YELLOW
  - New penetrator tube used for potting process
  - Fiber was fixed to the bottom of the tube using green modeling clay
  - Tube was cleaned with acetone
  - Fiber was cleaner with denatured alcohol
  - Both Epoxies were de-gassed in the vacuum chamber at ~ 30" mercury vacuum for 5-10 minutes
  - Epoxies application at atmospheric pressure. Paying attention to removal of air bubbles
  - Cure time between applications of hard and soft epoxy: overnight (at room temperature)
  - Cure time before applying pressure: ~ 5 days at room temperature.
  - Application and curing location: Lab B138
  - Hydraulic oil used for pressure testing: 30W Chevron
  - Pressure test specs: 5800 PSI; 10 cycles at 500 PSI/ minute ramp-up and down; final cycle held at 5800 PSI for 1 hour
  - Sectioning: Isomet 5000 diamond saw; Isocut Plus 11-2293-016 cutting fluid mix 1:9 to RO water ratio; diamond blade 5"x0.015" (Fig 9,10)
- Sample 2 (Fig 2.). DID leak during pressure testing. Difference from Sample 1 highlighted in yellow
  - Stainless steel tube was reused from previously potted penetrator. Old potting material scraped from the tube, and tube was bead-blasted using glass media
  - Fiber was fixed to the bottom of the tube using red modeling clay in order to prevent epoxy leakage during potting process
  - Tube was cleaned with acetone
  - Fiber was cleaner with denatured alcohol
  - Both Epoxies were de-gassed in the vacuum chamber at ~ 30" mercury vacuum for 5-10 minutes
  - Epoxies application at atmospheric pressure. Paying attention to removal of air bubbles
  - Cure time between applications of hard and soft epoxy: overnight (at room temperature)
  - Cure time before applying pressure: ~ 2 days at room temperature.
  - Application and curing location: Lab B138
  - Hydraulic oil used for pressure testing: 15W Royal Purple
  - Pressure test specs: 5800 PSI; 10 cycles at 1000 PSI/ minute ramp-up and down; final cycle held at 5800 PSI for 1 hour
  - Sectioning: Isomet 5000 diamond saw; Isocut Plus 11-2293-016 cutting fluid mix 1:9 to RO water ratio; diamond blade 6"x0.025" (Fig 9,10)# #

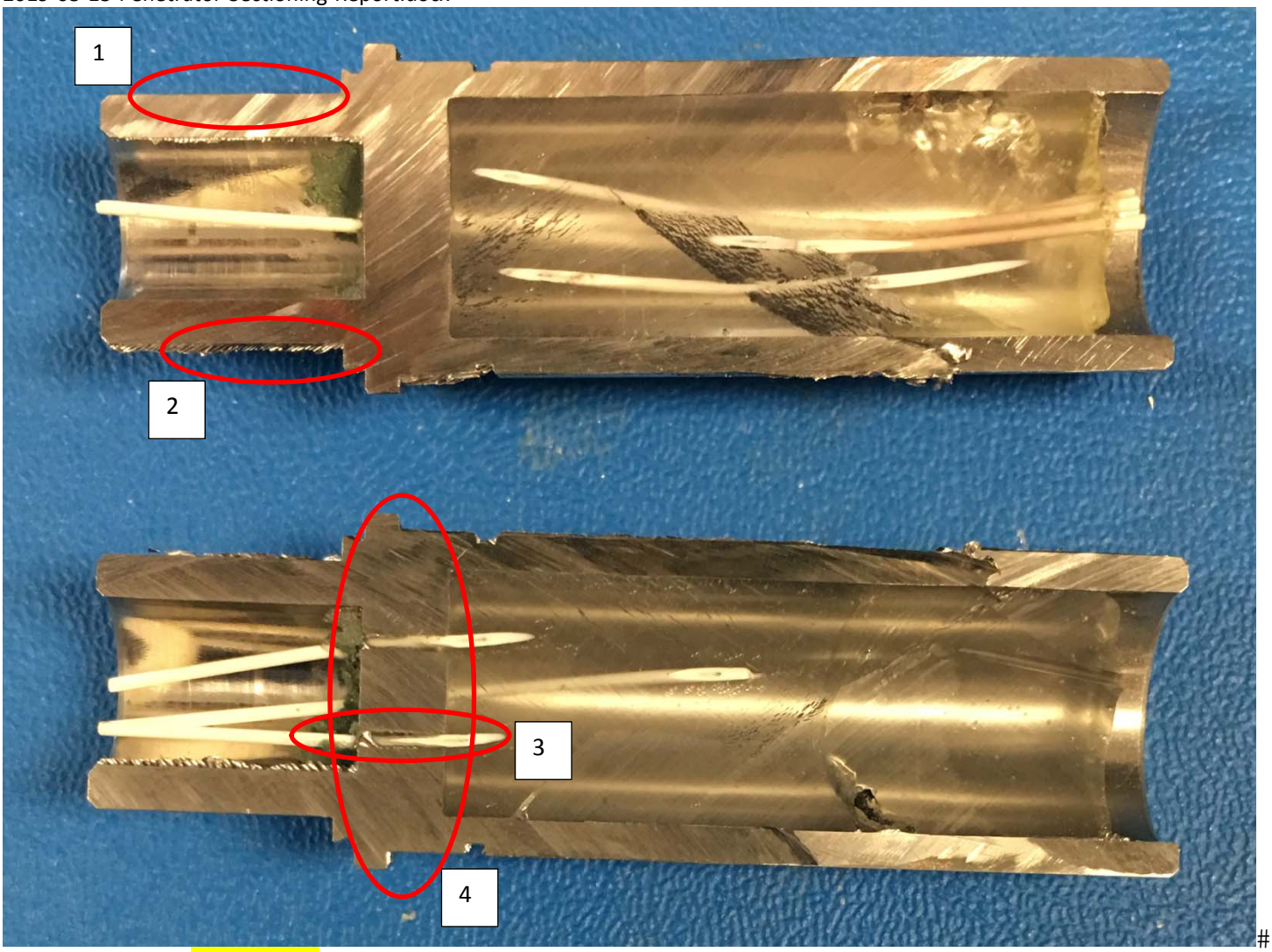

Fig 1. (Sample 1). Did not leak under pressure. Note the difference in presence/ absence of burrs on the edge depending on the blade transition from air to steel or steel to air (Illustration circles 1,2). Bottom of the penetrator has thick base designed to withstand the water pressure up to ~ 1000 meters (Illustration circle 4). Base has 4 small (0.040”-0.062”) holes designed for passing individual fibers (Illustration circle 3).

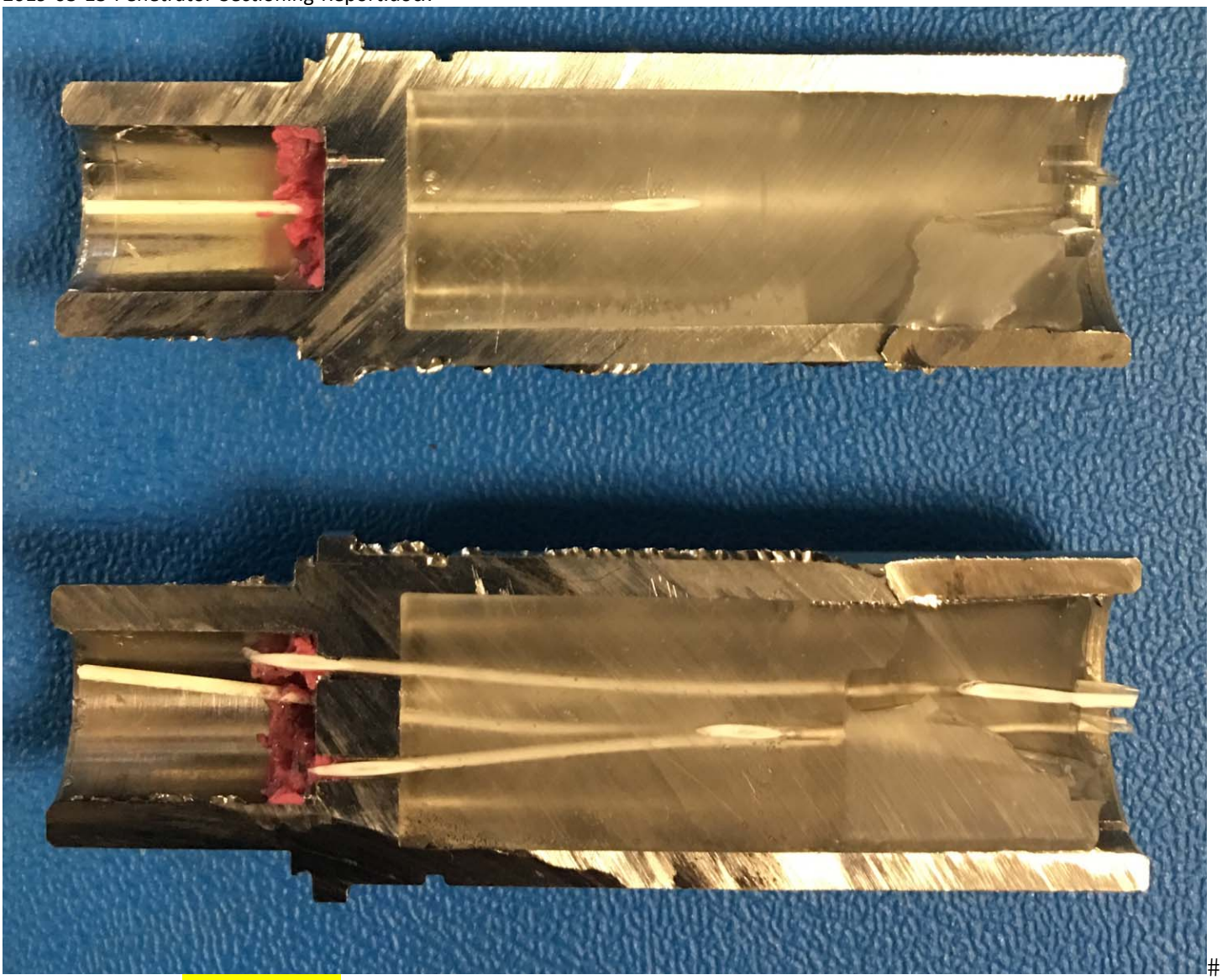 #

Fig 2. (Sample 2). Developed leak under pressure.#

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Fig 3. (Sample 1). No perceived gap between epoxy and optical fiber. Fiber can be pulled out by force, but some level of adhesion is present. No signs of liquids in the gap(s). (Illustration circle 1)#

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Fig 4. (Sample 1). There seems to be gap visible between the epoxy and the penetrator tube thru most of potting perimeter (illustration circles 1, 2). It is not clear if the gap is an artefact of cutting process or was it present before cutting. The argument against artefact is that the gap looks the same on top and bottom part of the picture irrespectively of blade transition from epoxy to steel or steel to epoxy (Illustration circles 3, 4) as compared to transition from steel to air and air to steel visible on Fig 1.

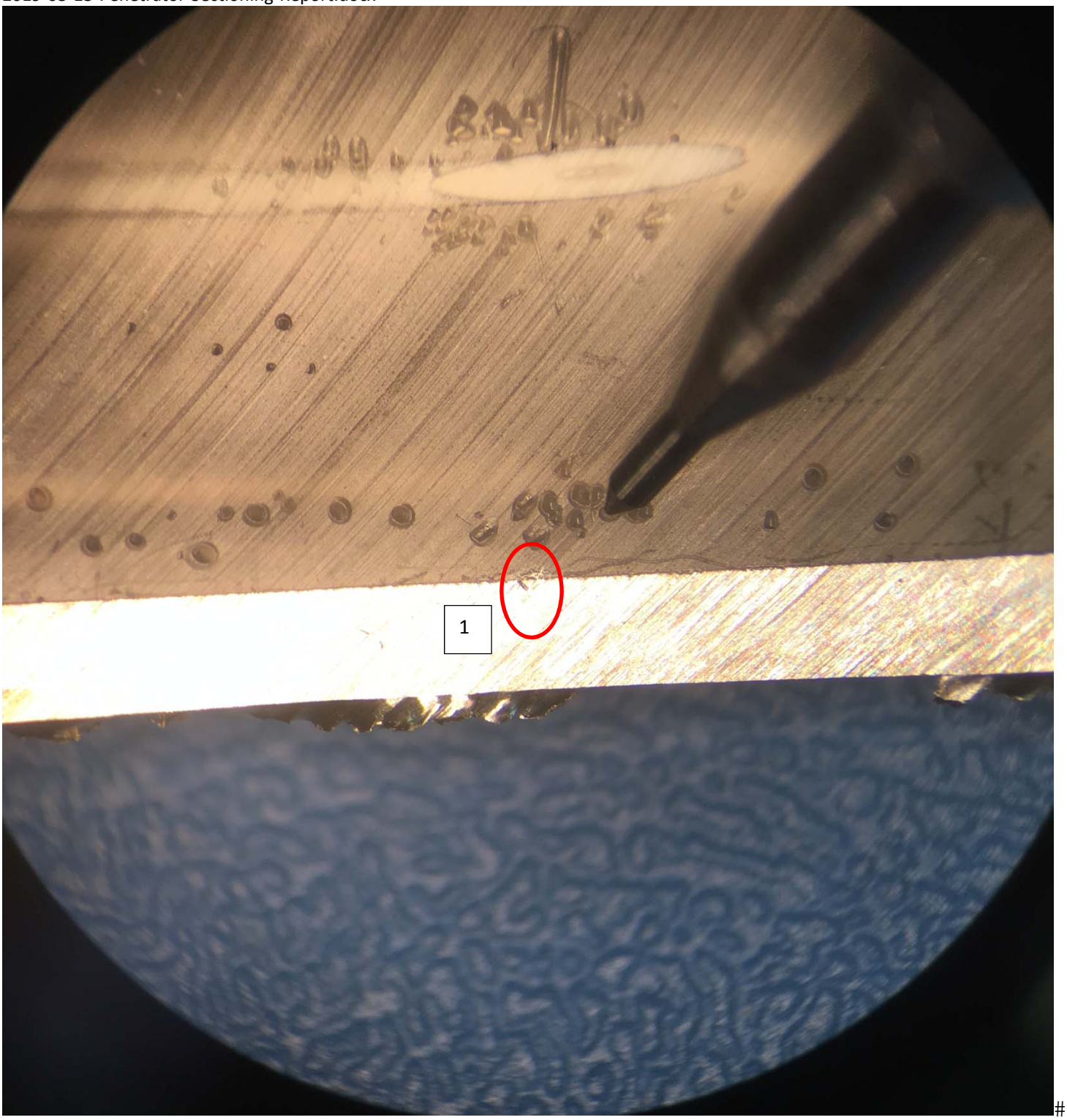

Fig 5. (Sample 2). There seems to be liquid present between the epoxy and the penetrator tube. When pressed with probing tool, micro droplets of liquid come out of the gap (Illustration circle 1)#

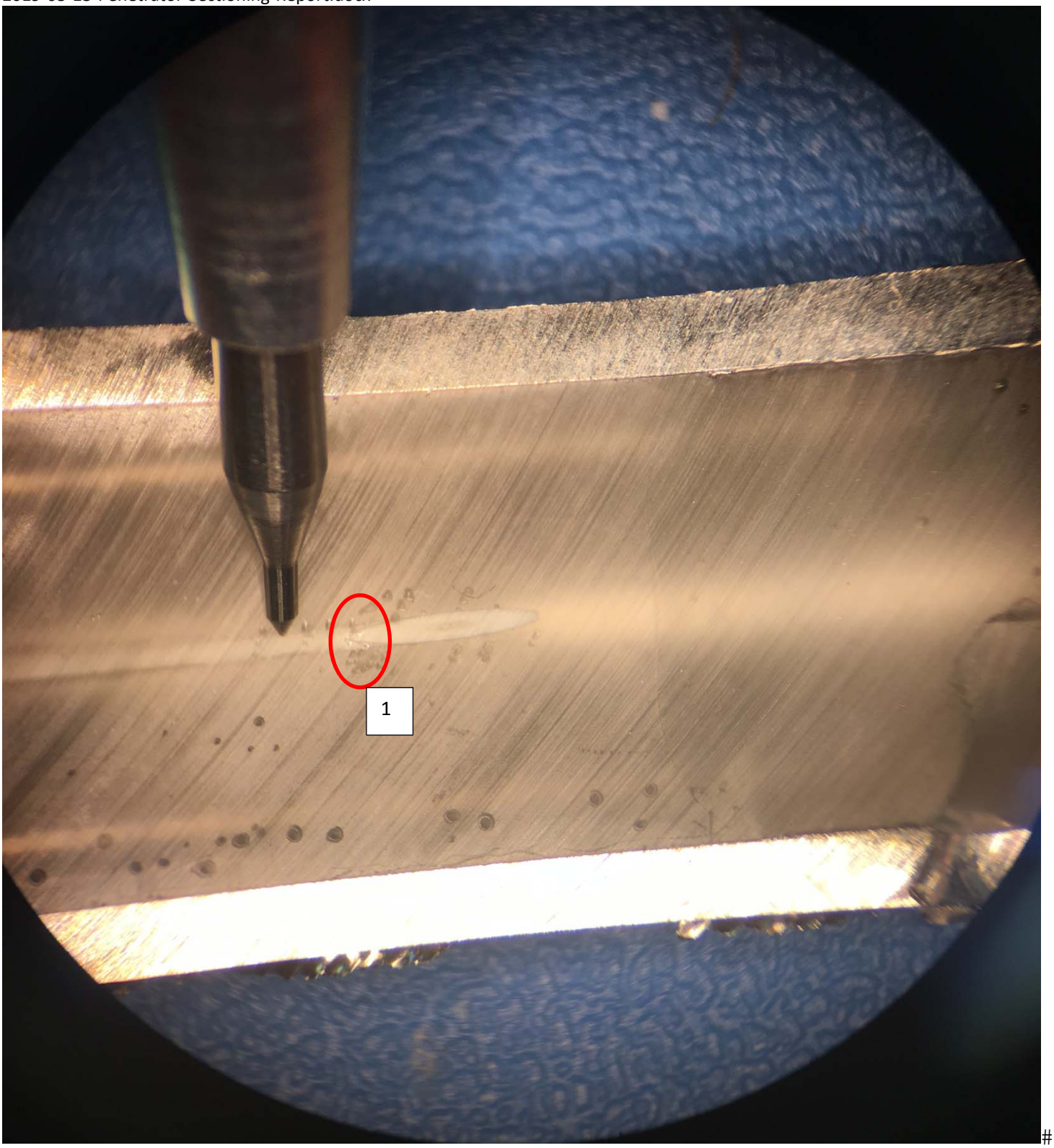

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Fig 6. (Sample 2). There seems to be liquid present between the epoxy and the optical fiber. When pressed with probing tool, micro droplets of liquid come out of the gap (Illustration circle 1)#

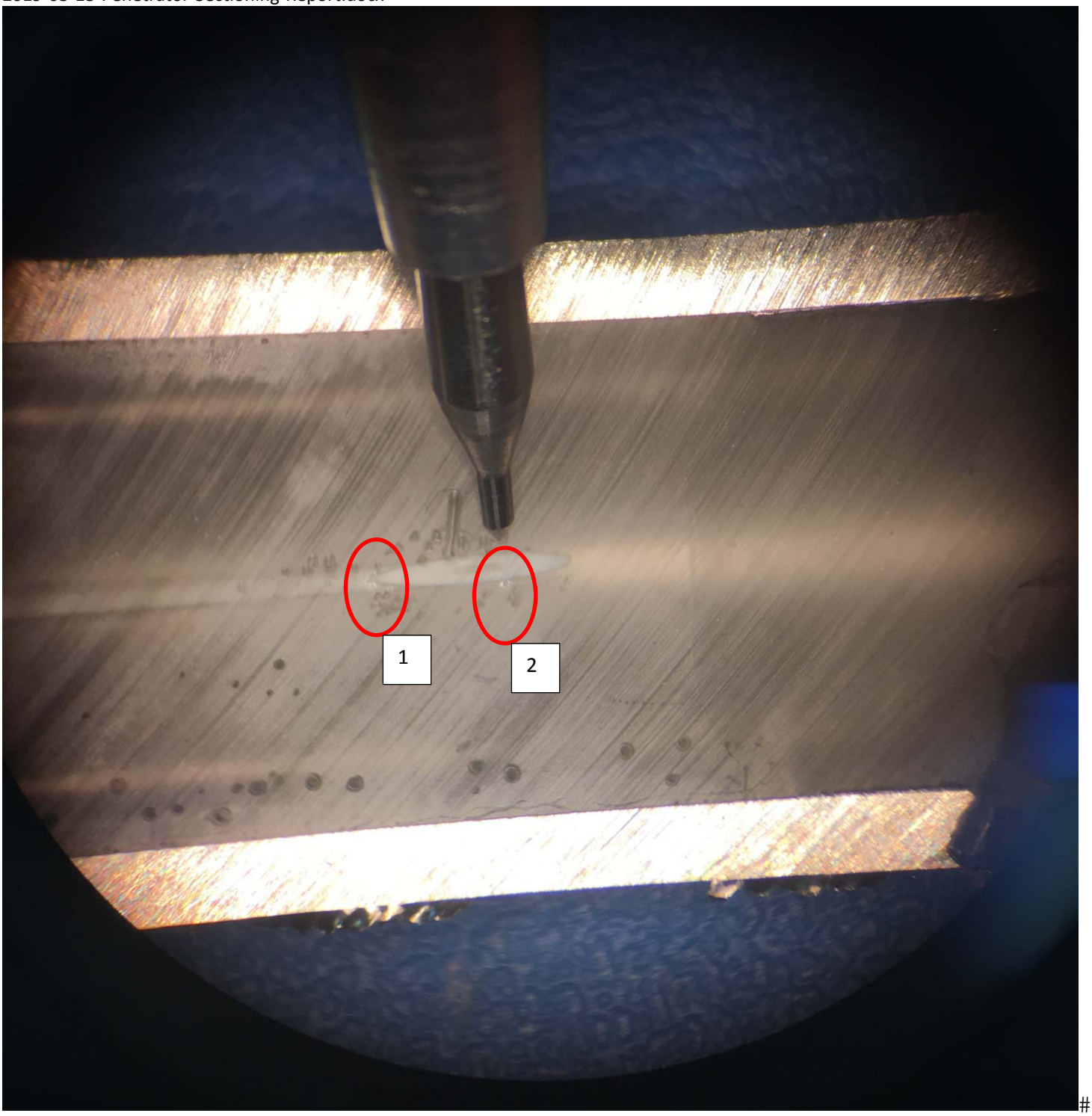

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Fig 7. (Sample 2). There seems to be liquid present between the epoxy and the optical fiber. When pressed with probing tool near other side of fiber section; micro droplets of liquid come out of the gap near that spot as well (Illustration circles 1, 2)#

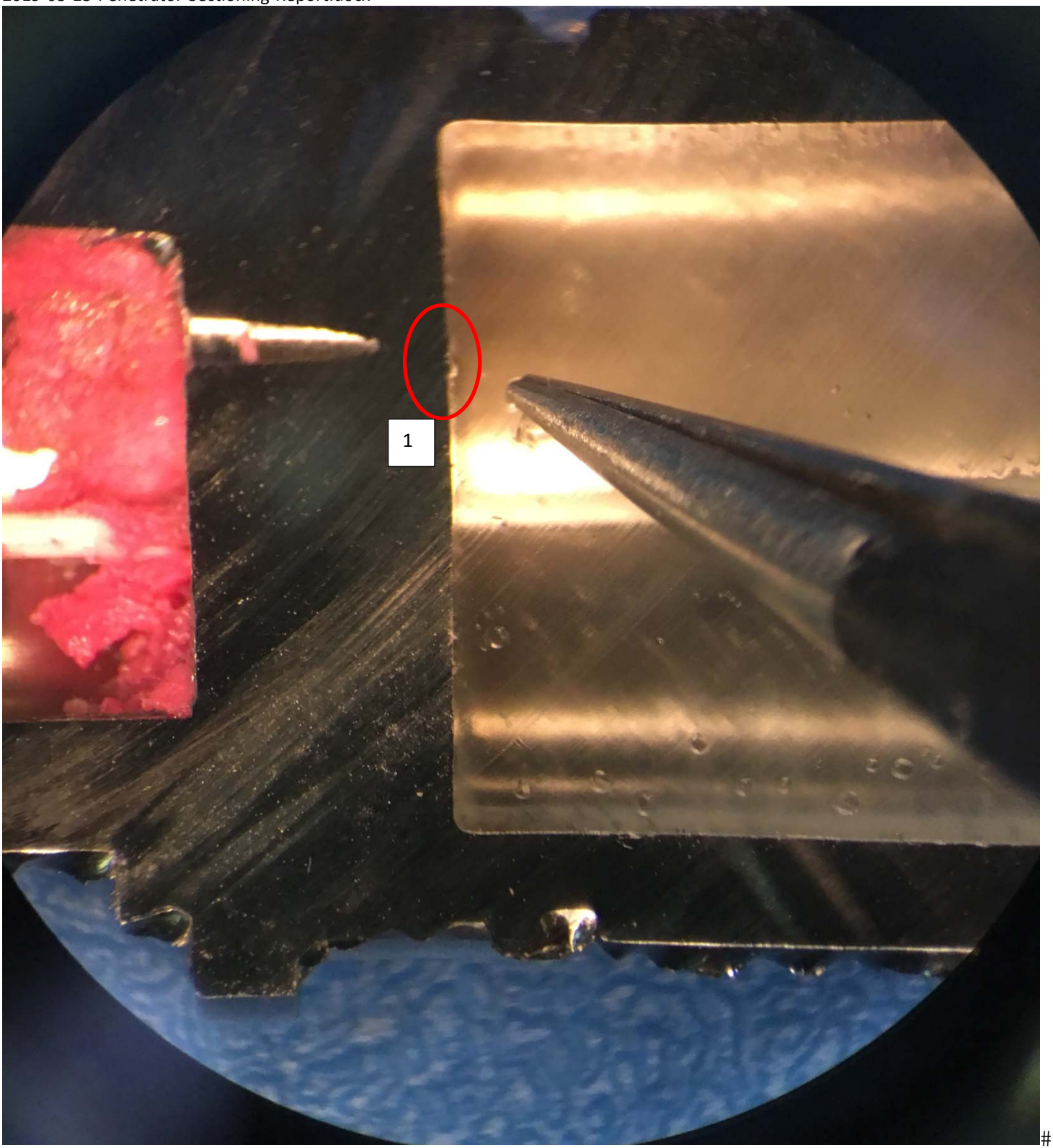

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Fig 8. (Sample 2). Similar to Fig 6, 7; when pressing with probing tool near the edge on the bottom of the potting pocket, micro droplets of liquid come out of the gap (Illustration circle 1). Visibility of the droplet is not so great in this picture; but it is visually apparent when viewing under stereo microscope

Fig 9. (Sample 3). Isomet 5000 automated sectioning saw setup#

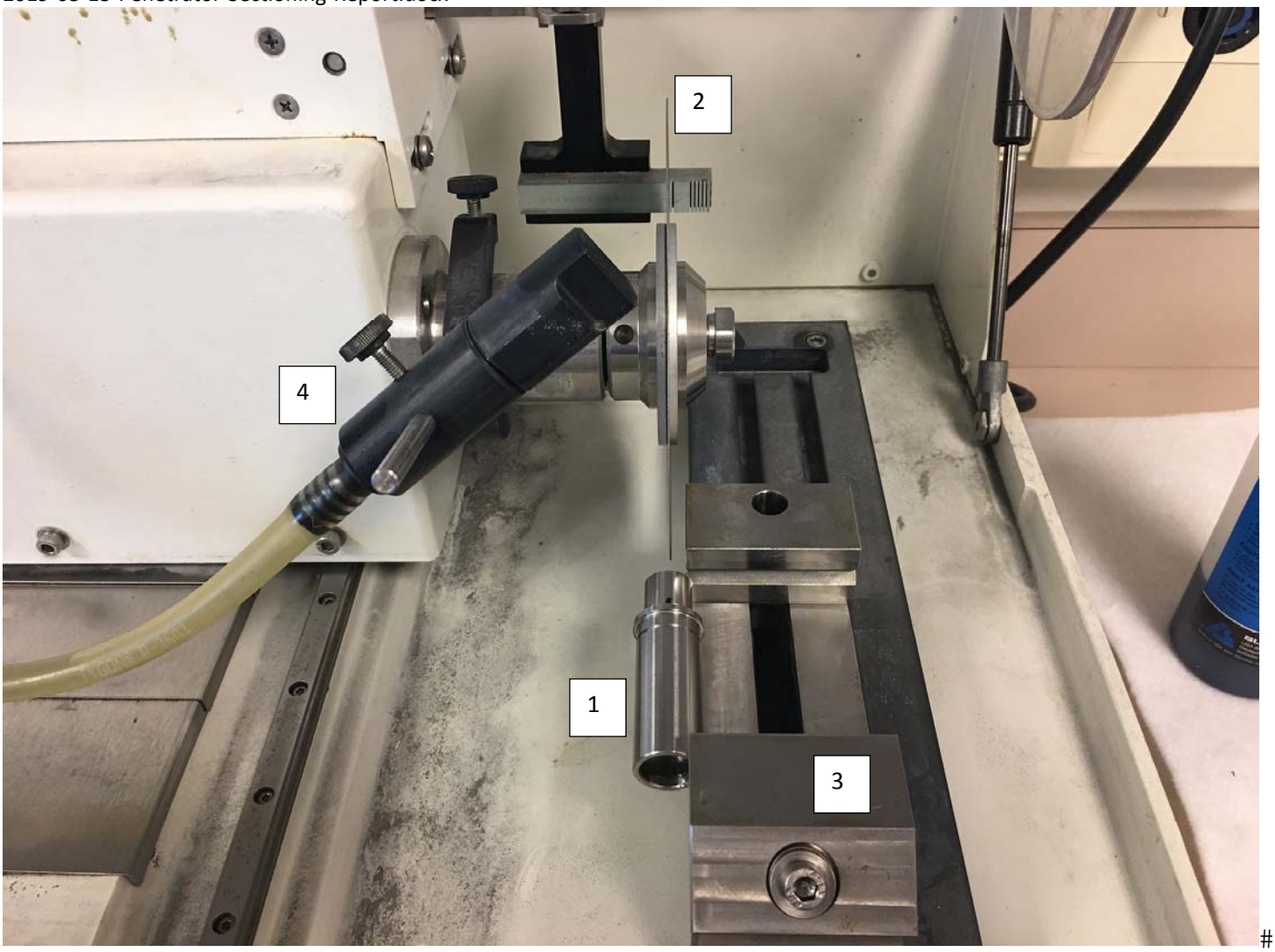

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Fig 10. (Sample 3). Sample positioning in the Isomet 5000 saw.
1: Sample
2: Diamond blade
3: Sample holding vise
4: Coolant jet tube#