USGS TRIGA Reactor Fuel Element Measurement Tool

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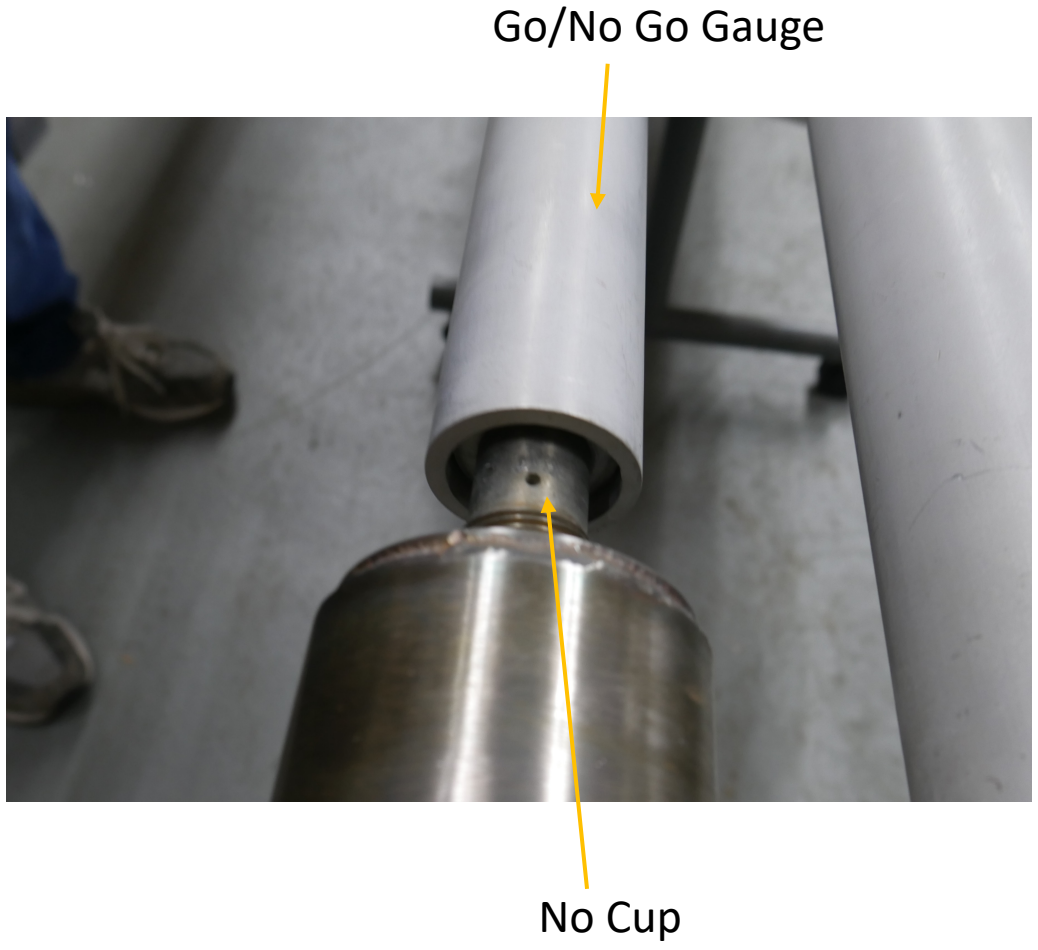
Abstract

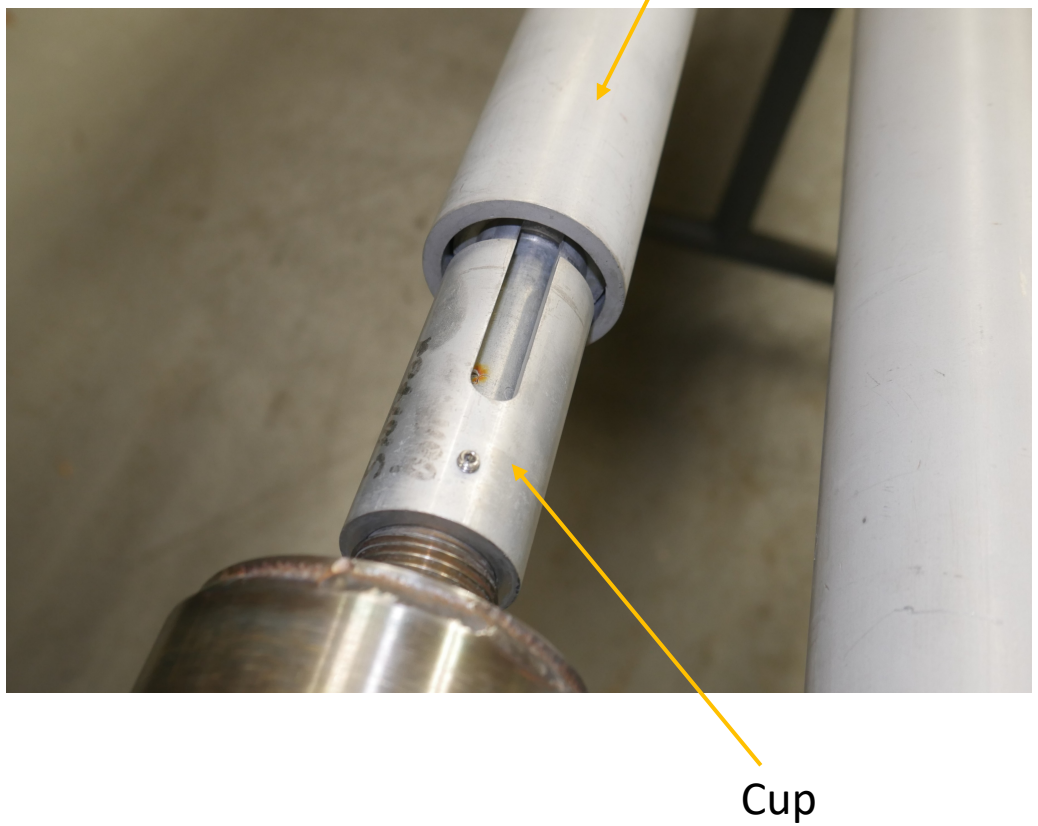
- The Fuel Element Measurement Tool (FEMT) historically required modifications to accommodate the different types of fuel series that are at the USGS. The USGS fuel inventory includes aluminum-clad (Al) fuel elements, stainless steel-clad (SS) fuel elements with no fins, press-on fins, integrated fins, streamlined fins, as well as standard fuel-follower control rods. Each type of fuel element requires different ways to hold the fuel element in the FEMT to be able to measure each fuel element properly leading to the supplemental or substituted components. The modifications historically made were altered “cups” that attach to the lower hydraulic piston. During the investigation, it was discovered that the design range of the FEMT was not accurate, the procedures for setting up the FEMT were not complete, and one of the supplemental components was not designed and made correctly. All of these lead to several new design changes and more stringent procedures to assure accurate fuel element measurements.

Original Setup A



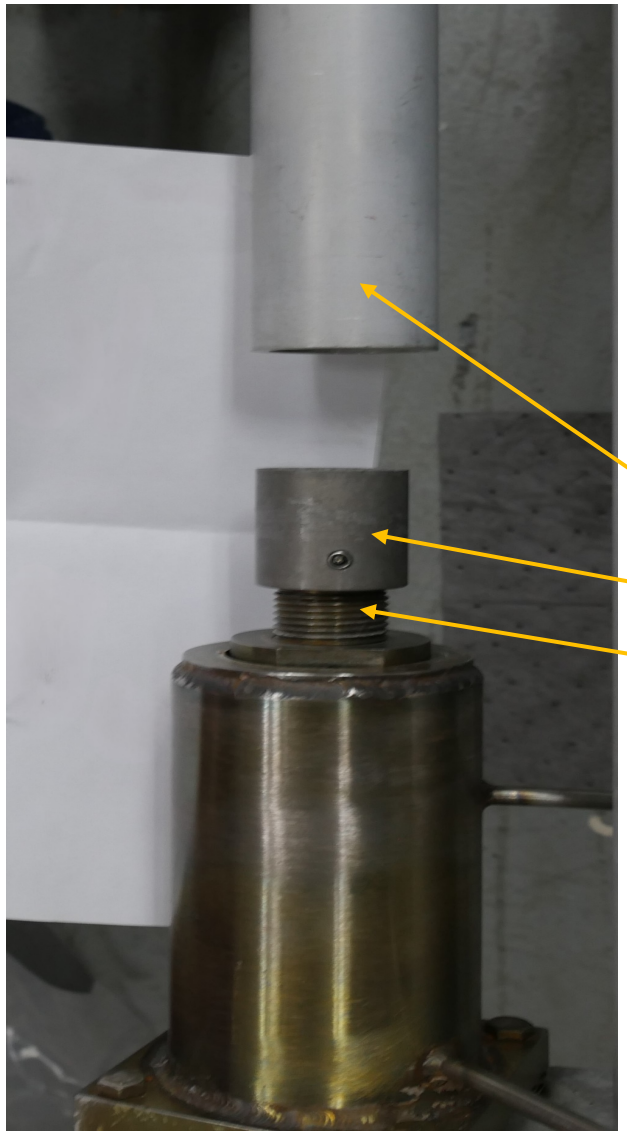
- This was the original design of the tool when the facility was built.
- Applied to all serial numbers between 1100 and 5899. The usual stainless steel-clad without fins.

Original Setup B



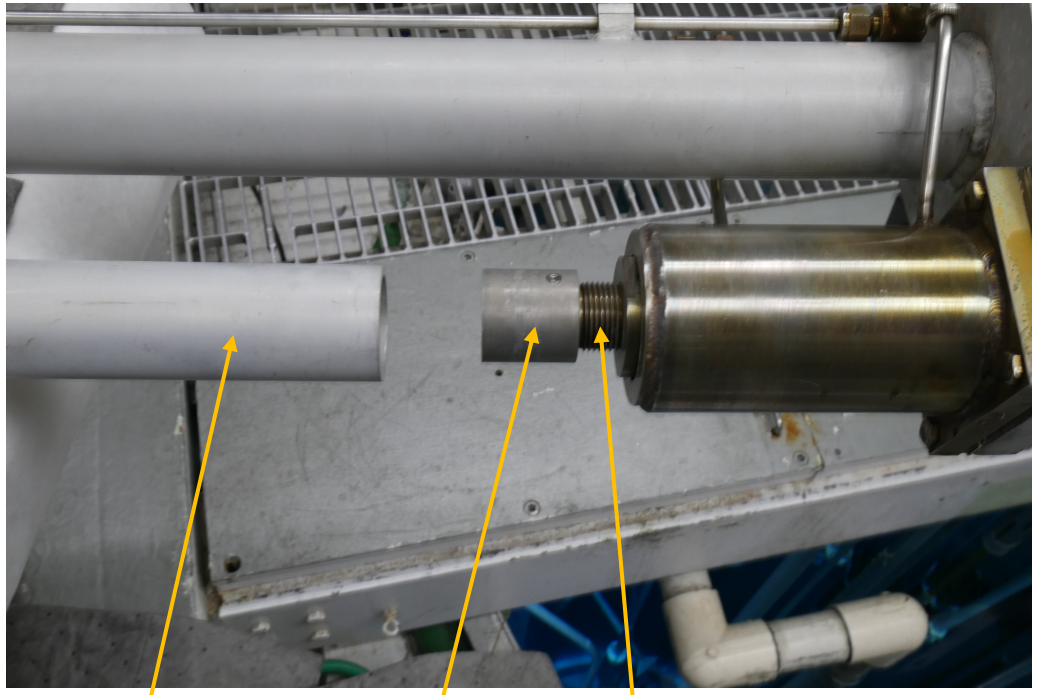
- Applied to serial numbers between 6000 and 9599. Consisting of stainless steel-clad with simple fins.
- This was a cup that was made for the facility according to GA drawings that were given to the facility.

Original Setup C



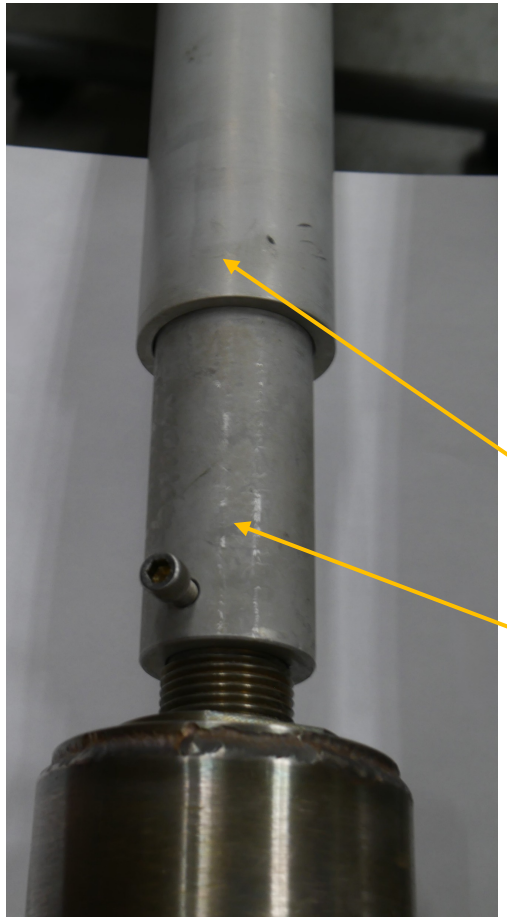
- Serial numbers 5900 to 5999. This is a specialty setup that will be discussed soon. Consisting of stainless steel-clad elements with a press-fit fin adapter.
- There was a specification in the procedure to have this cup sit ~0.25 inches above the threads.

Original Setup D



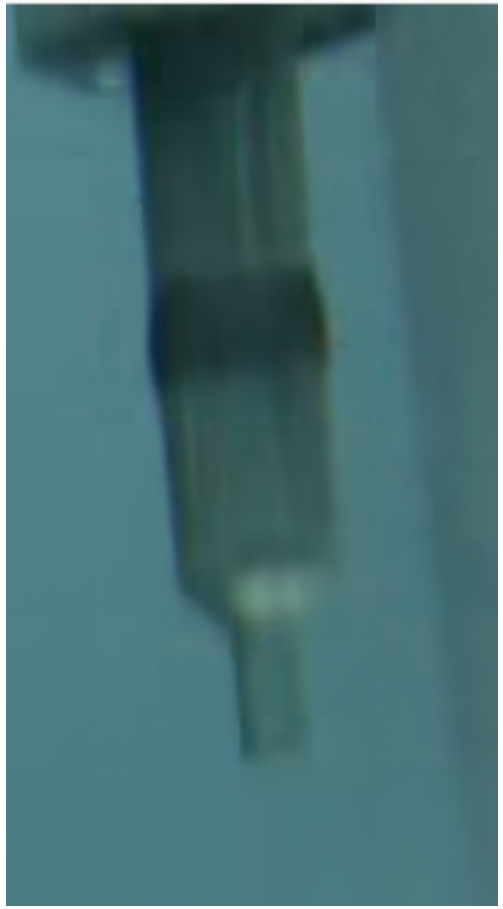
- Serial numbers above 9600. Stainless steel-clad elements of the streamlined design.
- This setup looks like Setup C but the cup sits up against the threads below the cup where Setup C was supposed to sit “~0.25” inches above threads.

Original Setup E



- Serial numbers 1 to 1099. The aluminum-clad element setup with no fins present. A problematic setup from the start.
- This cup was made because of a defect on the lower stem of the fuel elements that came from the welding process.
- The cup was supposed to mimic the original GA setup but with a larger hole for the stem with the weld defect to pass through.

Aluminum Clad Fuel Element Stem



- The black weld ring stopped the stem from seating in Setup A.

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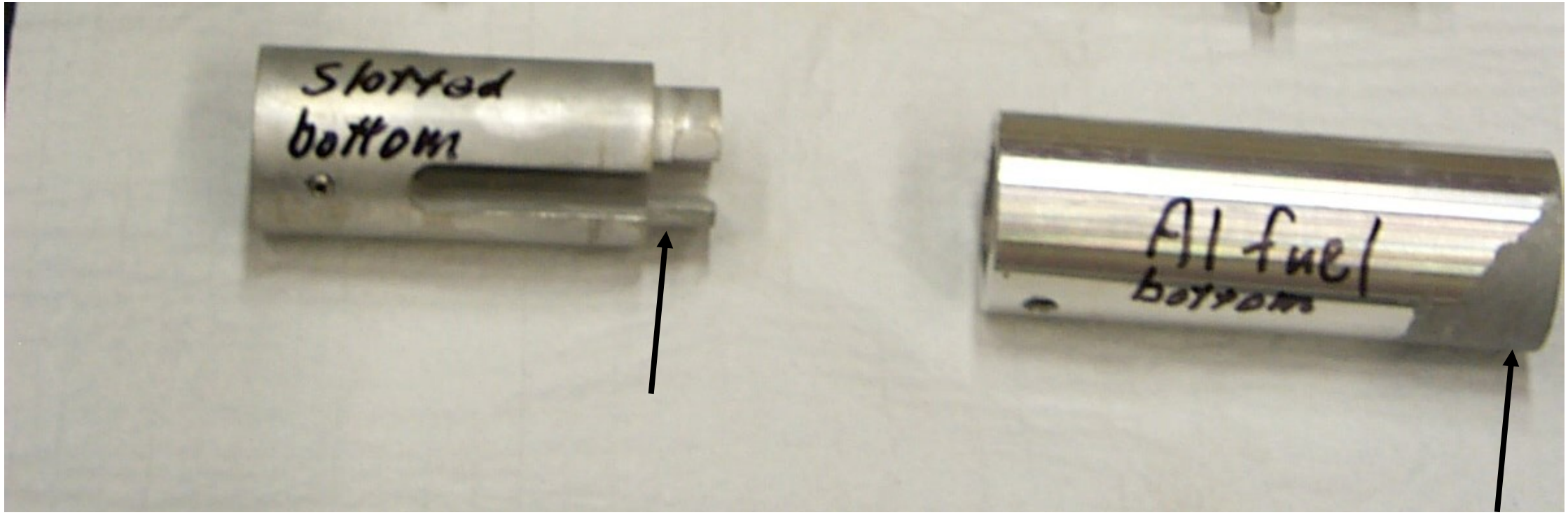
Setup B vs Setup E cups



Notice the difference in the ends of the cups on the right side. One is stepped down while the other is not.

Original Operating Procedure and its failure

- The original procedure required the staff to put the standard into the tool and zero the dial.
- There were no numbers in the procedure that would indicate the tool had reached its limit when measurements were conducted.
- It was just assumed that the tool had the range for 0.5” elongation.
- The staff didn’t know the bounds of the FEMT.
- This led to the failure of not knowing if a fuel element was not measured correctly.

2024 Aluminum Clad Elongation Measurements

Serial Number	Measured Deviation from Standard
860E	+0.147”
417E	+0.147”
423E	+0.149"
876E	+0.147”
673E	+0.147"

These measurements lead the staff to question the validity of the measurements. This kicked off the investigation of the FEMT and the different setups.

FEMT Configuration	Total Range	Index Point (Average of Three)	Shorter Limit	Longer Limit	Invalid Short	Invalid Long
Setup A	0.2140”	0.1113”	-0.1113”	0.1027”	0	0
Setup B	0.2105”	0.1120”	-0.1120”	0.0985”	0	3
Setup C	0.2170”	0.0292”	-0.0292”	0.1878”	3	0
Setup D	0.2200”	0.1038”	-0.1038”	0.1162”	0	0
Setup E	0.2115”	0.0658”	-0.0658”	0.1457”	0	45

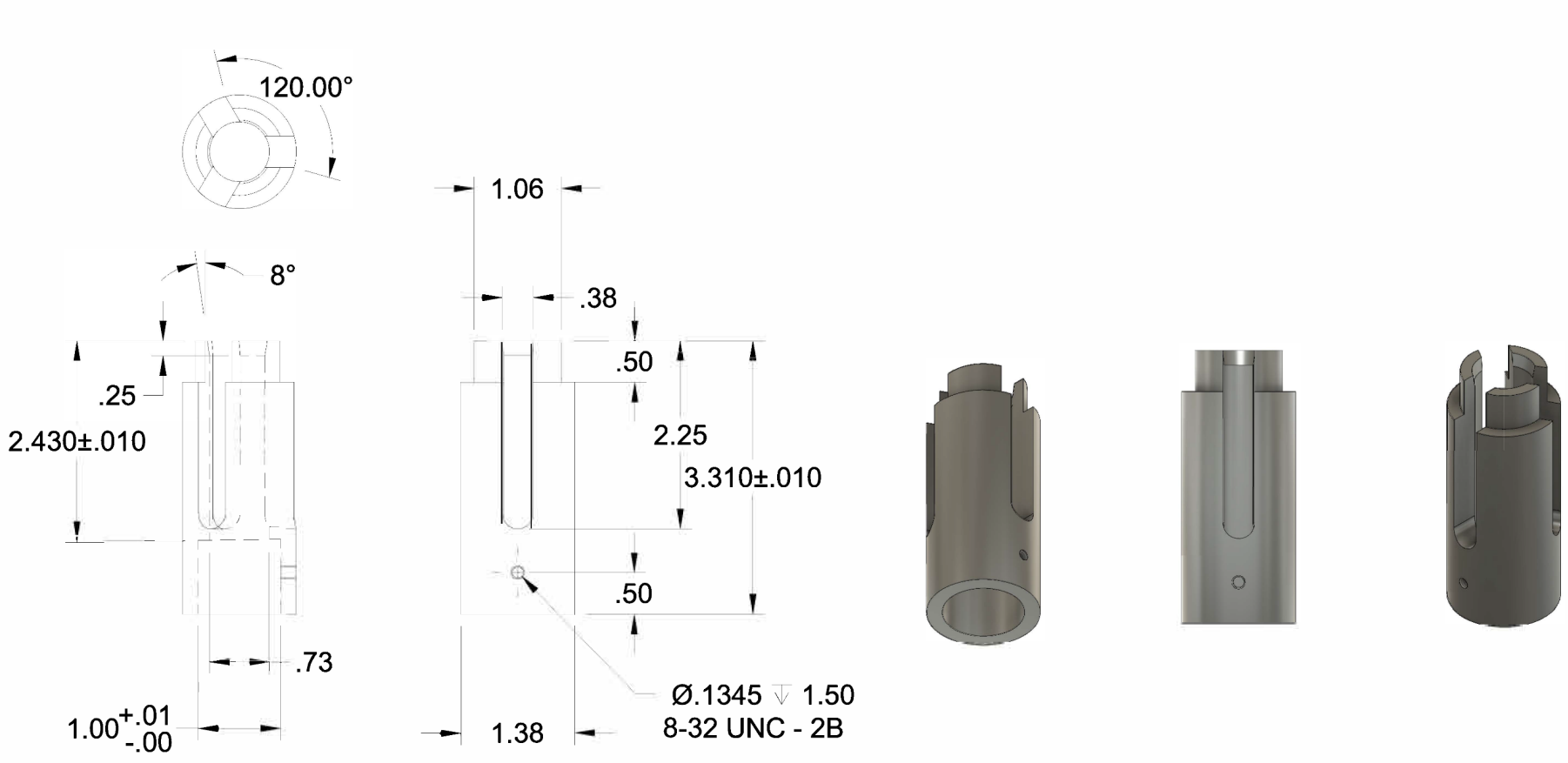
Table 1 – Setup Index Point, Ranges, and Invalid Measurement Data

The setups were each examined for their index point with the standard and appropriate fittings through experimentation. Giving the total range of compression measured of the hydraulic piston by the dial indicator, the minimum range above and below the index point of the standard. Using the total range and minimum ranges, an analysis was done on the fuel inventory historical measurements to determine invalid measurements.

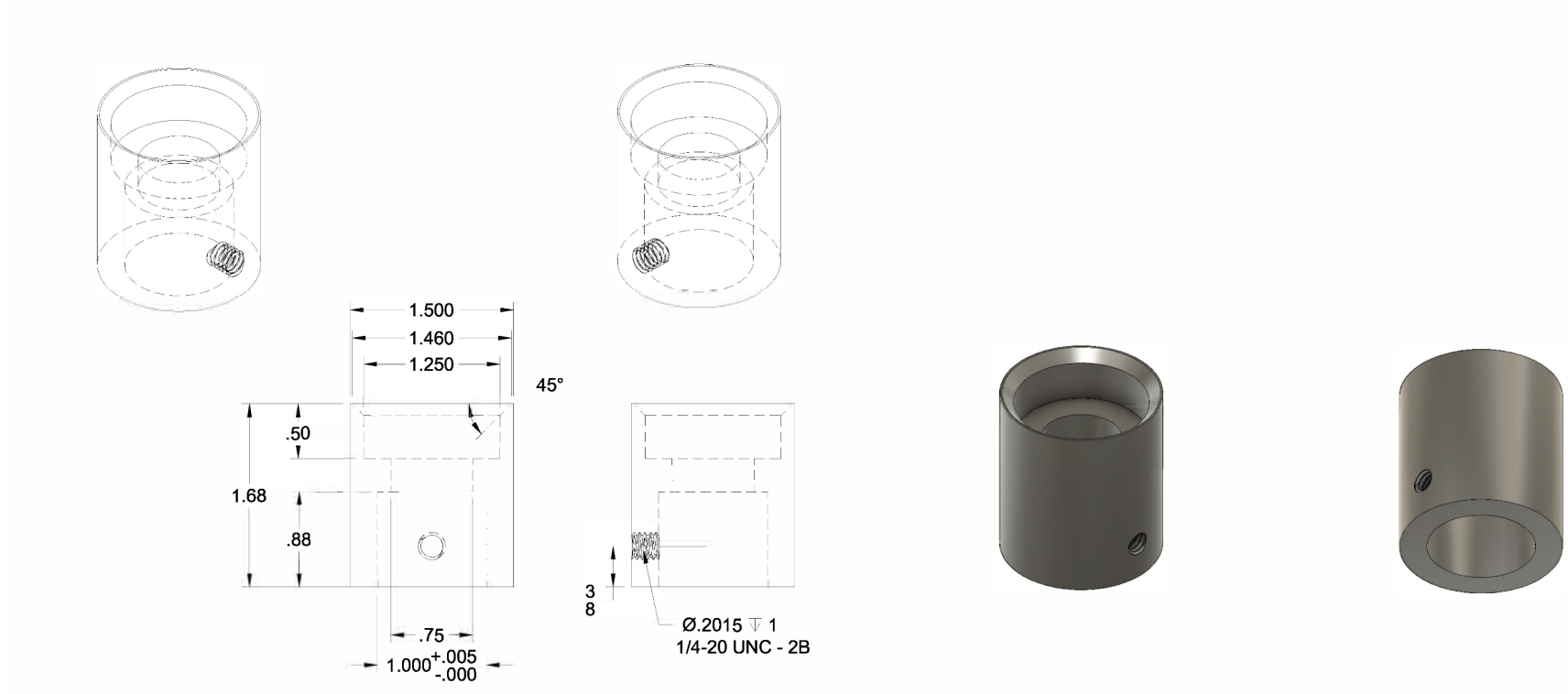
New procedure and cups

- Setup B was supposed to be capable for Setup A, B, and E.
- Investigation turned up the weld defect informing the staff that the Setup E cup was used for the Aluminum clad fuel elements.
- New Cup A was designed to encompass all fuel elements from Setup A, B, and E.
- New Cup B to replace Setup C. This will allow the staff to get rid of the 0.25” above threads.
- Old Setup D remains the same.
- Complete rewritten procedure with limits of the FEMT for each setup.

New Setup A cup (combining A, B, and E)



New Setup B cup



Required checks before measurements

Component	SETUP A	SETUP B	SETUP C	SETUP D
Series/Serials	1-5899/6000-9599	5900-5999	9600+	Control Rods
FEMT Mounting Point	Lower	Lower	Lower	Upper
FEMT Mounting Point Above or Below	Above	Above	Above	Below
Index Plate Thickness	Thin Plate (0.75”)	Thin Plate (0.75”)	Thick Plate (1.50”)	Thick Plate (1.50”)
Blocks Used	Yes	Yes	Yes	No
Block Thickness	Short (1.00”)	Short (1.00”)	Short (1.00”)	N/A
Reference Figure	Figure 1	Figure 1	Figure 2	Figure 3

Component	SETUP A	SETUP B	SETUP C	SETUP D
Go-No-Go Gauge Length	Short (22.62”)	Short (22.62”)	Short (22.62”)	Long (44.25”)
Bottom Fitting	FEMT-CUP-A Slotted Cup (3.220”)	FEMT-CUP-B Long Cup (1.68”)	FEMT-CUP-C Short Cup (1.50”)	N/A
Reference Element	Standard (24.103”)	Standard (24.103”)	Standard (24.103”)	Fuel Follower (45.500”)
Reference Element Extension	N/A	Short Extension (1.76”)	Long Extension (2.60”)	N/A

Distance	SETUP A	SETUP B	SETUP C	SETUP D
Element to Index Plate Top	1.00”	0.985”	1.00”	1.125”

Measurement	SETUP A	SETUP B	SETUP C	SETUP D
Index Reading of Reference Element	0.060”	0.100”	0.105”	0.100”

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Conclusion

- The historical knowledge is not always dependable.
- The assumptions that the FEMT was doing its job for all scenarios was bad.
- To make sure there is no need for assumptions, put the information into a training program or into the procedure.
- Started to use the new setups and have confirmed older measurements
- Have gotten new and confident measurements on fuel that was out of range on old FEMT setups.