

DYP-2S Corrosion Investigation

Colin Campbell

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1. Introduction

This report documents the investigation we performed at Stanford on the possible effects of corrosion in the Parker DYP-2S hydraulic valve. We were principally interested in the condition of the surfaces that are continually immersed in the working fluid, but the investigation also provided information about the construction of the valve and therefore which joints were likely candidates for the leaks that have been observed in some units.

We would like to acknowledge the help provided by Rich Duder, Senior Hydraulic Systems Engineer in the Parker Hydraulics Group, Parker Hannifin Corporation, for providing advice and new flapper assemblies from the assembly line.

2. Conclusions

After inspection under an optical microscope, we determined that the valve removed from service had slight surface corrosion but nothing close to compromising its function or fluid integrity. Neither the valve removed from service nor the new valve pulled from the assembly line had any visible defects in the joints sufficient to cause leaks. No biological growth of any kind was observed.

3. Methodology

Valve #22733 was removed from service at LASTI in April 2004, after ~1 year of continuous operation. The working fluid at LASTI is Houghto-Safe 419-TY (aka Aquamill), a water glycol hydraulic fluid with Ethylene oxide Propylene oxide ('EOP') as a thickening agent.

Two properties of the fluid were relevant to our investigation – the pH, which controls biological activity, and the Alkaline Reserve (AR), which controls corrosion.

The pH of the fluid (according to the product specification) is 9.5; to control biological activity a pH of 8.0 or above should be sufficient. Tests performed on the LASTI fluid on 6/5/03 measured a pH of 8.4.

The manufacturer recommends the AR be between 90 and 150, warning that below 90, corrosion could become a problem. The measurement of the LASTI fluid on 6/5/03 found an AR of 119.

One of the two motor units was separated from the valve base and the motor coils were removed, leaving only the motor base plate, beryllium copper support tube and flex tube, and the flapper. See Figure 1.

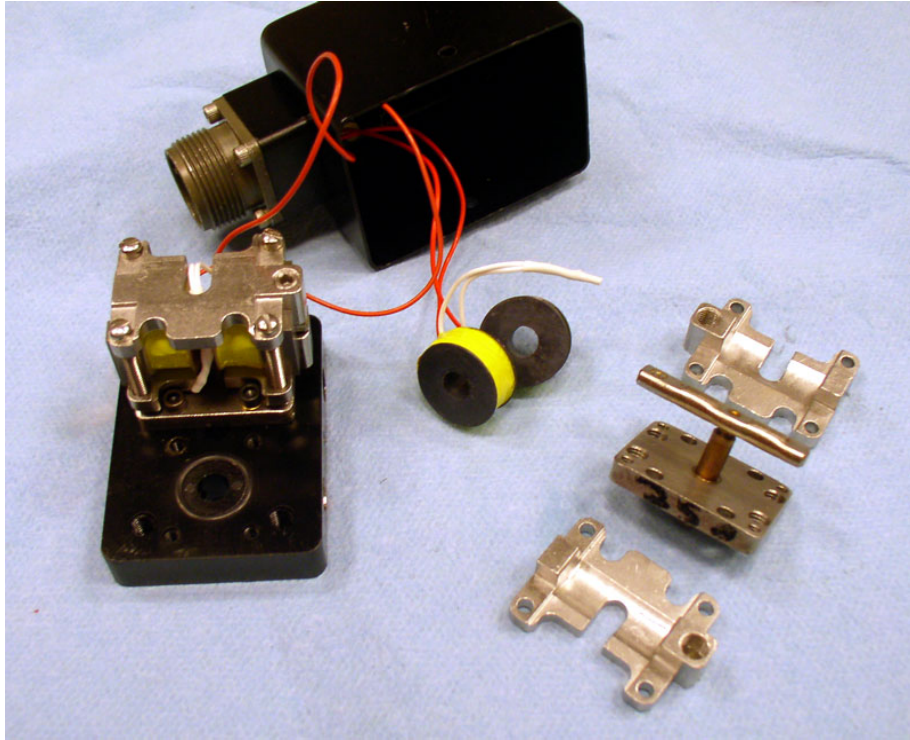


Figure 1. Disassembled valve from LASTI, showing T-shaped flapper assembly at right.

This subassembly was sectioned by wire EDM to allow us to view the interior surfaces of the flex tube assembly that contact the working fluid and inspect them for corrosion. A second identical subassembly was pulled directly from the Parker assembly line and sectioned in order to allow us to see the components in their original condition. See Figure 2.



Figure 2. Flapper assembly sectioned by wire EDM.

Figure 3 shows a schematic view of the resulting cross section through the flex tube assembly. First, the brazed joints were photographed under an optical microscope, and then the assembly was pulled apart to allow us a clear view of the inside of the support tube and the back side of the flex tube, which are the principal surfaces exposed to the working fluid.

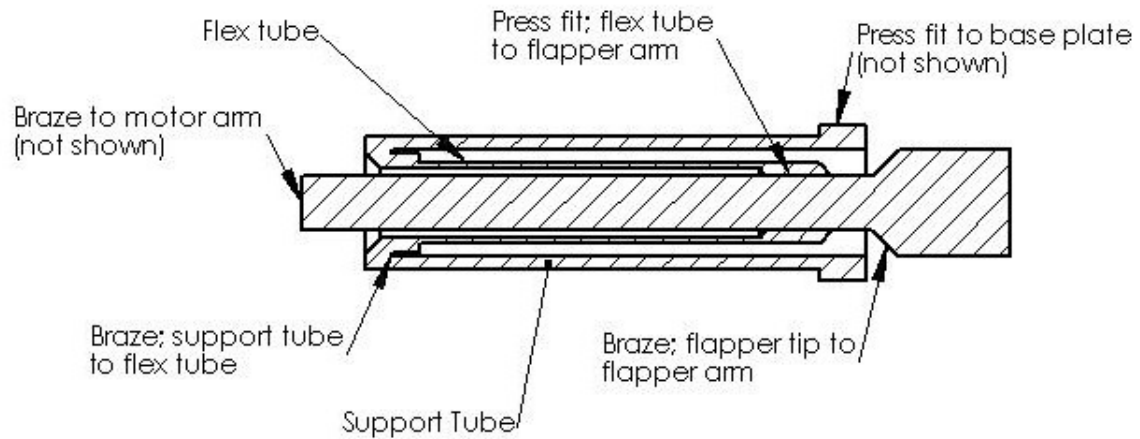
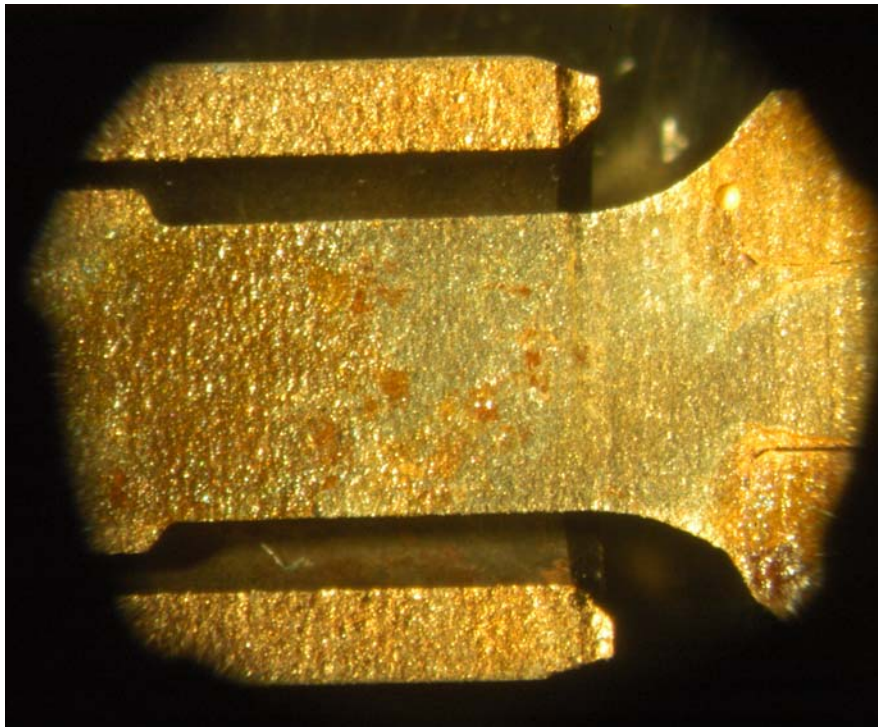


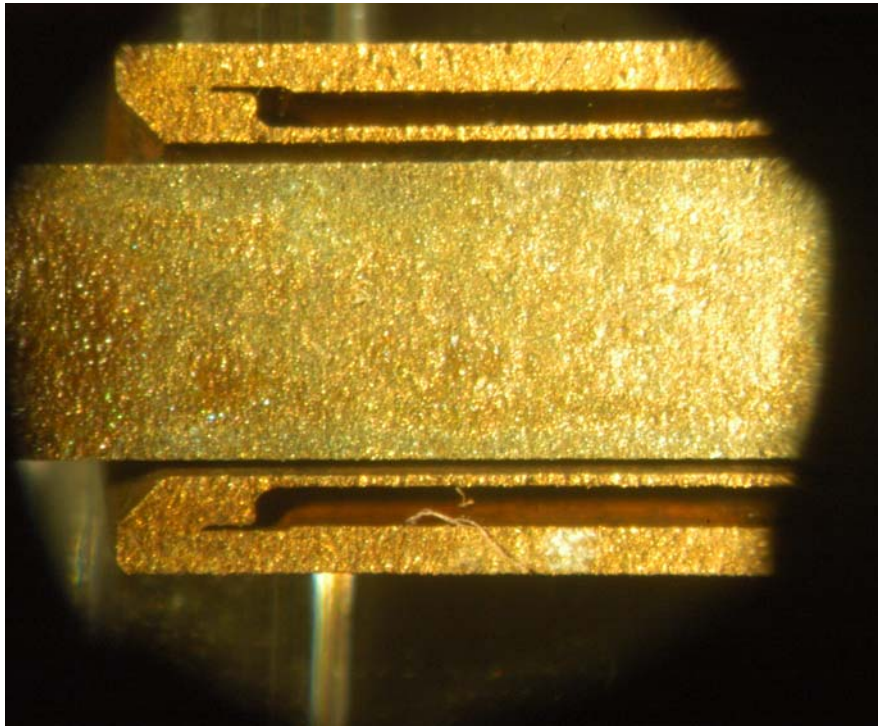
Figure 3. Schematic flapper assembly cross section.

3. Images

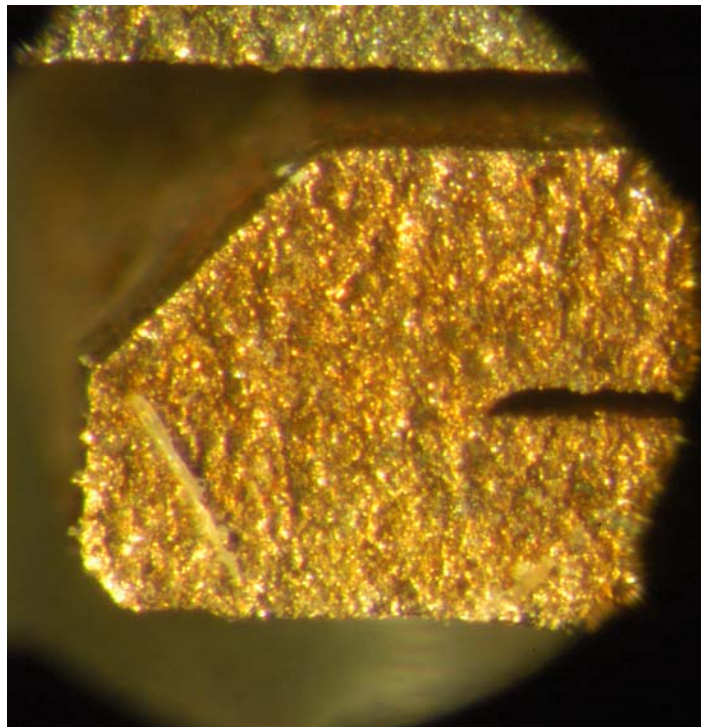
a. New Assembly (from Parker assembly line)



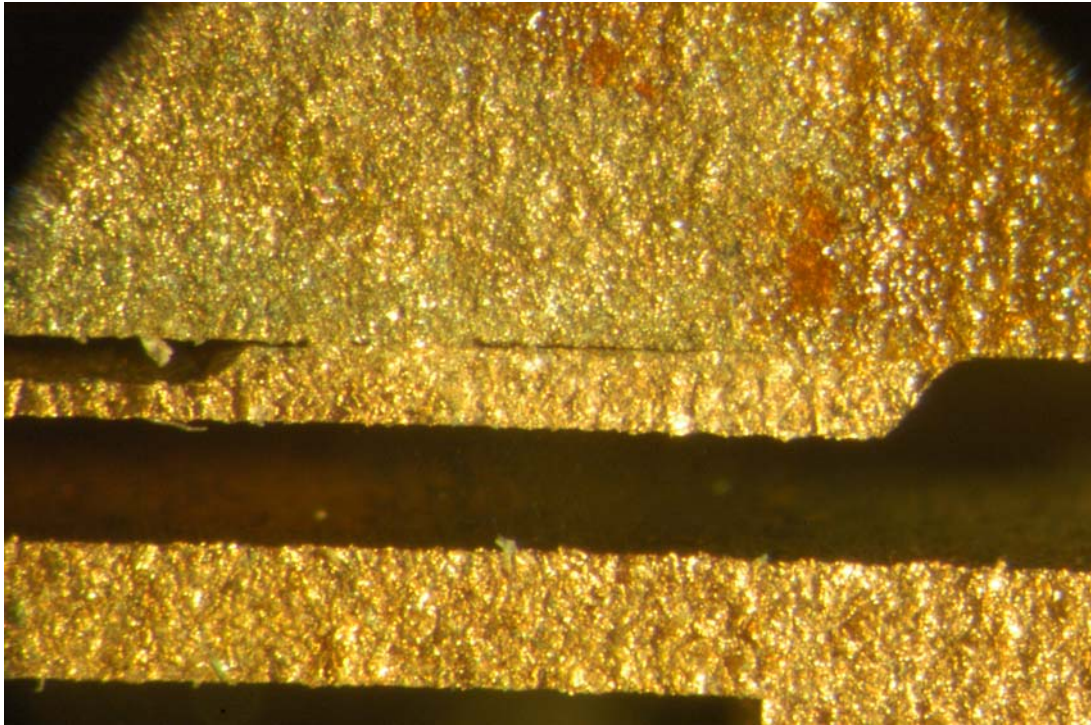
Overview – end of flapper arm, showing flapper tip brazed to the flapper arm.



Overview – flapper arm in center, surrounded by flex tube and support tube. Braze between flex tube and support tube visible in upper and lower left.



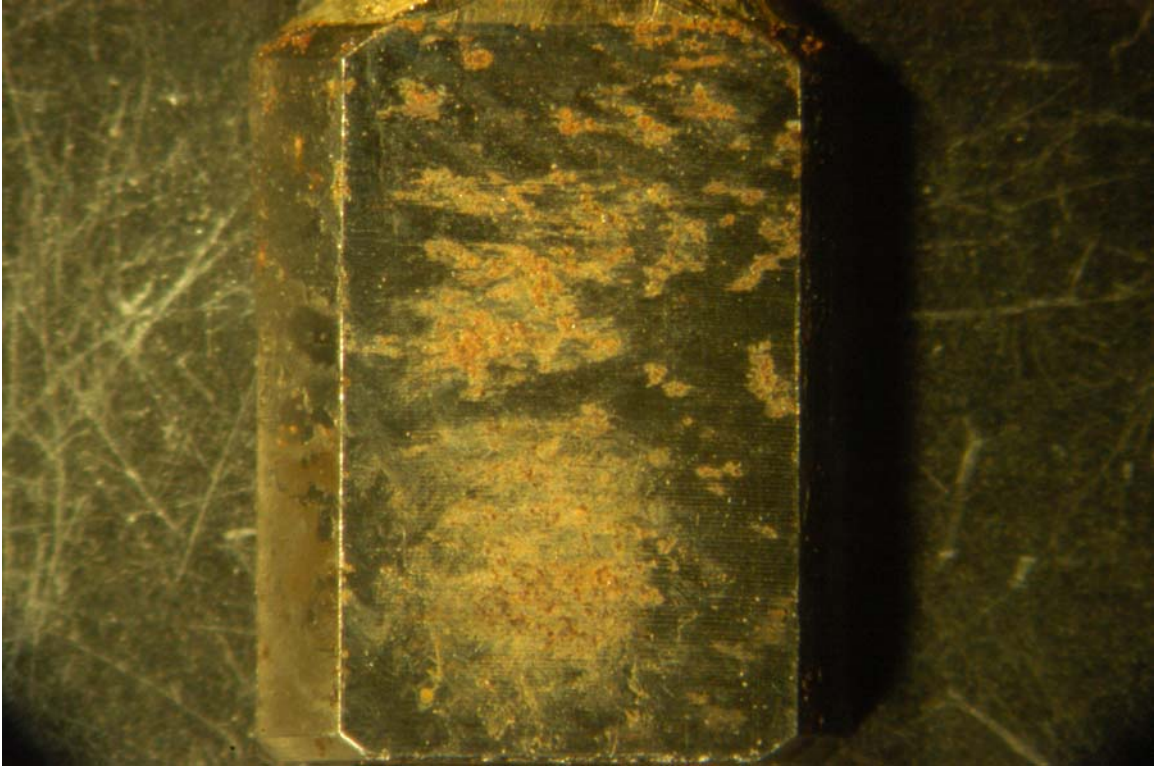
Detail of the braze between the flex and support tubes; from the lower left of previous frame



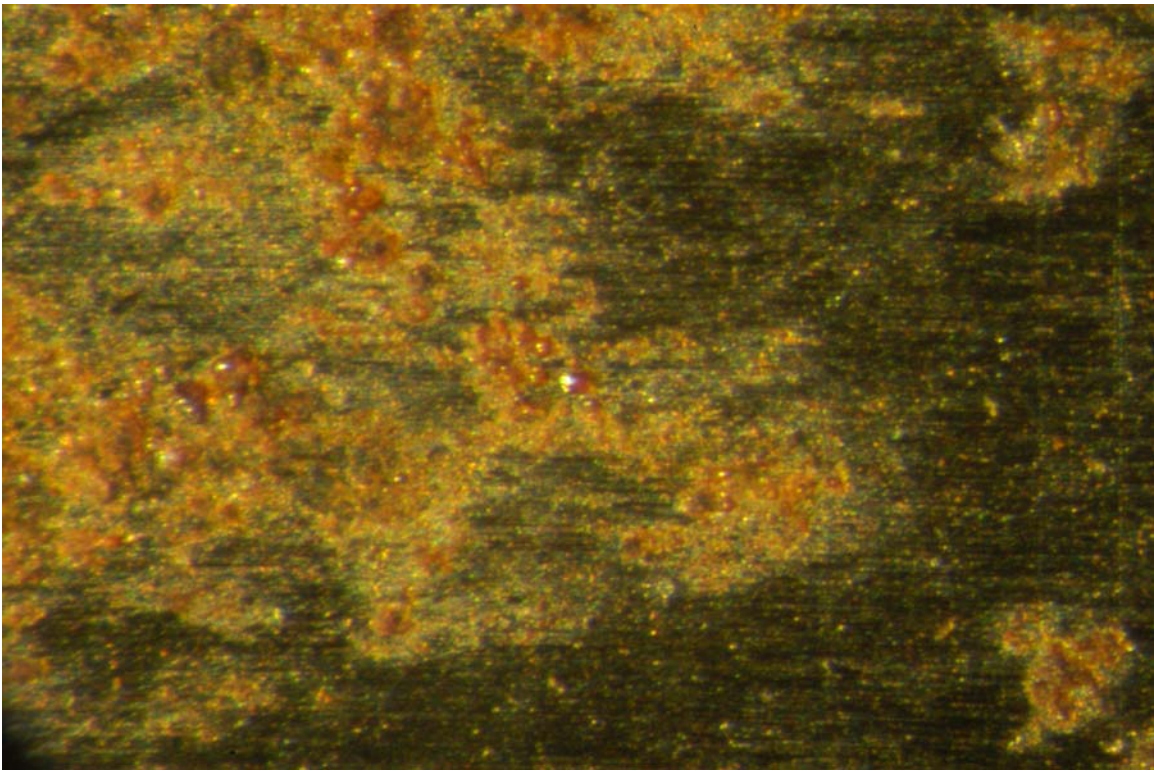
Detail of the press fit between the flex tube and the flapper arm



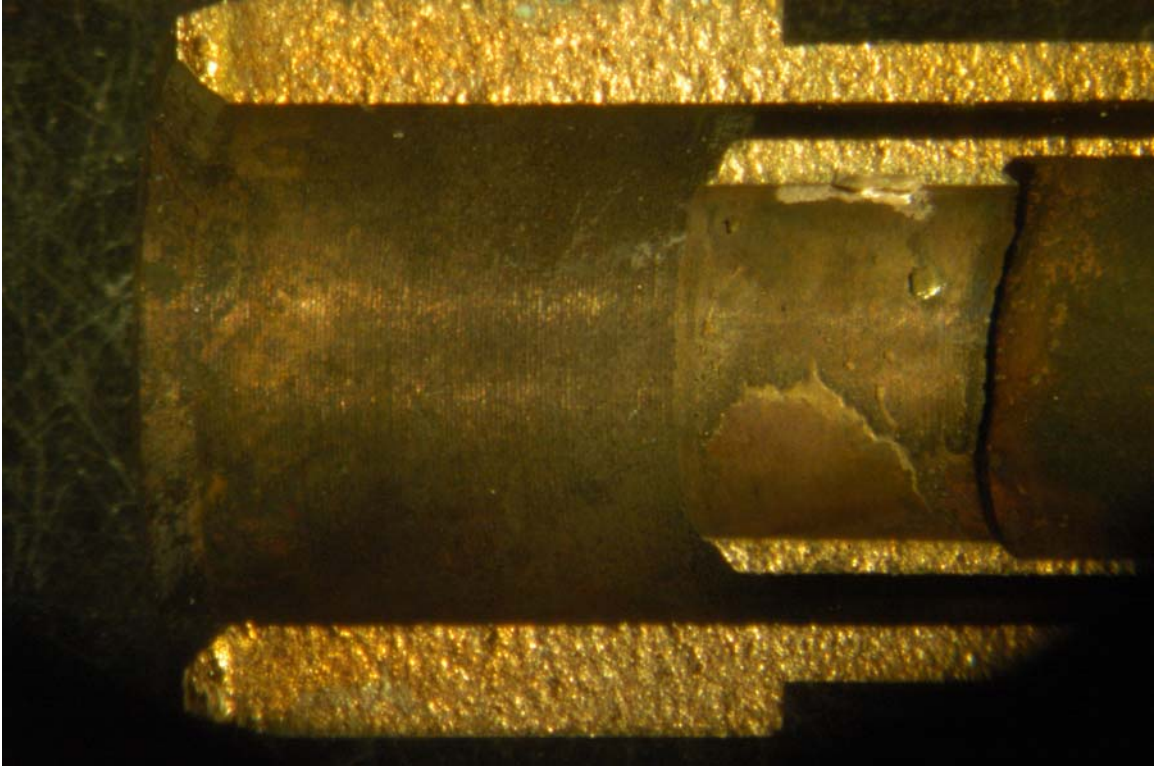
Detail of the press fit area on the flapper arm, after removing the flapper arm from the flex tube



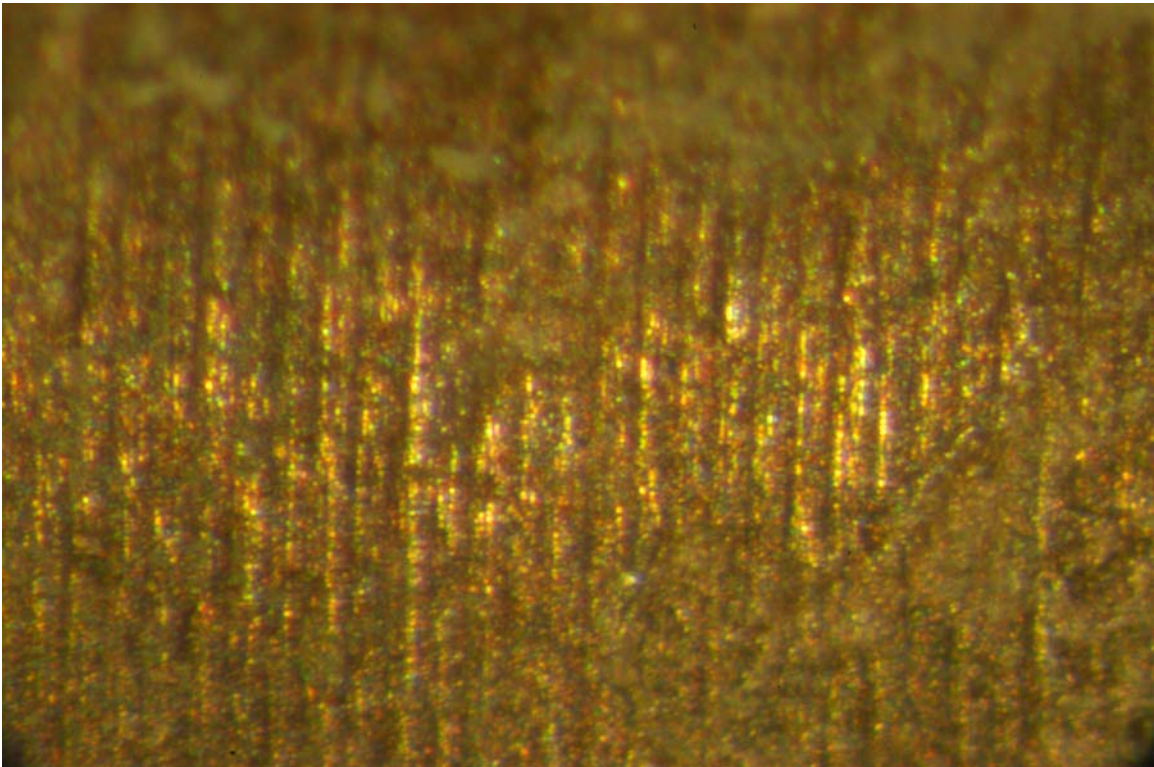
Flapper face. Corrosion seen here is from the wire EDM liquid.



Detail of rust from the EDM bath on the flapper face



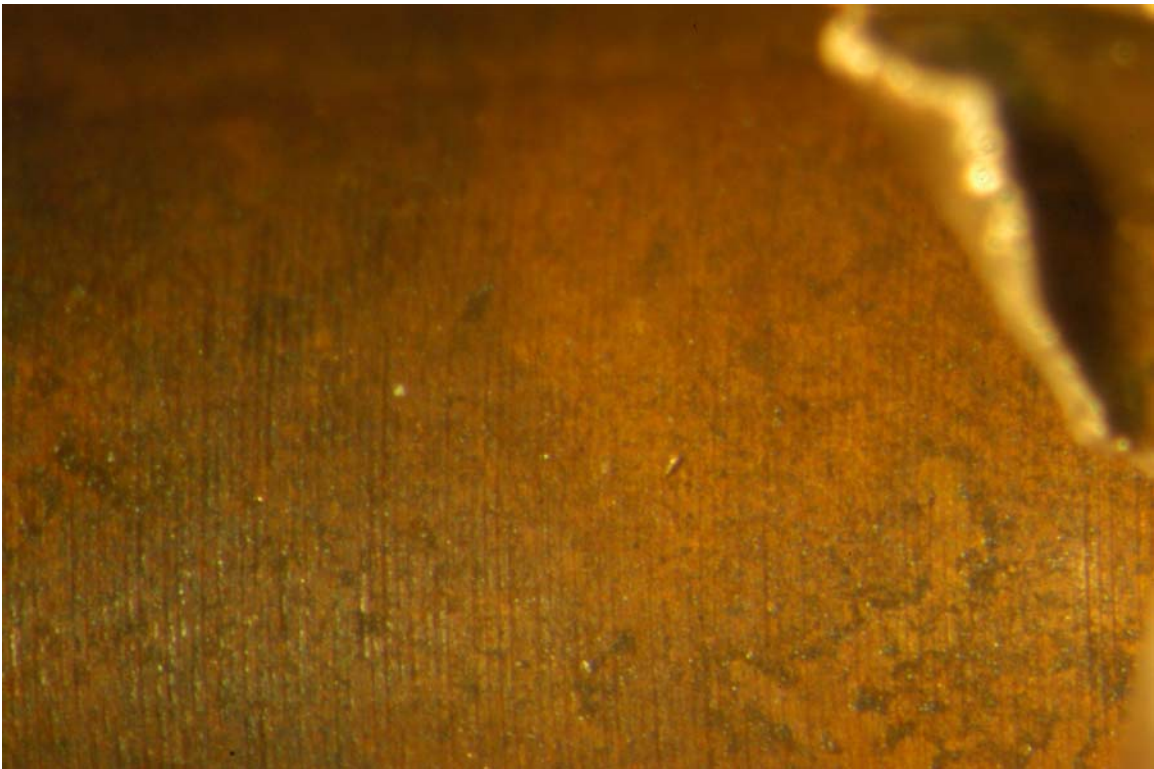
Flex tube on the right, support tube enclosing it. The press fit area on the flex tube is visible.



Detail of the press fit area on the flex tube, showing machining marks

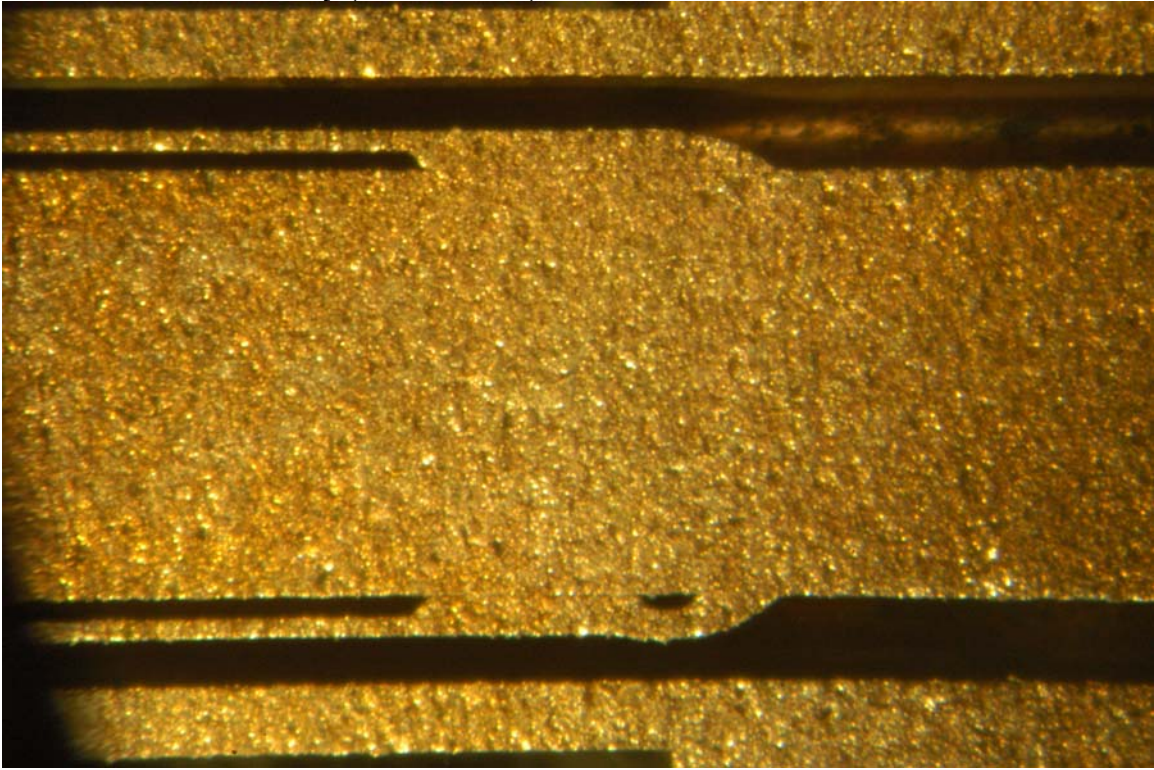


Inner surface of the support tube, after the flex tube has been peeled away on the right.

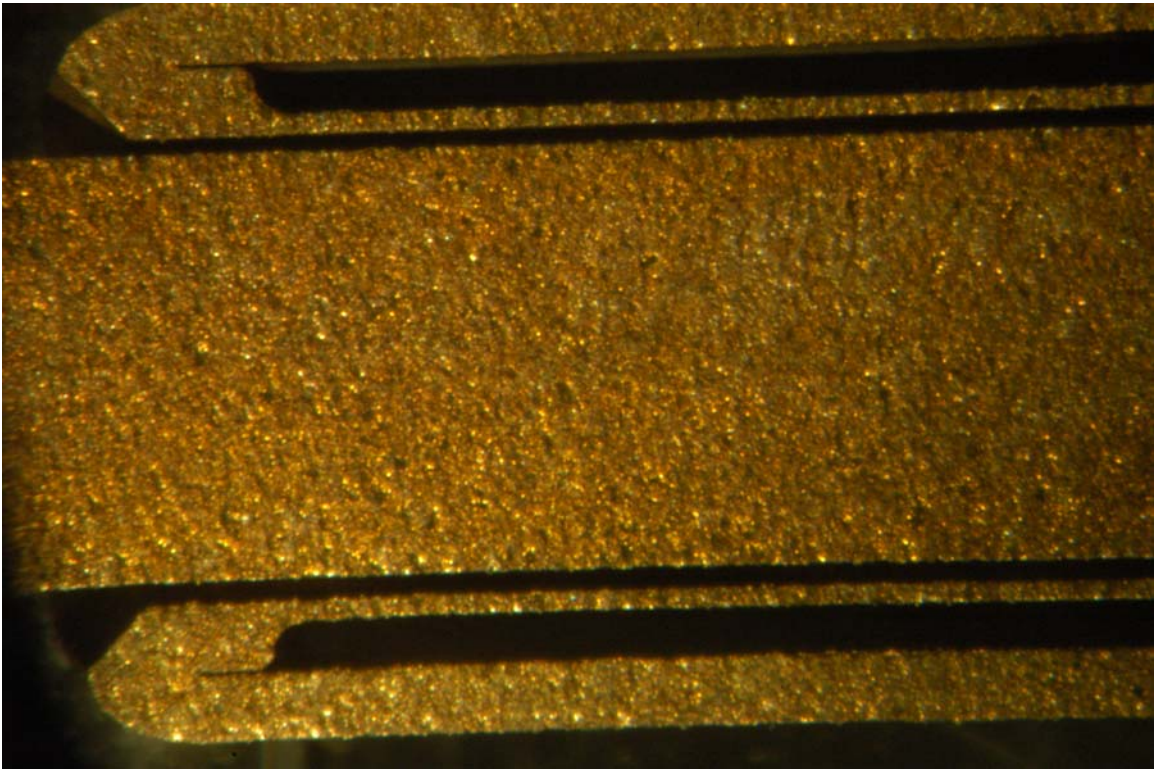


Detail of the inner surface of the support tube.

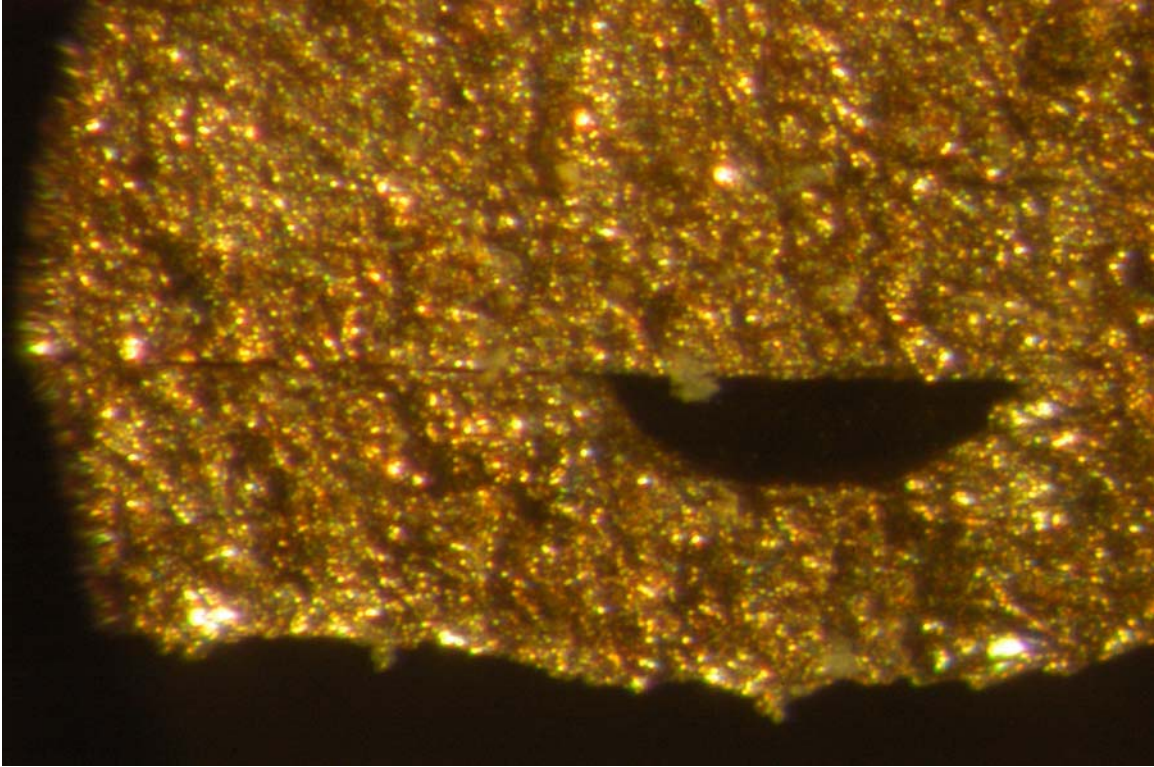
b. Used Assembly (from LASTI)



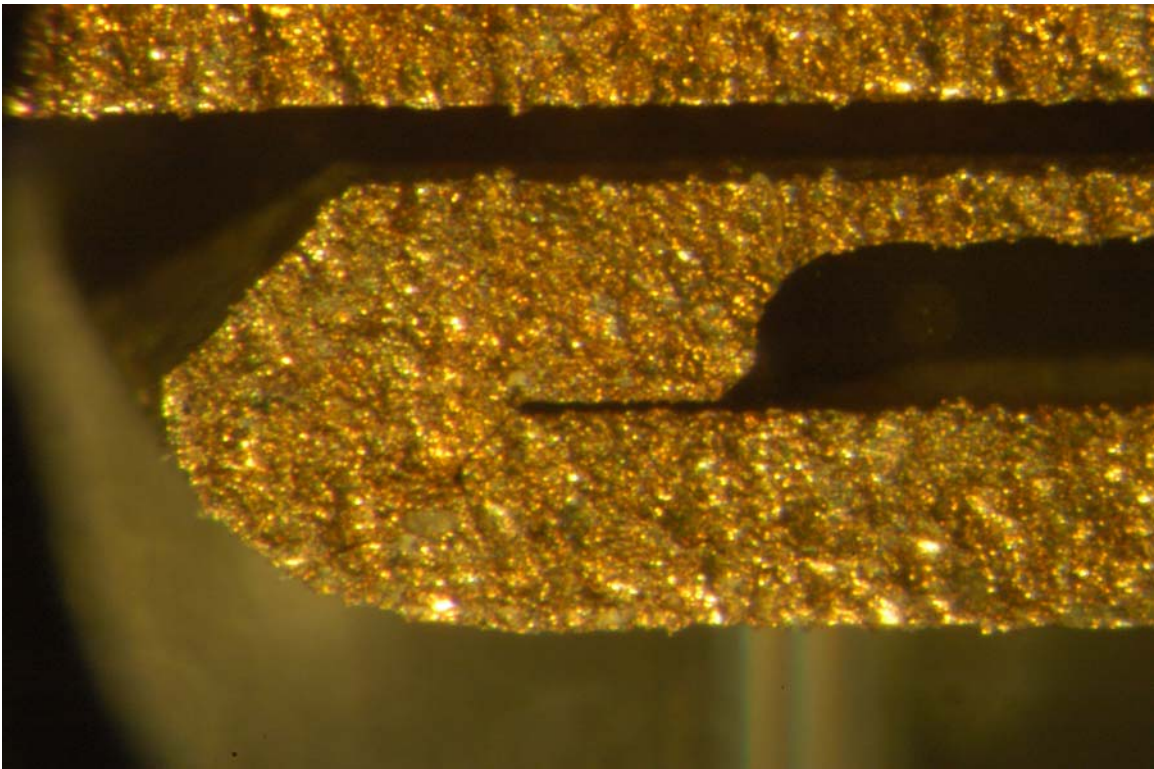
Overview – press fit from flex tube to flapper arm



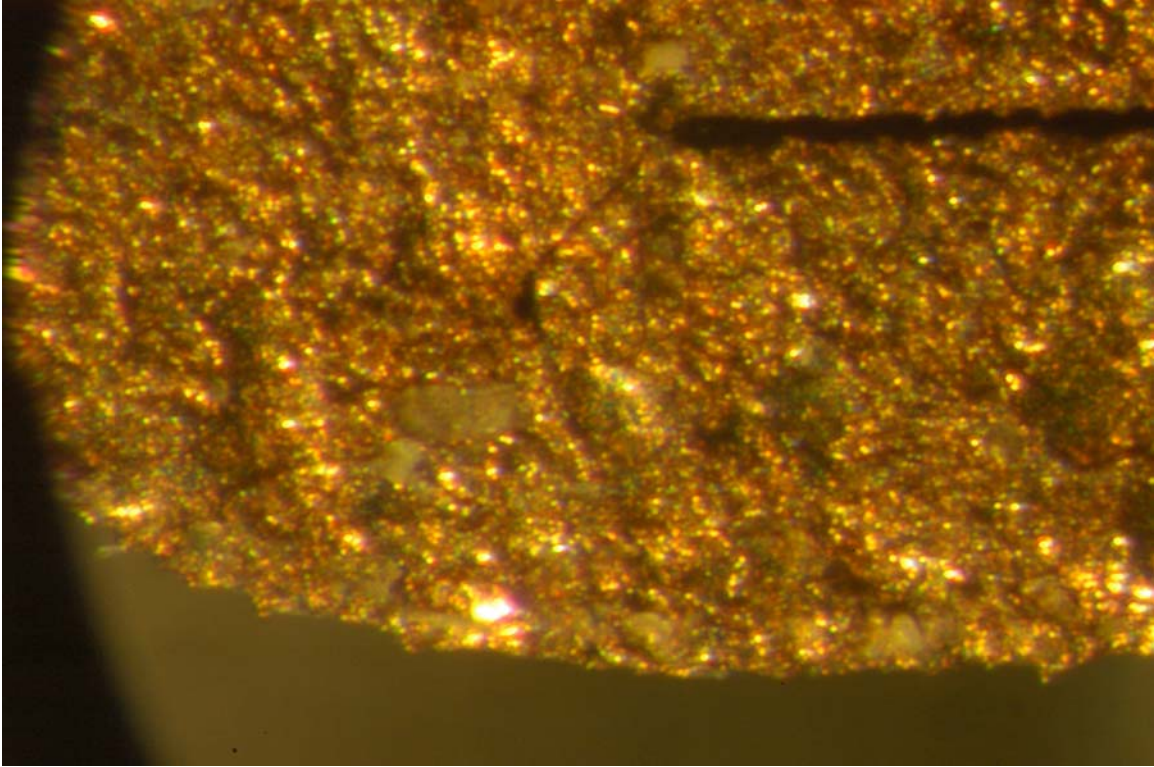
Overview – braze from flex tube to support tube



Detail – void in press fit from flex tube to flapper rmp



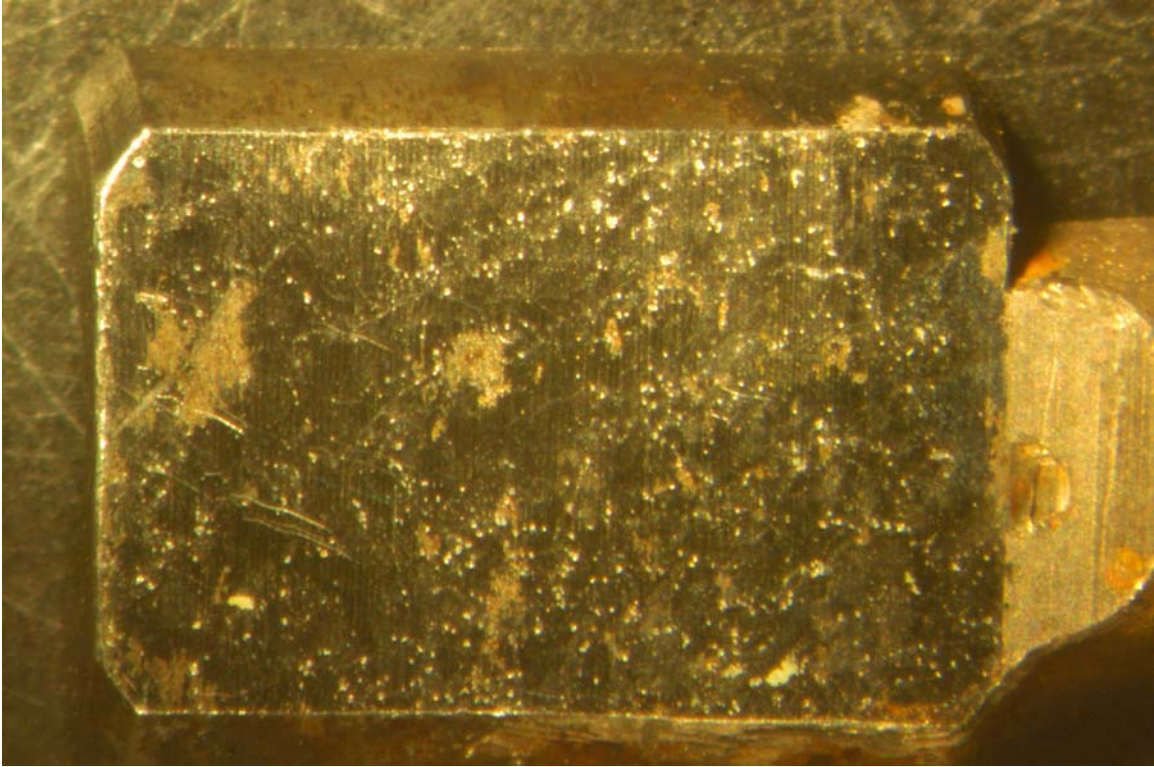
Detail – braze of flex tube to support tube. Note hairline crack extending to the lower left.



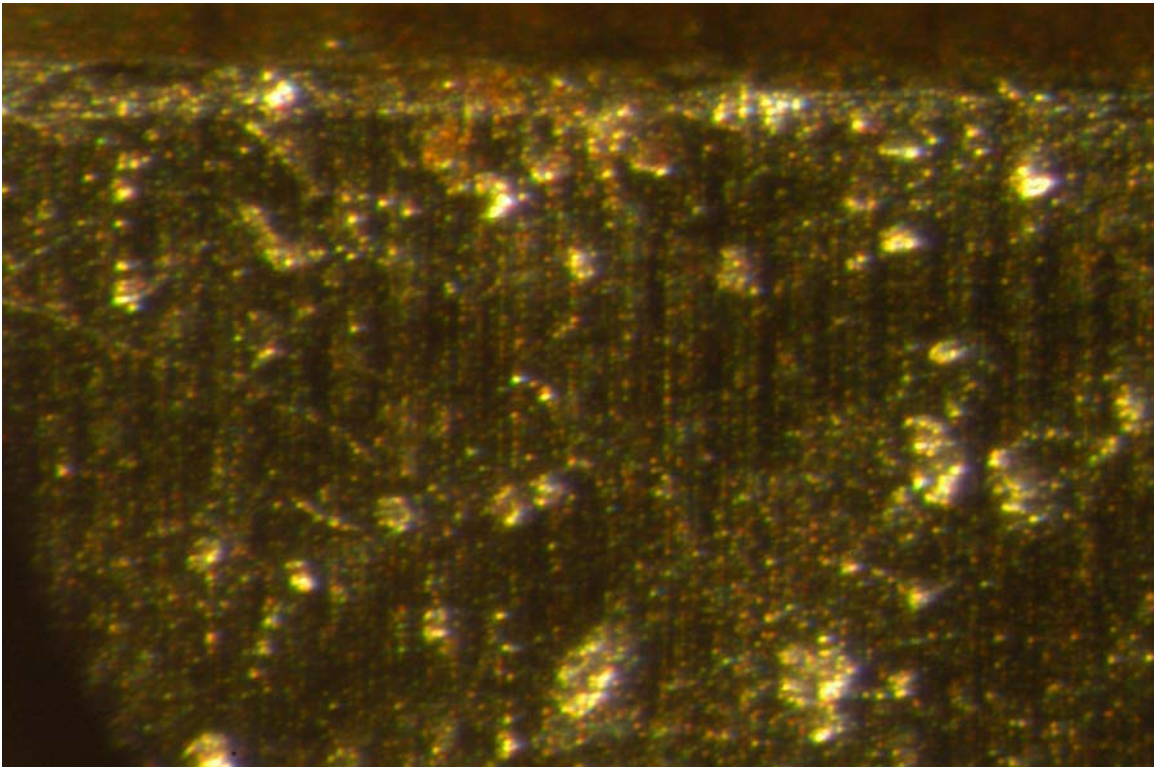
Detail of the hairline crack in the braze.



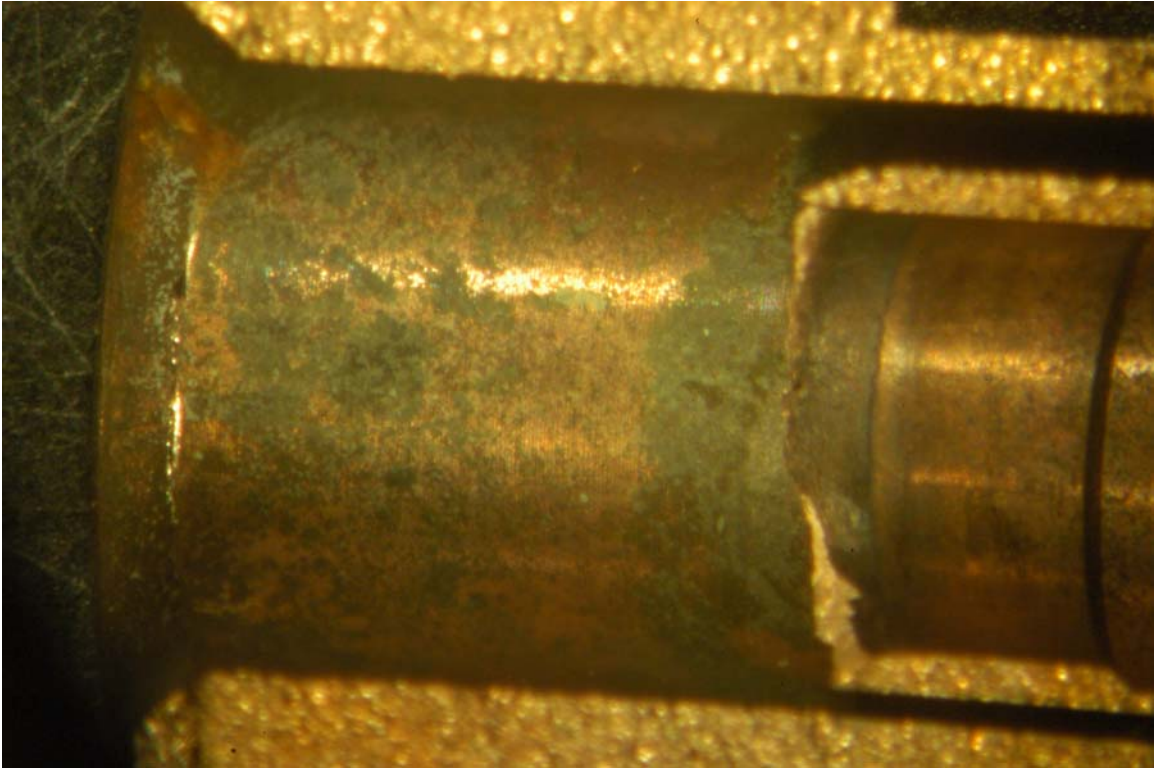
Press fit area on flapper arm, where flex tube was attached. It seems that some flux and/or braze material from the flapper arm/flapper tip joint crept up and partially brazed this joint as well.



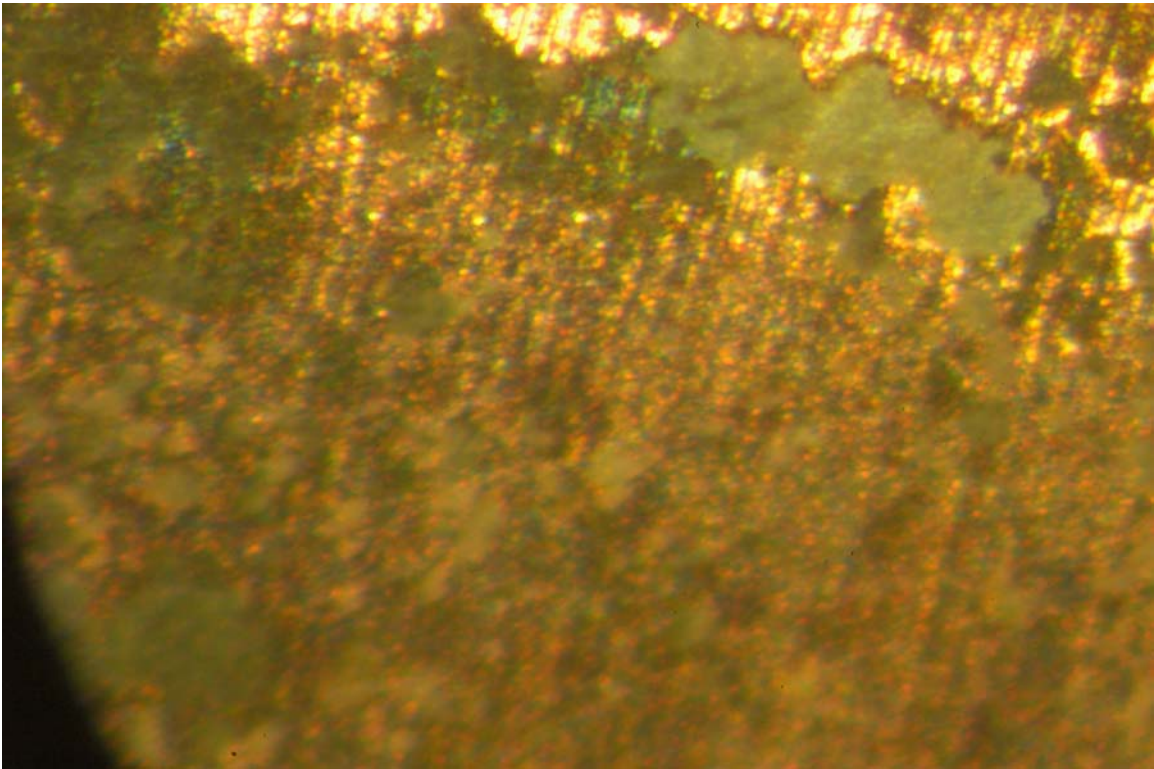
Flapper face. Note the small pits, possibly due to impact from particulates in the working fluid.



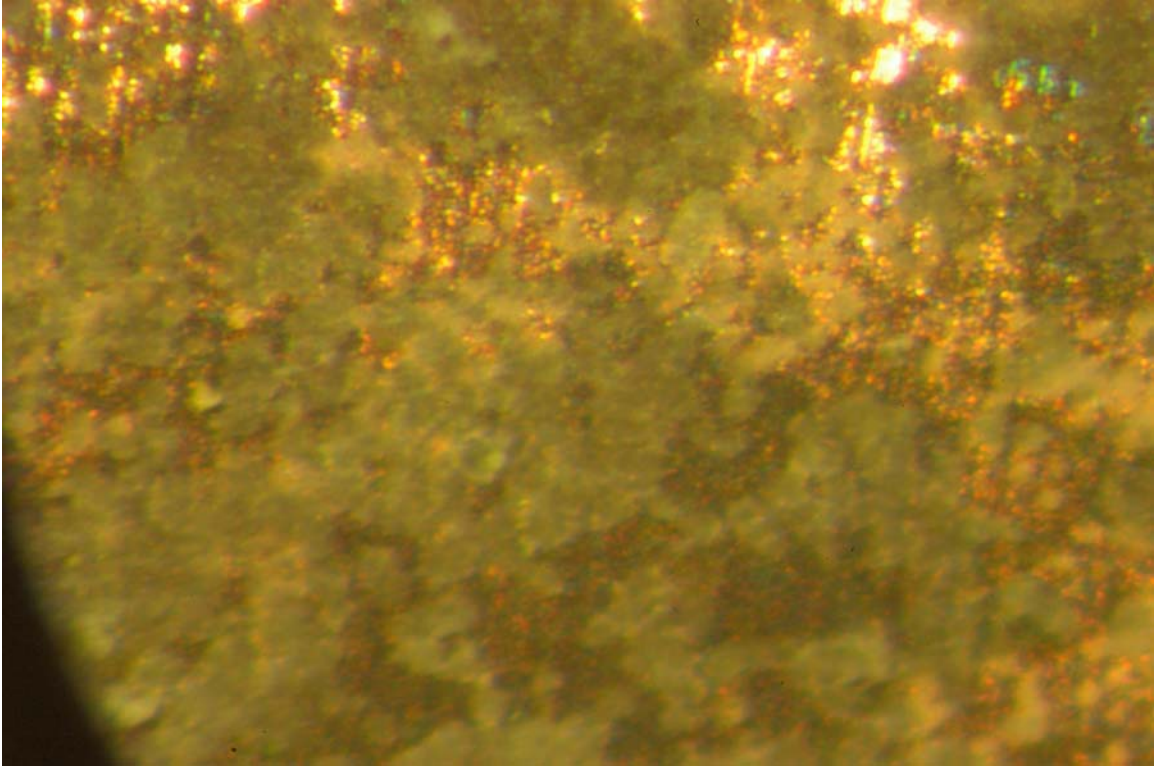
Detail of the small pits on the flapper face.



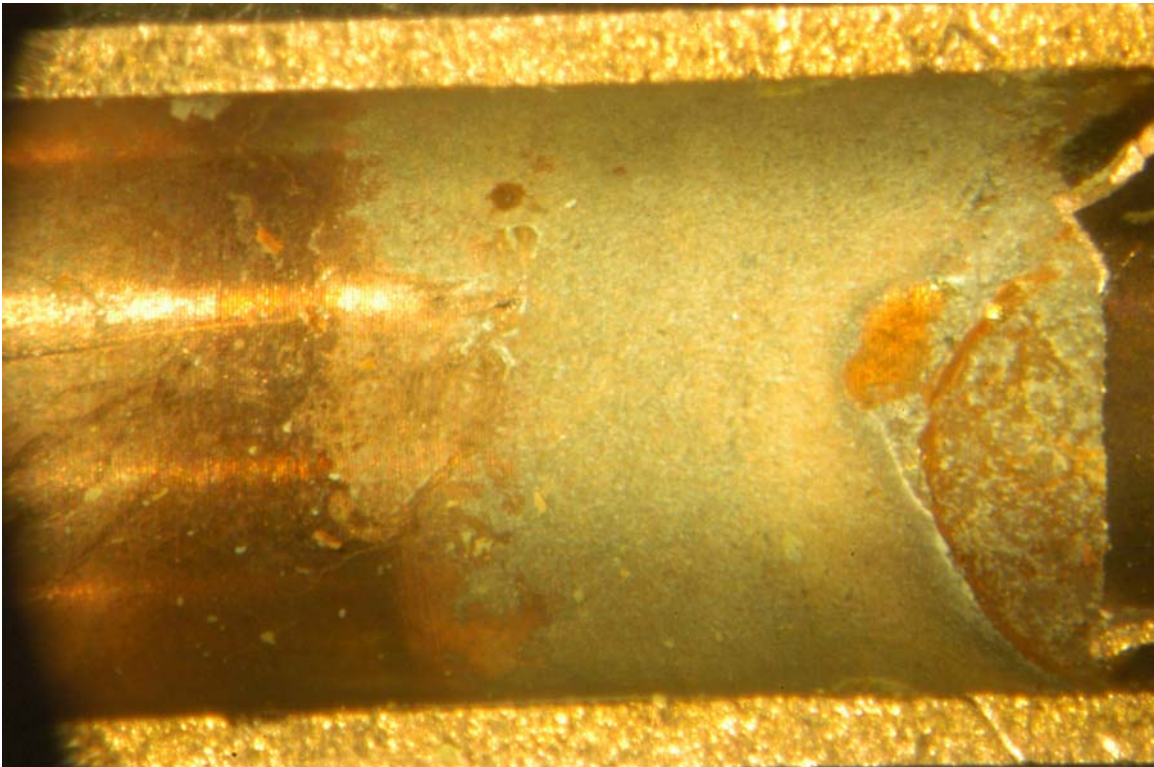
Inner surface of the support tube, with flex tube at right. Some corrosion is evident.



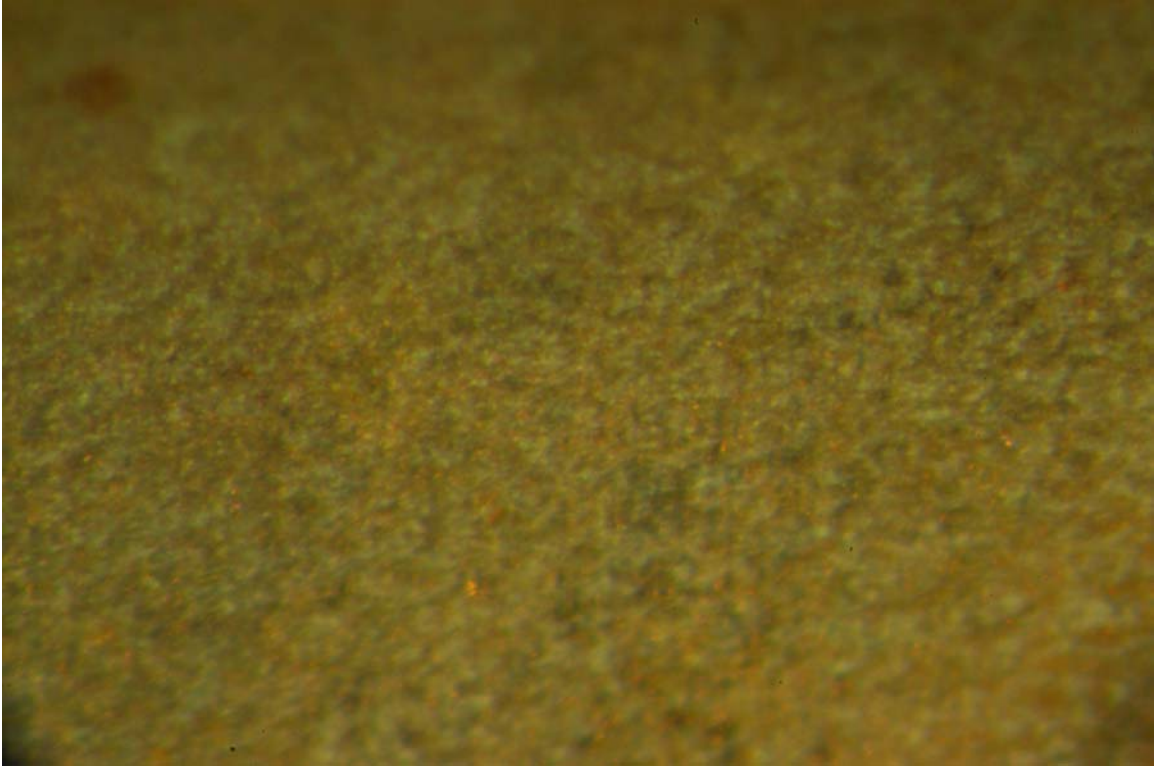
Detail of mild corrosion on inner surface of support tube.



Further detail of mild corrosion on inner surface of support tube.



Inner surface of support tube, with flex tube completely removed at right. Again, there is some mild surface corrosion.



Detail of mild corrosion on inner surface of support tube.