

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



ANC22FA047

COMPUTED TOMOGRAPHY

Specialist's Factual Report

June 10, 2024

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A. ACCIDENT

Location: Clear, Alaska
Date: June 26, 2022
Time: 1938 Alaska daylight time
0338 coordinated universal time (UTC) June 27, 2024
Helicopter: Bell UH-1B, N9970F

B. COMPUTED TOMOGRAPHY SPECIALIST

Specialist John Flynn
National Transportation Safety Board
Washington, DC

C. DETAILS OF THE INVESTIGATION

1.0 General

The collective actuator with attached irreversible valve assembly, the right lateral actuator with attached irreversible valve assembly, the left lateral actuator, and the irreversible valve assembly of the left lateral actuator from the accident helicopter were subjected to x-ray radiograph and computed tomography (CT) scanning to document their internal condition. The scanning was conducted from June 8 to June 23, 2023, in Chicago, Illinois by Varex Imaging, Inc under the direction of the NTSB using the Actis 225/500 microfocus CT system (225 kV) and the HPX-450-11 system with 4343N detector (450 kV). The Actis 225/500 microfocus CT system was used to scan the whole actuator while the HPX-450-11 system was used to scan the irreversible valve and a portion of the actuator cylinder as indicted in Table 1. The irreversible valve assembly of the left lateral actuator was scanned on December 5 and 6, 2023.

For the CT scans, the component was loaded into the imaging unit and placed on a turntable. The component was then rotated in front of the x-ray source, and the x-rays were captured by a detector after they went through the part. The x-ray source produced a cone shaped beam of x-rays, and the portion of the part imaged was adjusted slightly after each scan was completed until the entire assembly (or region of interest of the part) was scanned. The x-ray energy levels measured by the detector were recorded at several thousand different points during each rotation, and this information was converted into slice images using reconstruction algorithms.

The components were scanned using a total of 15,302 slices, and the total size of the combined data sets was approximately 59.59 GB. The complete scan protocols are given in Table 1. The digital radiograph and CT axial slice images were provided by Varex to the NTSB where they were examined, processed, and analyzed to evaluate the components.

Table 1. Scan Protocol

CT System	225 kV	450 kV	225 kV	450 kV	225 kV	450 kV
Component/Area	Collective (whole part)	Collective (valve and ball joint)	Right Lateral (whole part)	Right Lateral (valve and ball joint)	Left Lateral (actuator portion)	Left Lateral (valve)
Number of Slices	3066	1920	3987	1920	3009	1400
Voxel ¹ Size - X Direction (millimeter(mm))	0.146	0.15	0.146	0.15	0.146	0.125
Voxel Size - Y Direction (mm)	0.146	0.15	0.146	0.15	0.146	0.125
Voxel Size - Z Direction (mm)	0.14	0.15	0.14	0.15	0.14	0.125
Image Projections per Revolution	1800	5760	1800	5760	1800	3600
Exposure Time (milliseconds)	285.6	285.6	285.6	285.6	285.6	285.6
Frames to Avg (frames per projection)	2	1	2	1	2	1
X-ray Source Voltage (kilovolts)	222	450	222	450	222	450
X-ray Source Current (mA)	0.575	1.4	0.575	1.4	0.575	0.89
Source Filter Thickness (mm)	1	5.5	1	5.5	1	4.5
Source Filter Material	brass	brass	brass	brass	brass	copper
Image Matrix Size (pixels)	1536 x 1536	1024 x 1024	1536 x 1536	1024 x 1024	1536 x 1536	1400 x 1400

The data sets of slice images were examined, processed, and analyzed by the NTSB using the VGStudioMax software package to convert the axial slice data into orthogonal slice images and a three-dimensional reconstructed image of the component. As part of the evaluation, some sections of the components were digitally removed or rendered transparent to allow closer observation of interior parts. In all the images, the higher density areas were shown as brighter shades of gray and lower density areas were shown as darker shades of gray. Each 2-D quadrant within the images shows a scale at the bottom of that quadrant - note that the scales in each quadrant may be different. The pointers shown in some of the images denote specific areas of interest within that image. The numbers associated with the pointer are the gray value at the pointer location and the three positional coordinates of the pointer.

Some of the actuators internal components were “virtually unrolled” using the CT image visualization software. This process required the identification of a path for

¹ A voxel is a three-dimensional picture element (pixel).
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the software to use when unrolling the data set, and it resulted in a cylindrical structure being "unrolled" to show a round surface as a flat planar image.

The images of the actuators were examined for any signs of missing or damaged parts, contamination, or any other anomalies. Specific results (including example images) are presented in subsequent sections of this report.

2.0 Description of Actuators

The collective actuator, the right lateral actuator and the left lateral actuator are similar to each other. The main difference is that some components/parts were not included on the accident actuators when they were CT scanned. The collective actuator (see Figure 1) and the right lateral actuator (see Figure 2) included the hydraulic cylinder assembly (see Figure 5) and the irreversible hydraulic pressurized valve assembly (see Figure 6). The left lateral actuator consisted of two pieces, a portion of the hydraulic cylinder assembly (see Figure 3) and the irreversible valve (see Figure 4). The irreversible valve had separated from the actuator during the accident and was recovered after the initial CT scans were completed.



Figure 1. Collective actuator.



Figure 2. Right lateral actuator.



Figure 3. Left lateral actuator cylinder assembly.



Figure 4. Left lateral actuator irreversible valve.

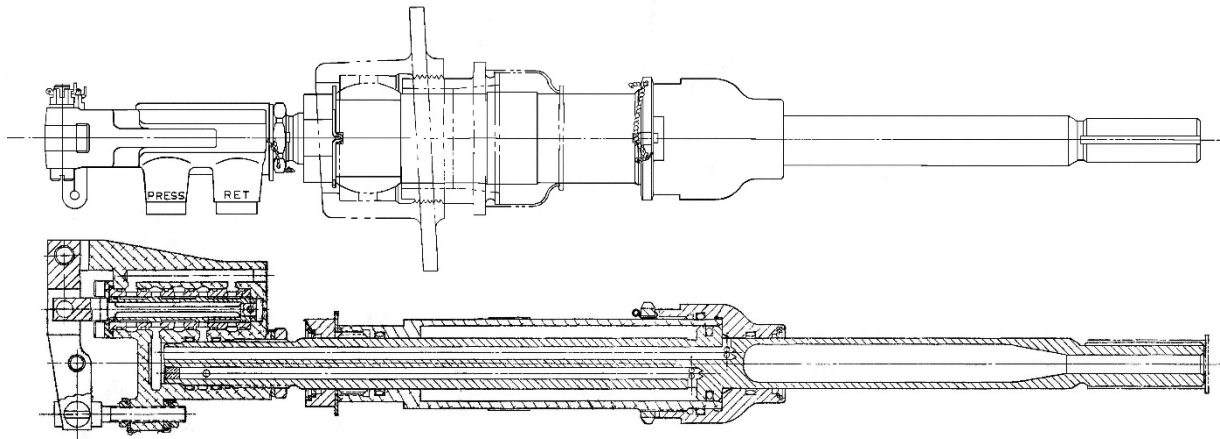


Figure 5. Flight control servo hydraulic cylinder assembly. (Courtesy of Woodward)

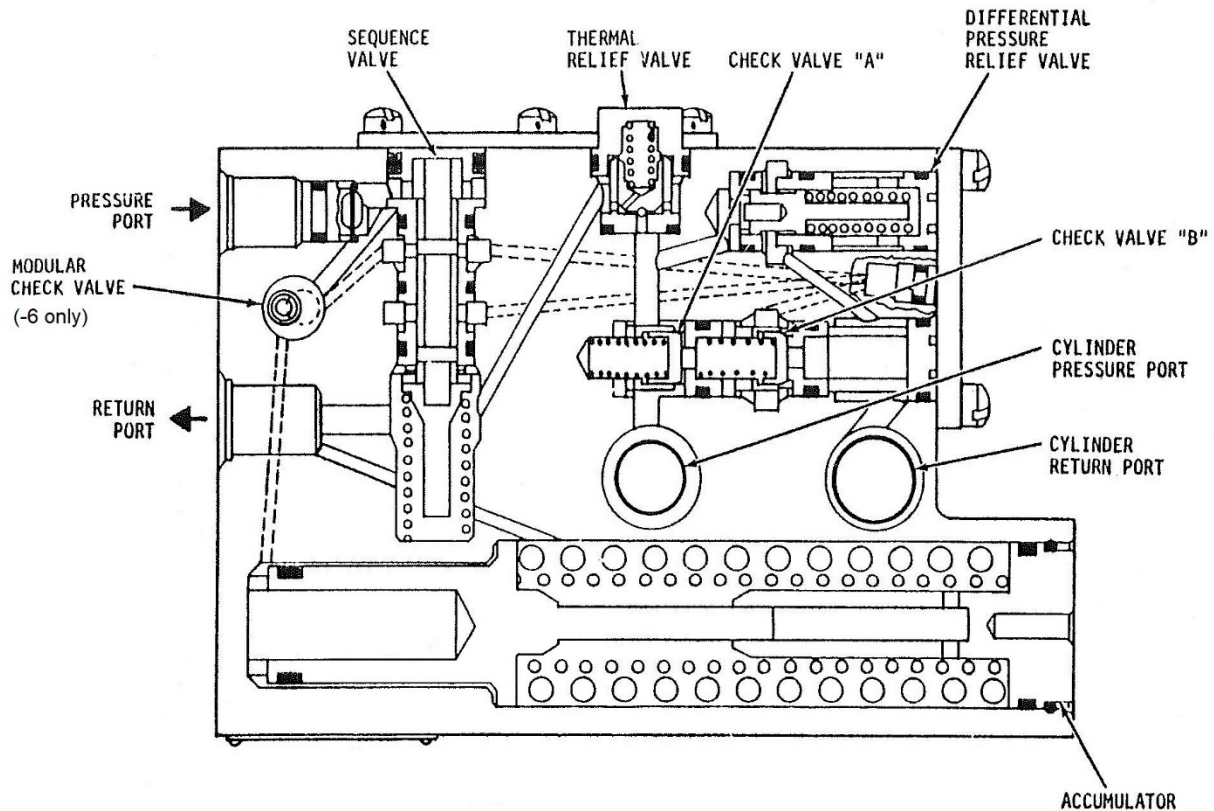


Figure 6. Irreversible hydraulic pressurized valve assembly. (Courtesy of HR Textron)

3.0 Computed Tomography Results

3.1 Collective Actuator

The CT results for the collective actuator with attached irreversible valve assembly are shown in Figures 7 through 53. Review of the images indicated that, when the scans were conducted, the following indications were noted:

1. There were indications of a bulging cap for the sequence valve of the collective actuator irreversible valve assembly. (Figure 13)
2. There were indications of gaps and distortions in the seals in the collective actuator cylinder assembly and the irreversible valve assembly. (Figures 21, 22, 23, 24, 45, 46, 49, and 50)
3. There were indications of medium density particles and/or material inside the piston rod of the collective actuator cylinder assembly and irreversible valve assembly. (Figures 25 and 53)
4. There were indications of cracks in the irreversible valve housing near the accumulator spring end. (Figures 26 and 27)

5. There were indications of low density particles and/or material in the hydraulic passage 1 inlet of the collective actuator cylinder assembly. (Figure 36)
6. There were indications of high density particles and/or material in the threads of the piston rod of the collective actuator cylinder assembly. (Figure 40)
7. There were indications of medium density material between the cylinder and ball joint retainer of the collective actuator. (Figure 43)

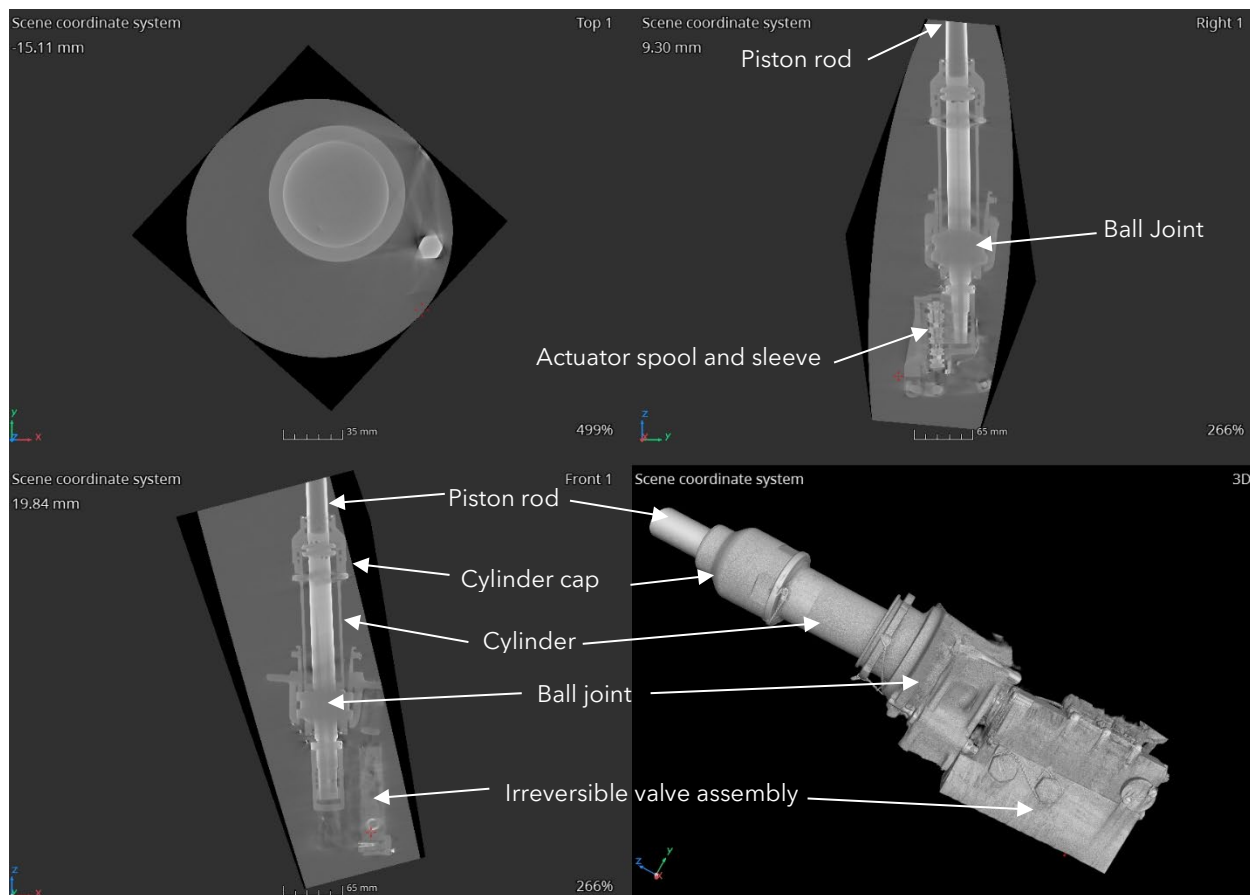


Figure 7. Collective actuator - overview. (225 kV)

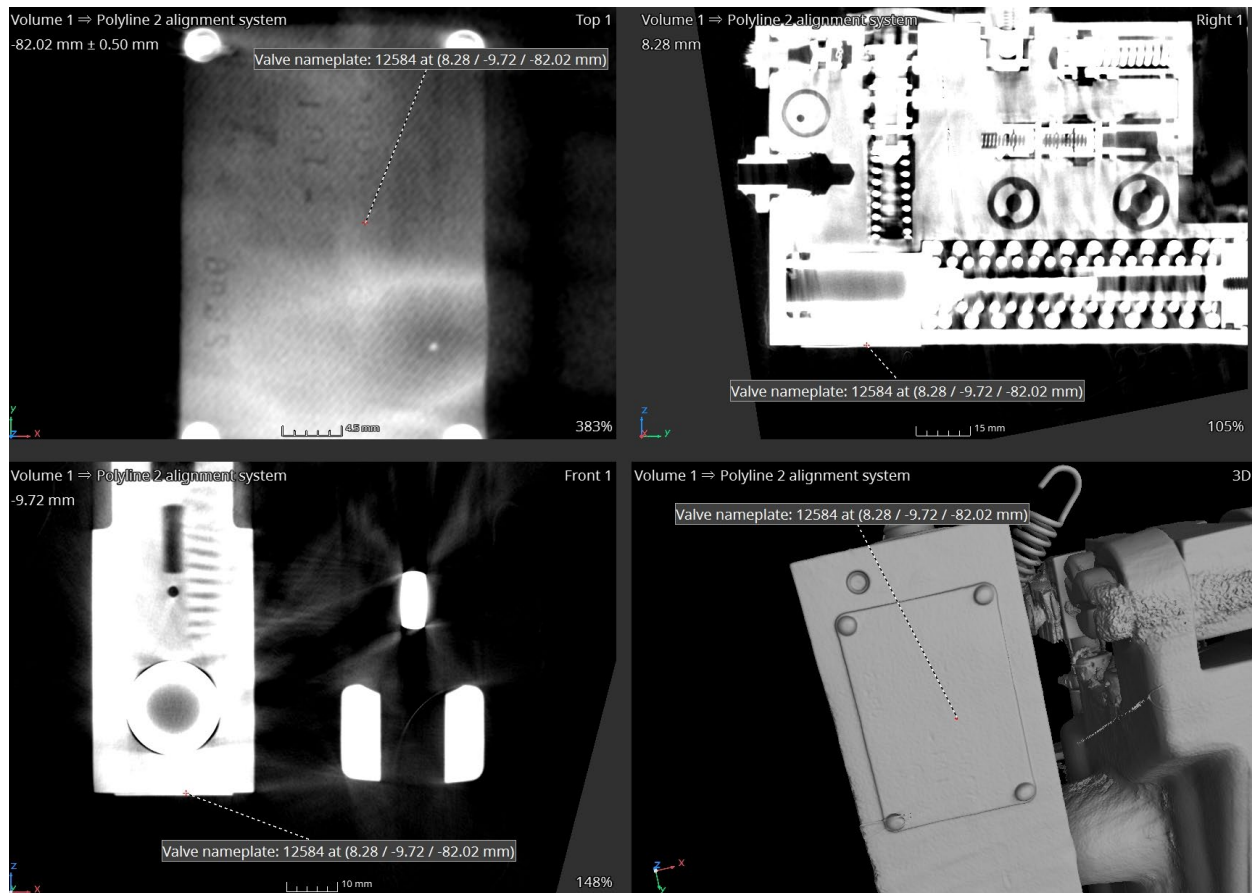


Figure 8. Collective actuator - irreversible valve - nameplate. (450 kV)

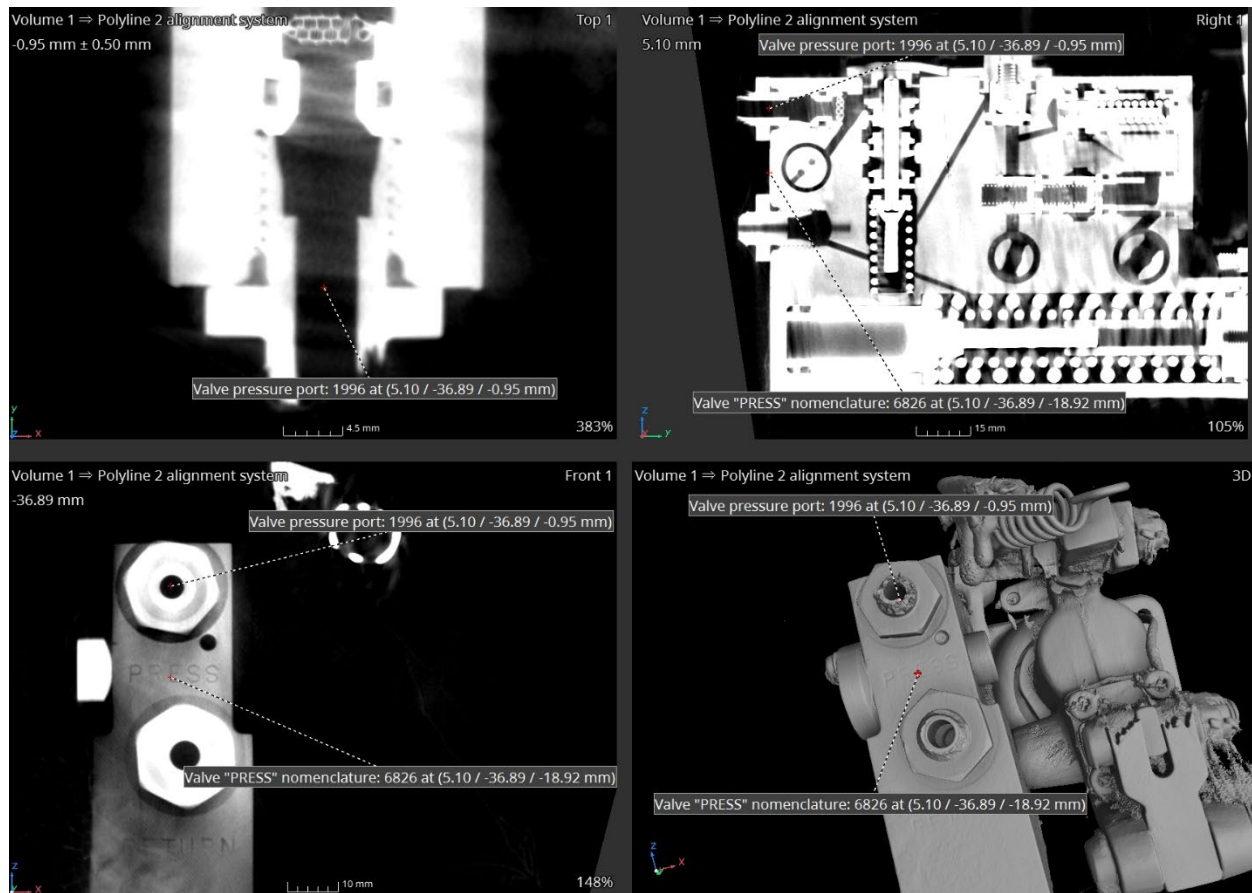


Figure 9. Collective actuator - irreversible valve - pressure port and nomenclature. (450 kV)

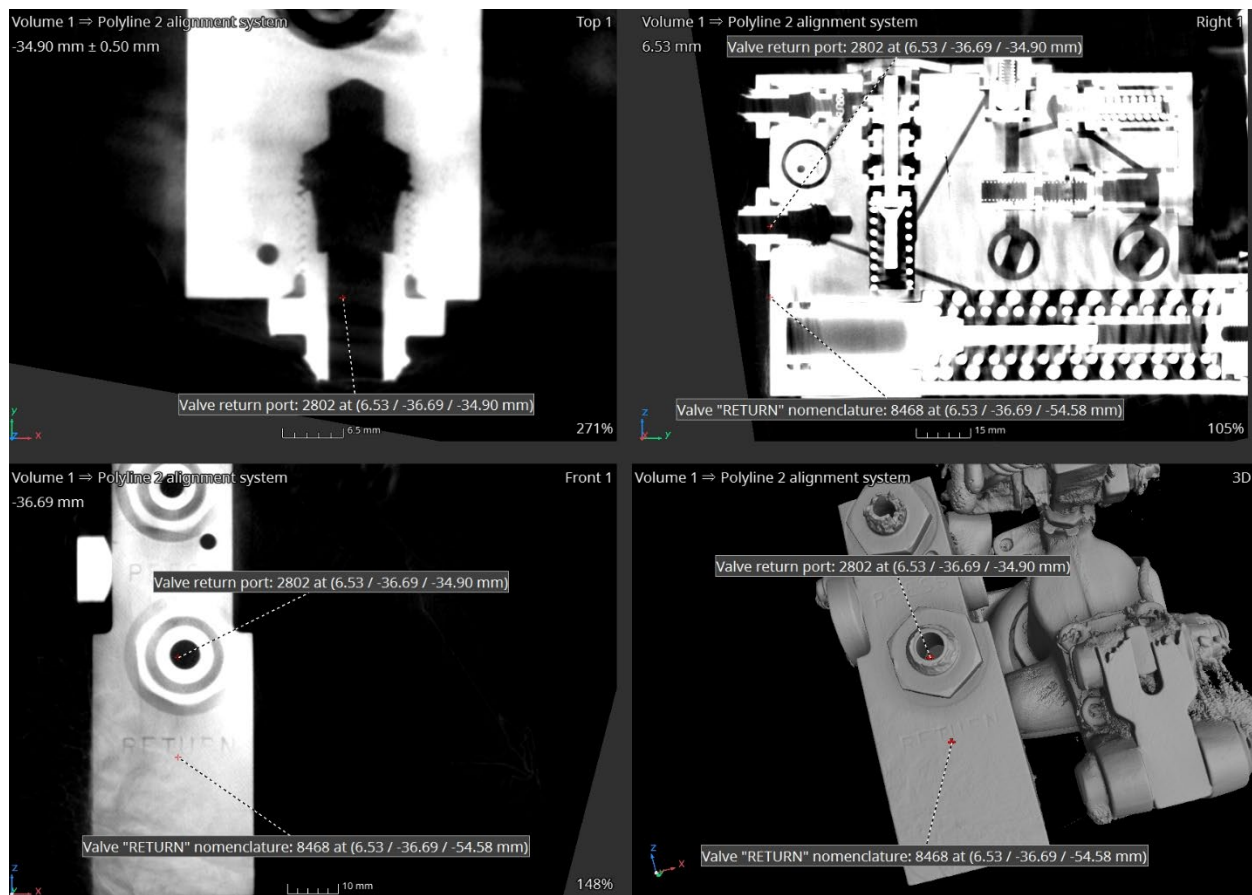


Figure 10. Collective actuator - irreversible valve - return port and nomenclature. (450 kV)

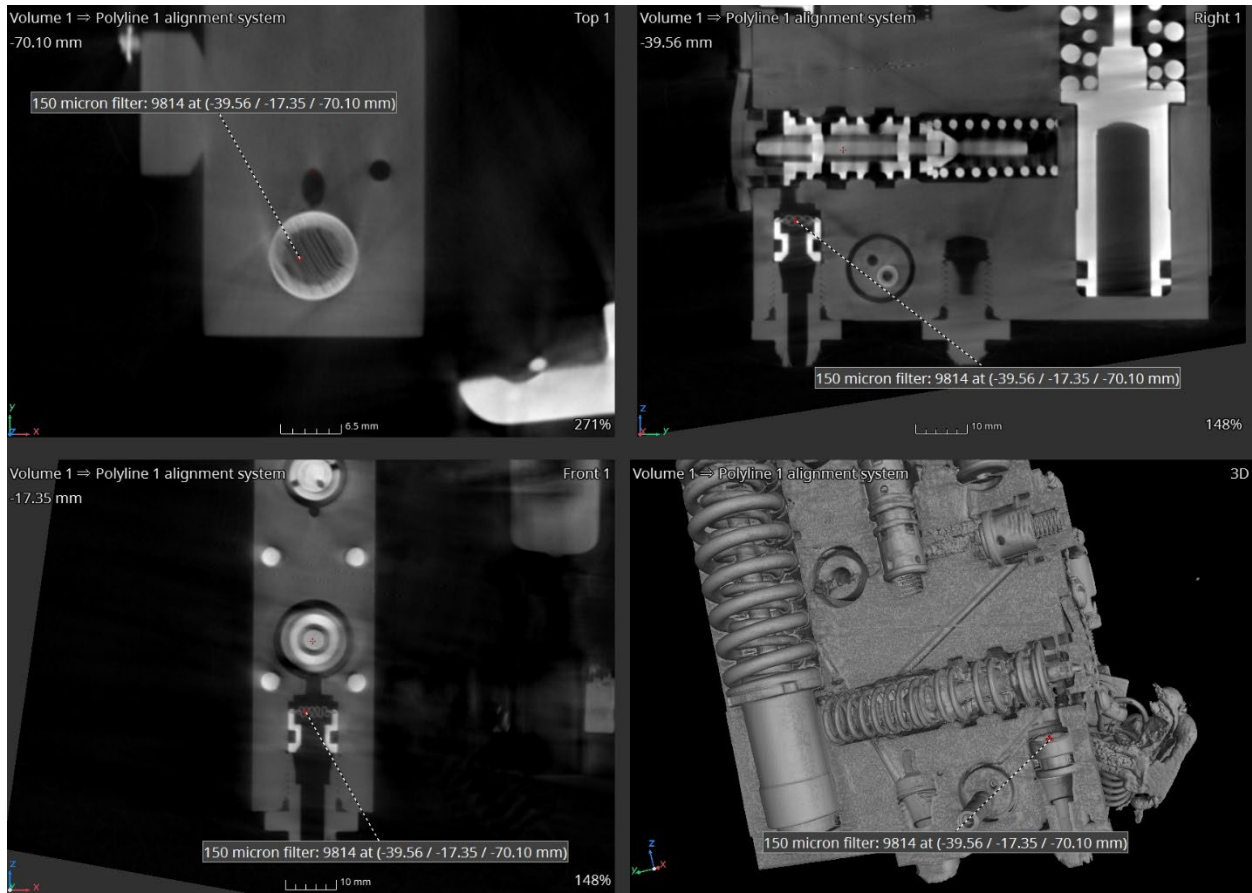


Figure 11. Collective actuator - irreversible valve - 150 micron filter. (450 kV)

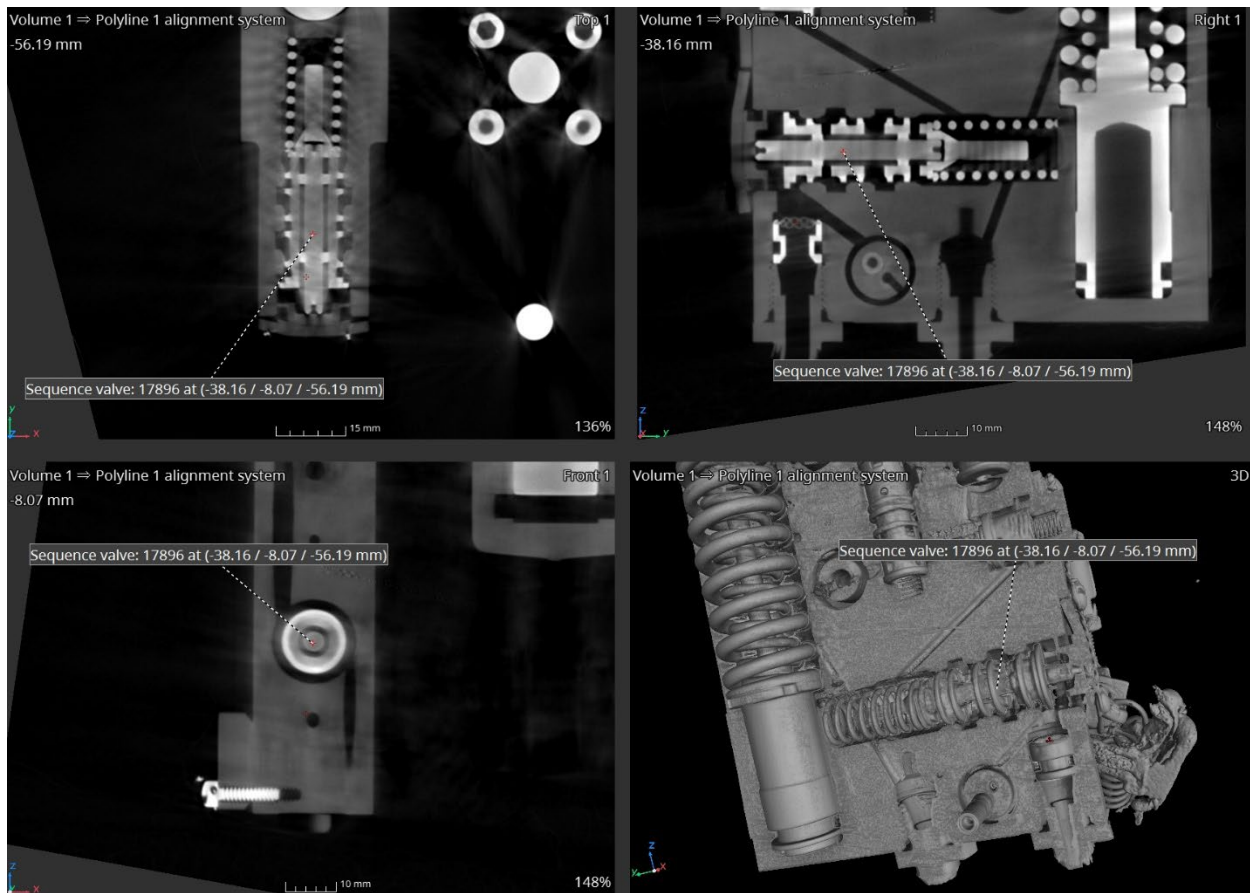


Figure 12. Collective actuator - irreversible valve - sequence valve. (450 kV)

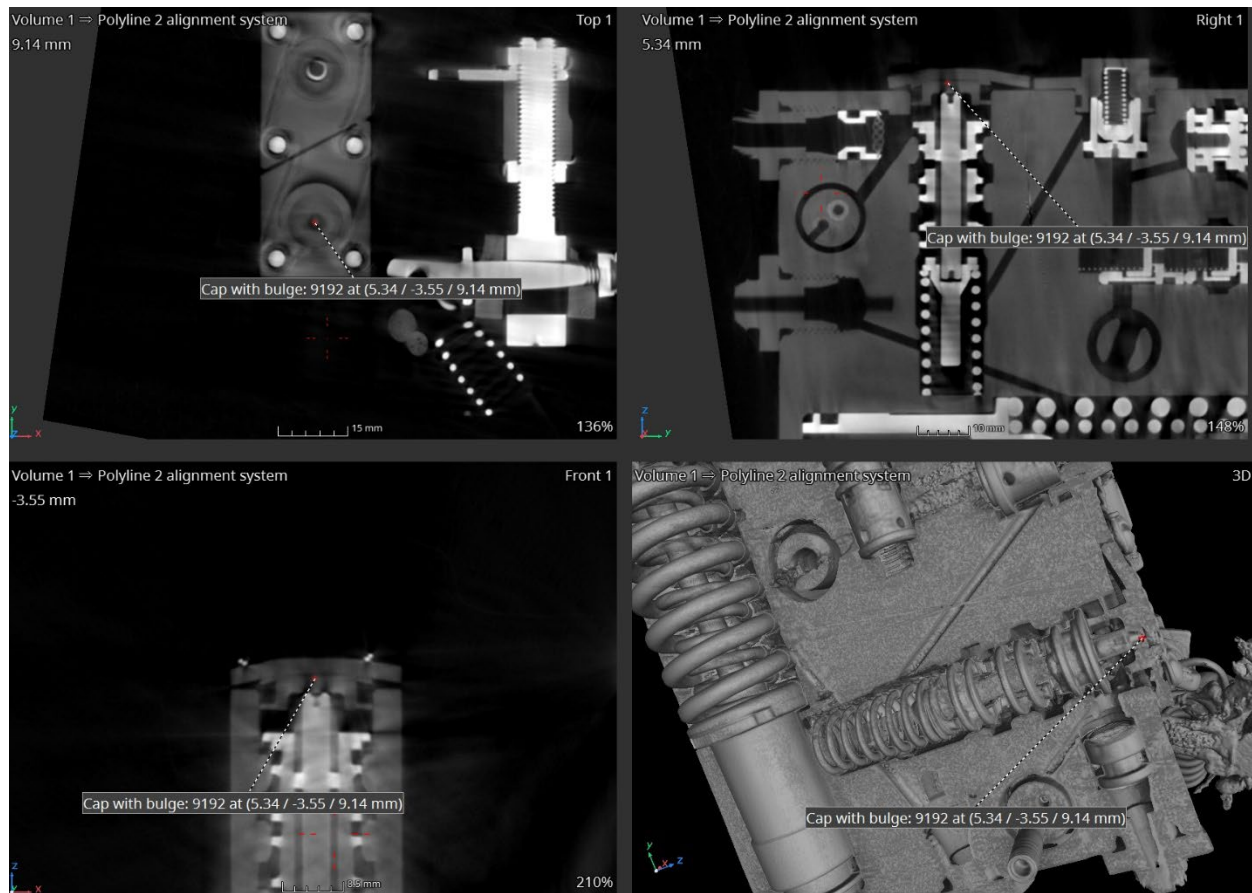


Figure 13. Collective actuator - irreversible valve - cap with bulge. (450 kV)

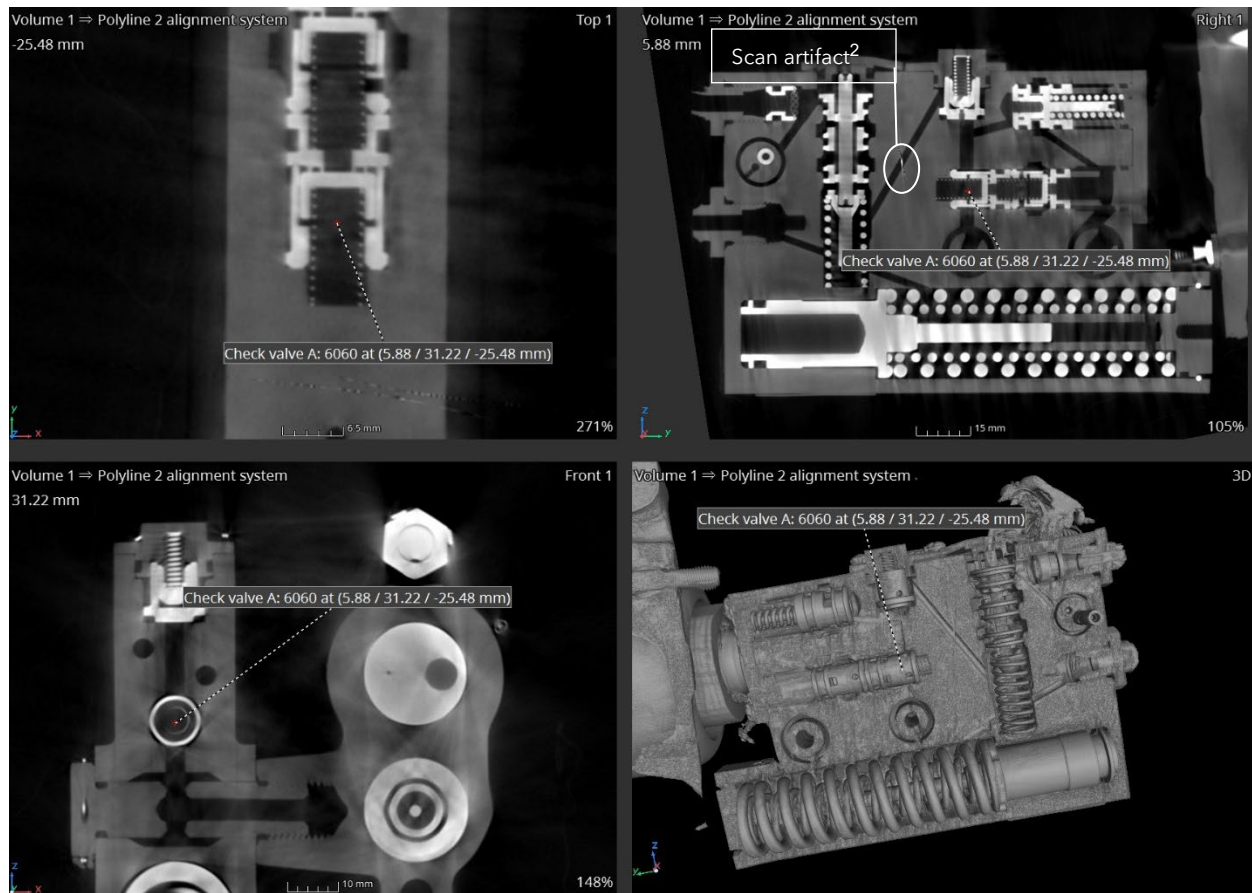


Figure 14. Collective actuator - irreversible valve - check valve A. (450 kV)

² A CT image artifact is any discrepancy between the reconstructed values in a CT image and what is expected based on the material density and the sample geometry. This scan artifact is a ring artifact and is caused by a mis calibrated or defective detector element, which results in rings centered on the center of rotation.

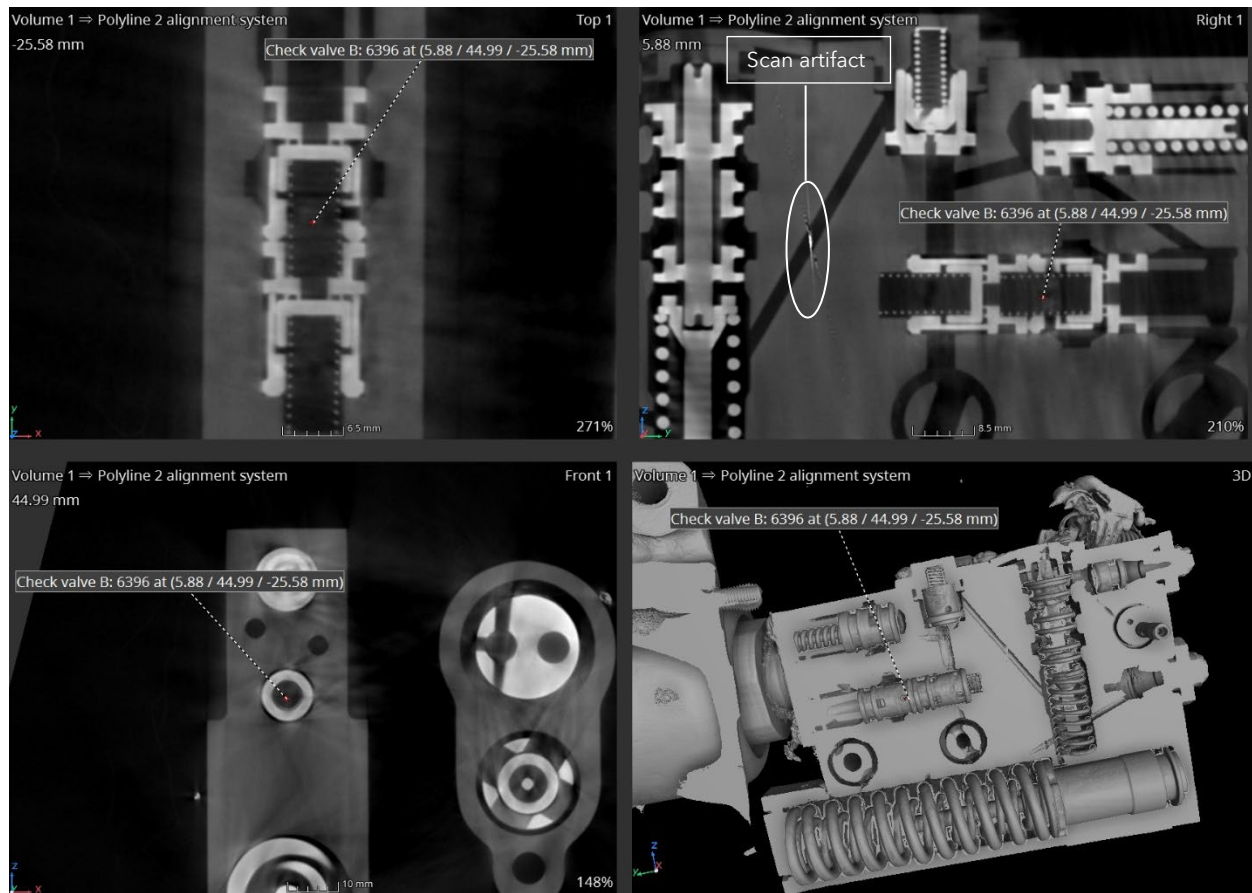


Figure 15. Collective actuator - irreversible valve - check valve B. (450 kV)

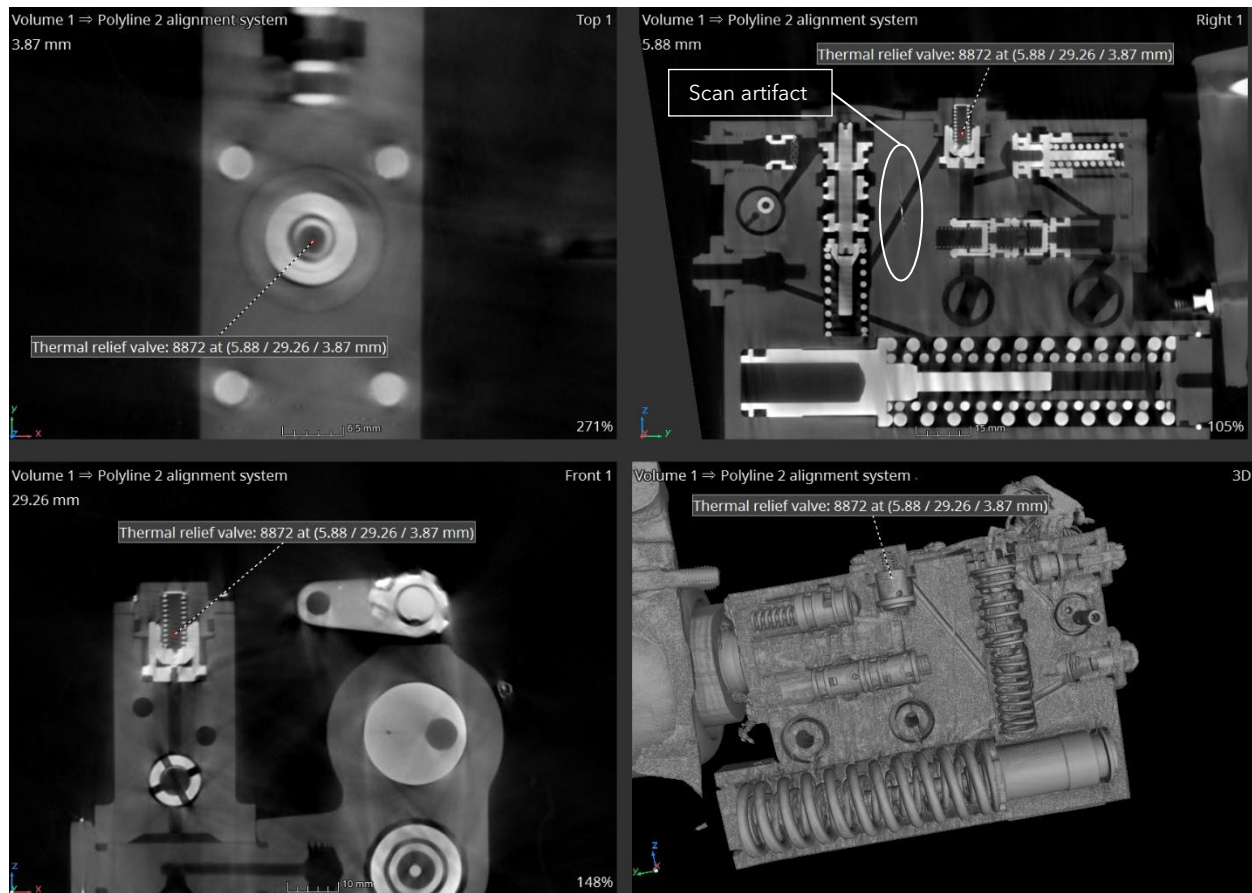


Figure 16. Collective actuator - irreversible valve - thermal relief valve. (450 kV)

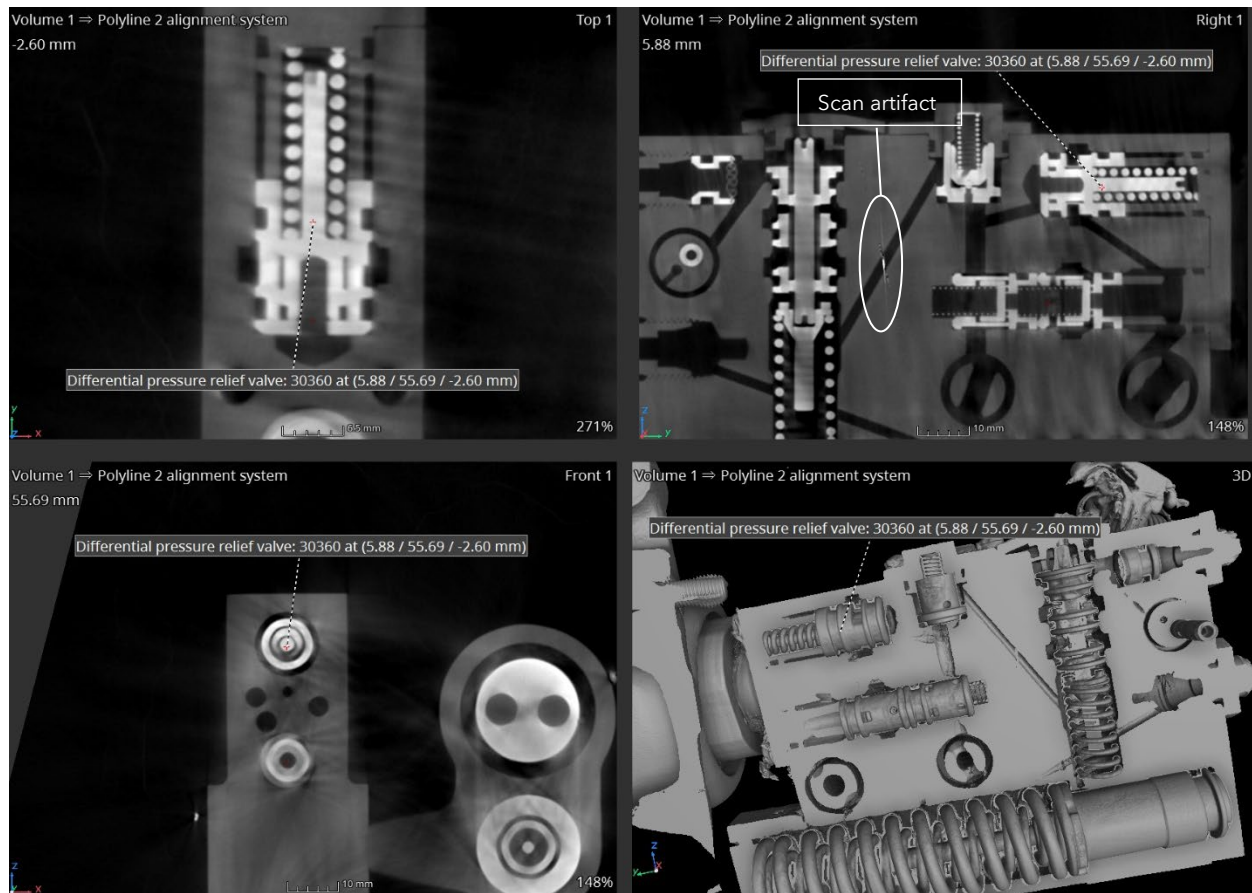


Figure 17. Collective actuator - irreversible valve - differential pressure relief valve. (450 kV)

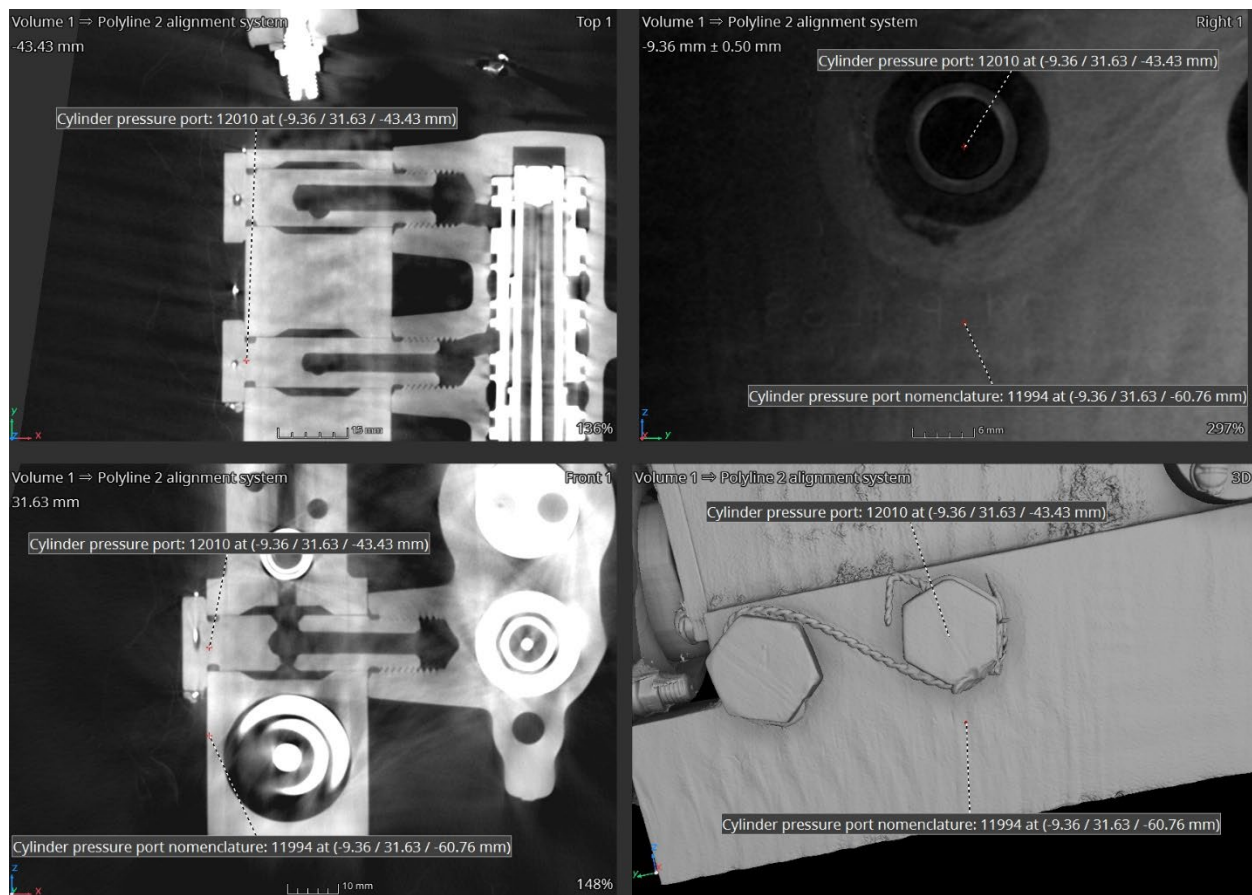


Figure 18. Collective actuator - irreversible valve - cylinder pressure port and nomenclature. (450 kV)

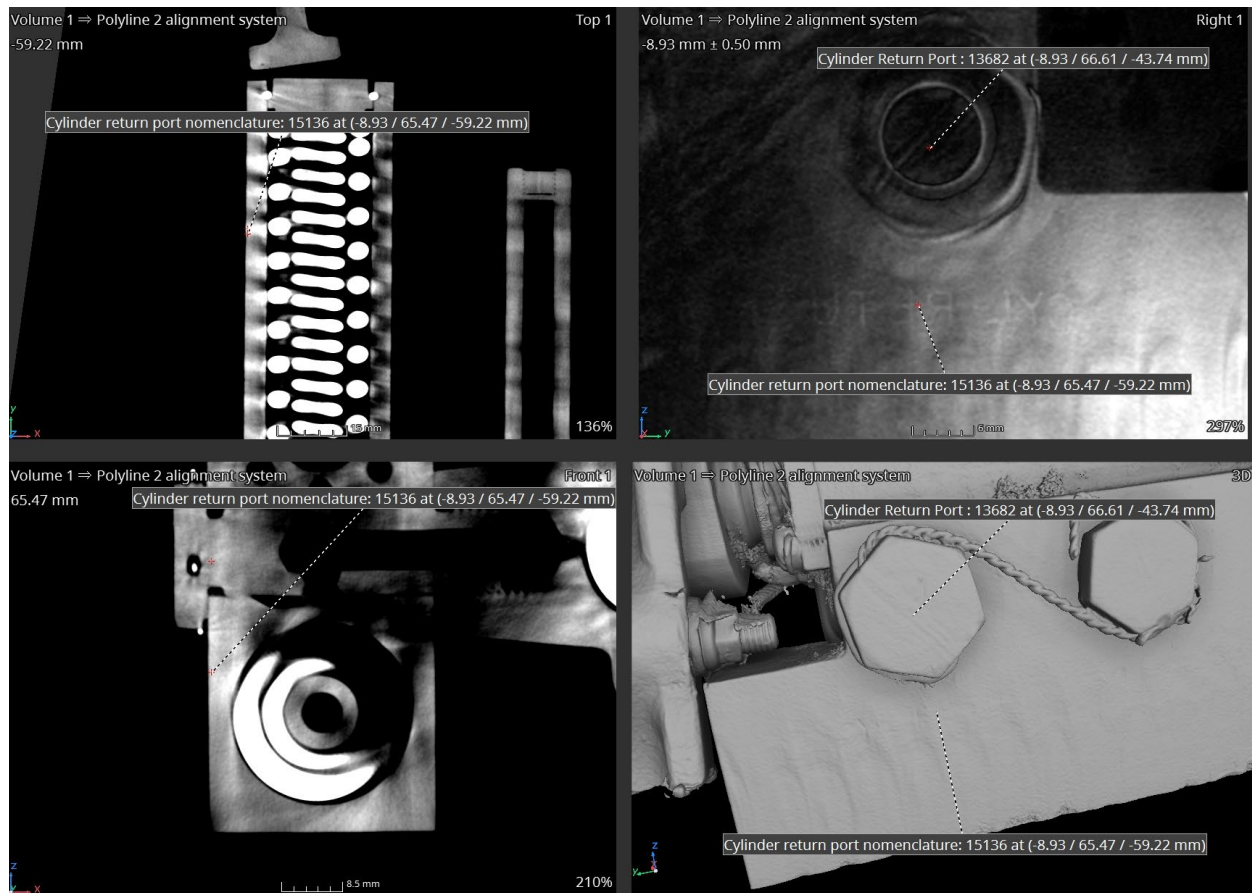


Figure 19. Collective actuator - irreversible valve - cylinder return port and nomenclature. (450 kV)

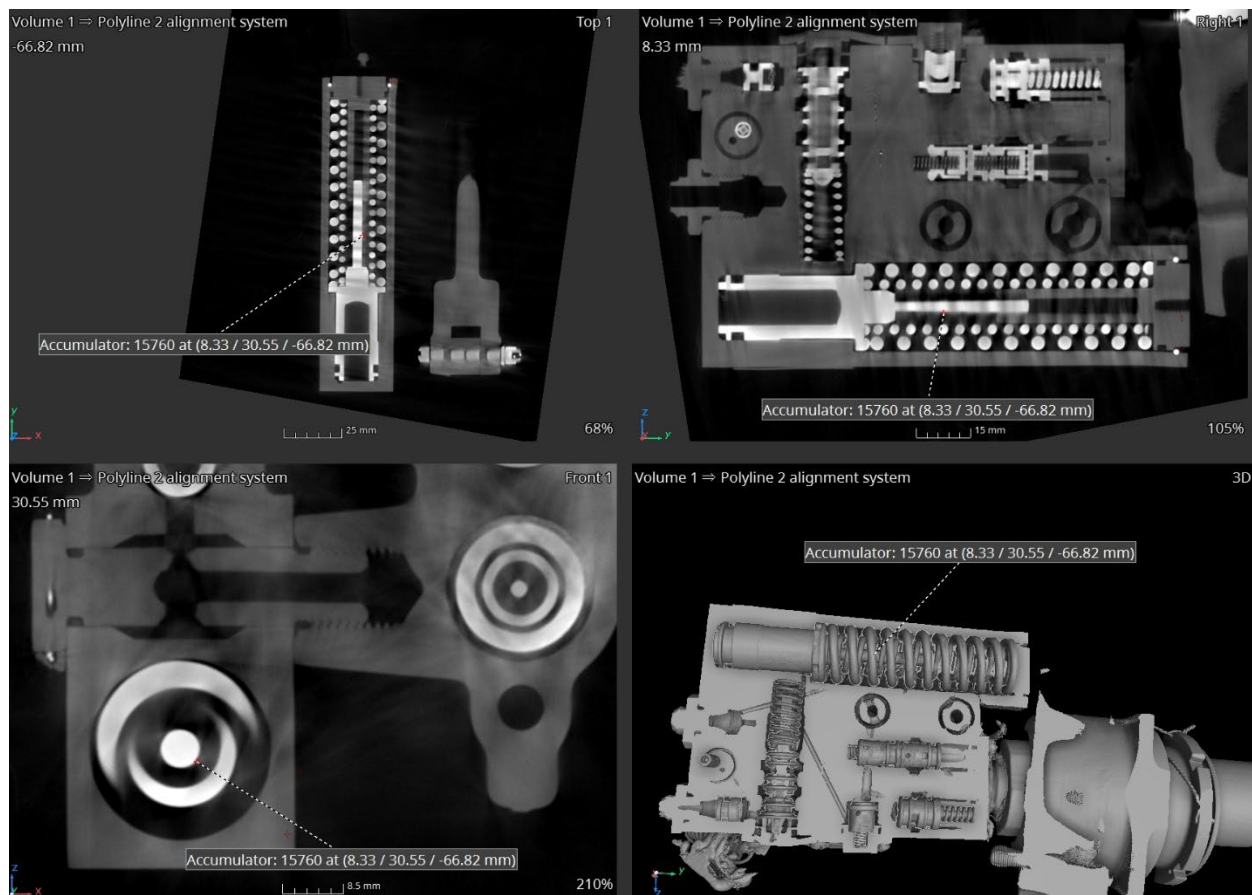


Figure 20. Collective actuator - irreversible valve - accumulator. (450 kV)

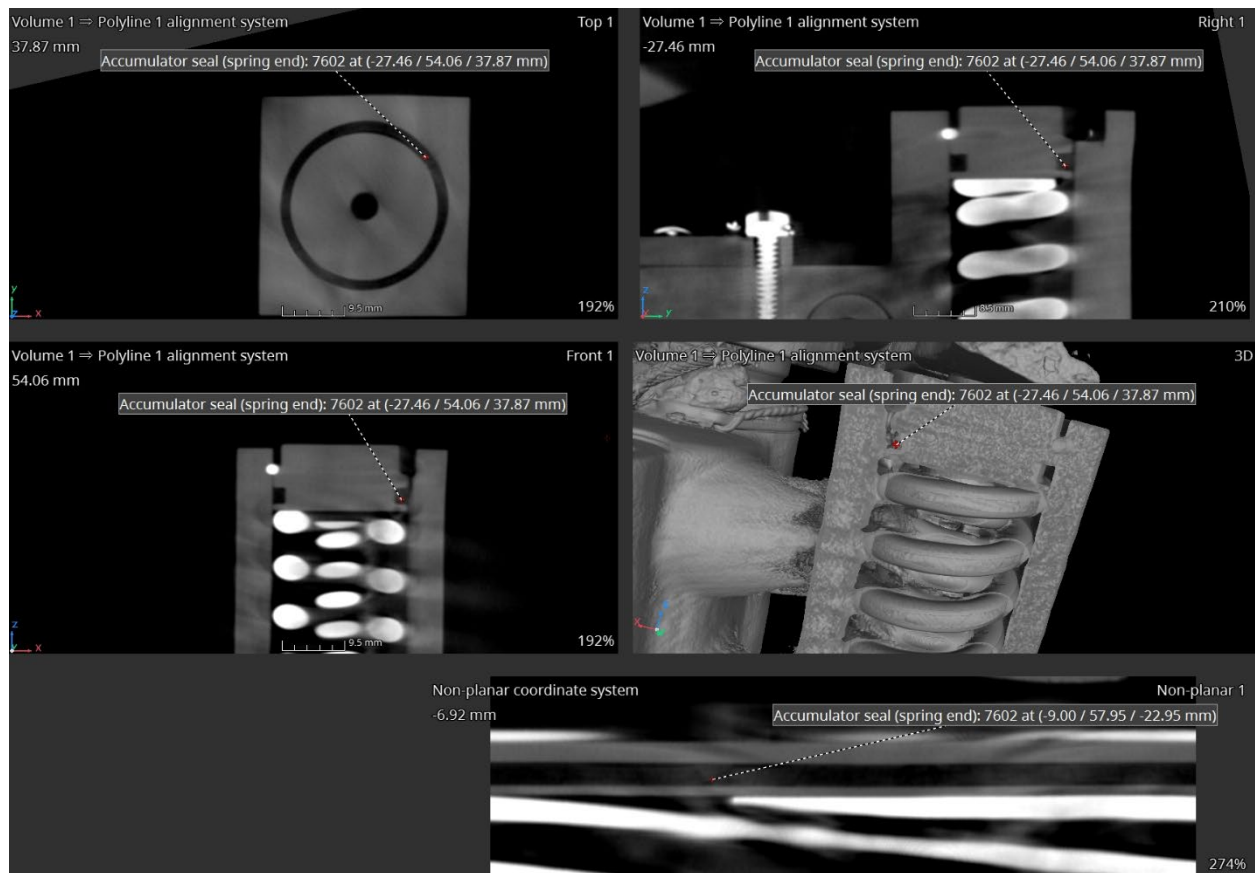


Figure 21. Collective actuator – irreversible valve - accumulator seal at spring end. (450 kV)



Figure 22. Collective actuator - irreversible valve - accumulator seal unrolled at spring end. (450 kV)

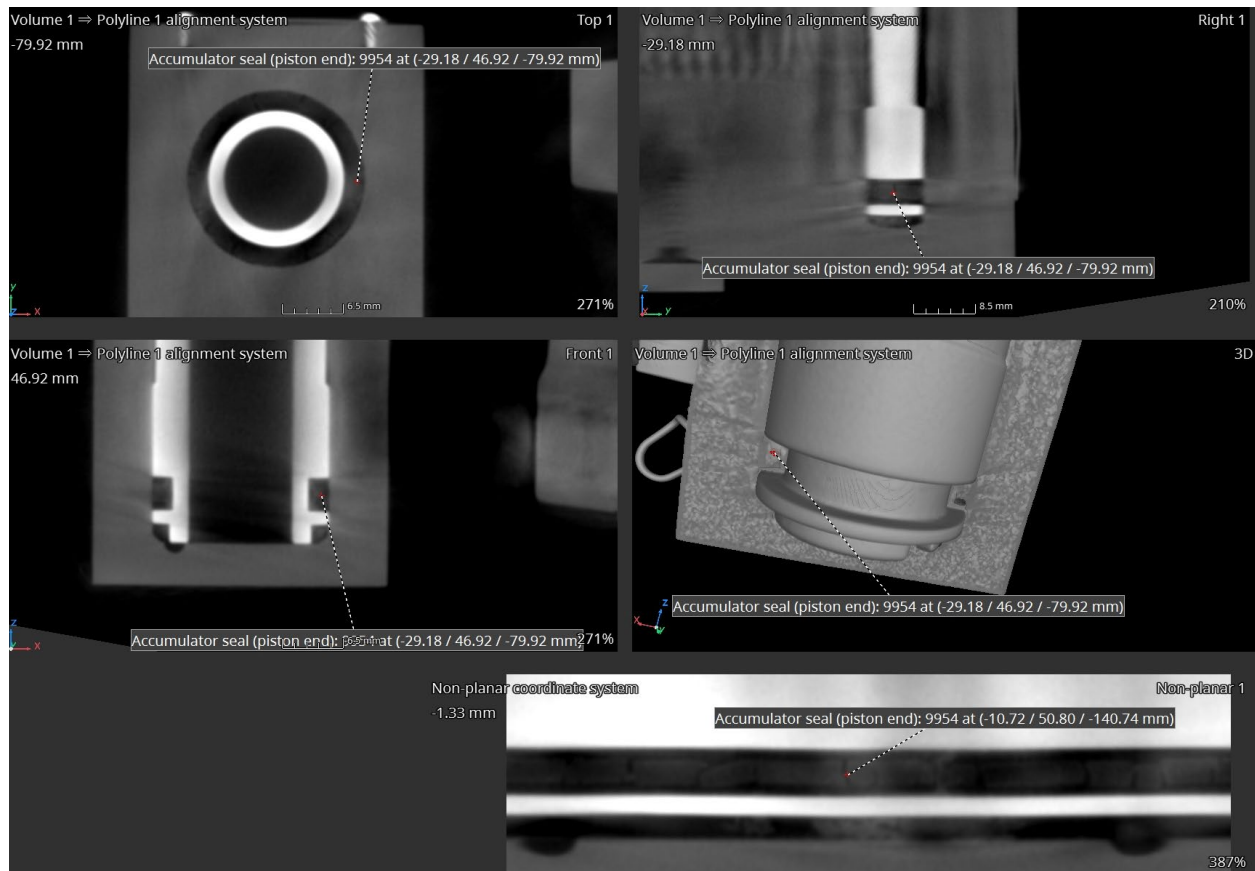


Figure 23. Collective actuator – irreversible valve – accumulator seal at piston end. (450 kV)

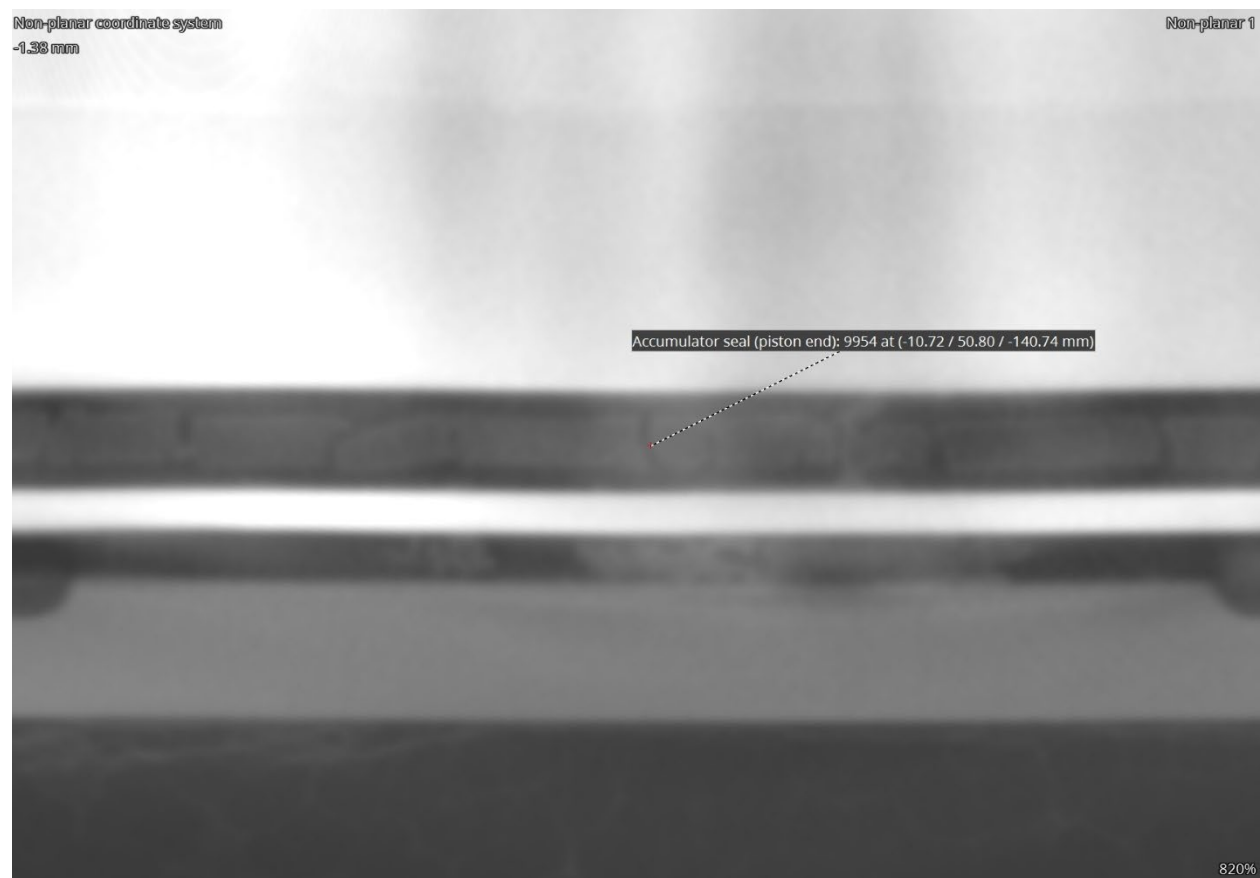


Figure 24. Collective actuator - irreversible valve - accumulator seal unrolled at piston end. (450 kV)

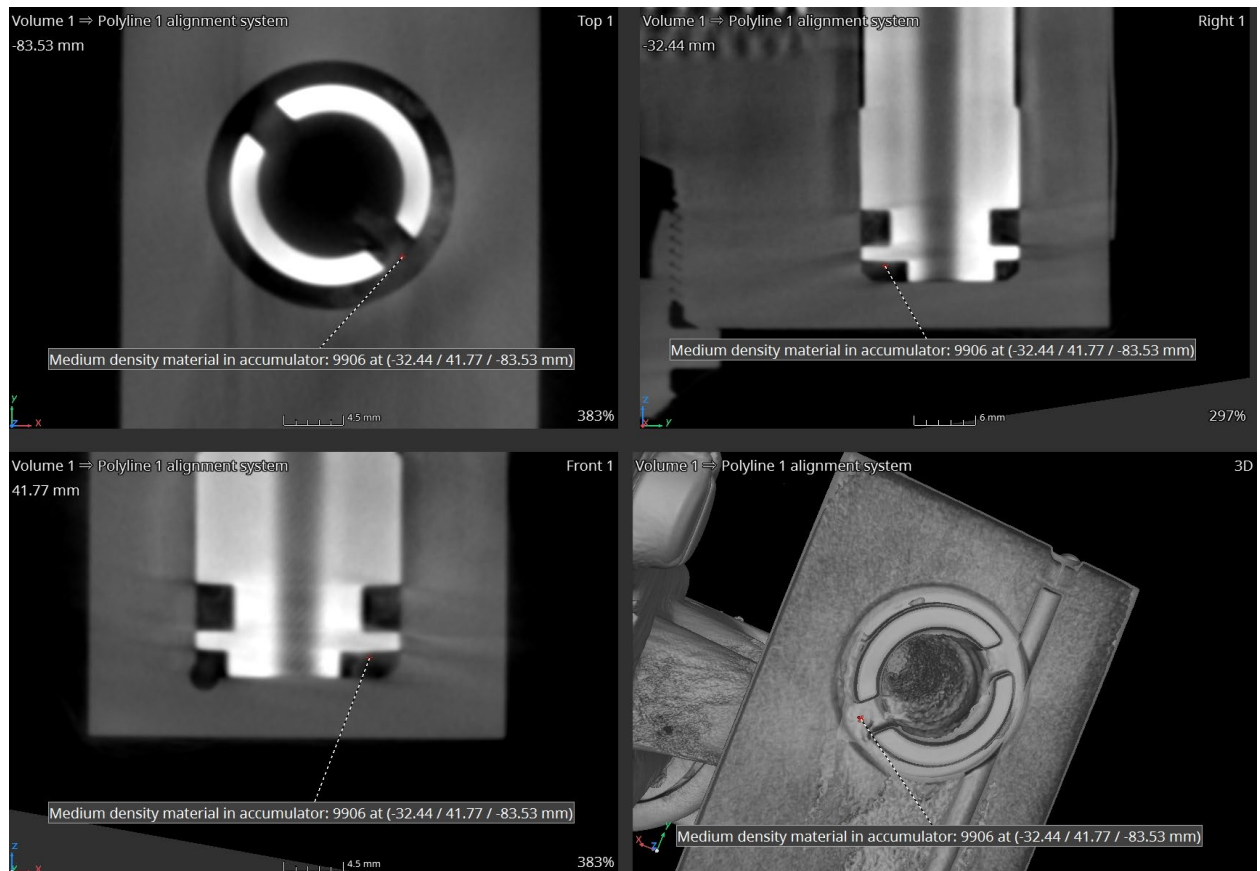


Figure 25. Collective actuator - irreversible valve - medium density material in accumulator inlet. (450 kV)

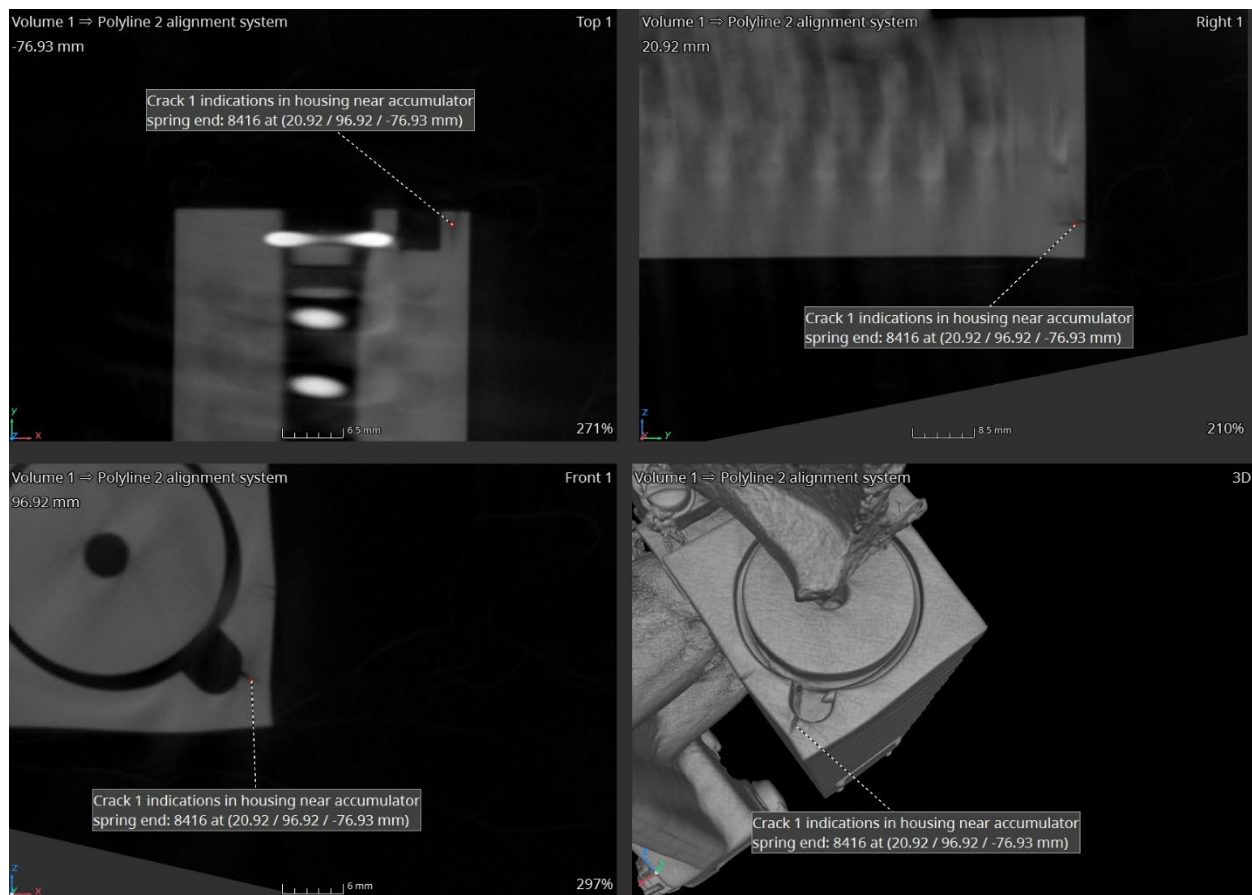


Figure 26. Collective actuator - irreversible valve - crack 1 indications in housing near accumulator spring end. (450 kV)

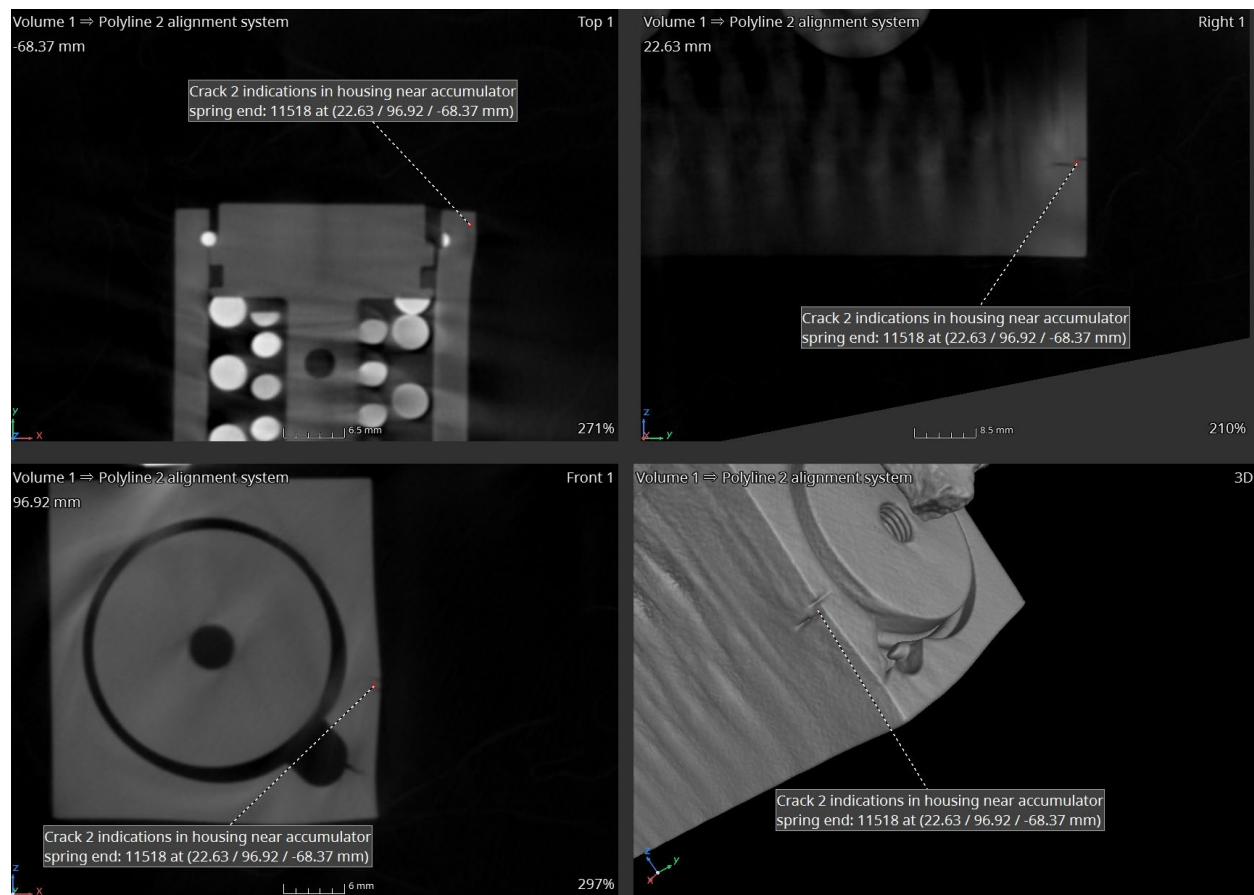


Figure 27. Collective actuator - irreversible valve - crack 2 indications in housing near accumulator spring end. (450 kV)

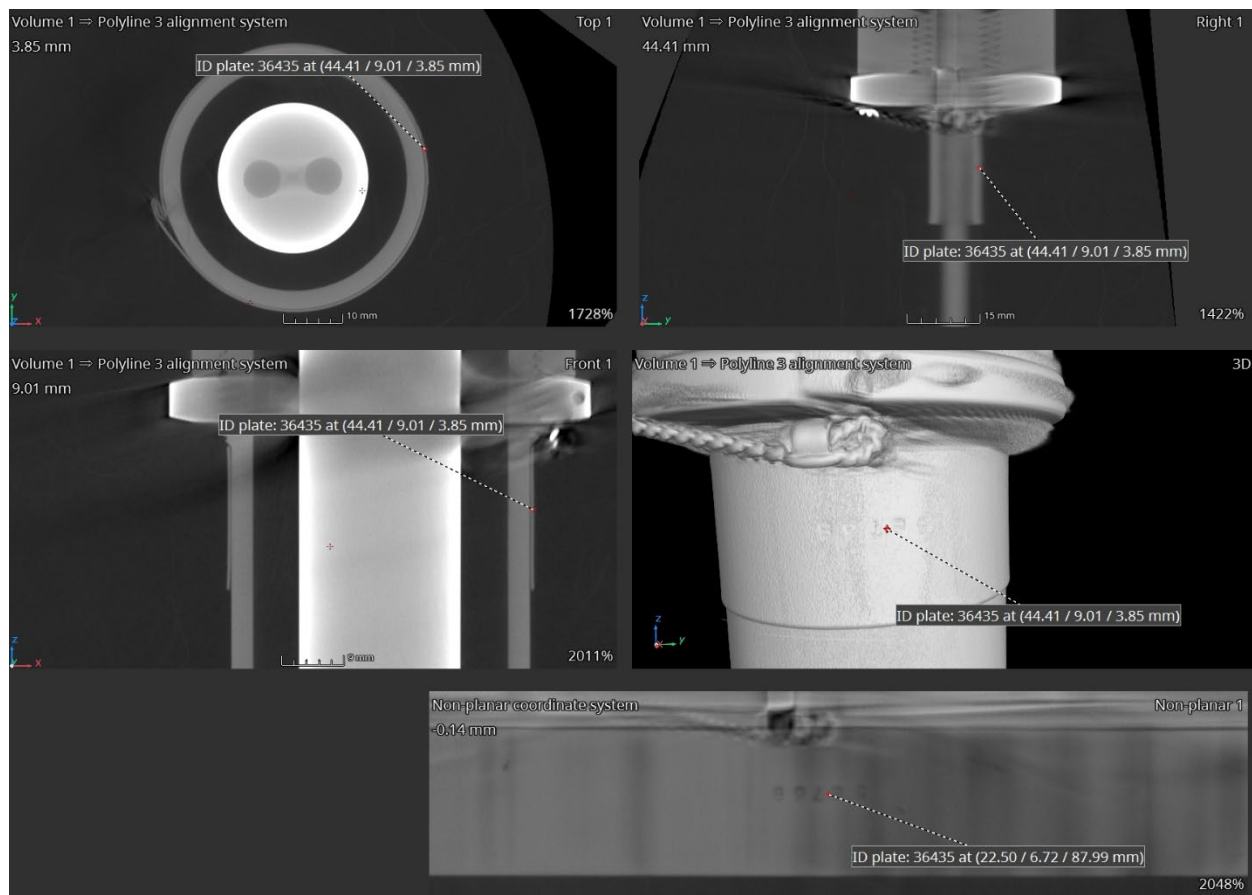


Figure 28. Collective actuator - cylinder assembly - ID plate. (225 kV)

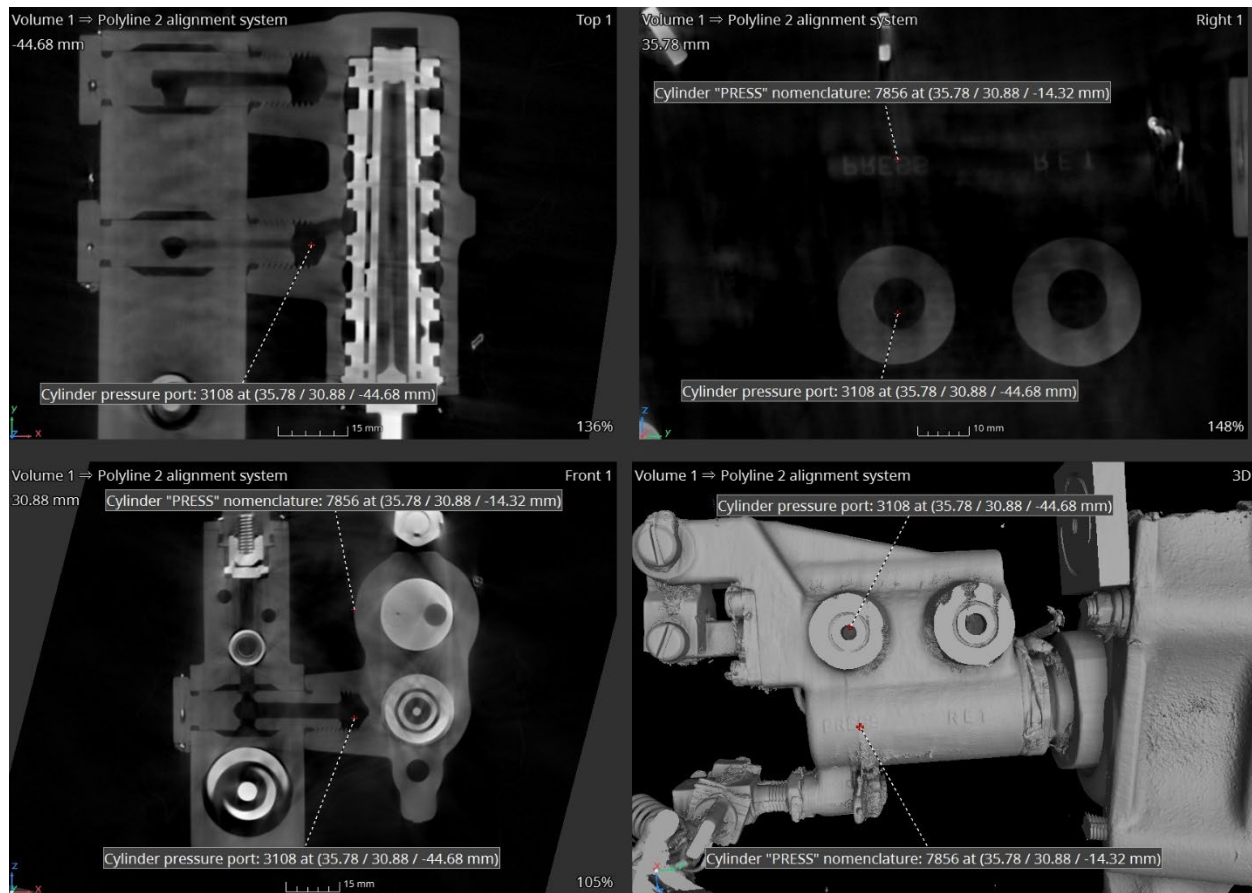


Figure 29. Collective actuator - cylinder assembly - pressure port and "PRESS" nomenclature. (450 kV)

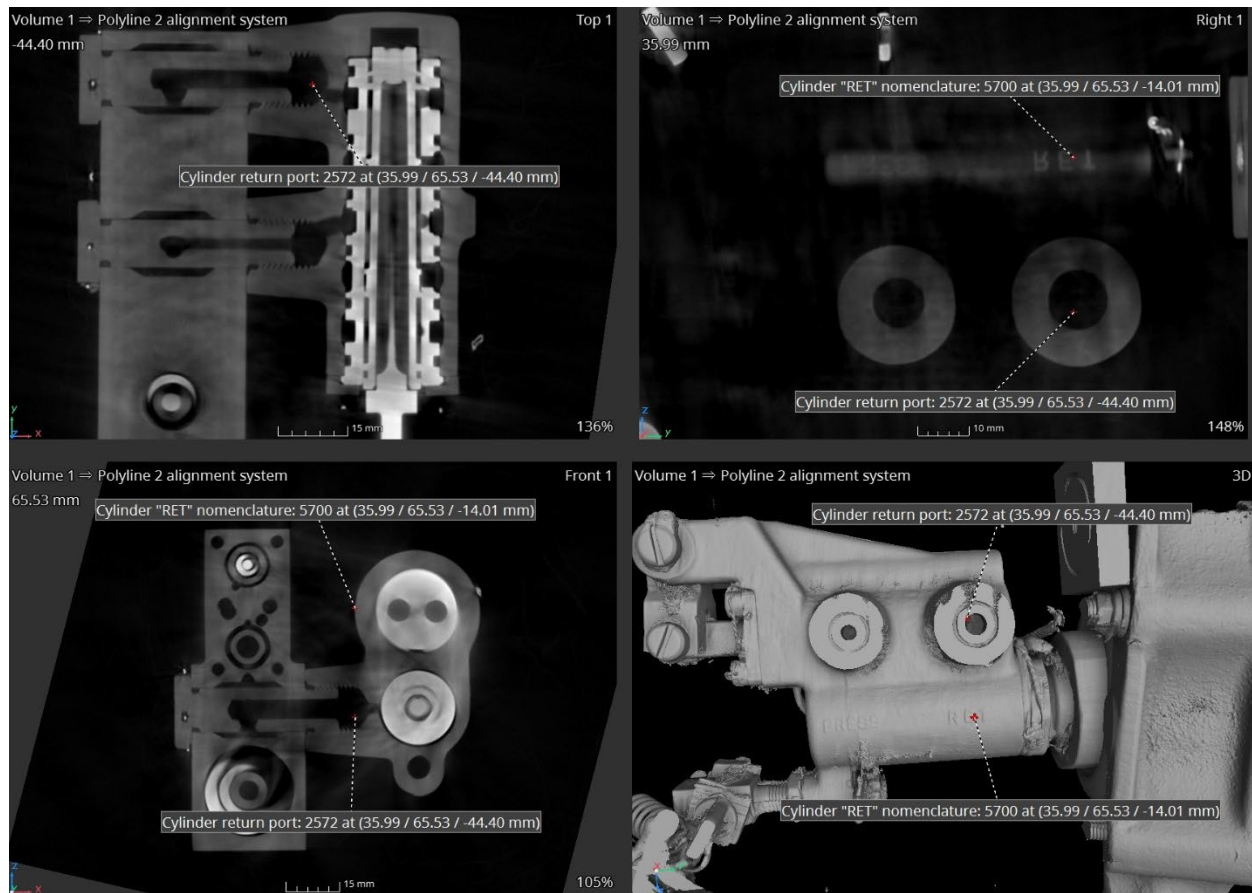


Figure 30. Collective actuator - cylinder assembly return port and "RET" nomenclature. (450 kV)

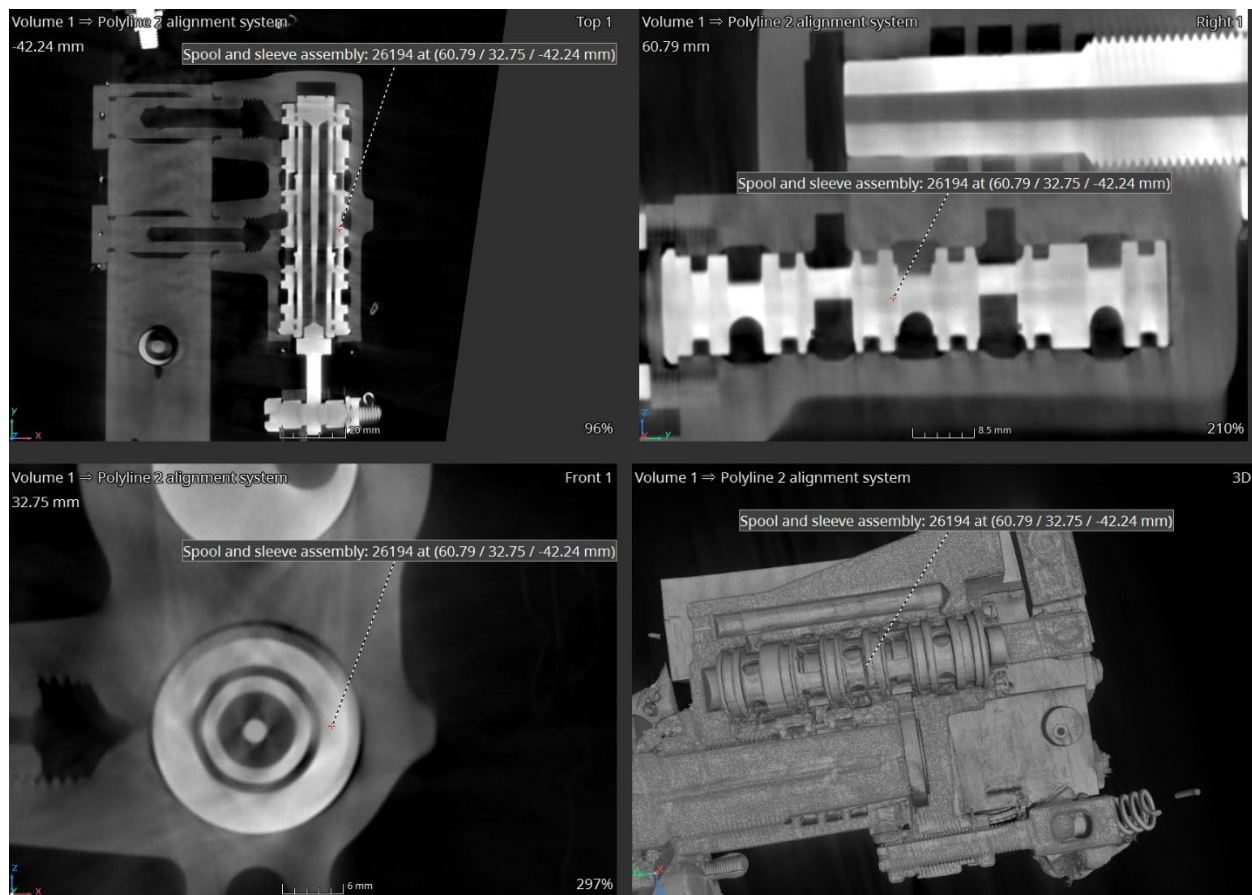


Figure 31. Collective actuator - cylinder assembly - spool and sleeve. (450 kV)

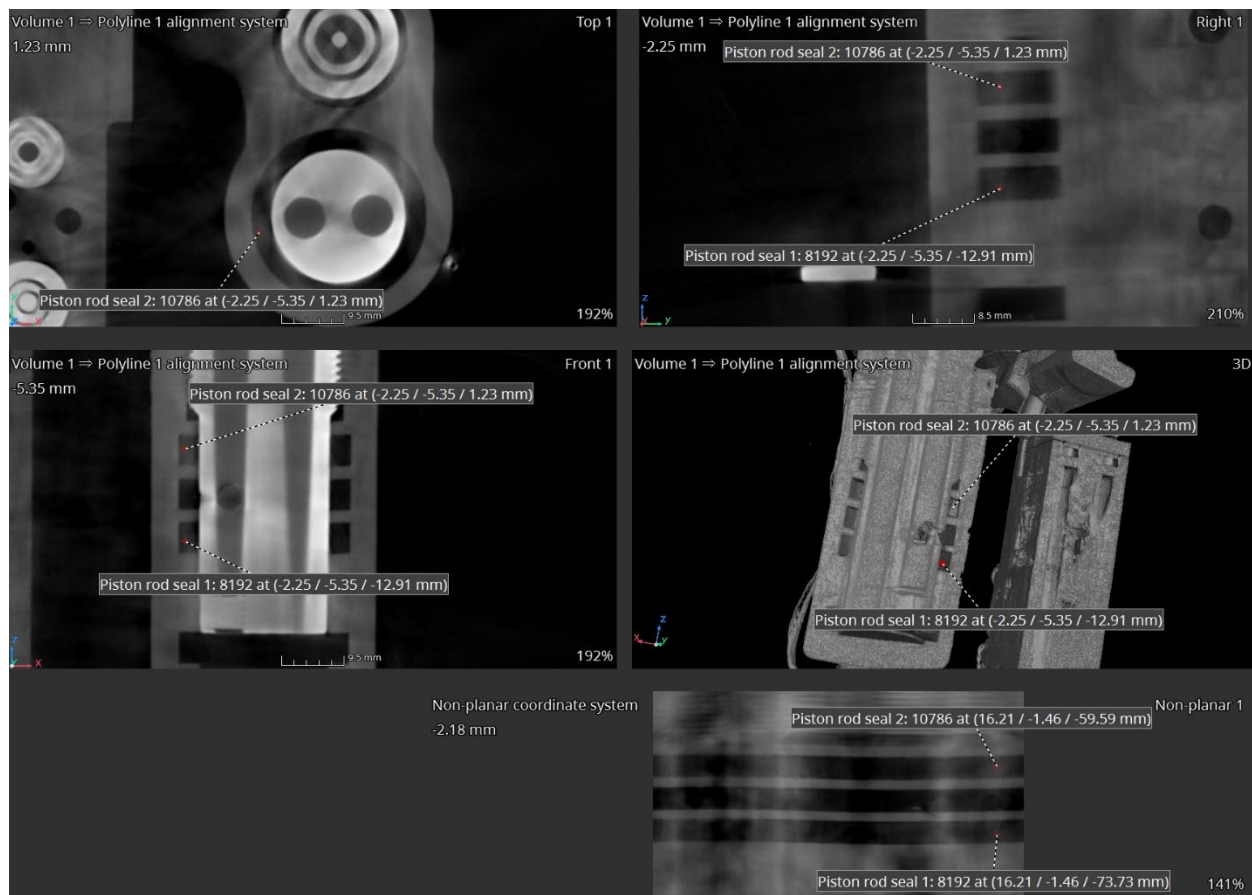


Figure 32. Collective actuator - cylinder assembly - piston rod seals 1 and 2. (450 kV)

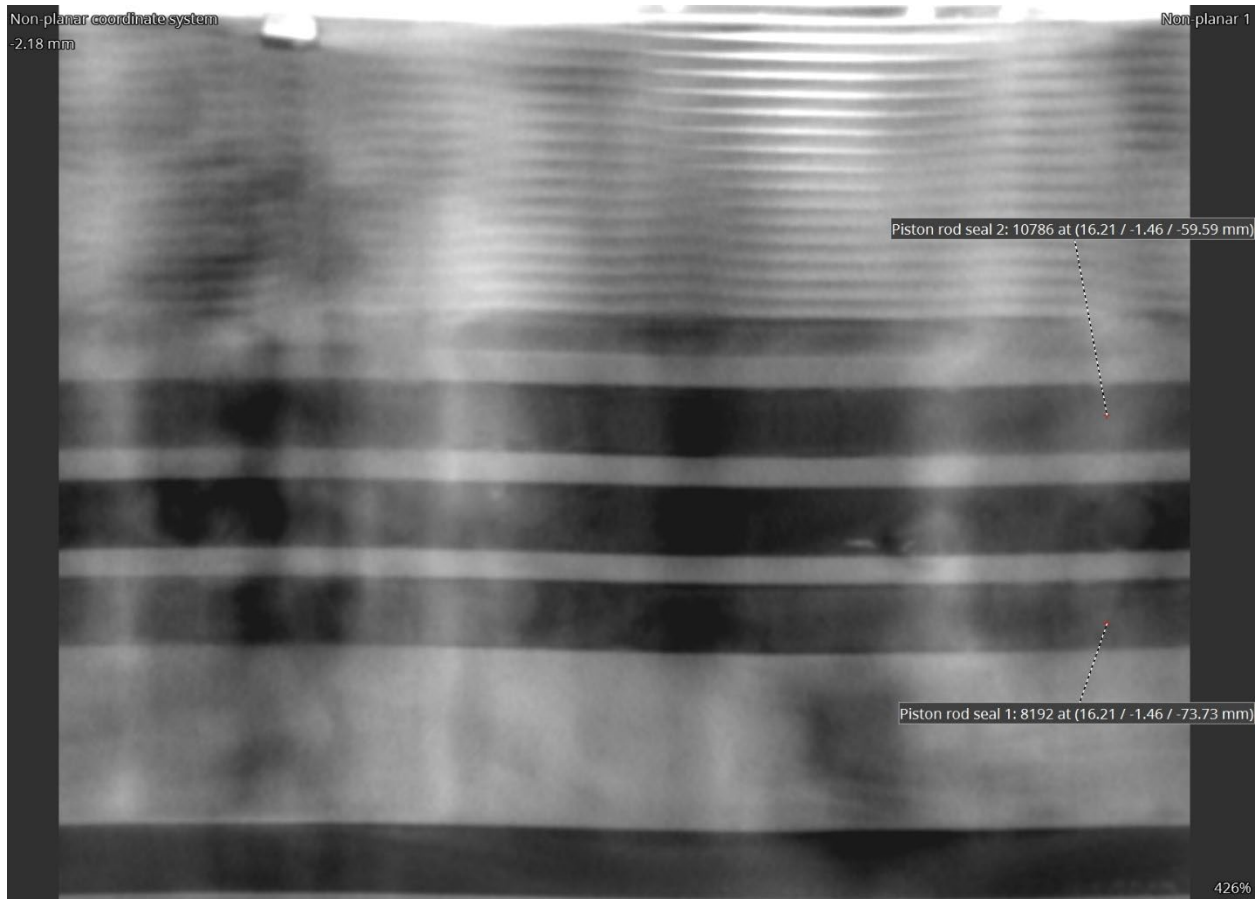


Figure 33. Collective actuator - cylinder assembly - piston rod seals 1 and 2 unrolled. (450 kV)

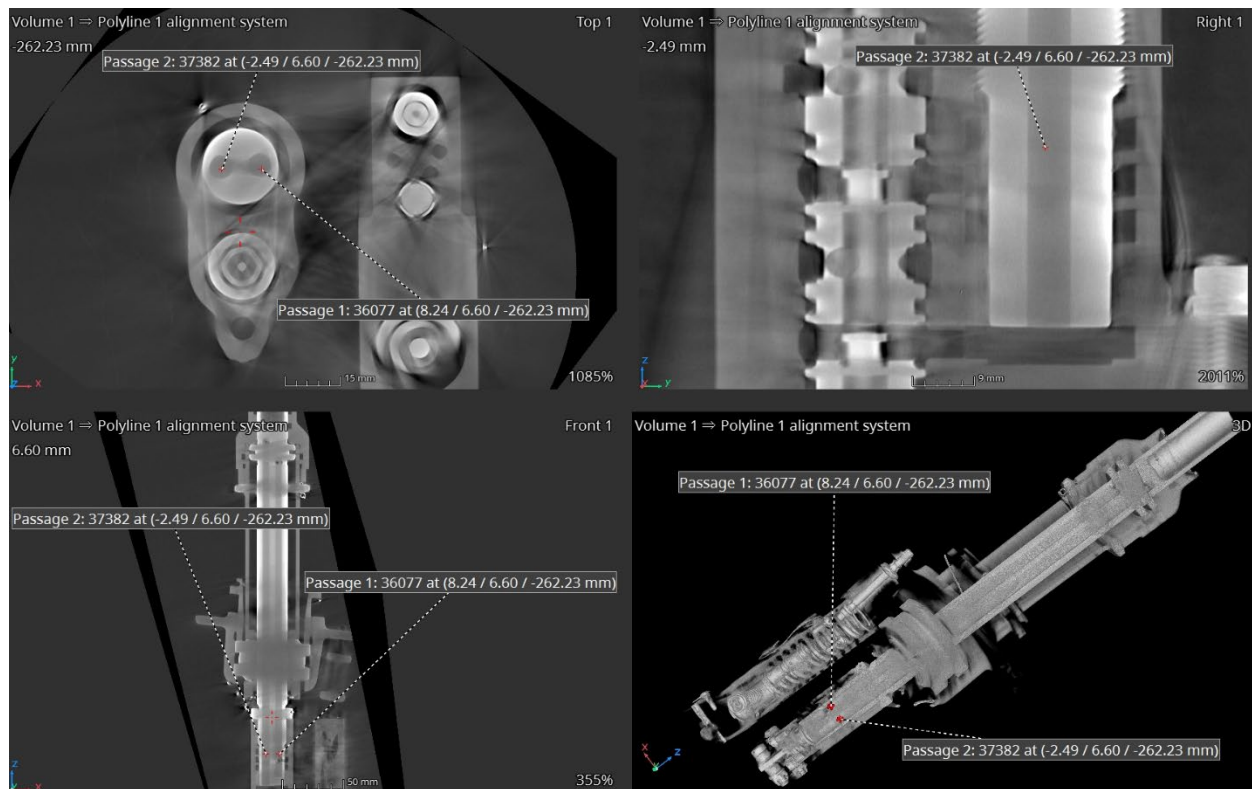


Figure 34. Collective actuator - cylinder assembly - hydraulic passages. (225 kV)

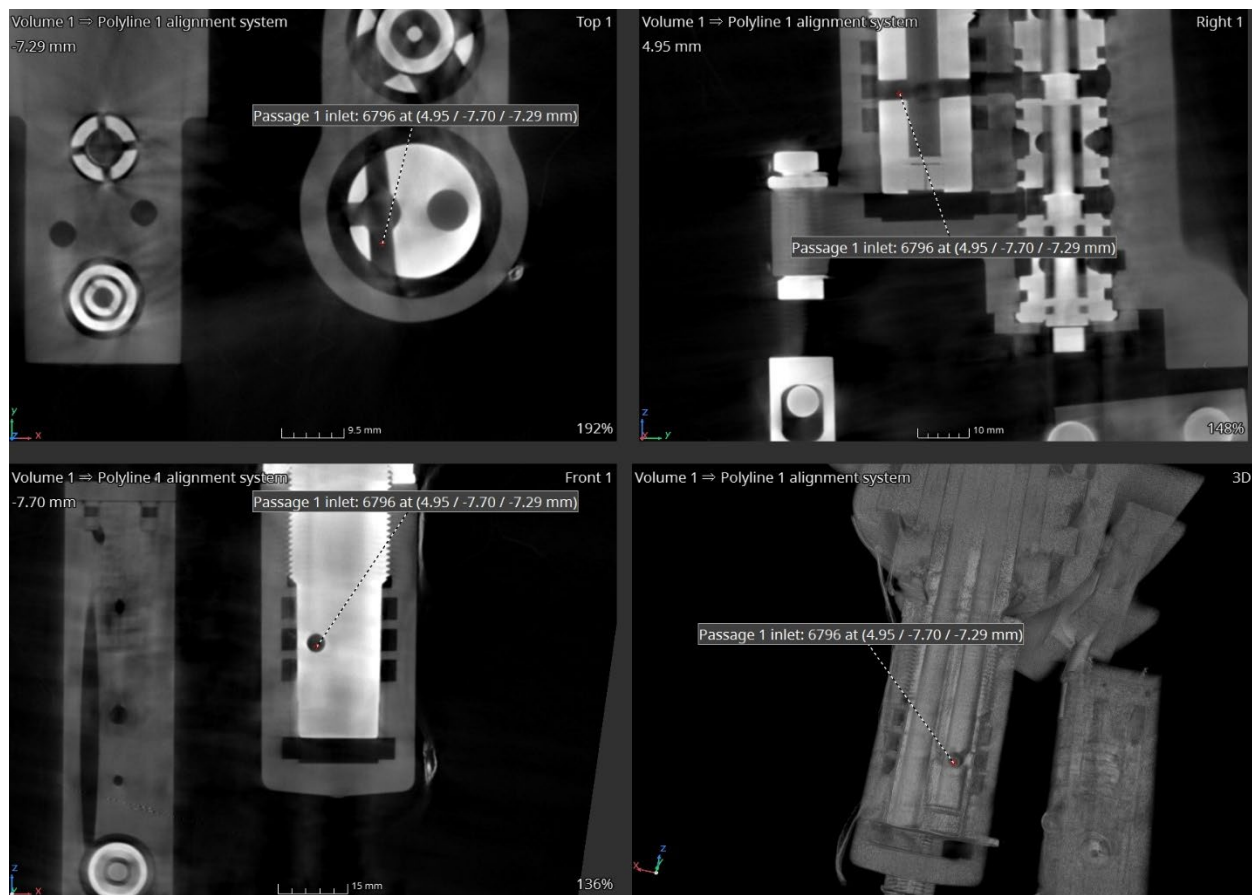


Figure 35. Collective actuator - cylinder assembly - passage 1 inlet. (450 kV)

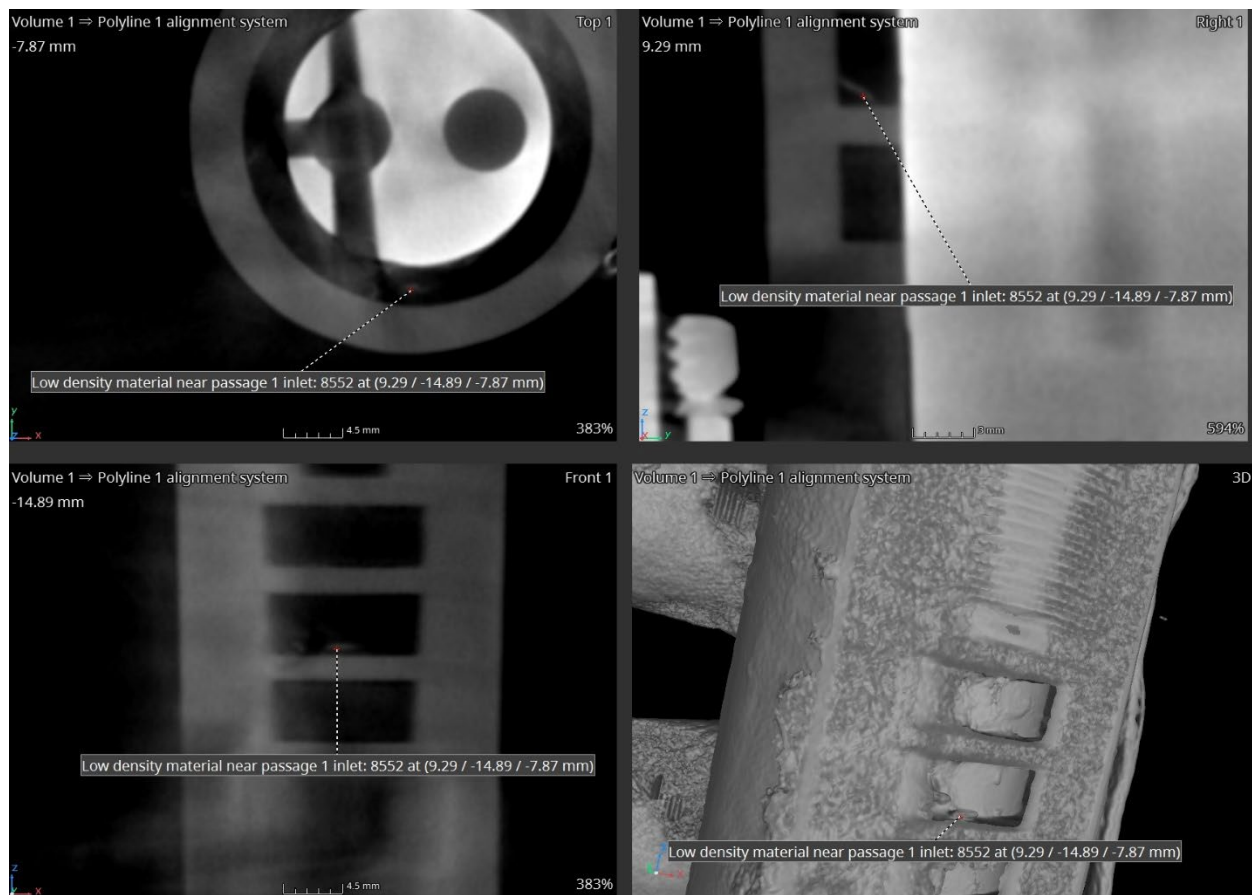


Figure 36. Collective actuator - cylinder assembly - low density material near passage 1 inlet. (450 kV)

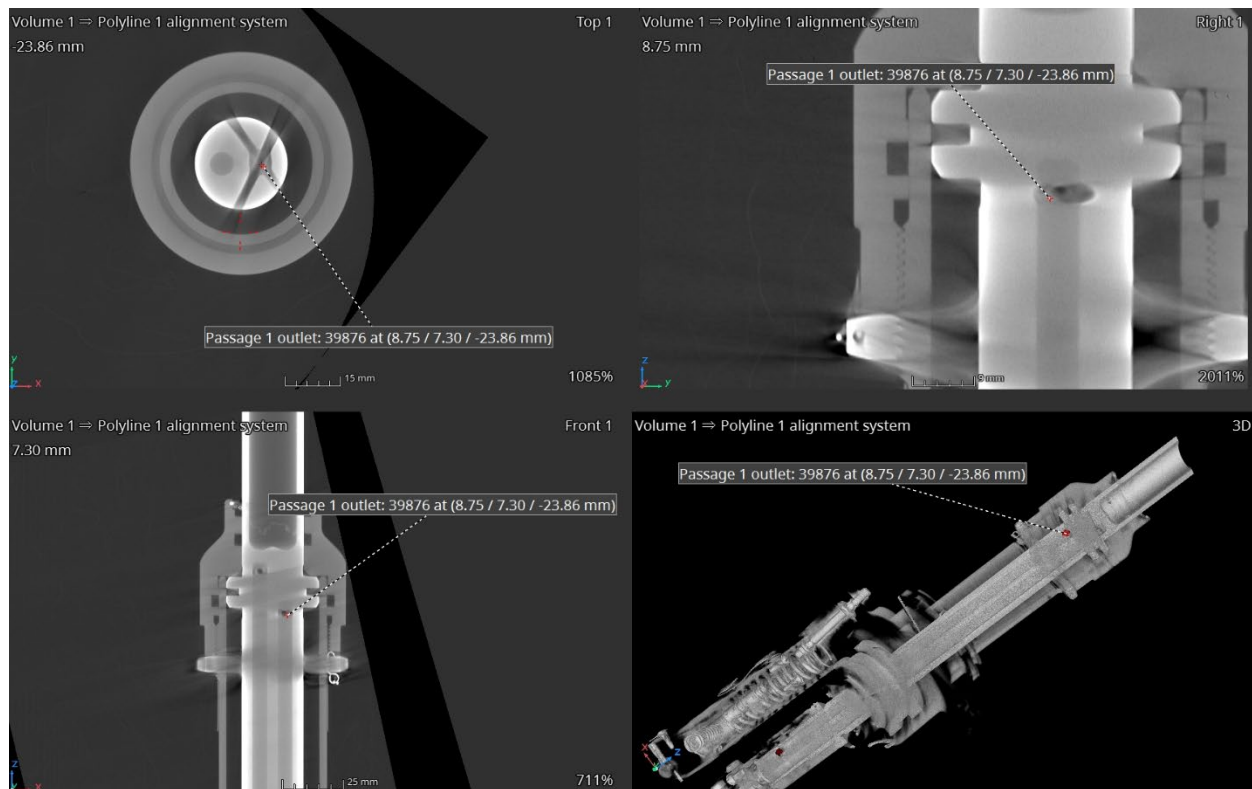


Figure 37. Collective actuator - cylinder assembly - passage 1 outlet. (225 kV)

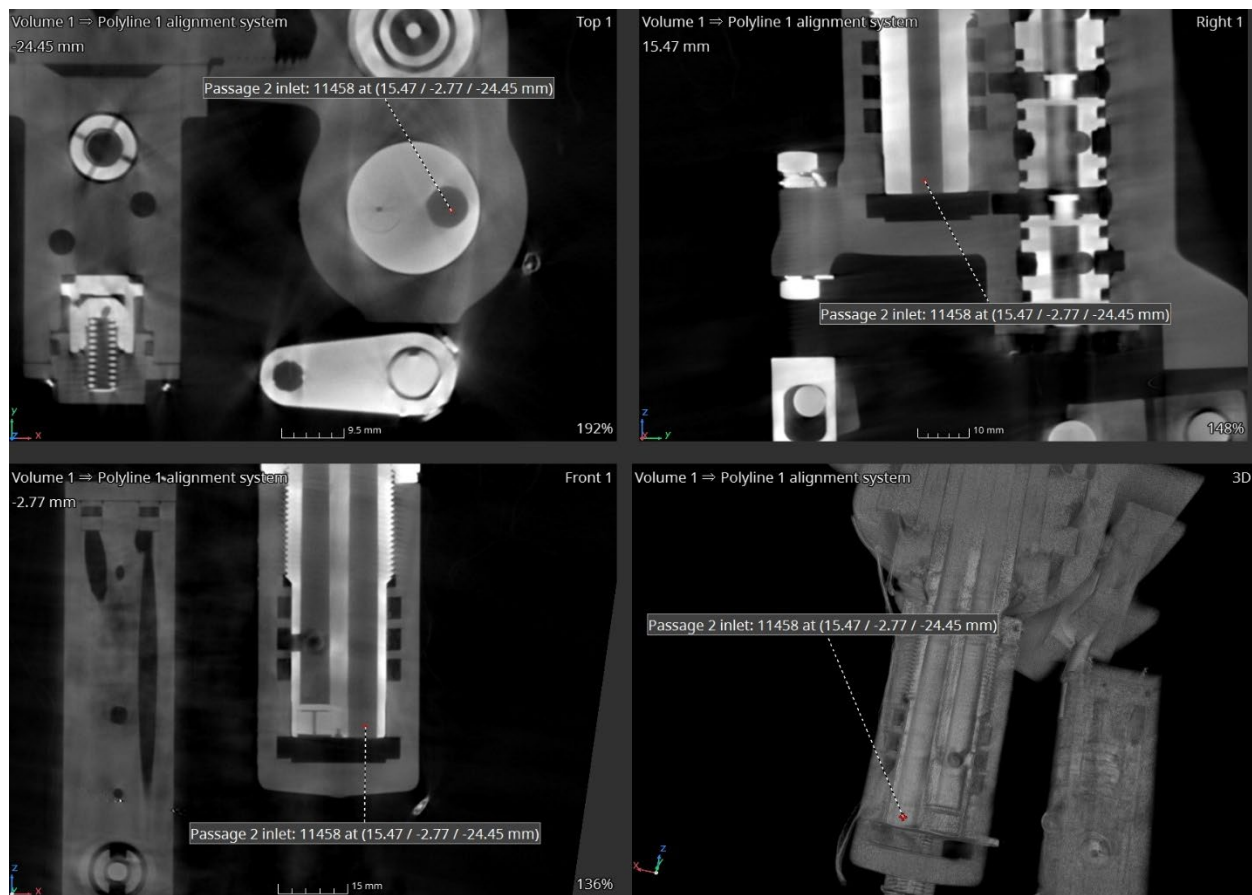


Figure 38. Collective actuator - cylinder assembly - passage 2 inlet. (450 kV)

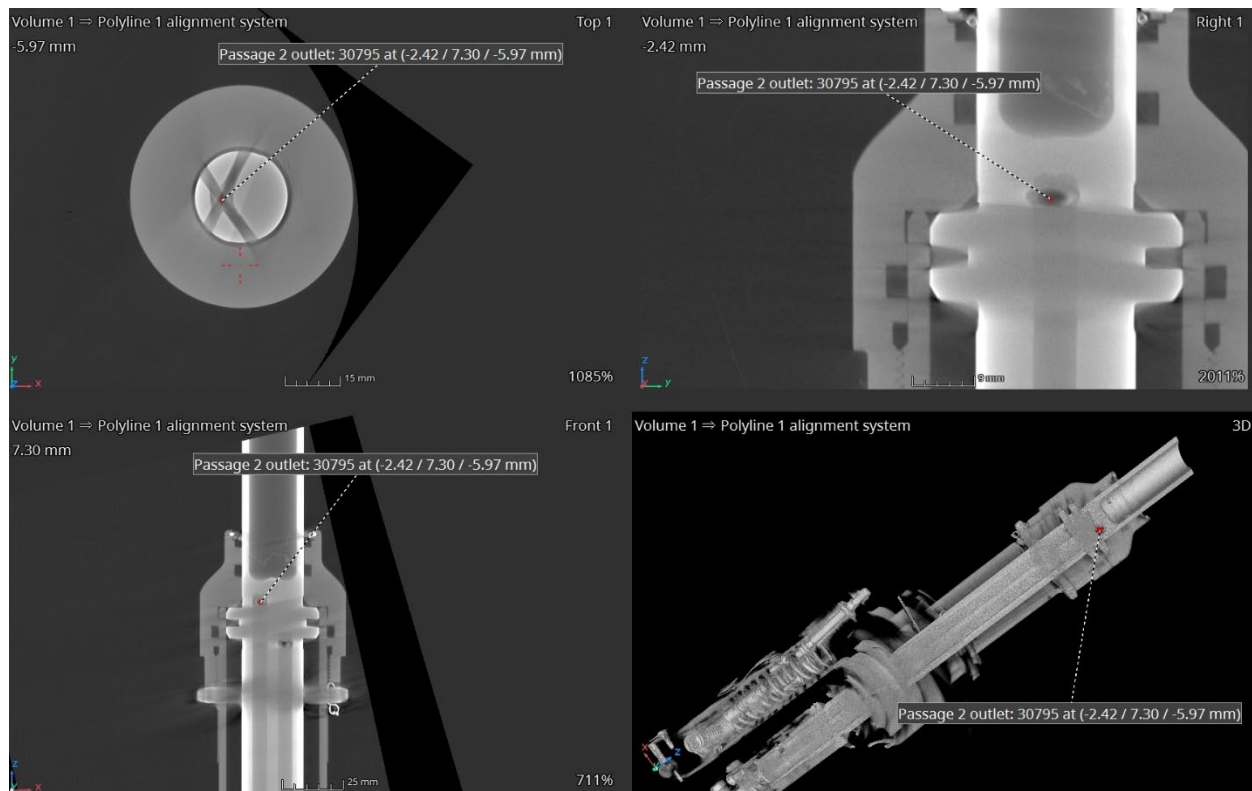


Figure 39. Collective actuator - cylinder assembly - passage 2 outlet. (225 kV)



Figure 40. Collective actuator - cylinder assembly - high density material in threads of the piston rod. (450 kV)

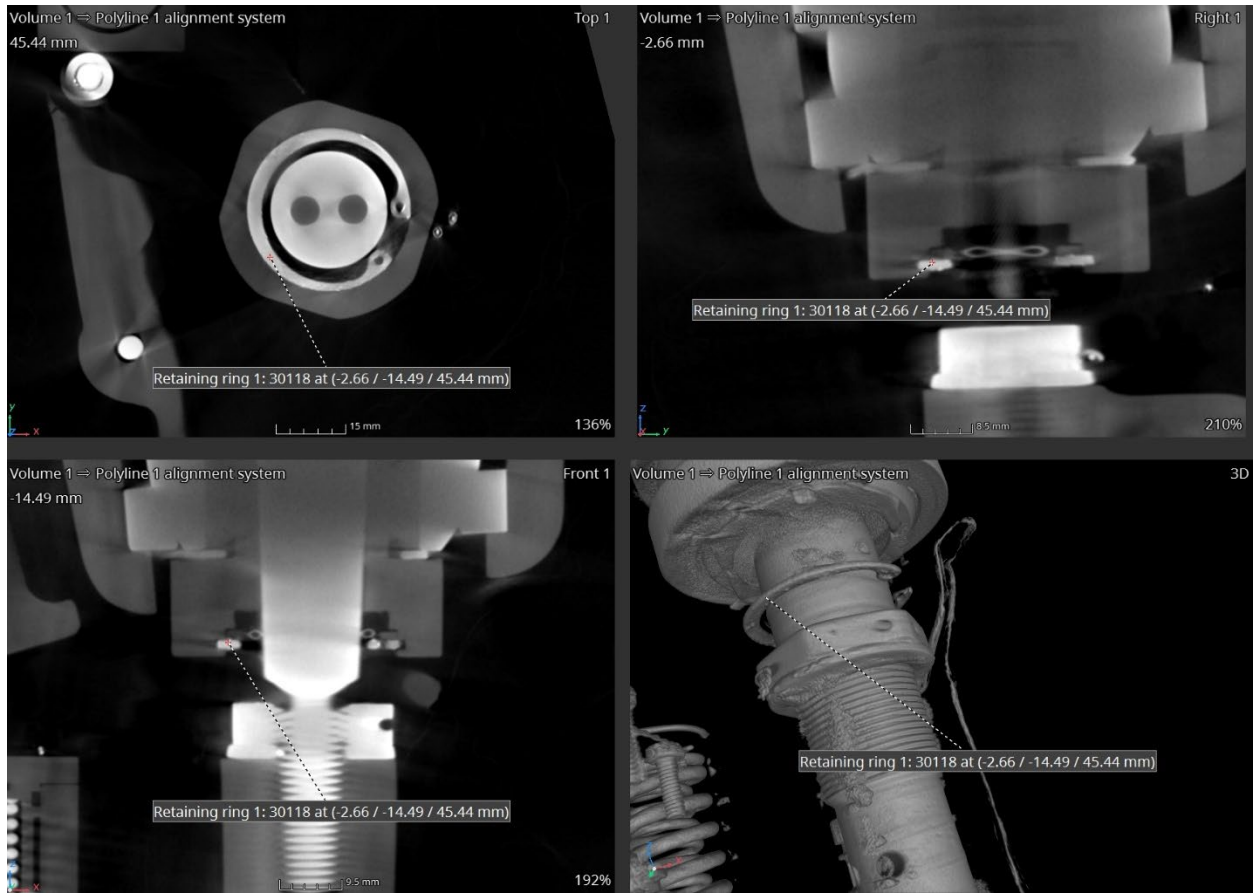


Figure 41. Collective actuator - cylinder assembly - retaining ring 1. (450 kV)

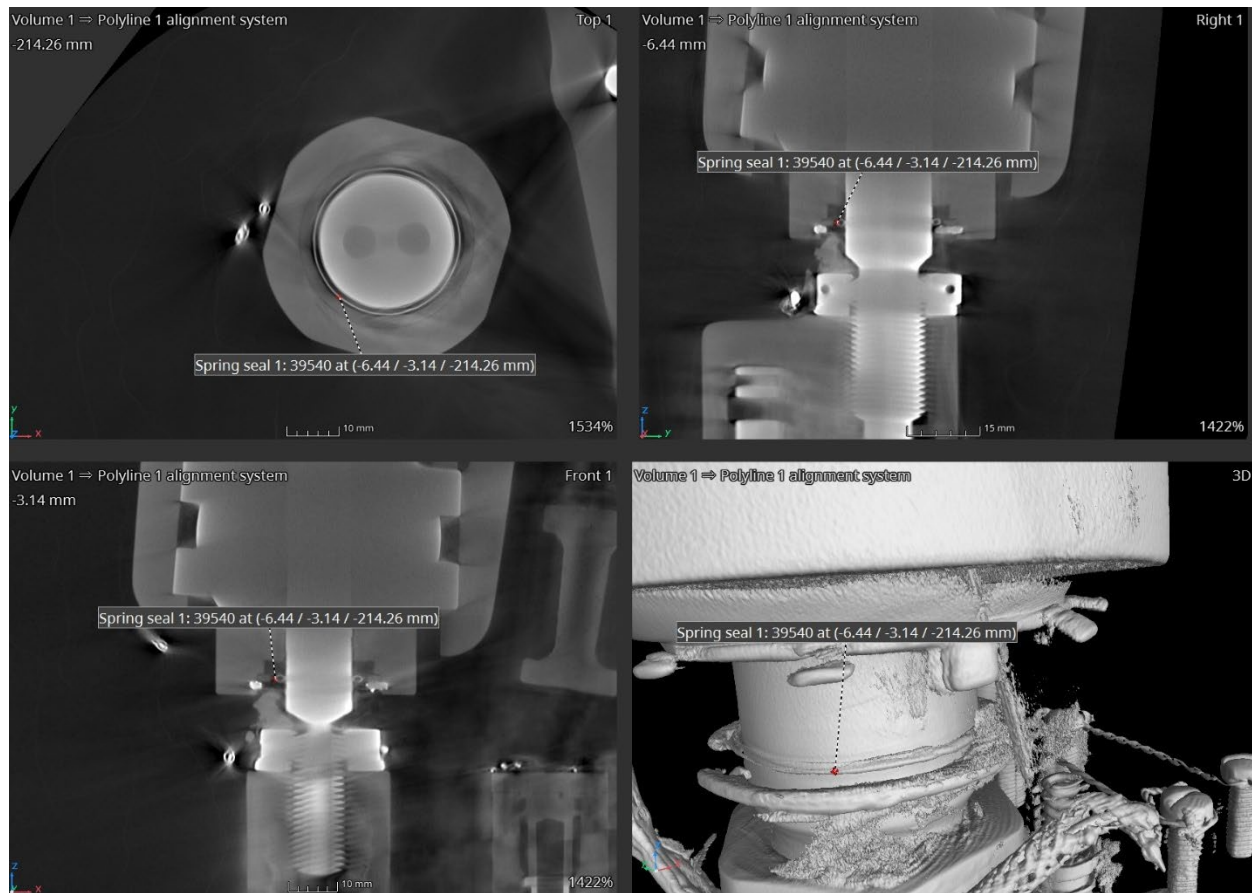


Figure 42. Collective actuator - cylinder assembly - spring seal 1. (450 kV)

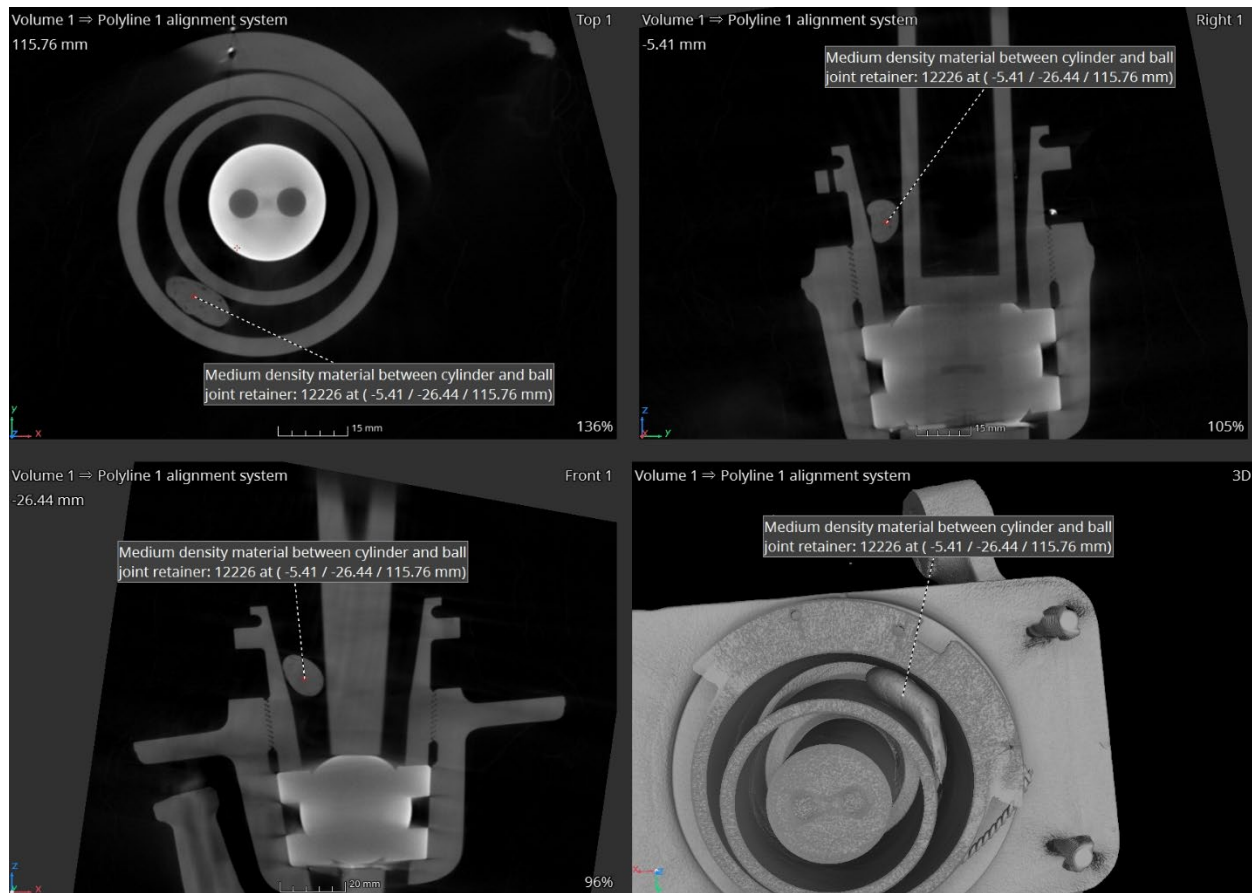


Figure 43. Collective actuator - cylinder assembly - medium density material between cylinder and ball joint retainer. (450 kV)

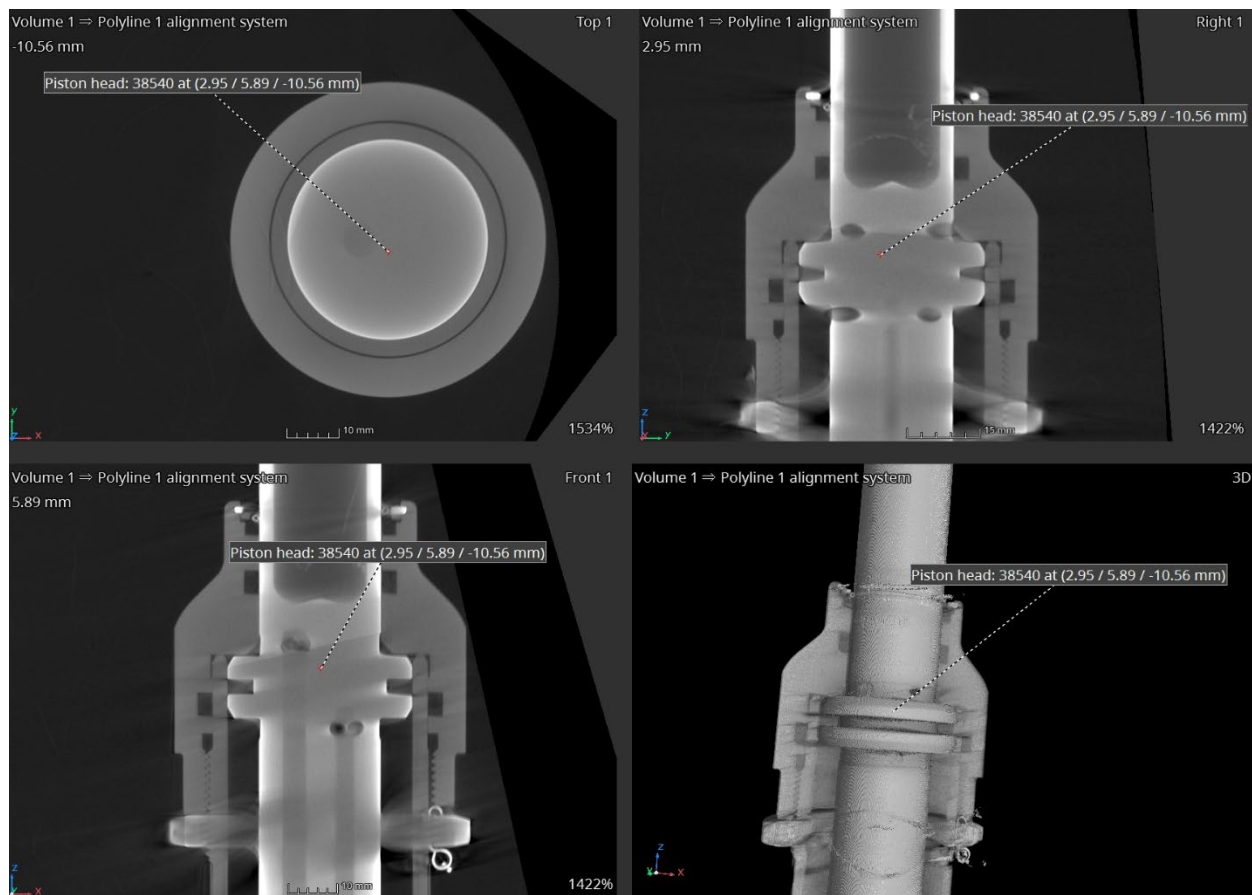


Figure 44. Collective actuator - cylinder assembly - piston head. (225 kV)

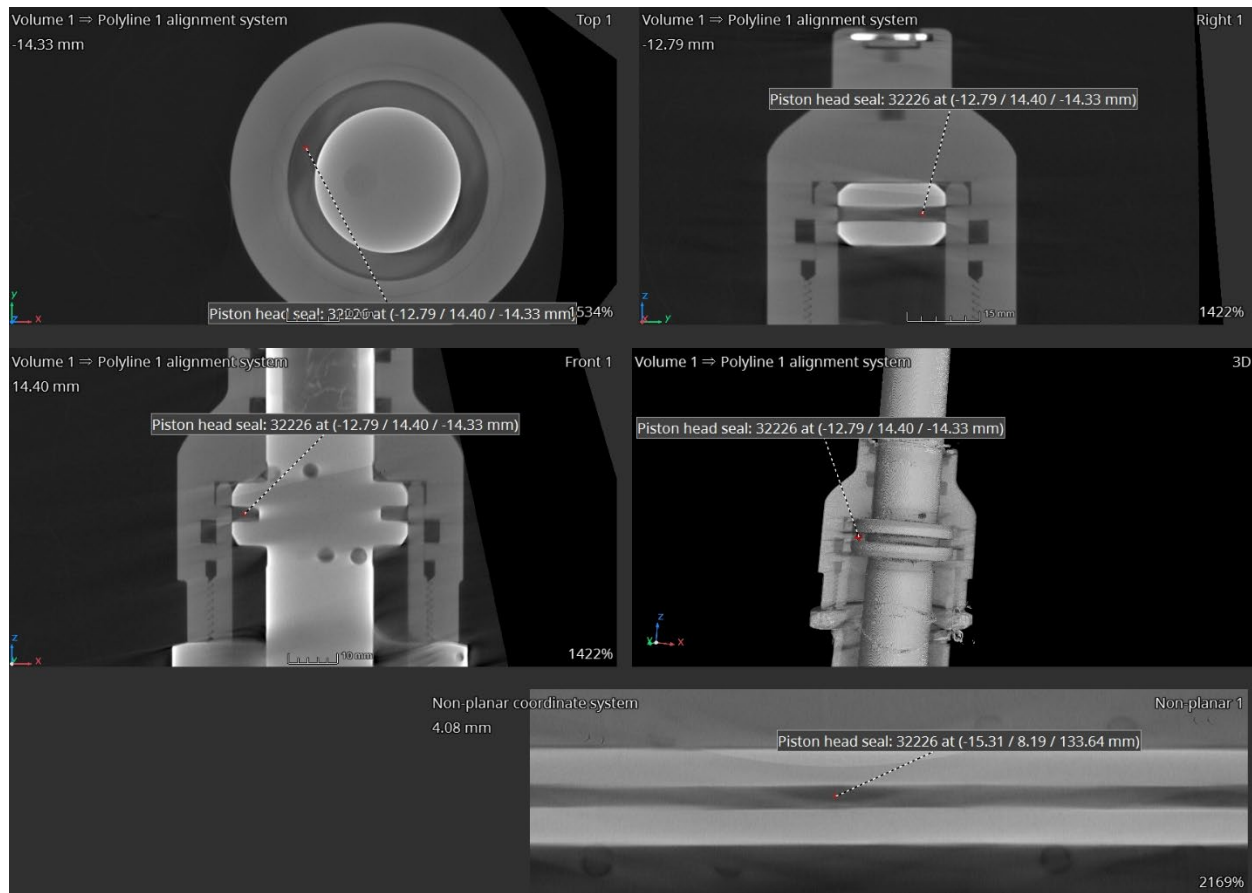


Figure 45. Collective actuator - cylinder assembly - piston head seal. (225 kV)

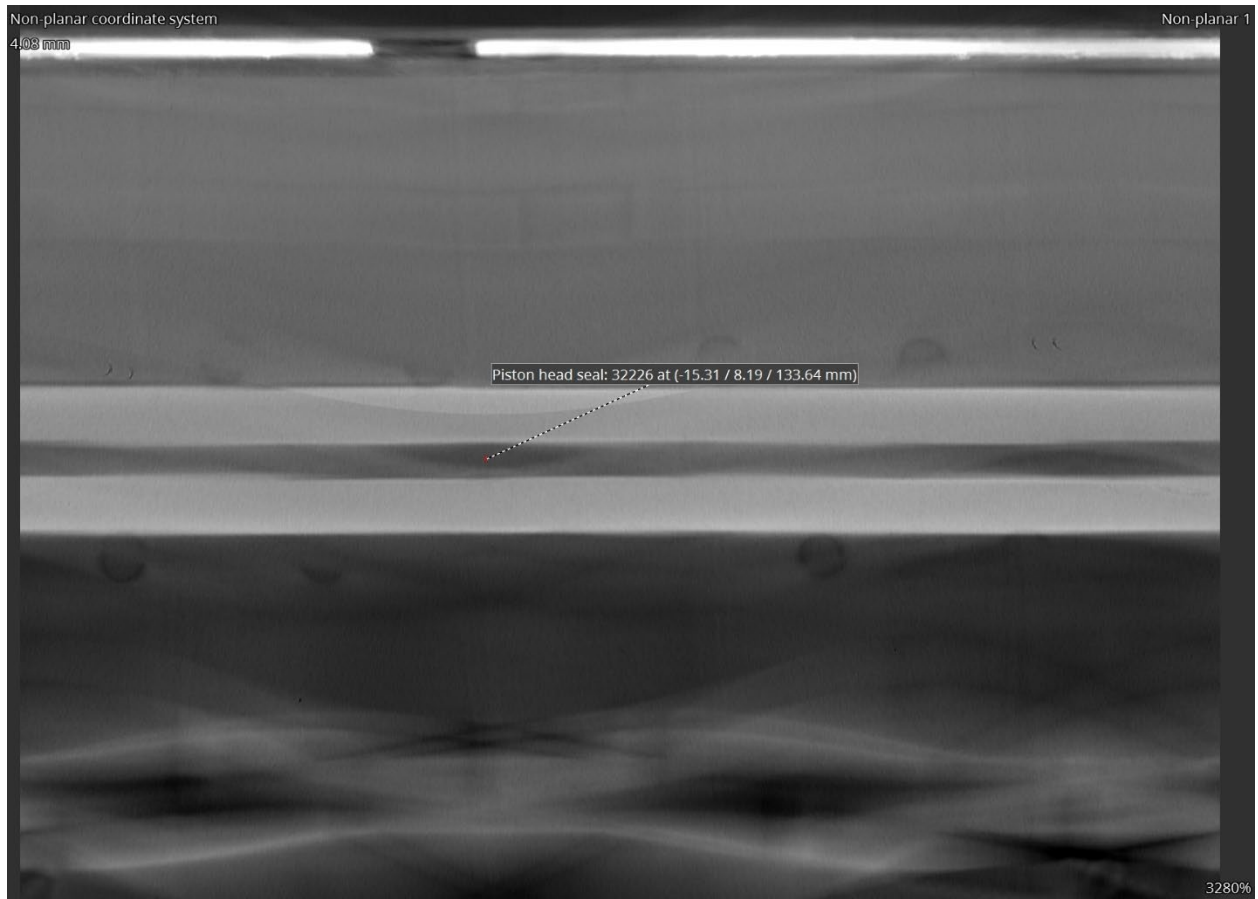


Figure 46. Collective actuator - cylinder assembly - piston head seal unrolled. (225 kV)

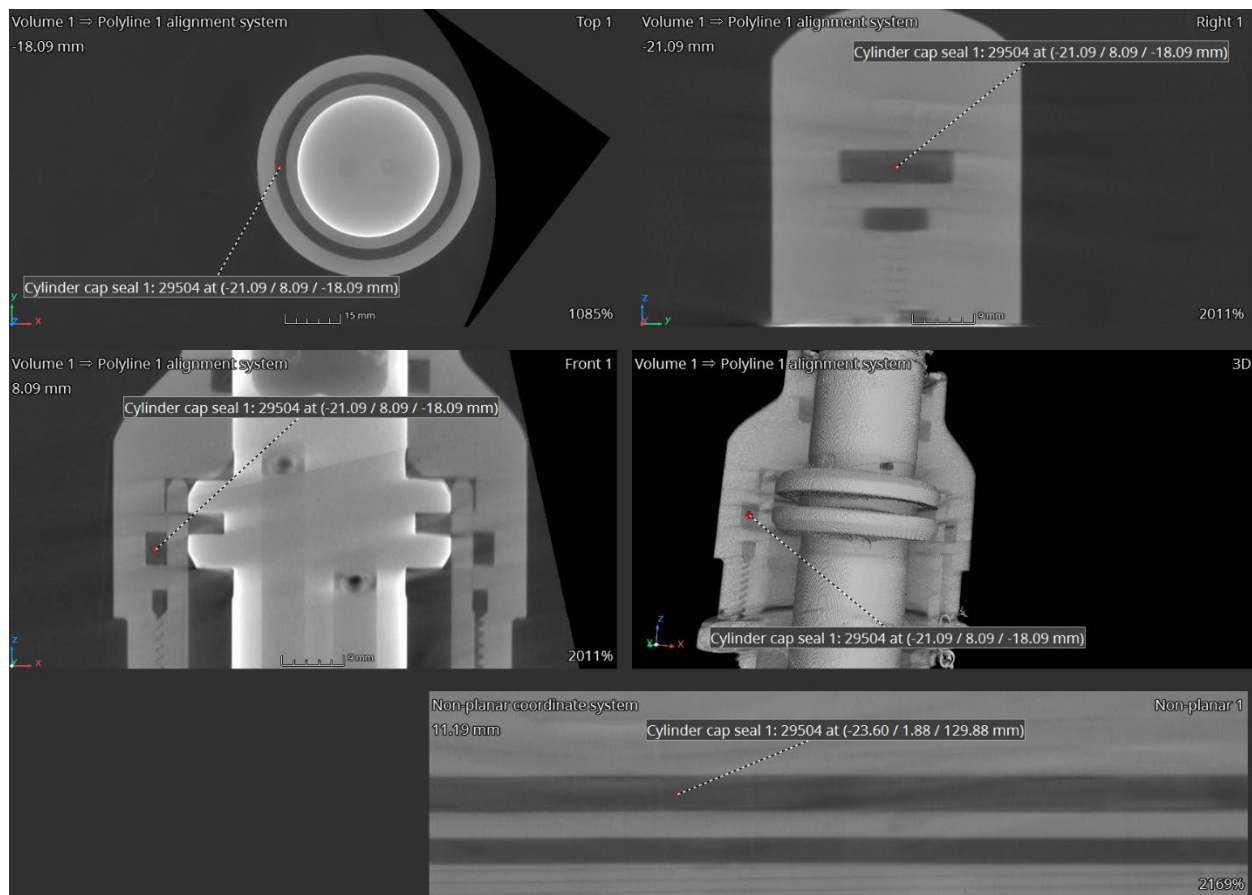


Figure 47. Collective actuator - cylinder assembly - cylinder cap seal 1. (225 kV)



Figure 48. Collective actuator - cylinder assembly - cylinder cap seal 1 unrolled. (225 kV)

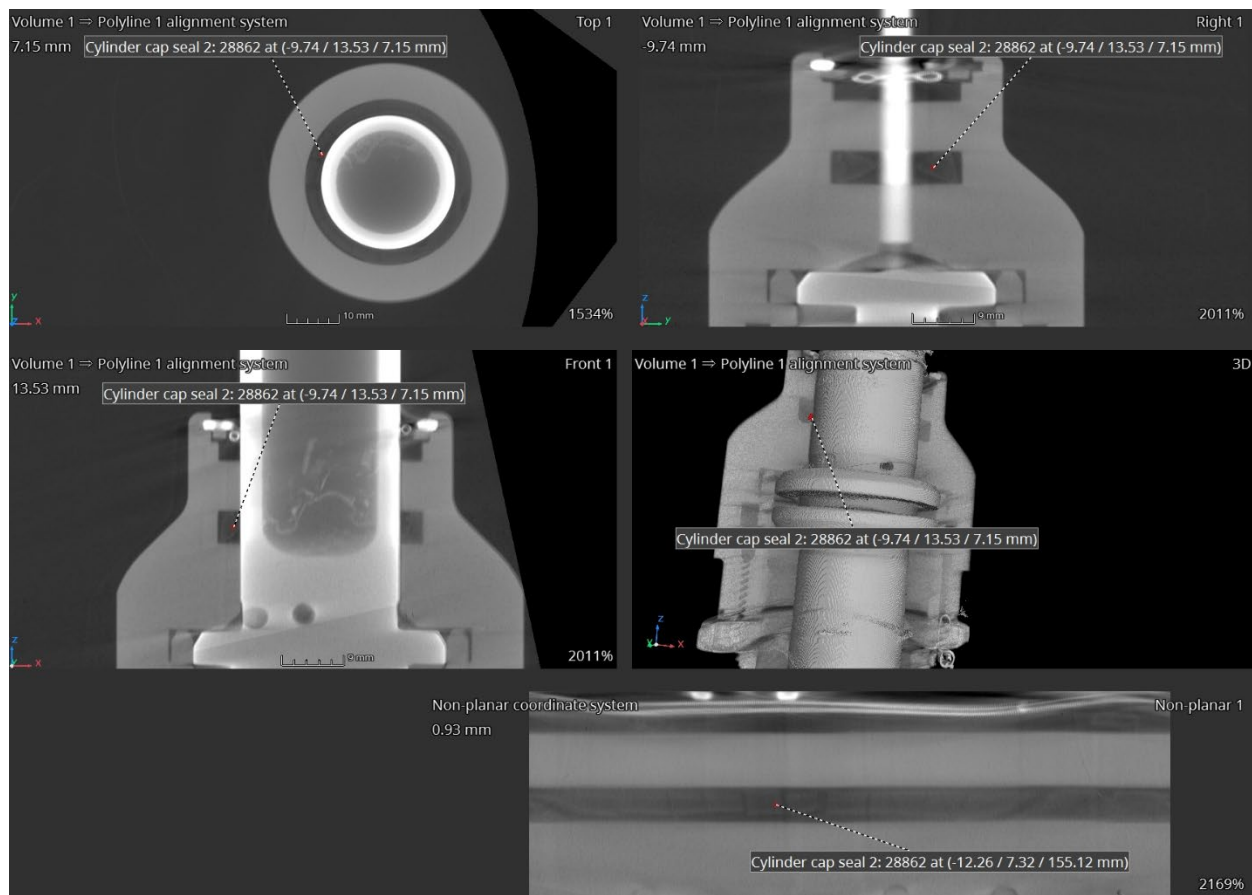


Figure 49. Collective actuator - cylinder assembly - cylinder cap seal 2. (225 kV)

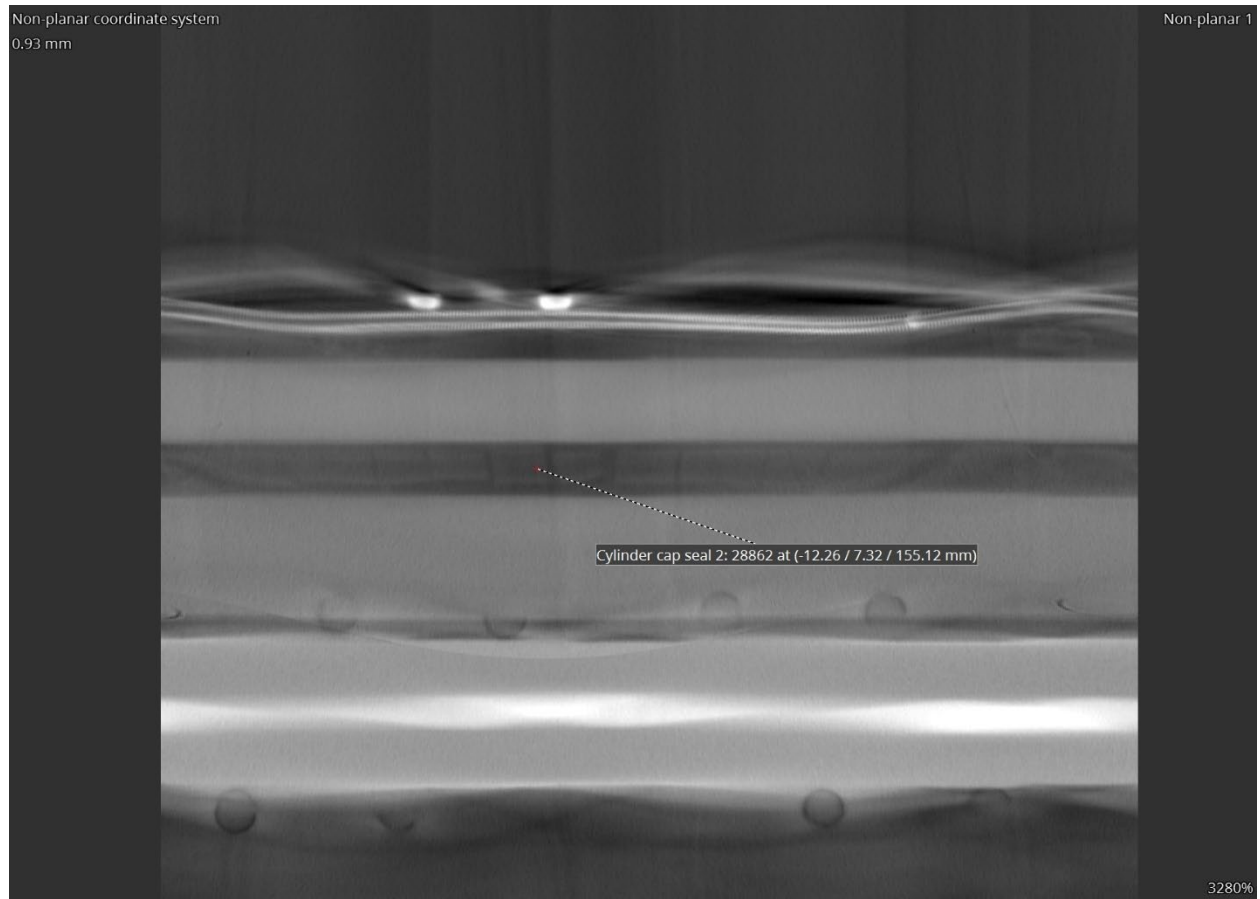


Figure 50. Collective actuator - cylinder assembly - cylinder cap seal 2 unrolled. (225 kV)

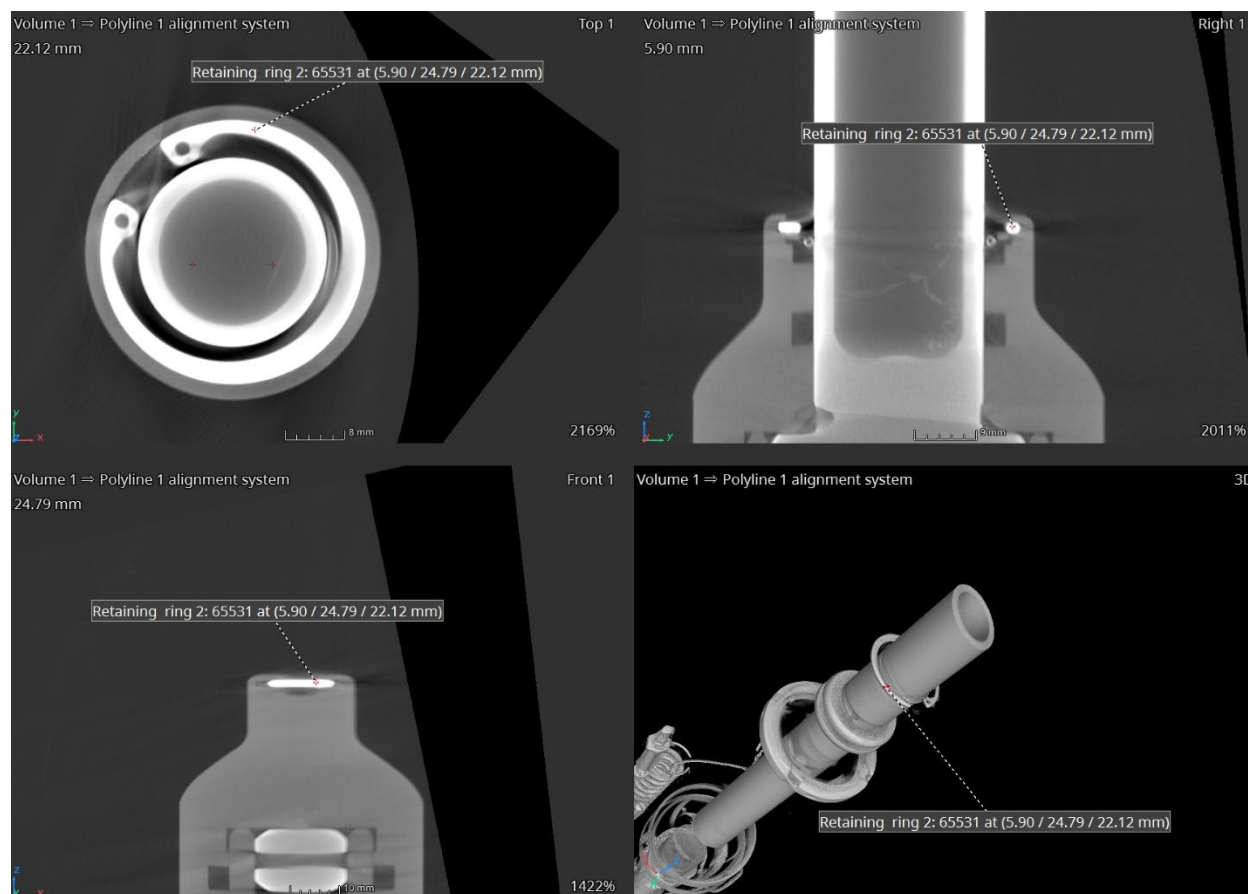


Figure 51. Collective actuator - cylinder assembly - retaining ring 2. (225 kV)

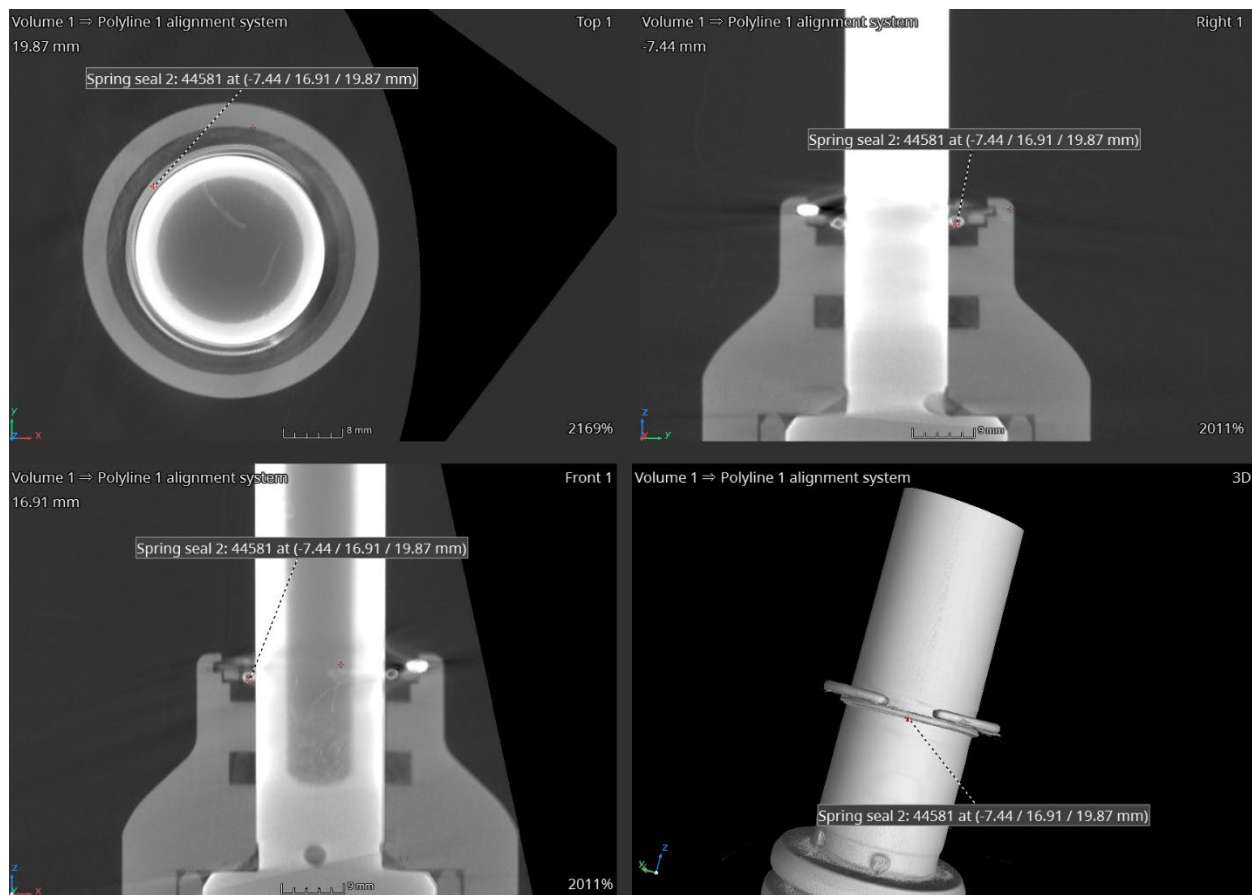


Figure 52. Collective actuator - cylinder assembly - spring seal 2. (225 kV)

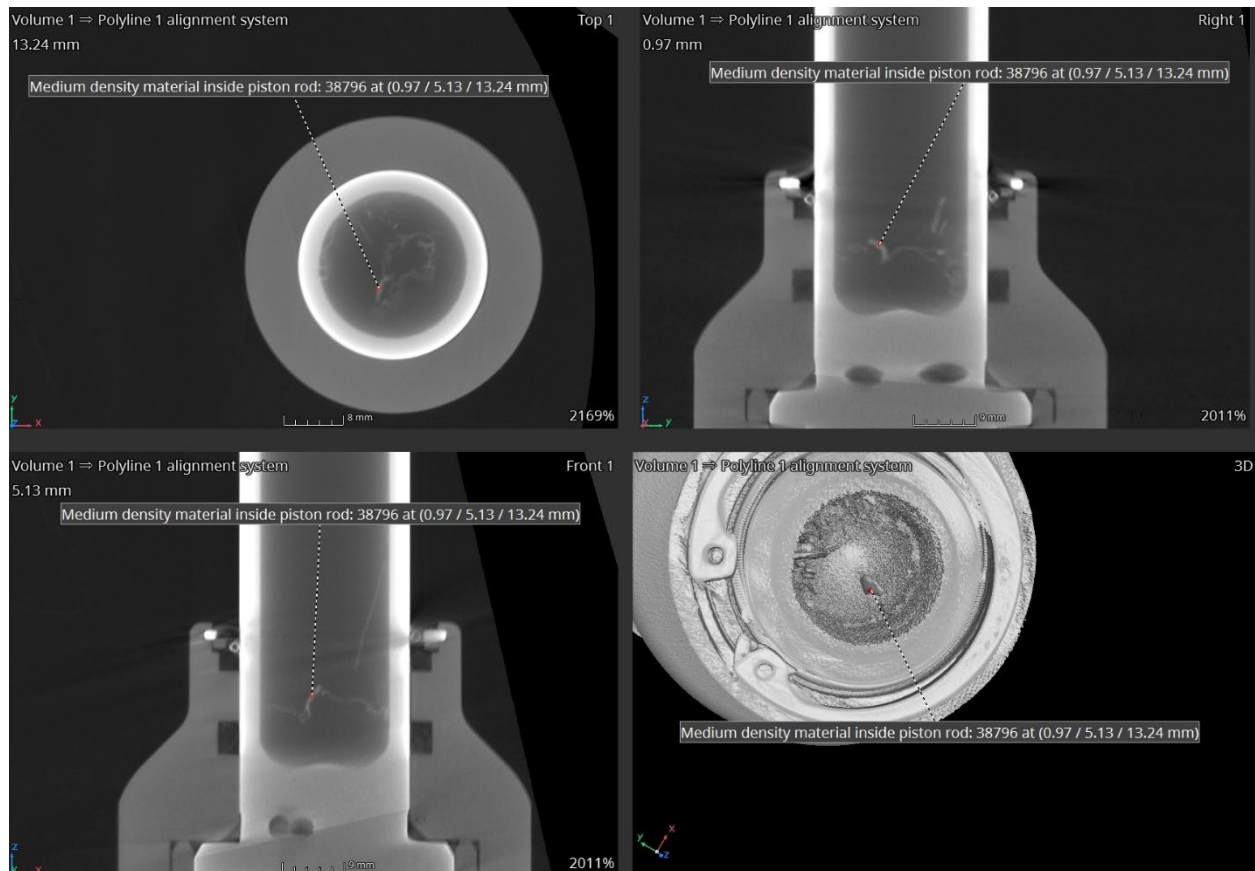


Figure 53. Collective actuator - cylinder assembly - medium density material inside piston rod. (225 kV)

3.2 Right Lateral Actuator

The computed tomography (CT) results for the right lateral actuator are shown in Figures 54 through 96. Review of the images indicated that, when the scans were conducted, the following indications were noted:

1. There were indications of low density particles and/or material in the return port of the right lateral actuator irreversible valve assembly. (Figure 58)
2. There were indications of a bulging/damaged cap for the sequence valve of the right lateral actuator irreversible valve assembly. (Figures 61 and 62)
3. There were indications of gaps and distortion in the seals in the right lateral actuator cylinder assembly and the irreversible valve assembly. (Figures 70, 71.)
4. There were indications of safety wire between the cylinder housing and the ball joint retainer. (Figure 87)

5. There were indications of medium density particles and/or material inside the piston rod of the right lateral actuator cylinder assembly. (Figure 96)

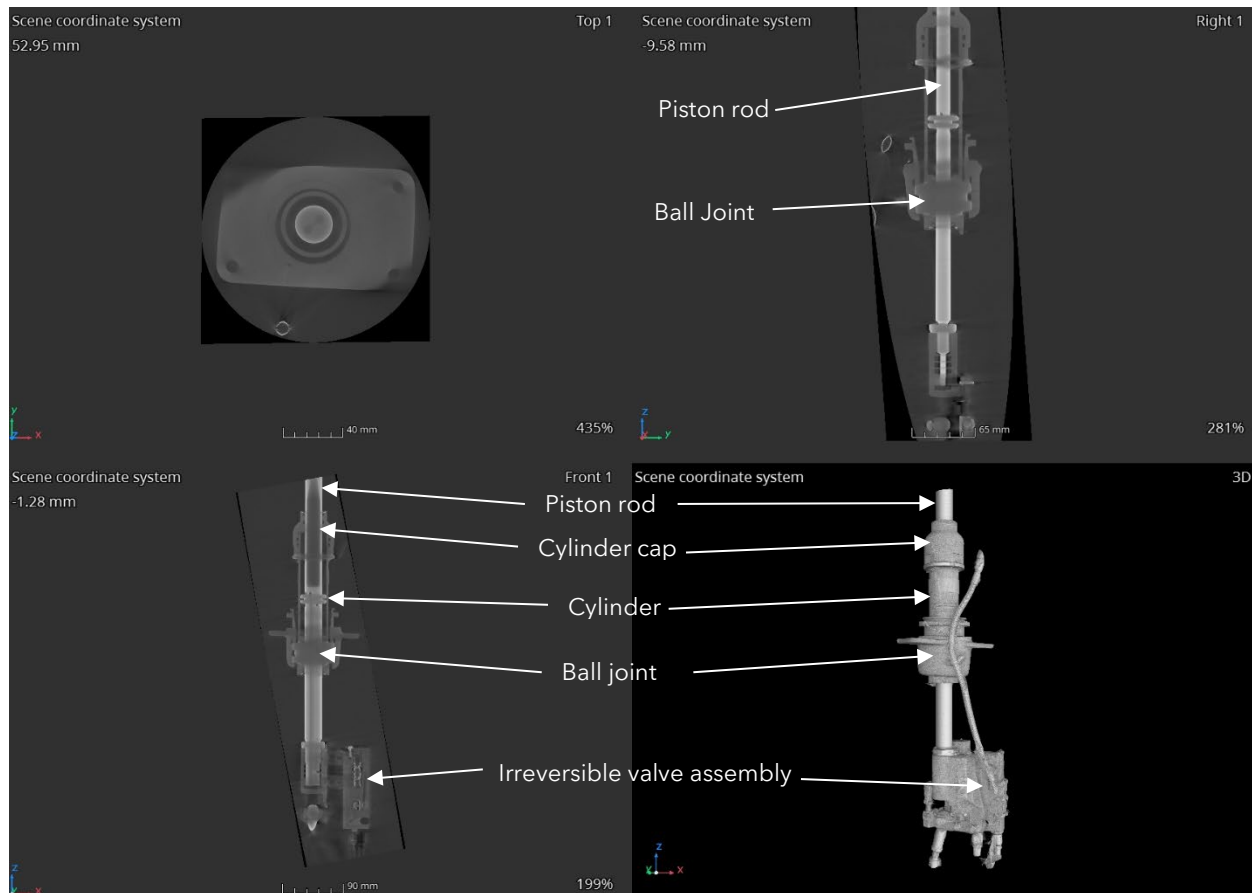


Figure 54. Right lateral actuator - overview. (225 kV)

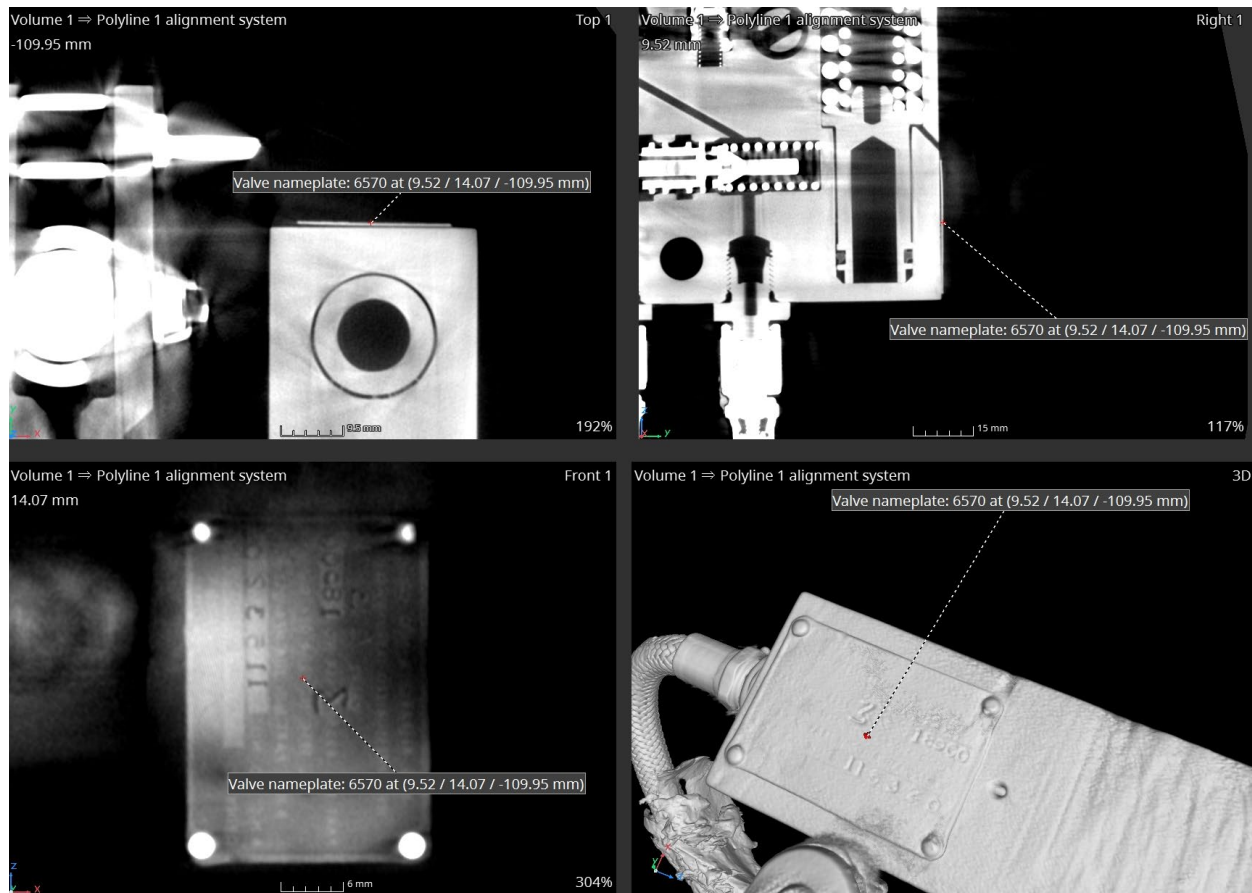


Figure 55. Right lateral actuator - irreversible valve - nameplate. (450 kV)

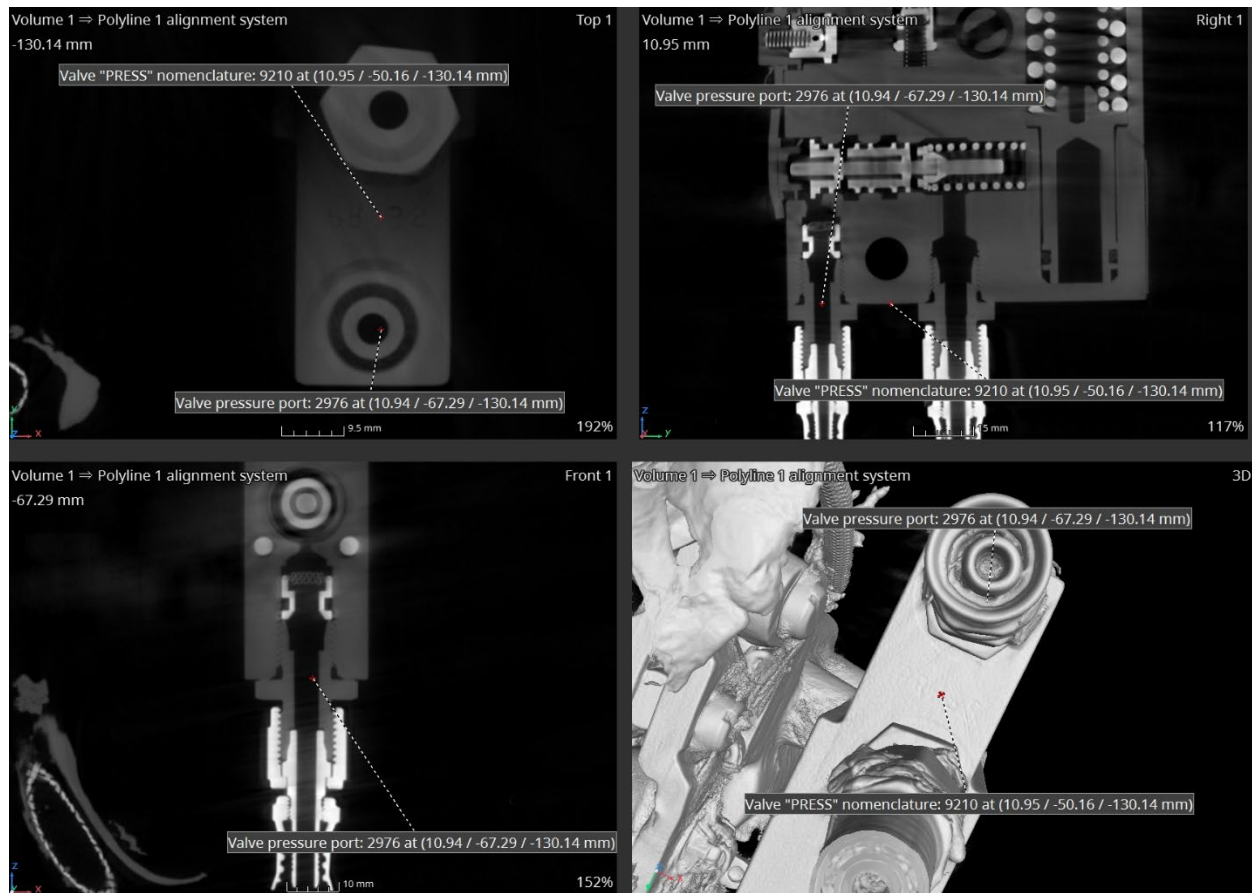


Figure 56. Right lateral actuator - irreversible valve - pressure port and nomenclature. (450 kV)

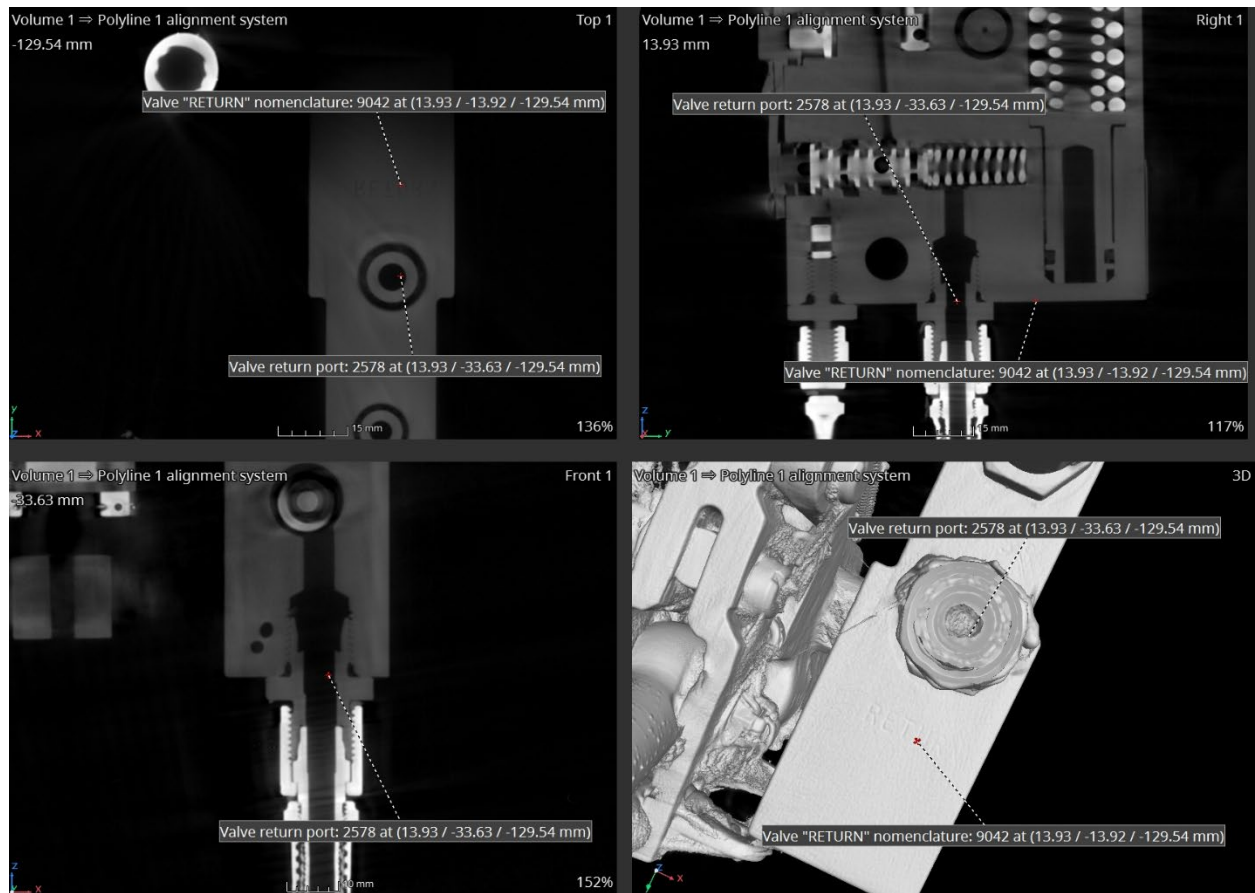


Figure 57. Right lateral actuator - irreversible valve - return port and nomenclature. (450 kV)

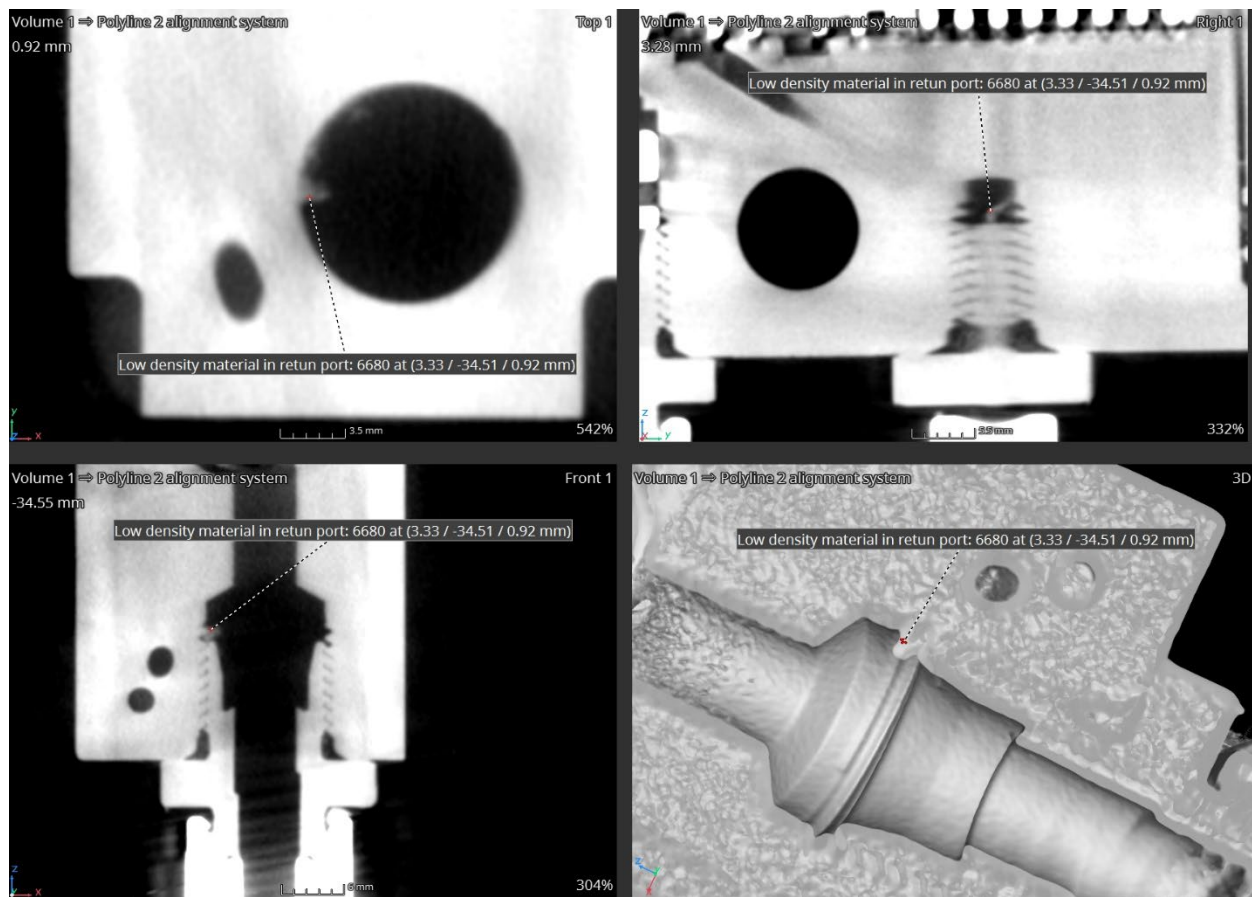


Figure 58. Right lateral actuator - irreversible valve - low density material in return port. (450 kV)

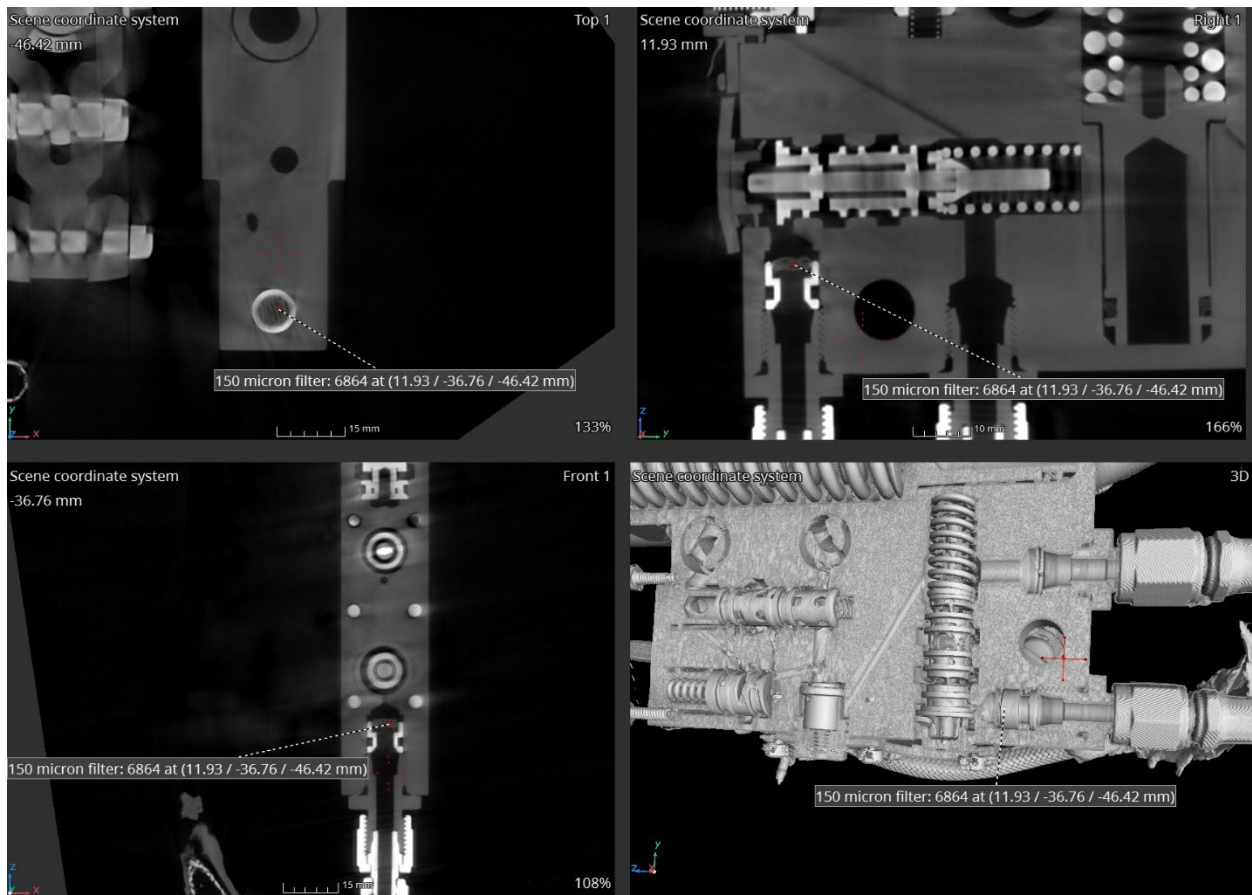


Figure 59. Right lateral actuator - irreversible valve - 150 micron filter. (450 kV)

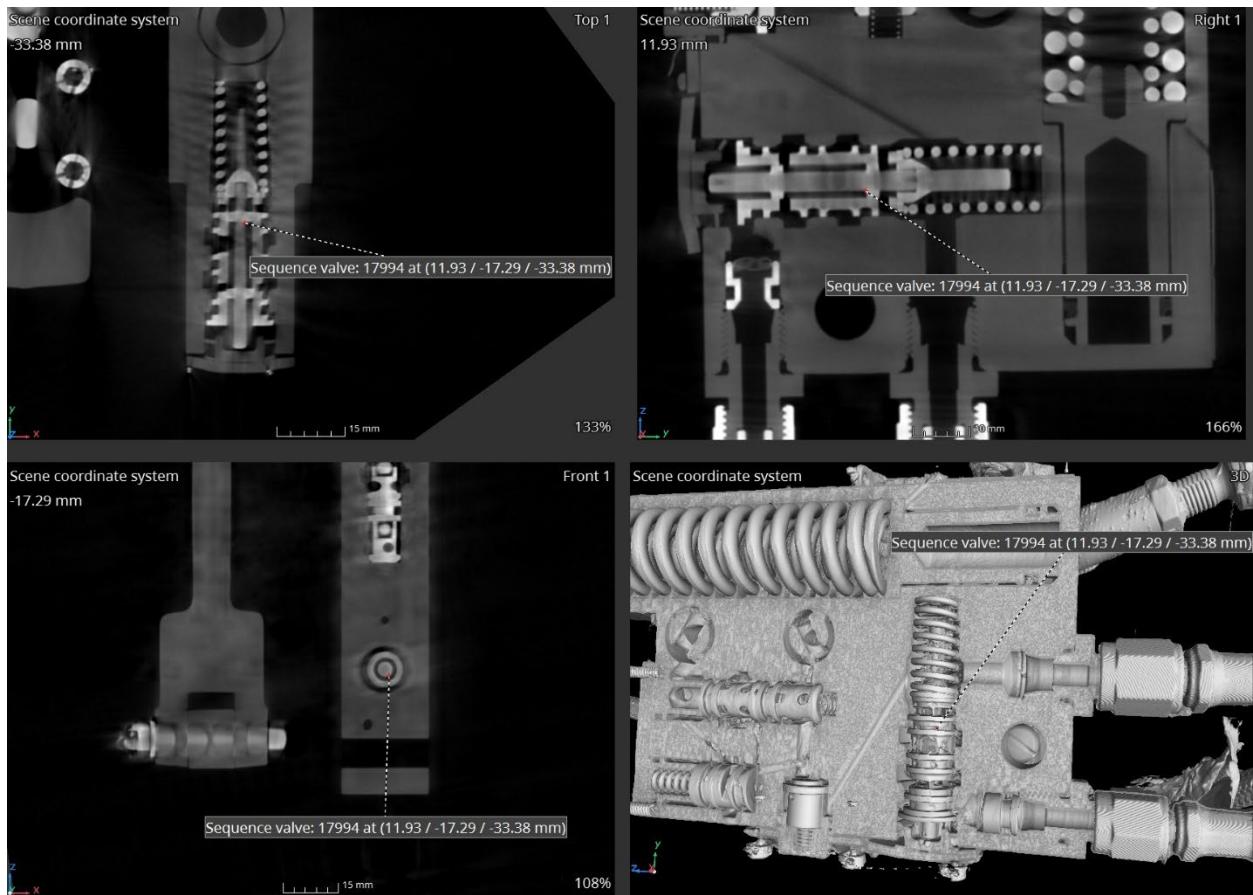


Figure 60. Right lateral actuator - irreversible valve - sequence valve. (450 kV)

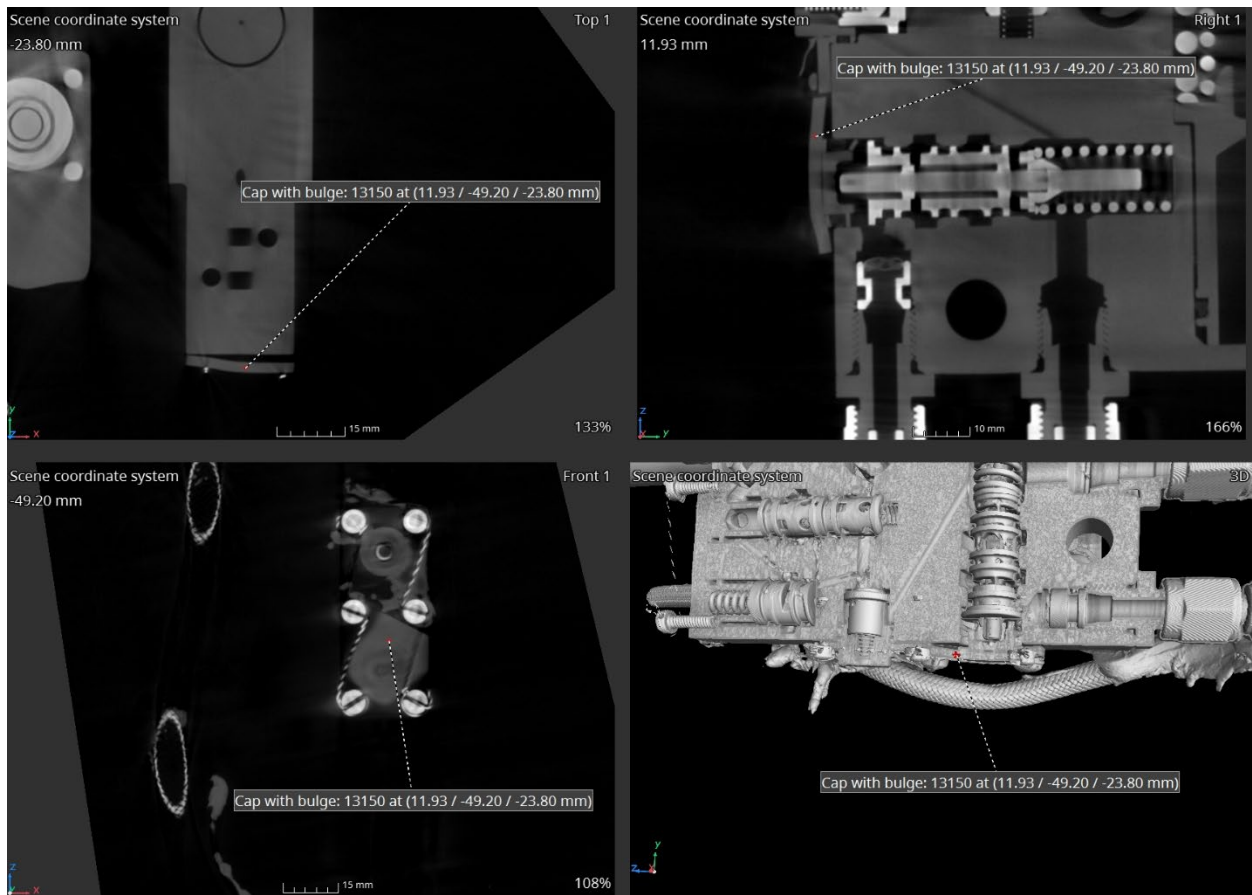


Figure 61. Right lateral actuator - irreversible valve - cap with bulge. (450 kV)

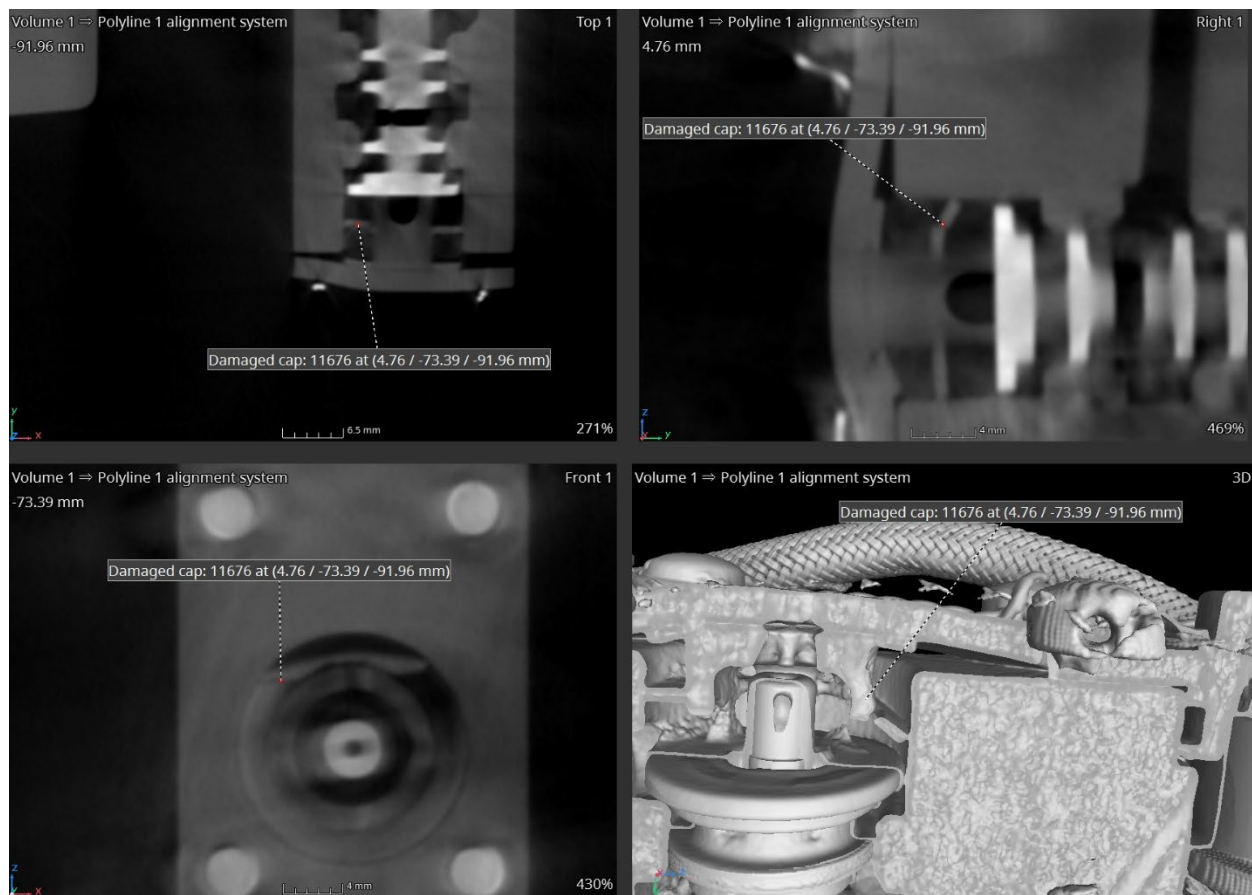


Figure 62. Right lateral actuator - irreversible valve - damaged cap. (450 kV)

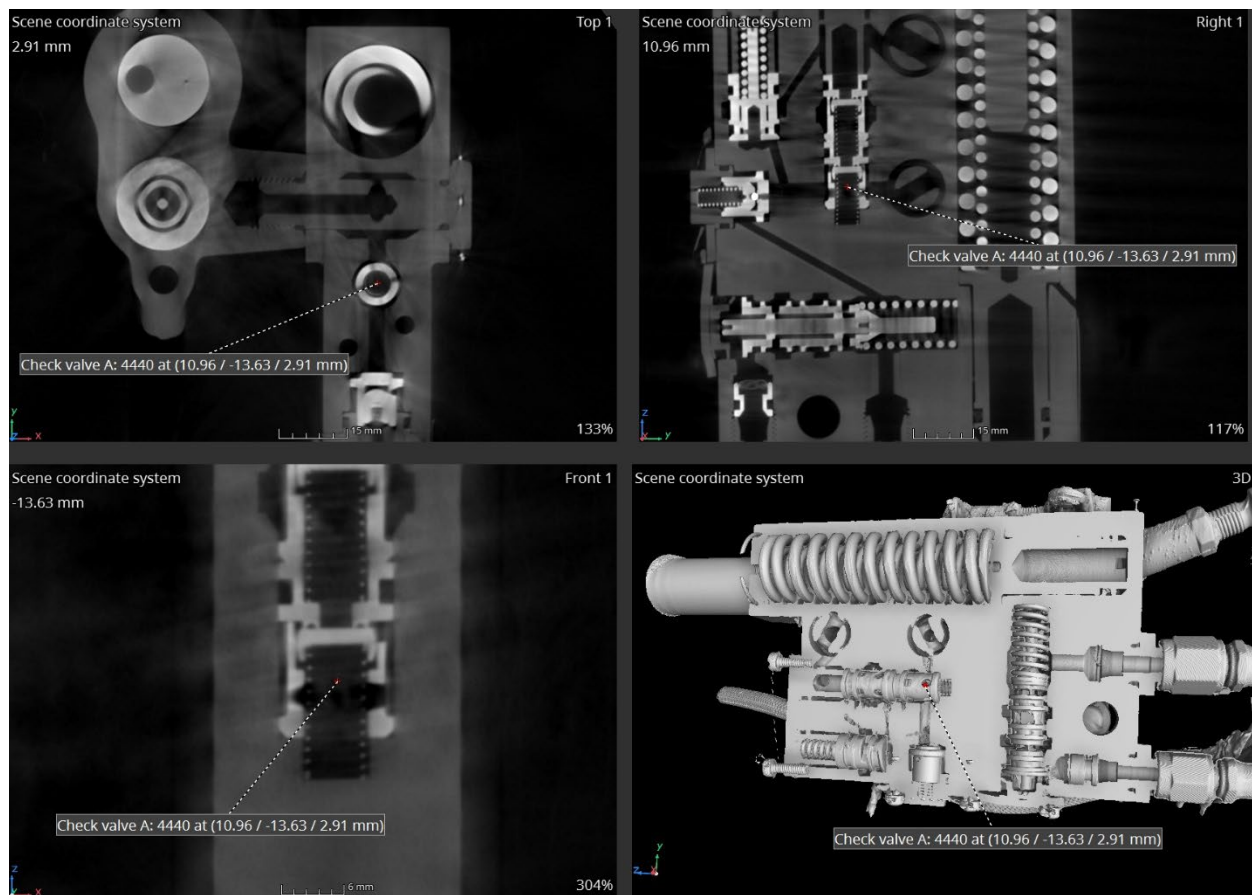


Figure 63. Right lateral actuator - irreversible valve - check valve A. (450 kV)

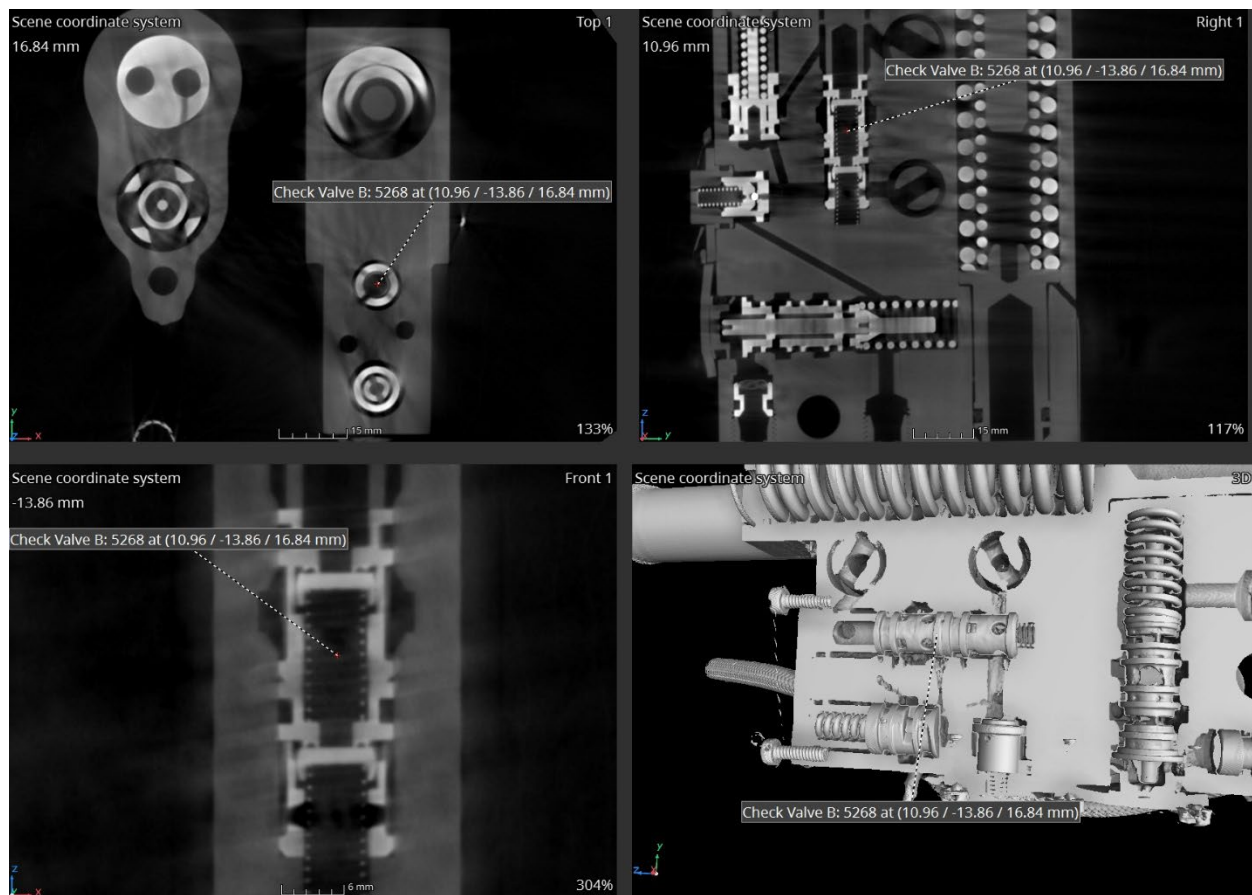


Figure 64. Right lateral actuator - irreversible valve - check valve B. (450 kV)

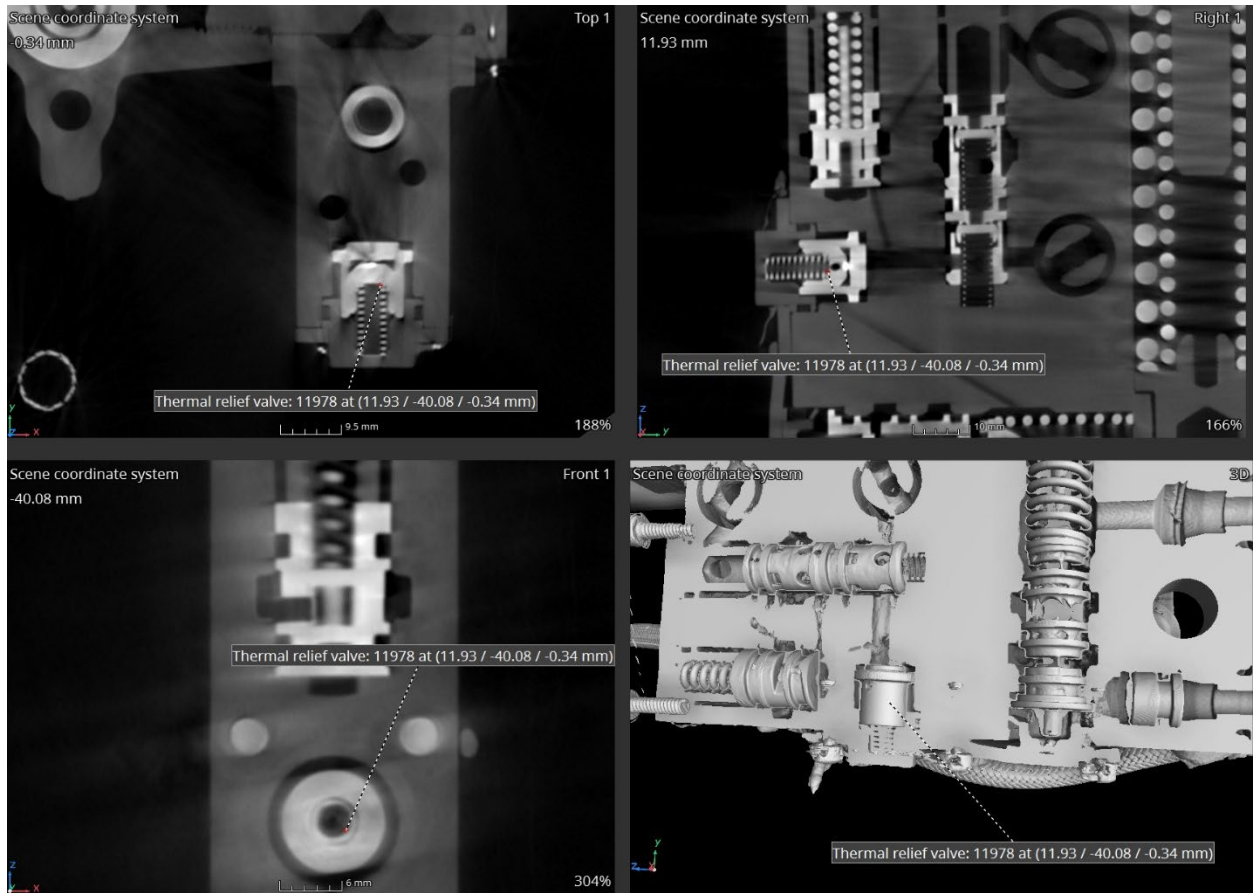


Figure 65. Right lateral actuator - irreversible valve - thermal relief valve. (450 kV)

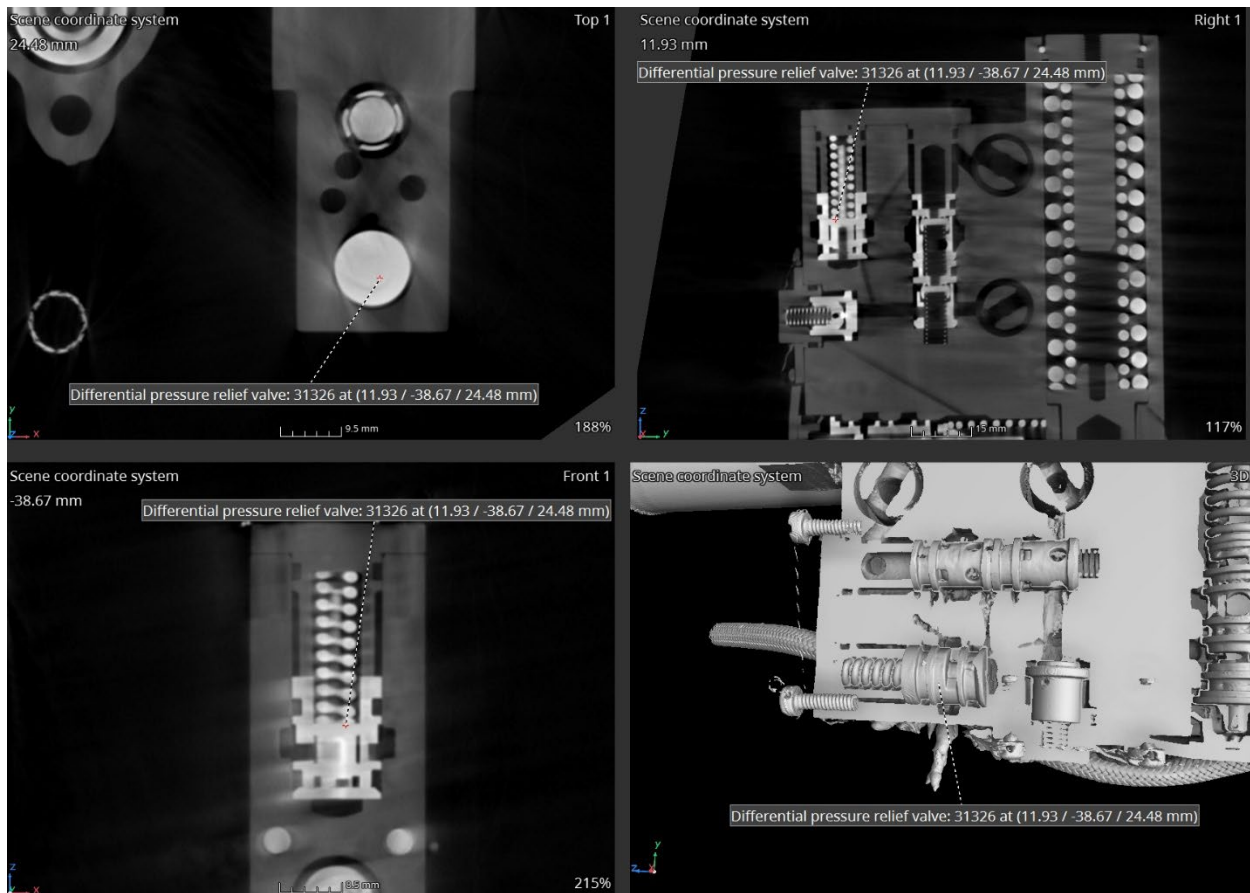


Figure 66. Right lateral actuator - irreversible valve - differential pressure relief valve. (450 kV)

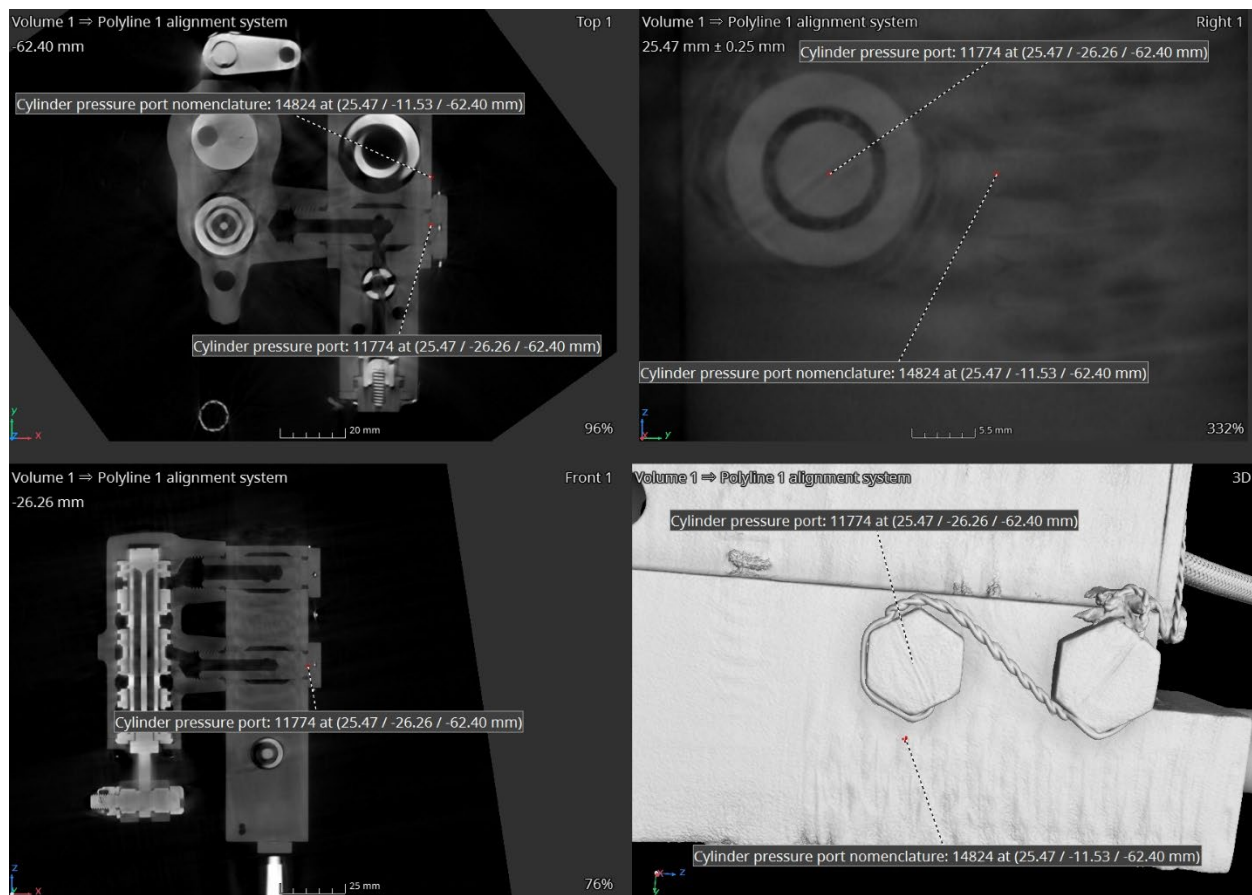


Figure 67. Right lateral actuator - irreversible valve - cylinder pressure port and nomenclature. (450 kV)

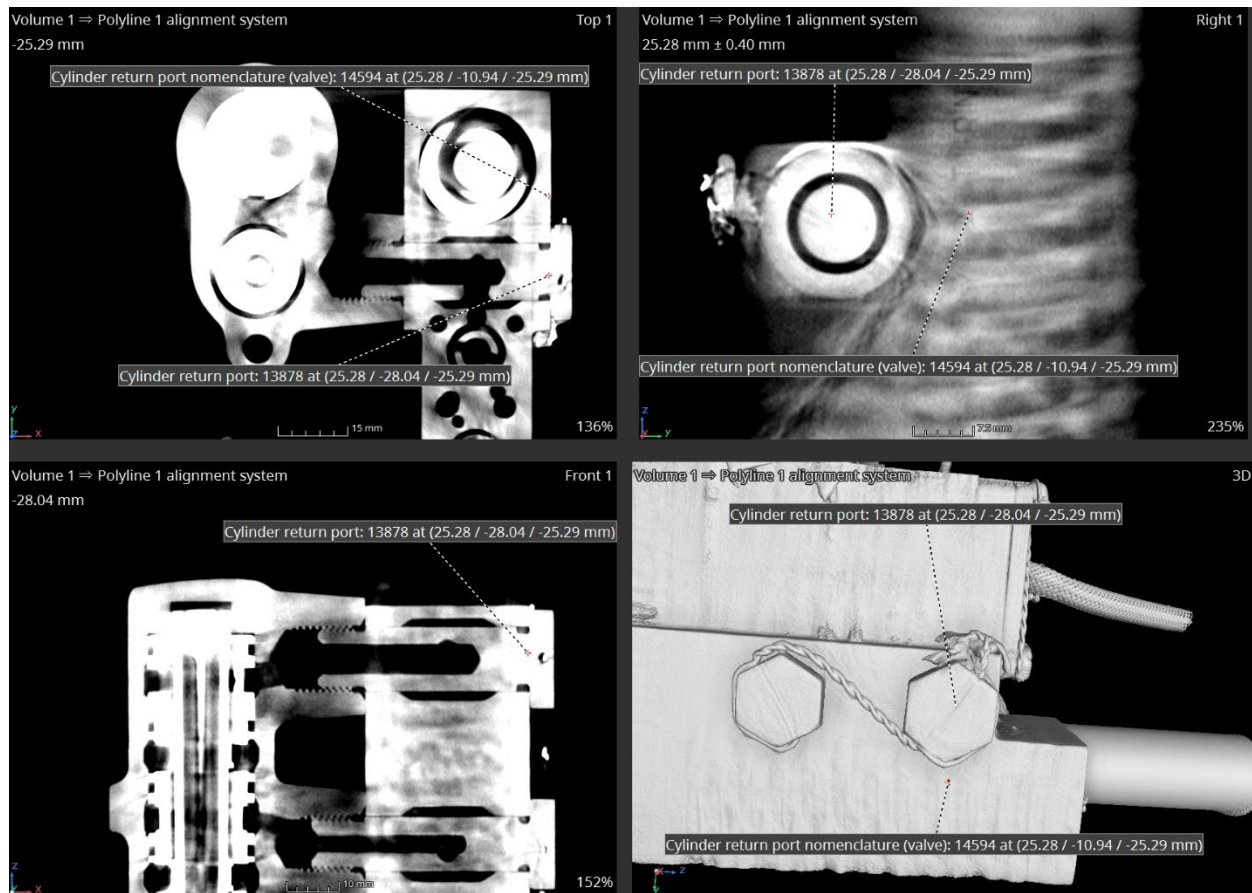


Figure 68. Right lateral actuator - irreversible valve - cylinder return port and nomenclature. (450 kV)

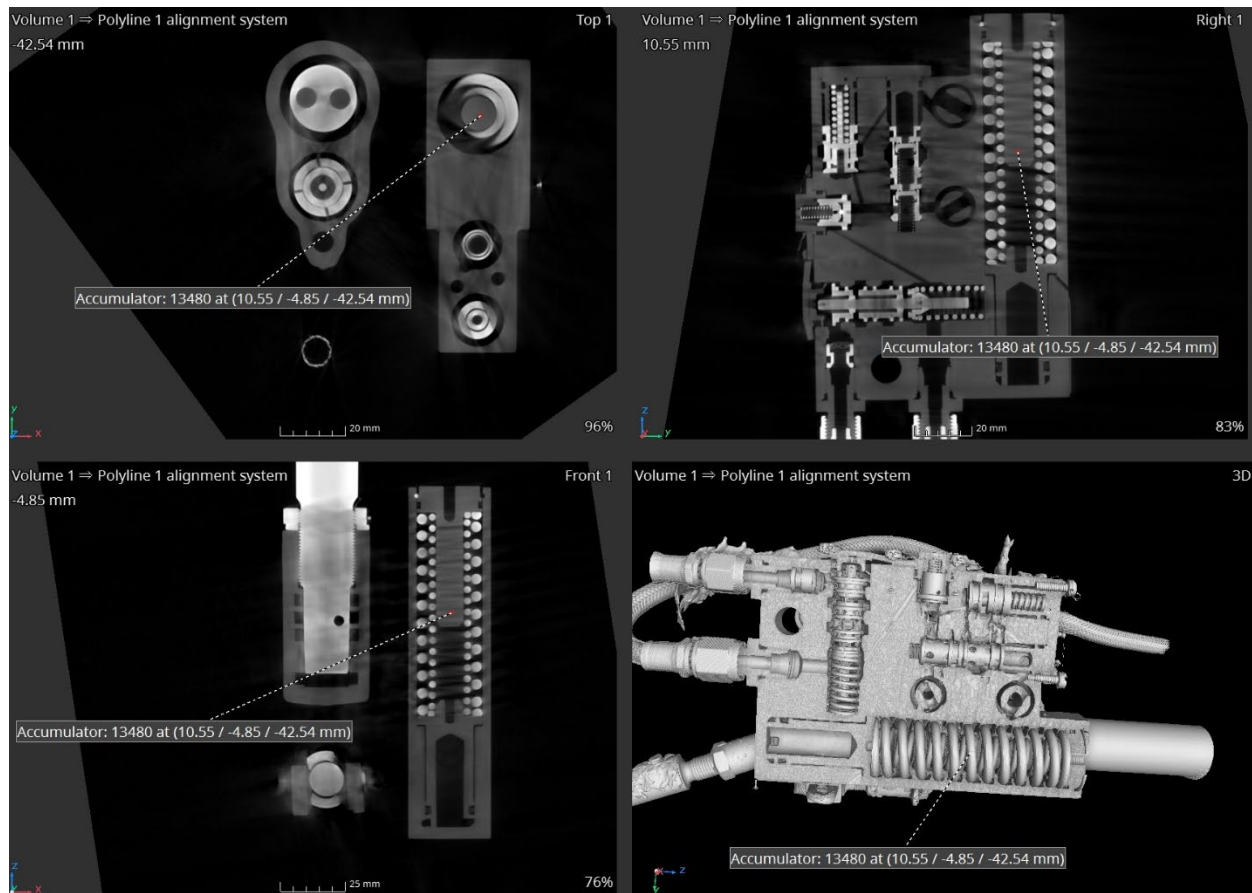


Figure 69. Right lateral actuator - irreversible valve - accumulator. (450 kV)

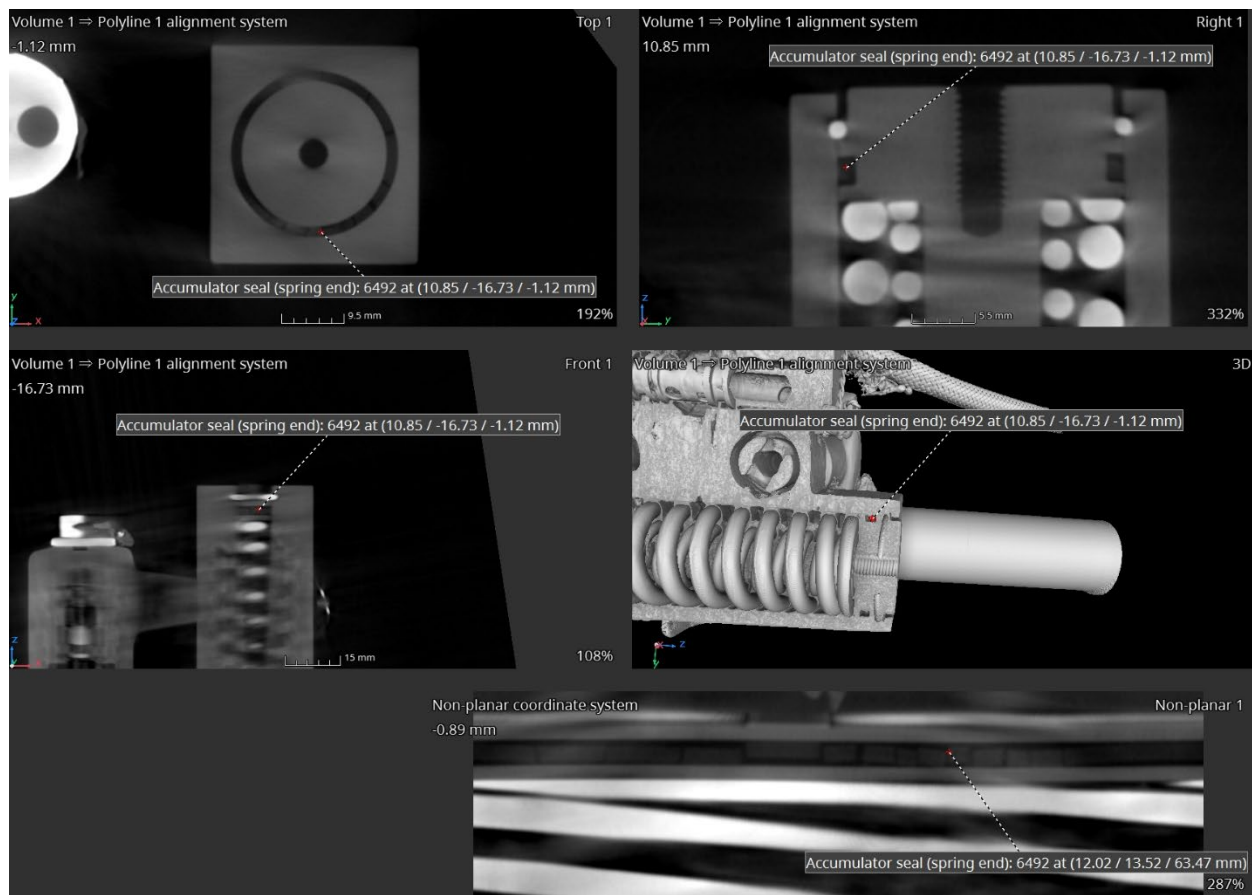


Figure 70. Right lateral actuator - irreversible valve - accumulator seal at spring end. (450 kV)

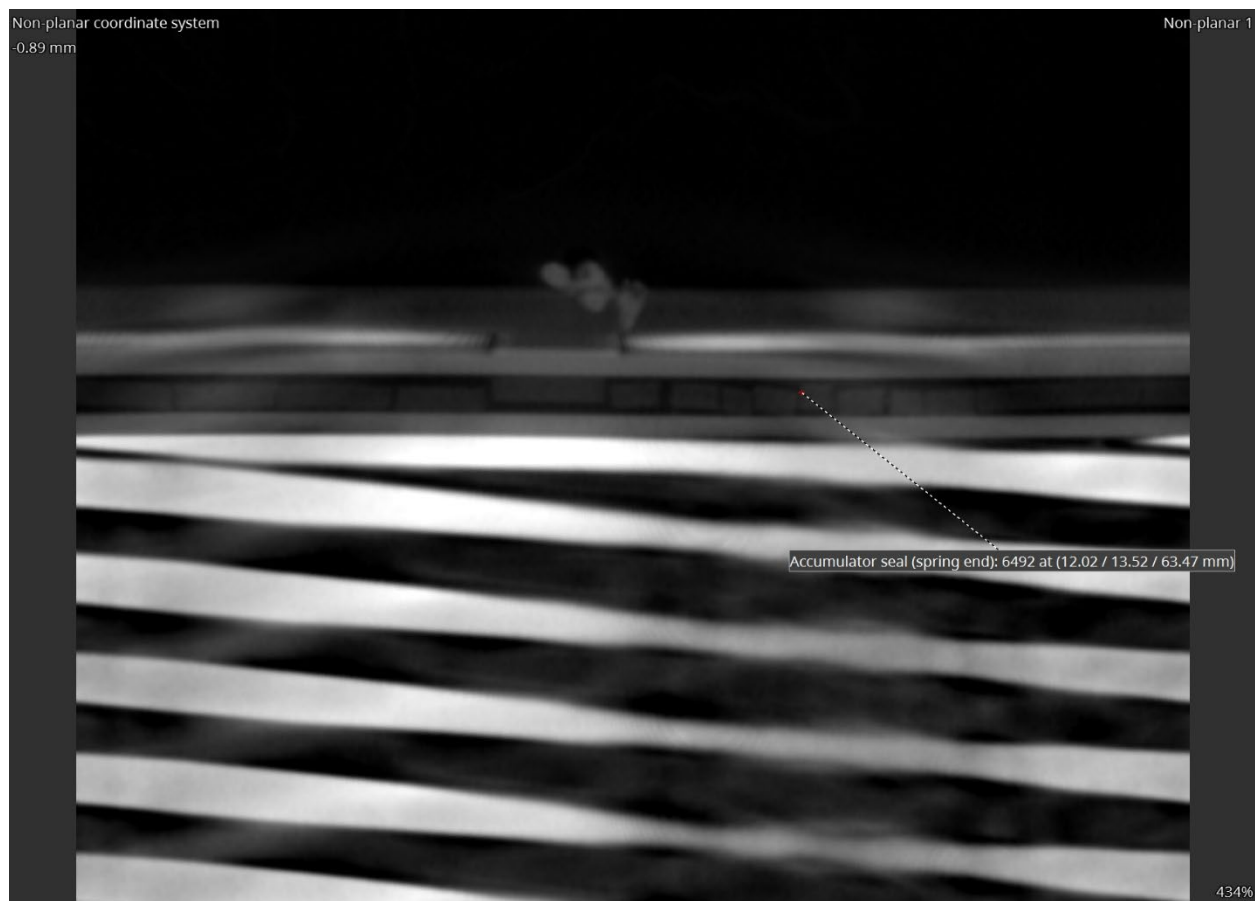


Figure 71. Right lateral actuator - irreversible valve - accumulator seal unrolled at spring end. (450 kV)

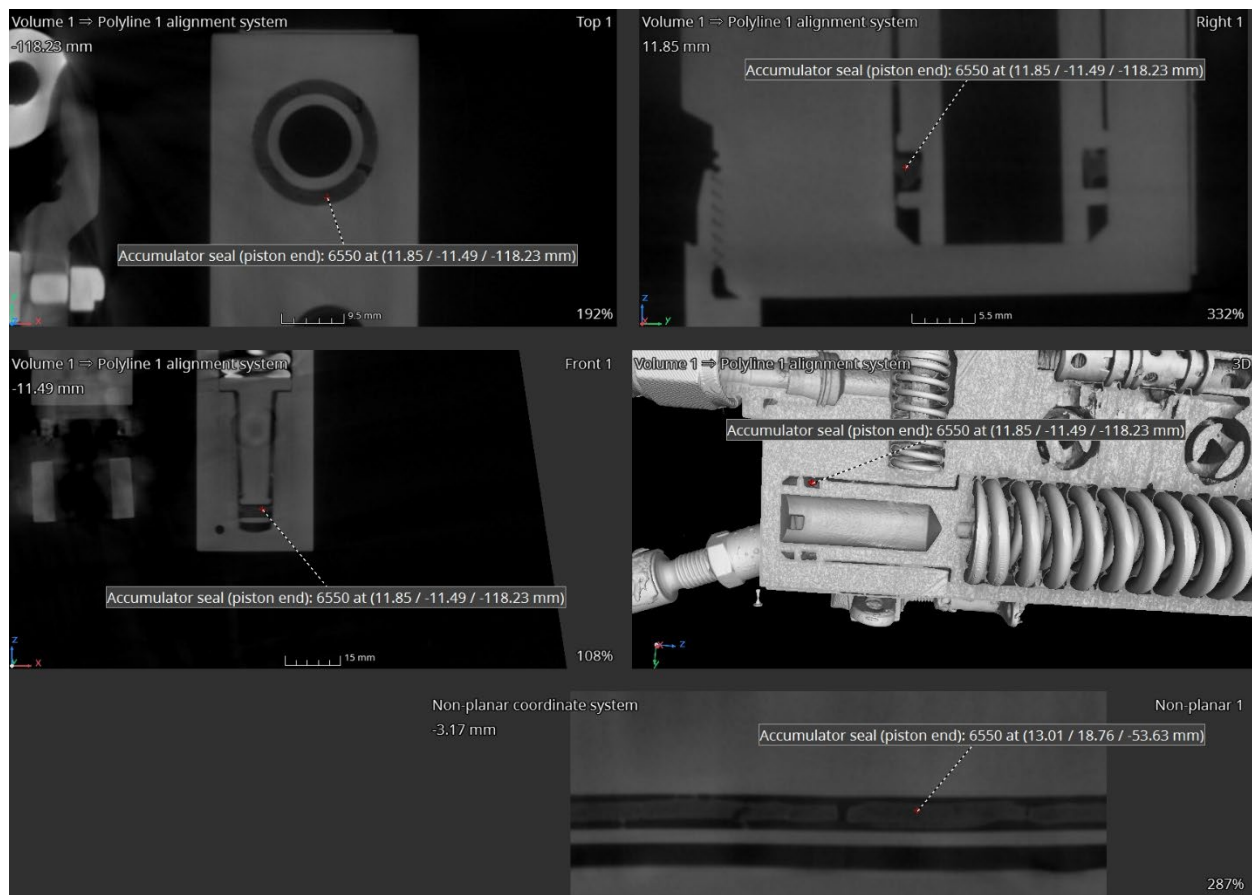


Figure 72. Right lateral actuator - irreversible valve - accumulator seal at piston end. (450 kV)

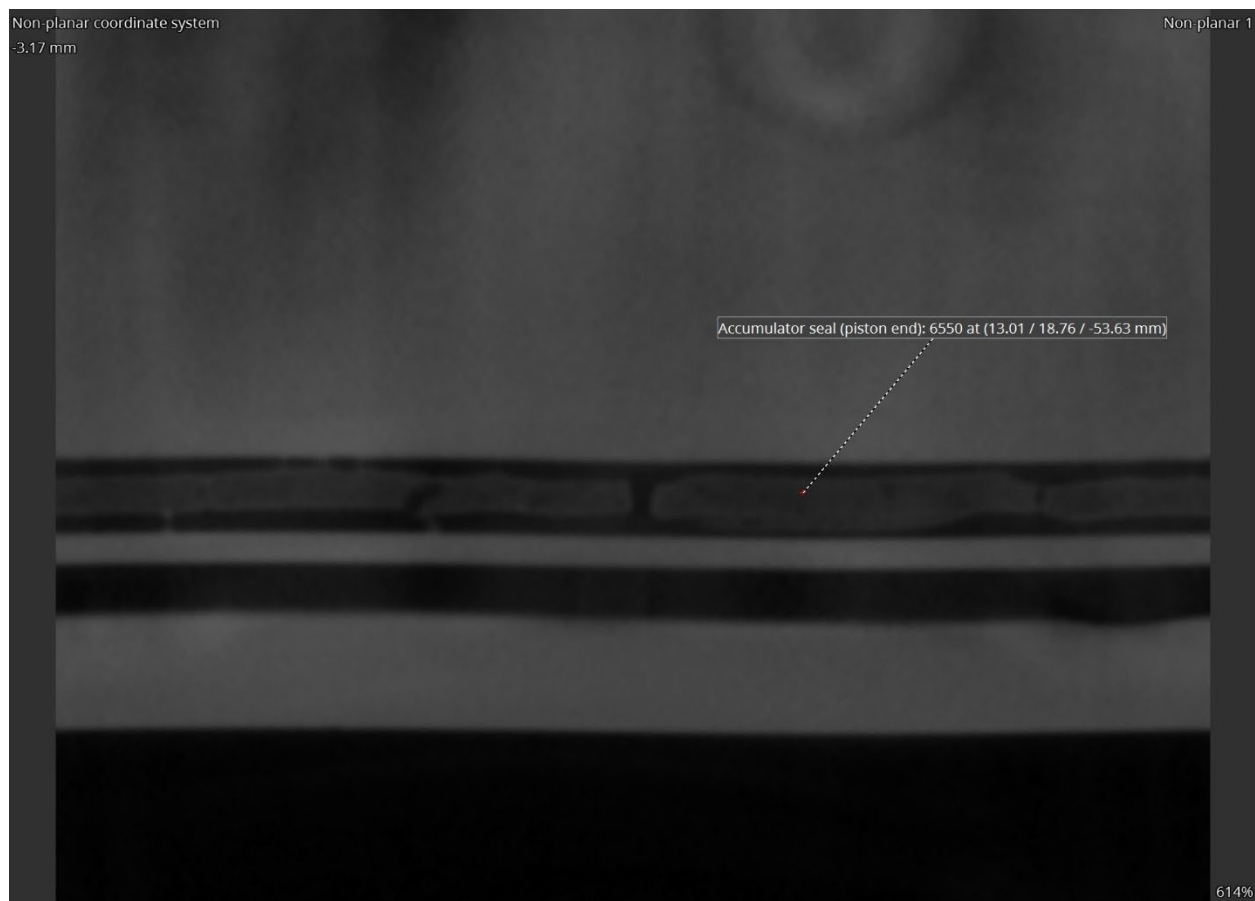


Figure 73. Right lateral actuator - irreversible valve - accumulator seal unrolled at piston end. (450 kV)

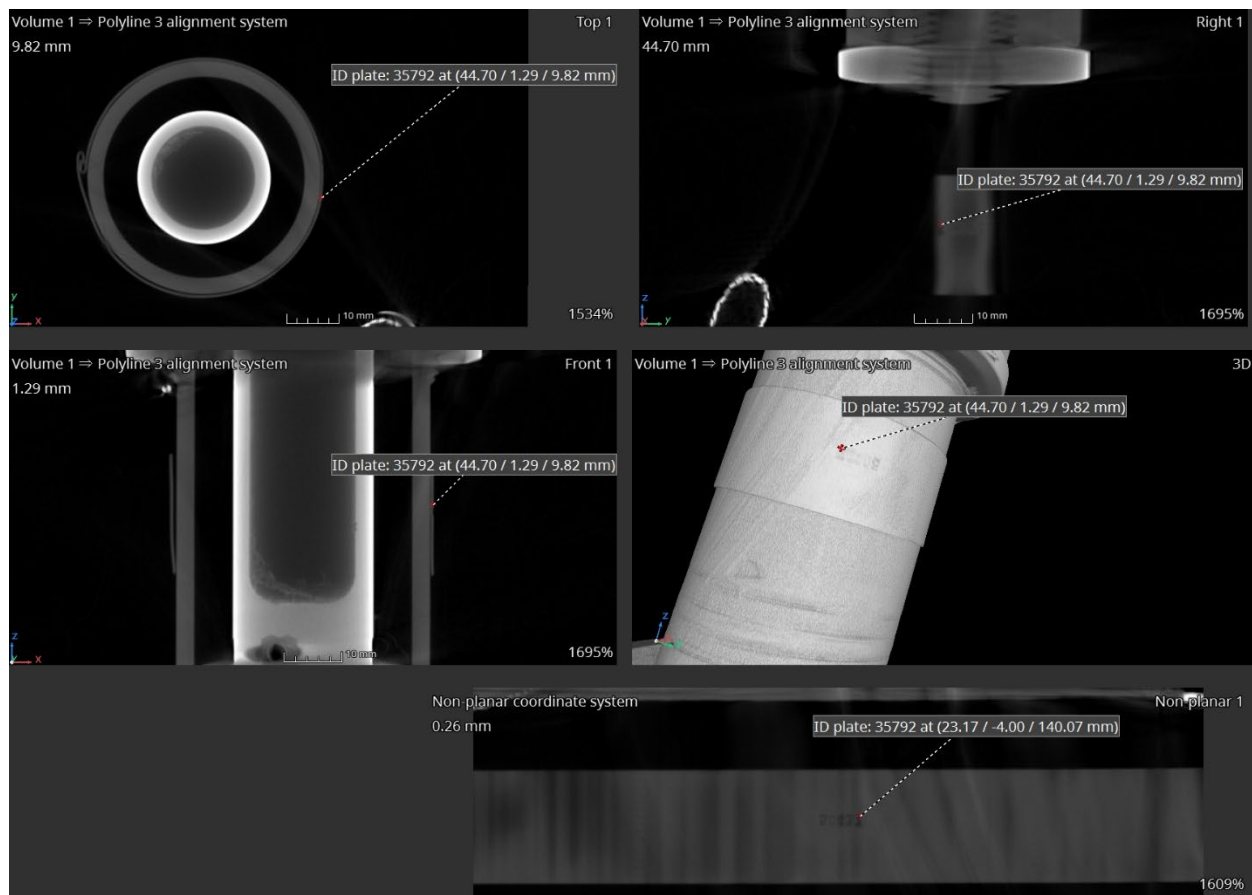


Figure 74. Right lateral actuator - cylinder assembly - ID plate. (225 kV)

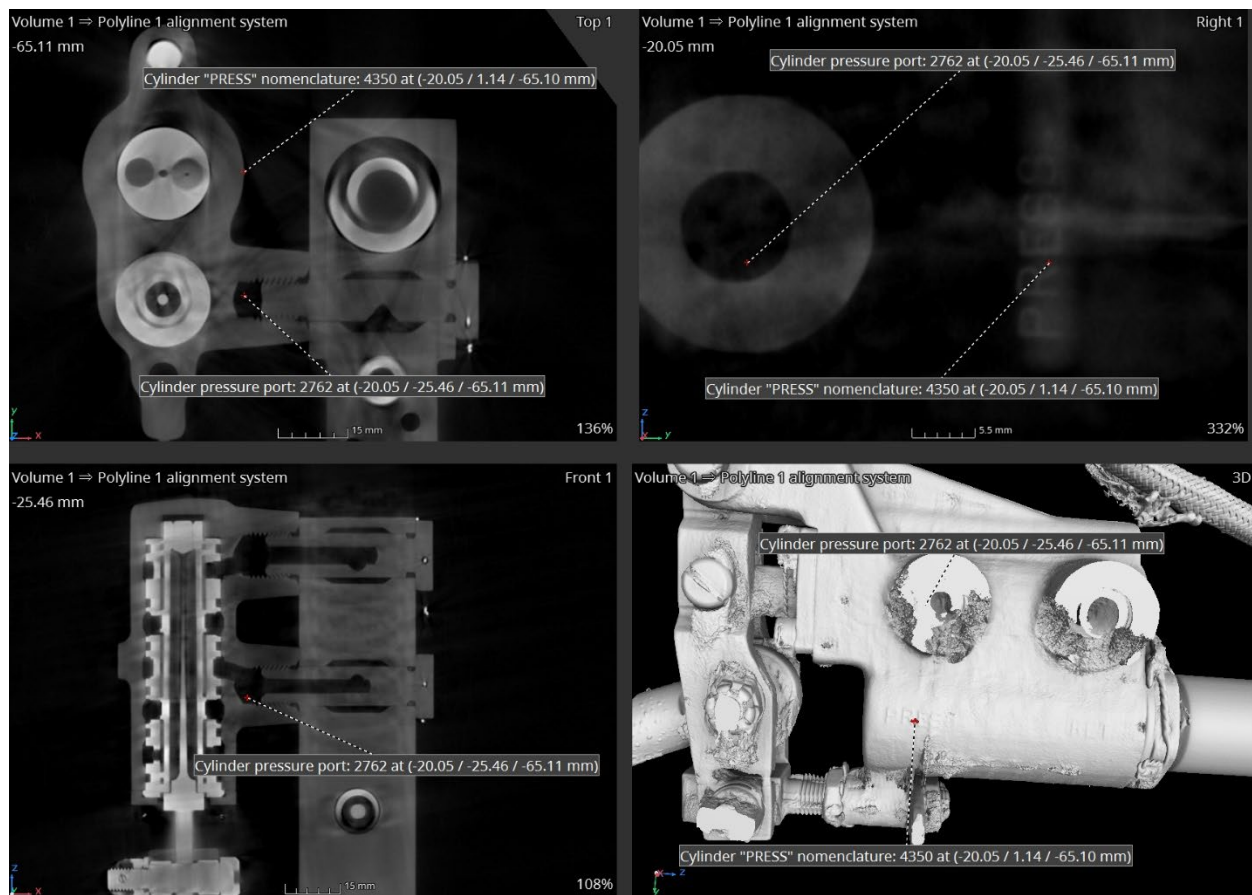


Figure 75. Right lateral actuator - cylinder assembly - pressure port and "PRESS" nomenclature. (450 kV)

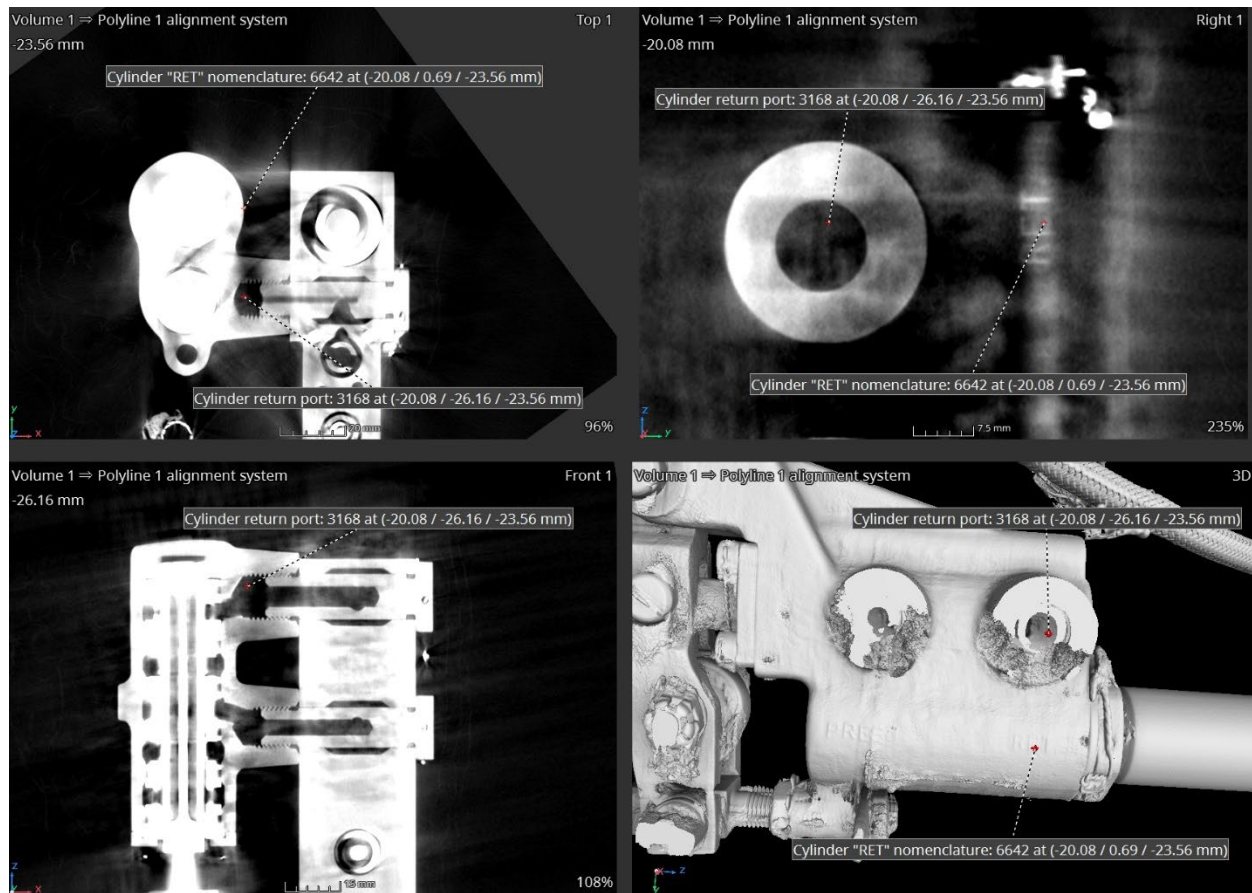


Figure 76. Right lateral actuator - cylinder assembly return port and "RET" nomenclature. (450 kV)

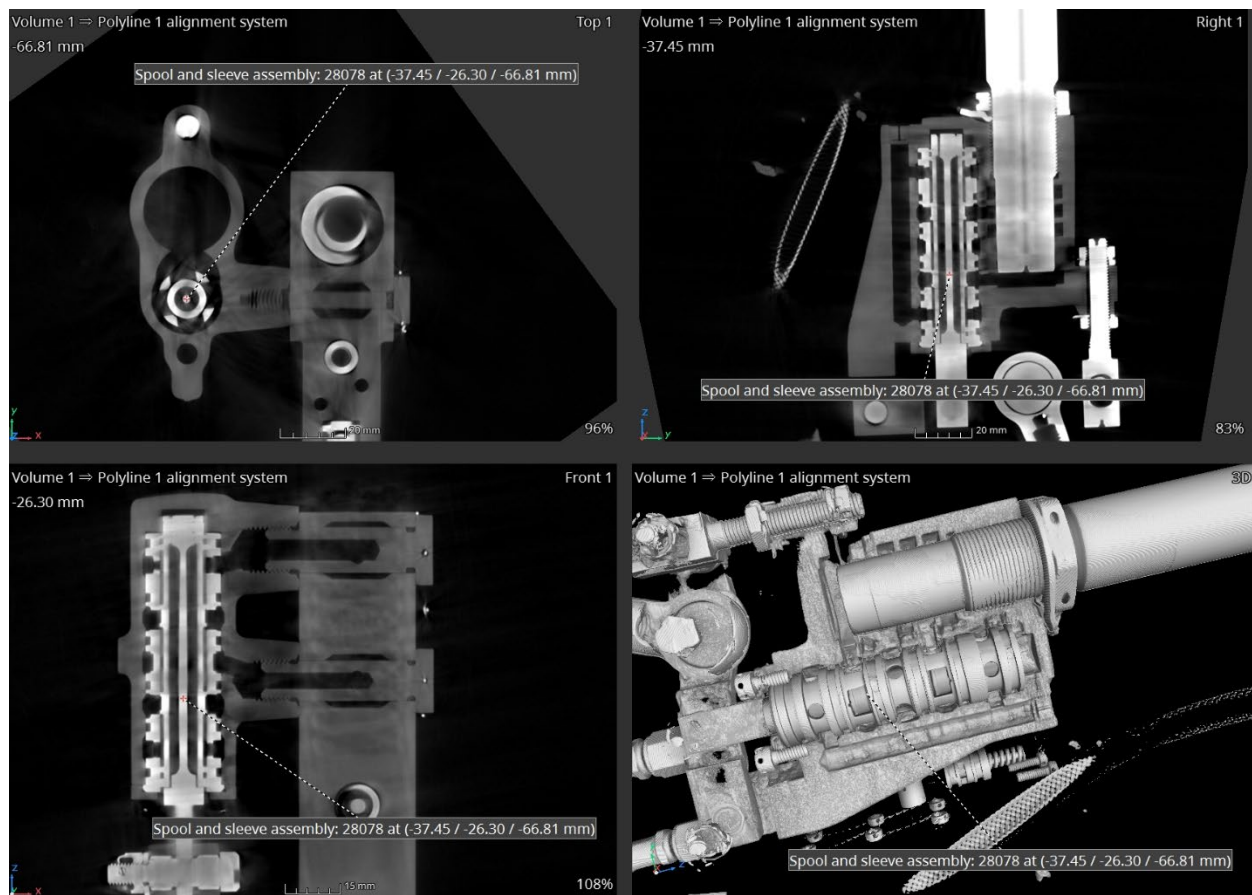


Figure 77. Right lateral actuator - cylinder assembly - spool and sleeve. (450 kV)

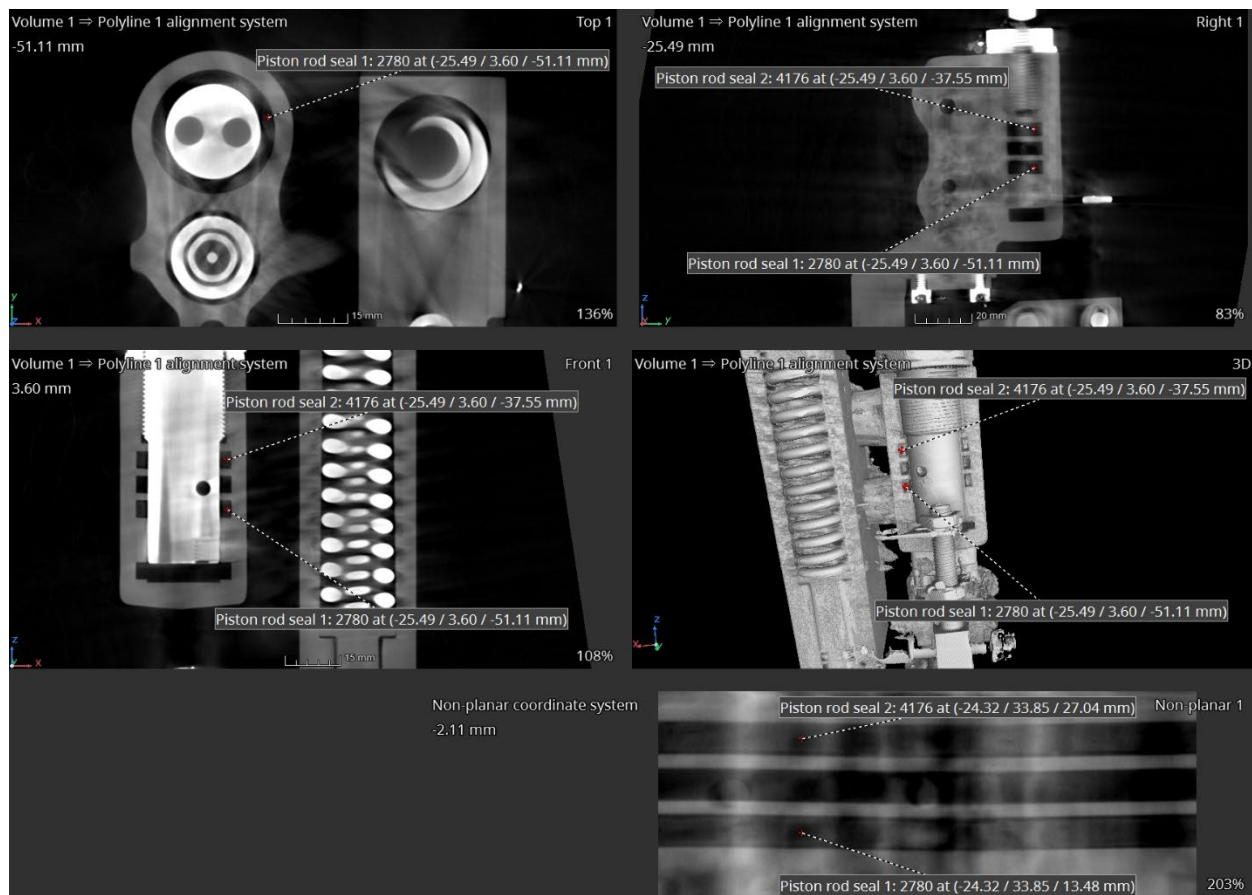


Figure 78. Right lateral actuator - cylinder assembly - piston rod seals 1 and 2. (450 kV)



Figure 79. Right lateral actuator - cylinder assembly - piston rod seals 1 and 2 unrolled. (450 kV)

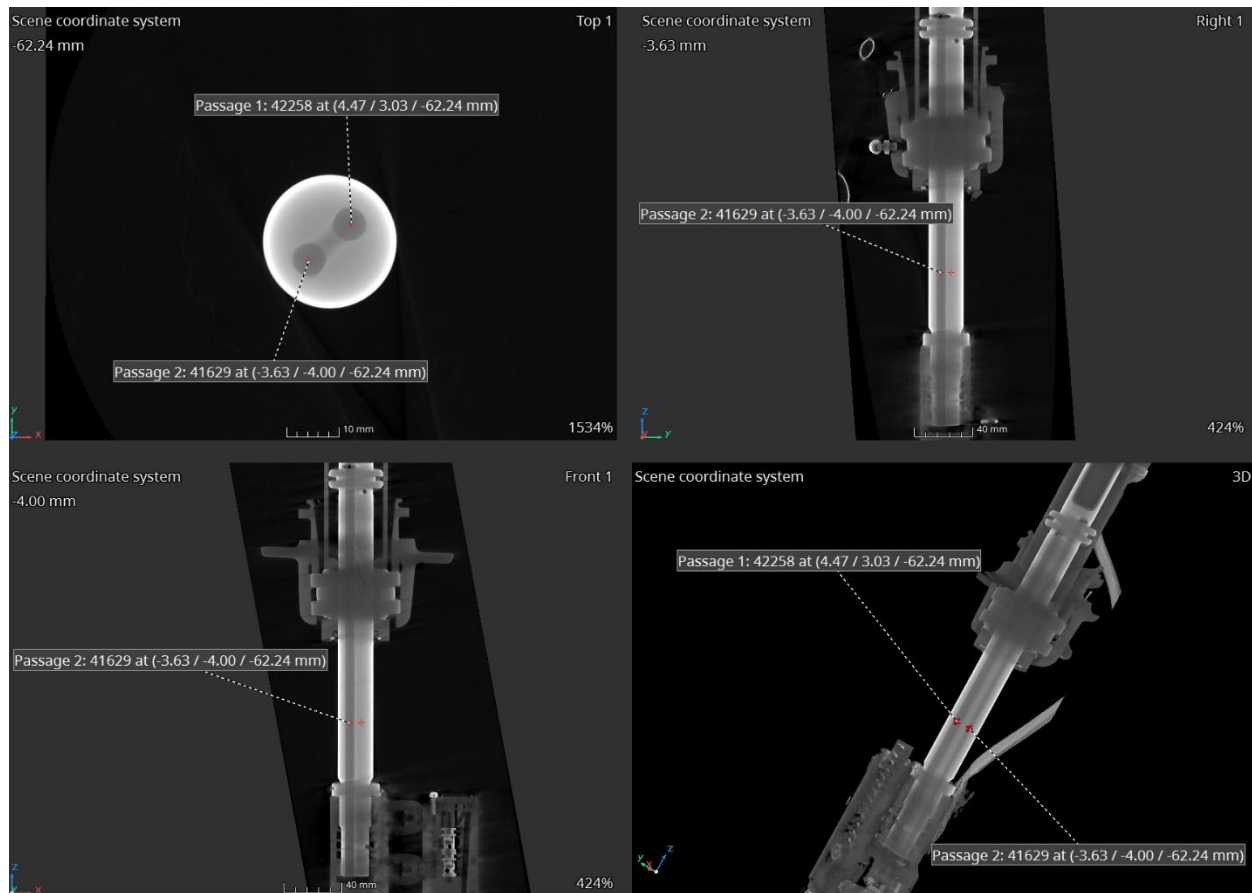


Figure 80. Right lateral actuator - cylinder assembly - hydraulic passages. (225 kV)

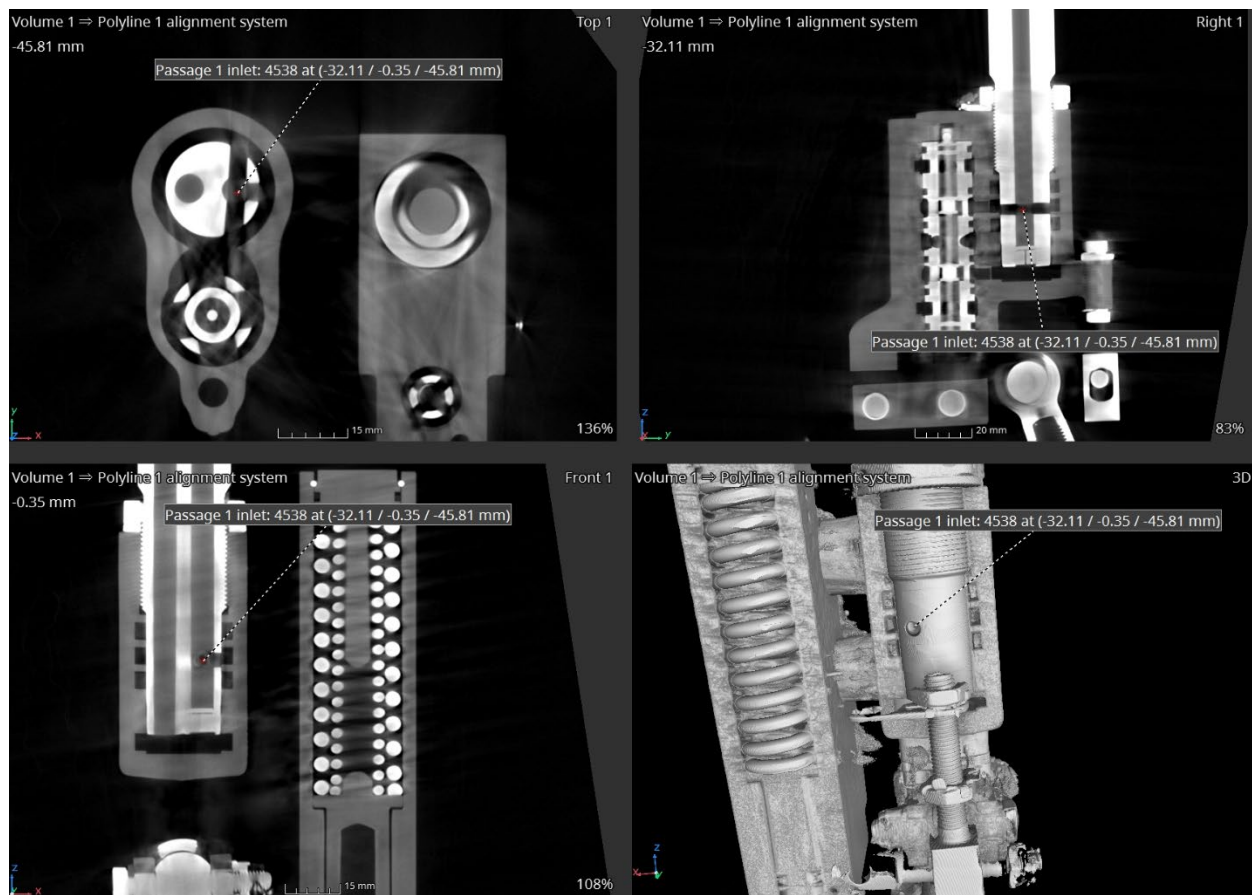


Figure 81. Right lateral actuator - cylinder assembly - passage 1 inlet. (450 kV)

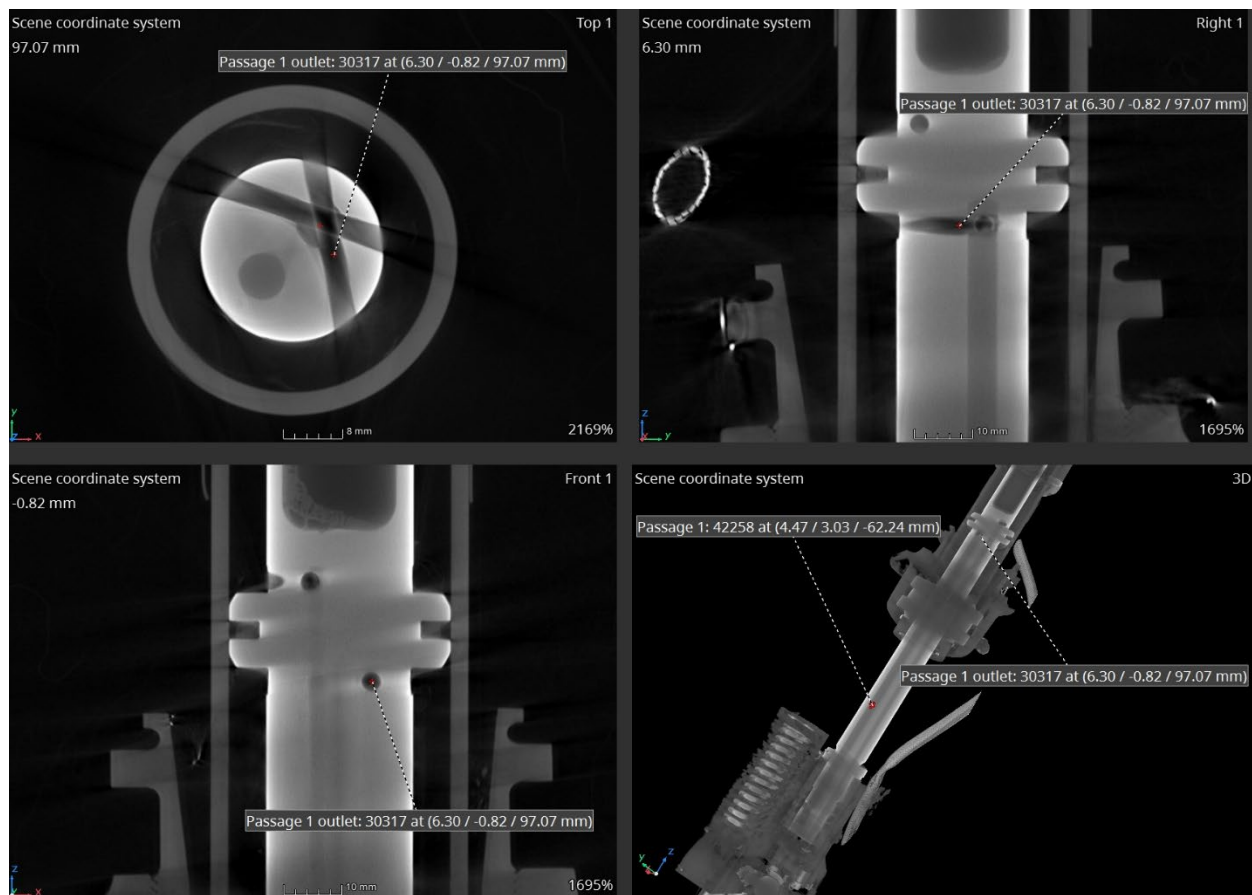


Figure 82. Right lateral actuator - cylinder assembly - passage 1 outlet. (225 kV)

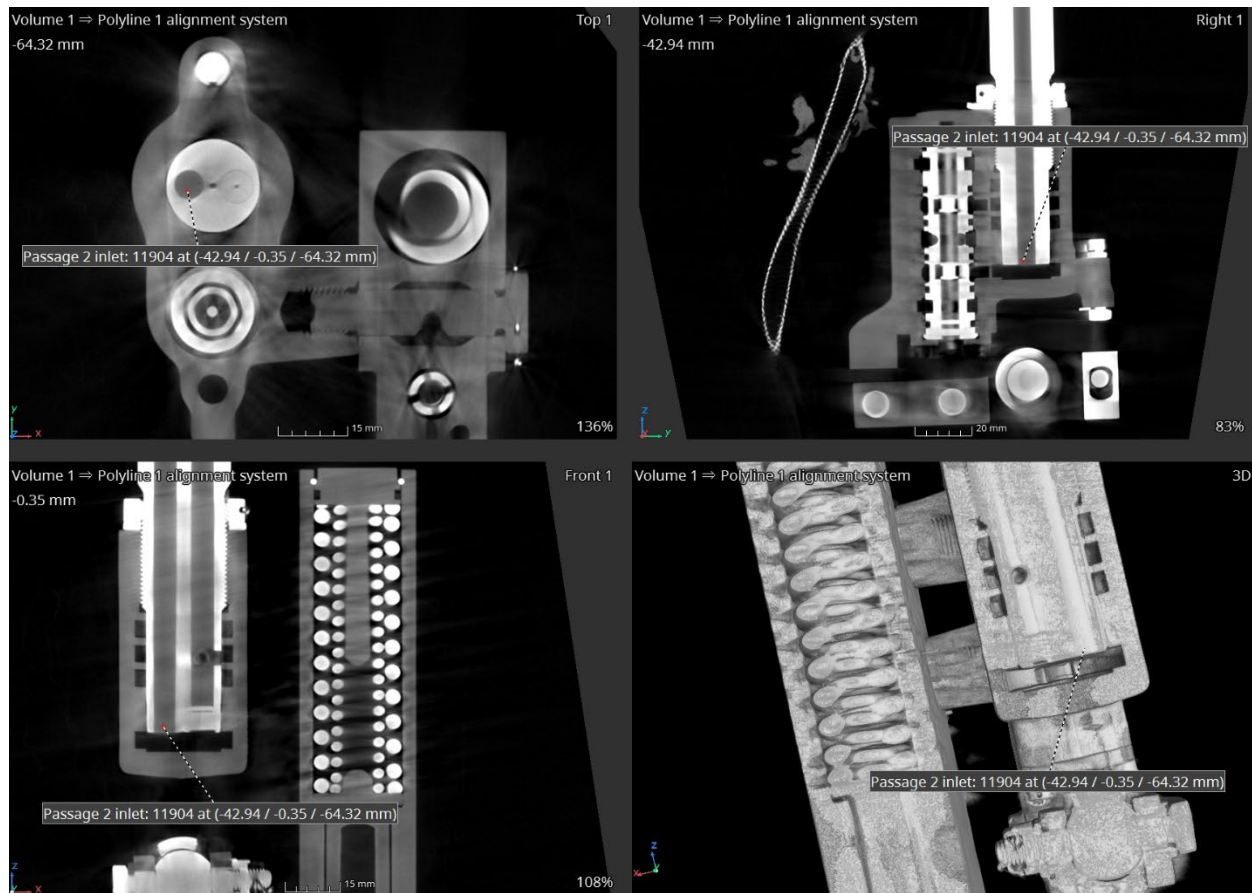


Figure 83. Right lateral actuator - cylinder assembly - passage 2 inlet. (450 kV)

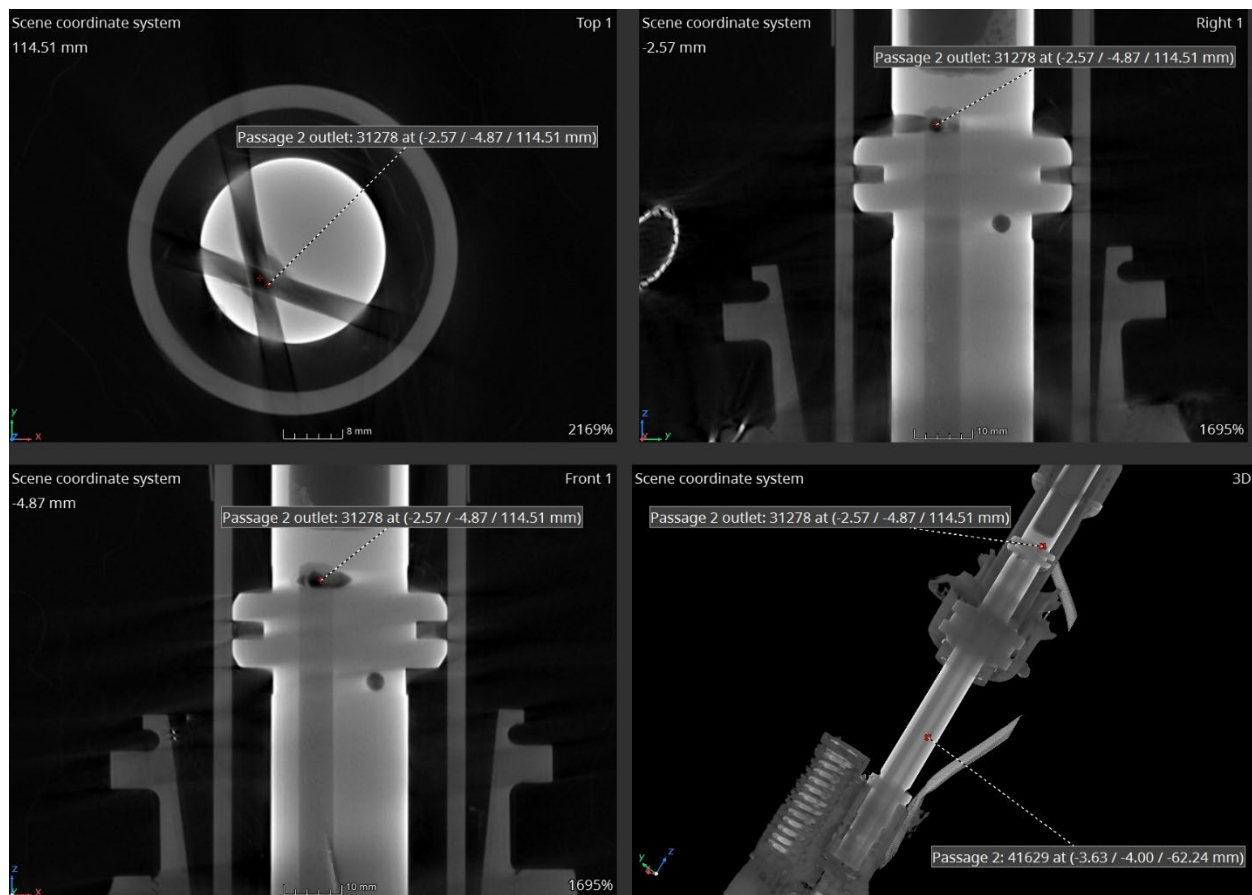


Figure 84. Right lateral actuator - cylinder assembly - passage 2 outlet. (225 kV)



Figure 85. Right lateral actuator - cylinder assembly - retaining ring 1. (225 kV)

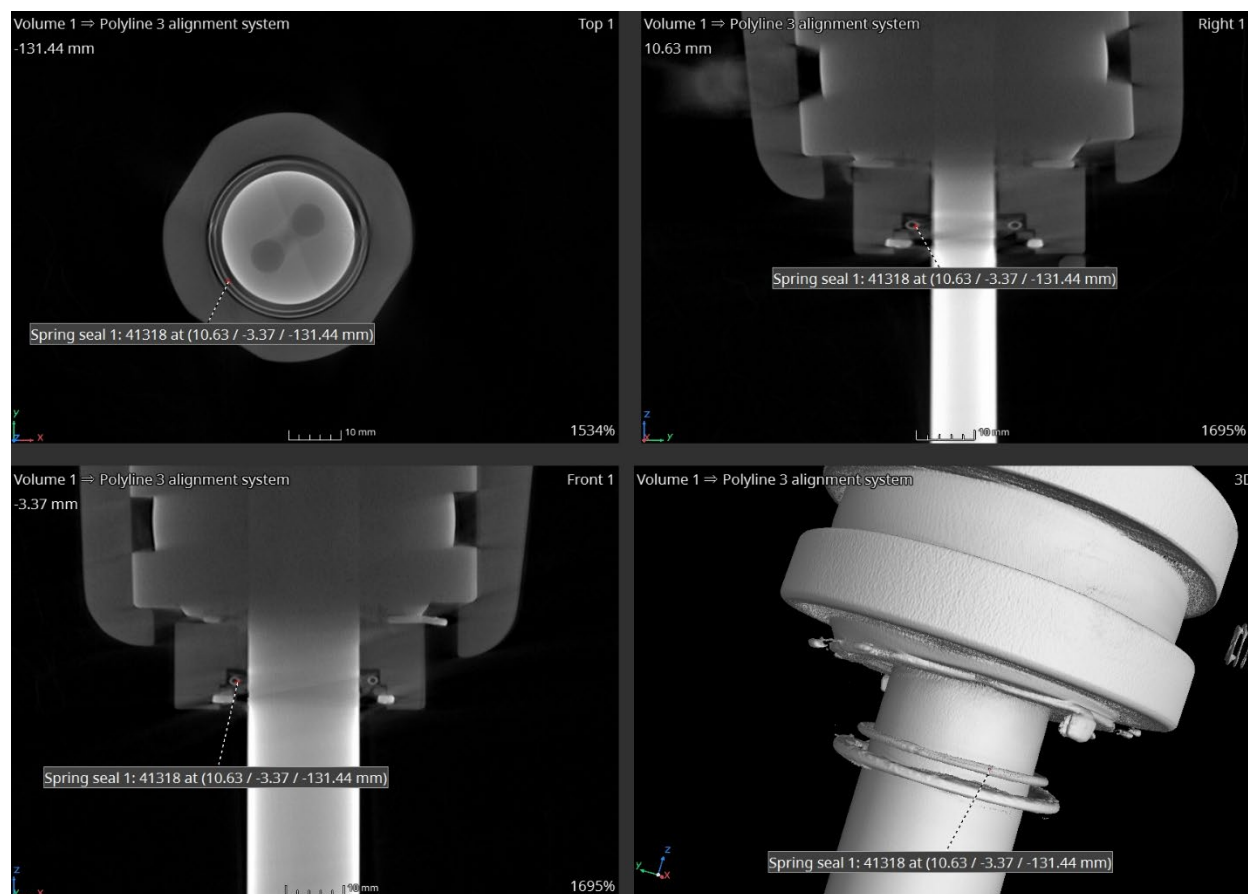


Figure 86. Right lateral actuator - cylinder assembly - spring seal 1. (225 kV)

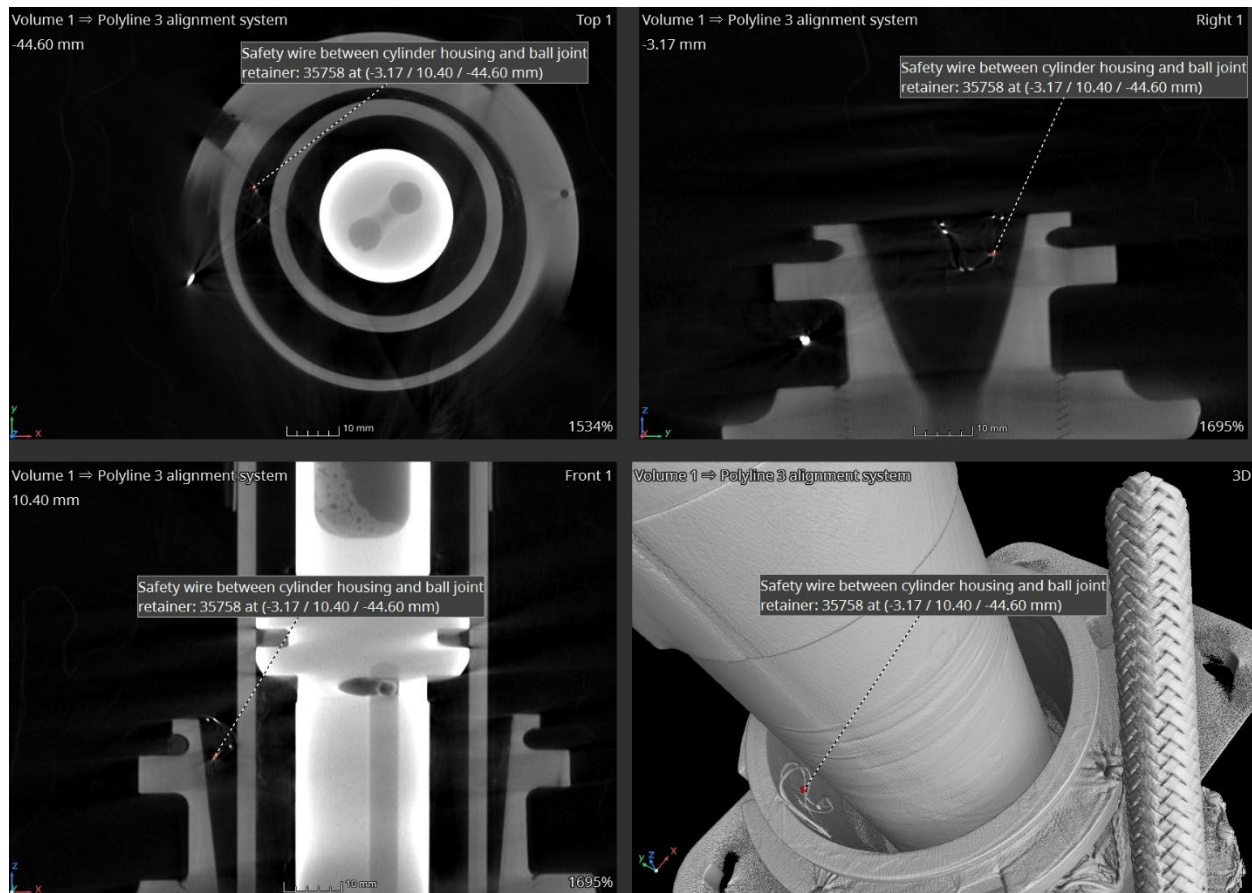


Figure 87. Right lateral actuator - cylinder assembly - safety wire between the cylinder housing and the ball joint retainer. (225 kV)

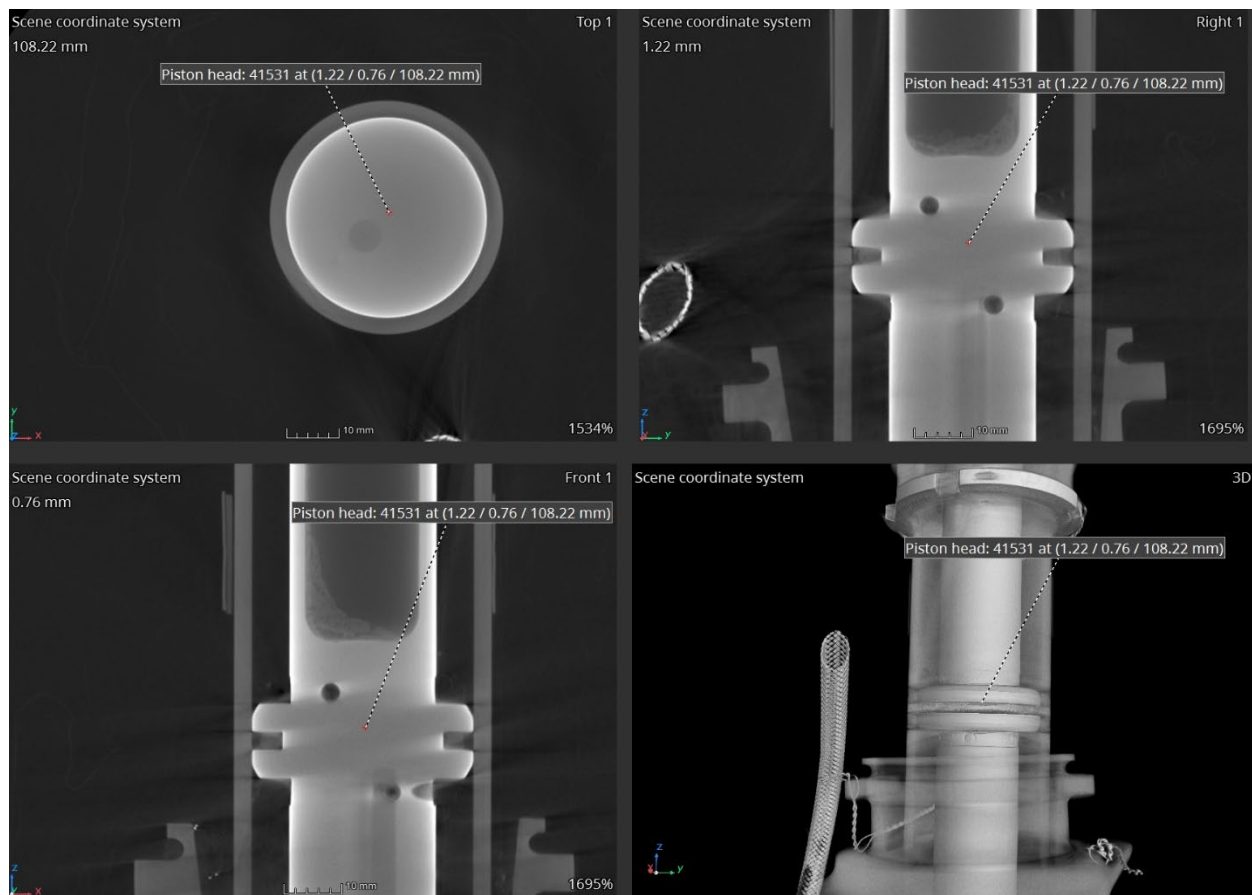


Figure 88. Right lateral actuator - cylinder assembly - piston head. (225 kV)

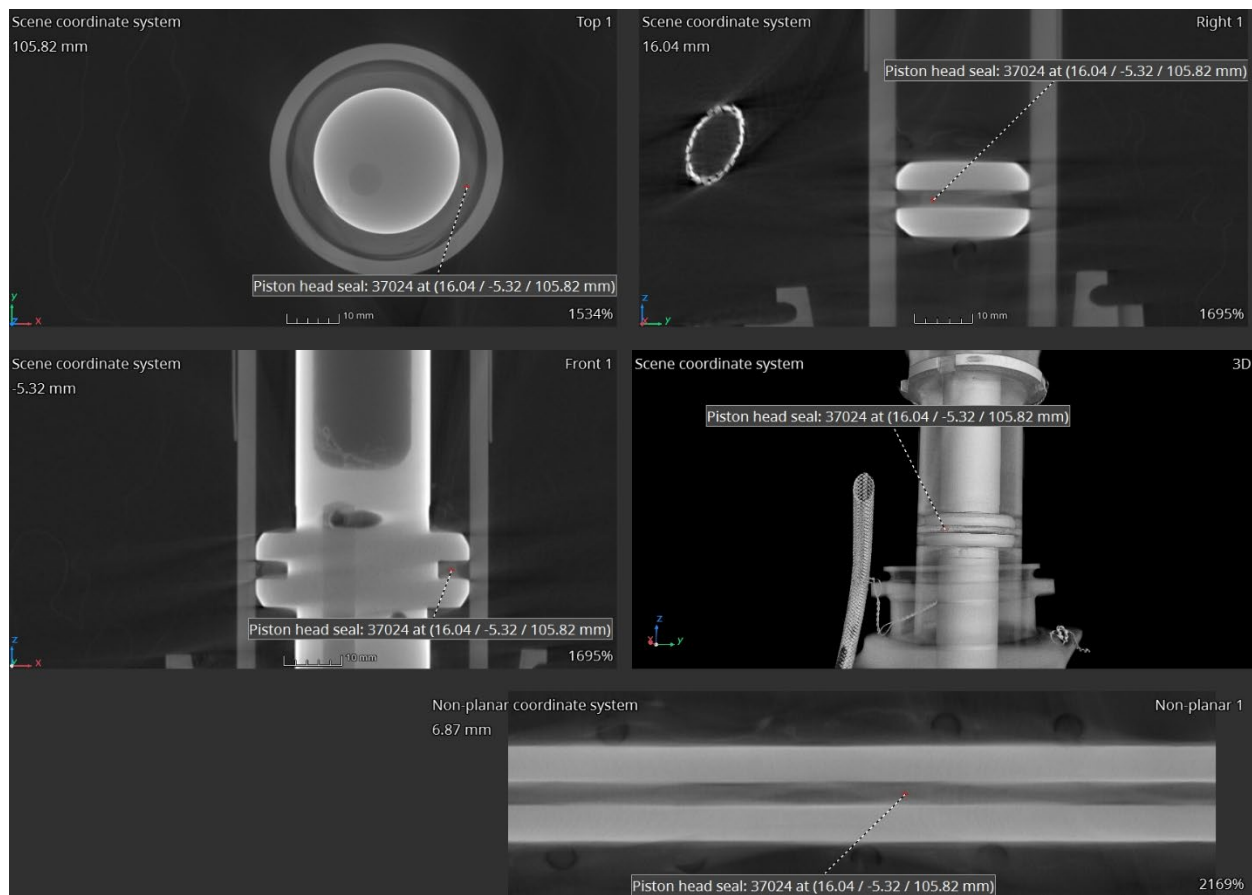


Figure 89. Right lateral actuator - cylinder assembly - piston head seal. (225 kV)

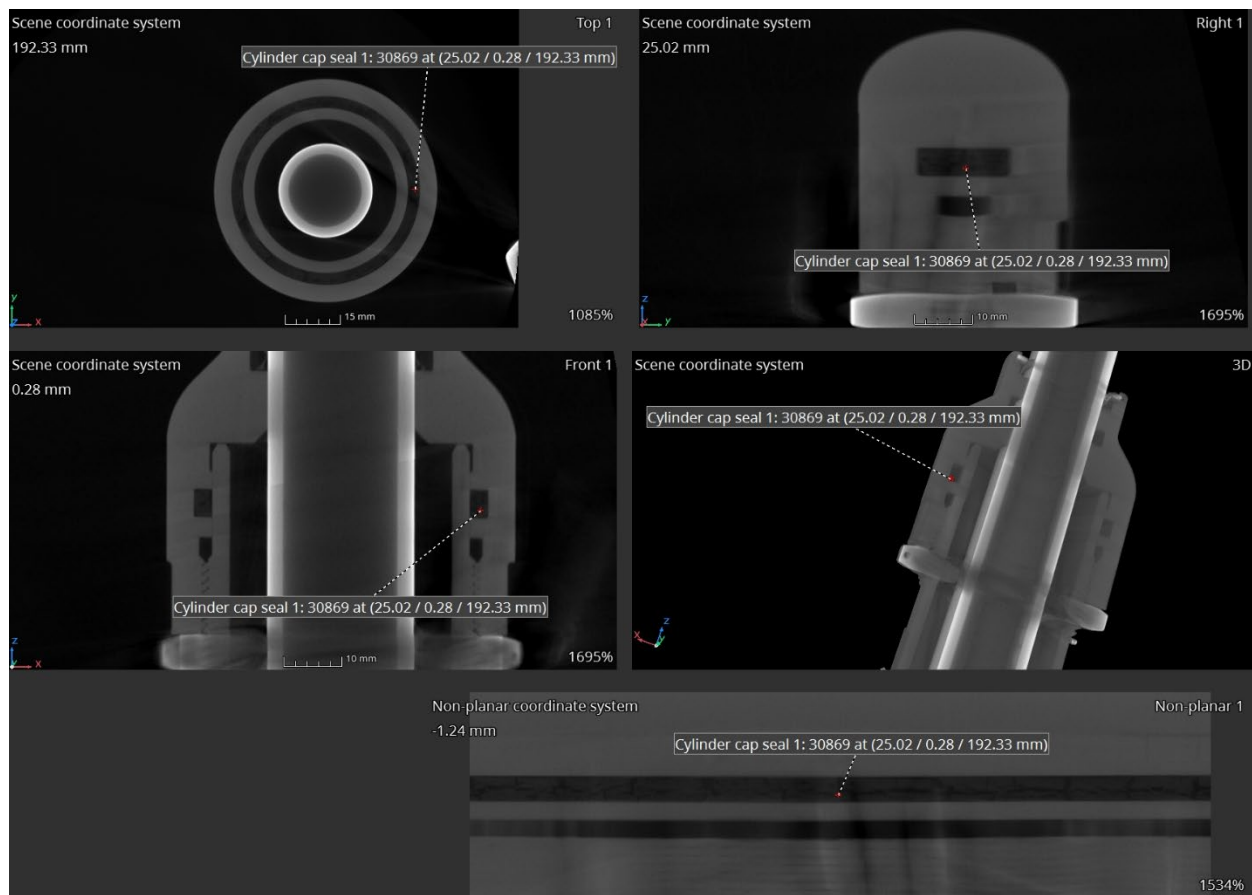


Figure 90. Right lateral actuator – cylinder assembly – cylinder cap seal 1. (225 kV)

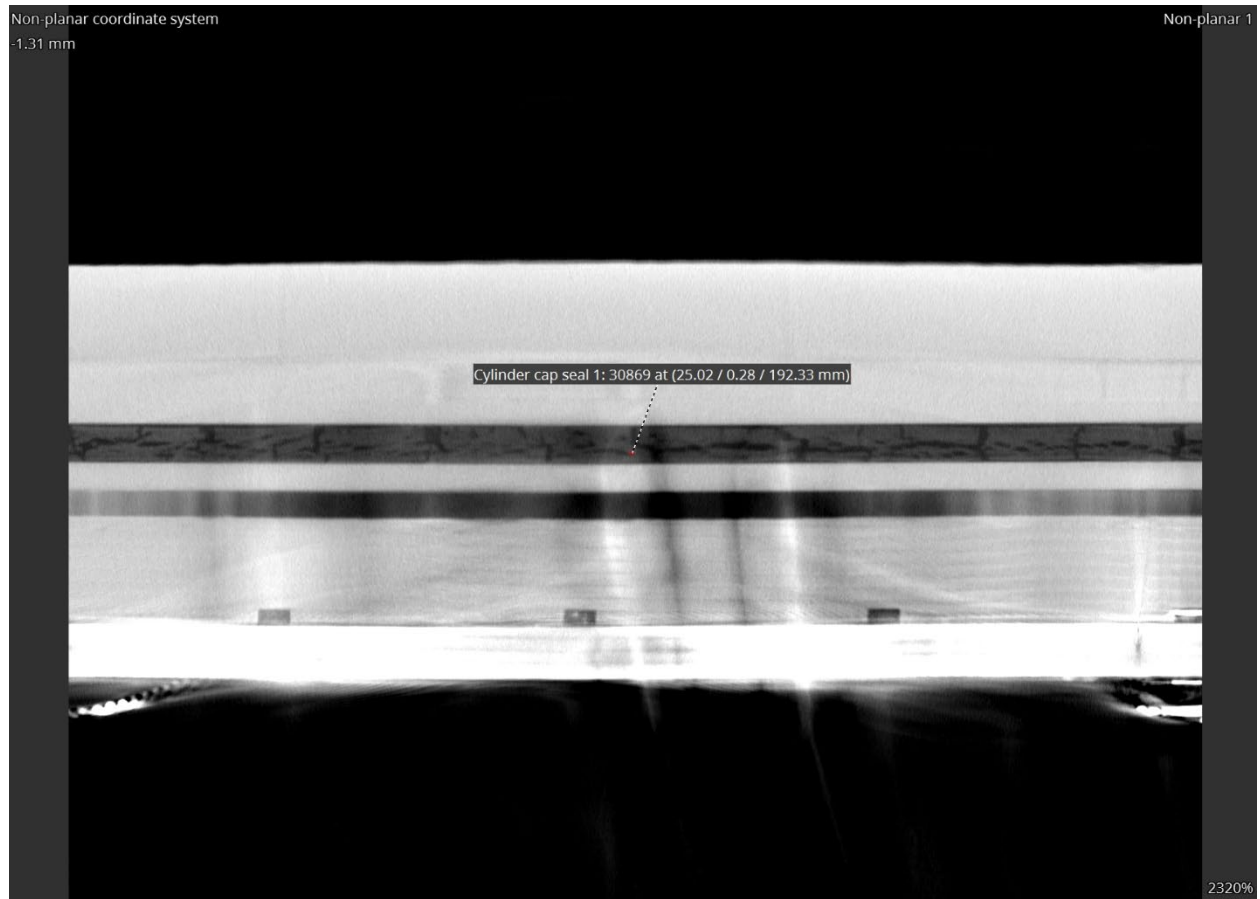


Figure 91. Right lateral actuator - cylinder assembly - cylinder cap seal 1 unrolled. (225 kV)

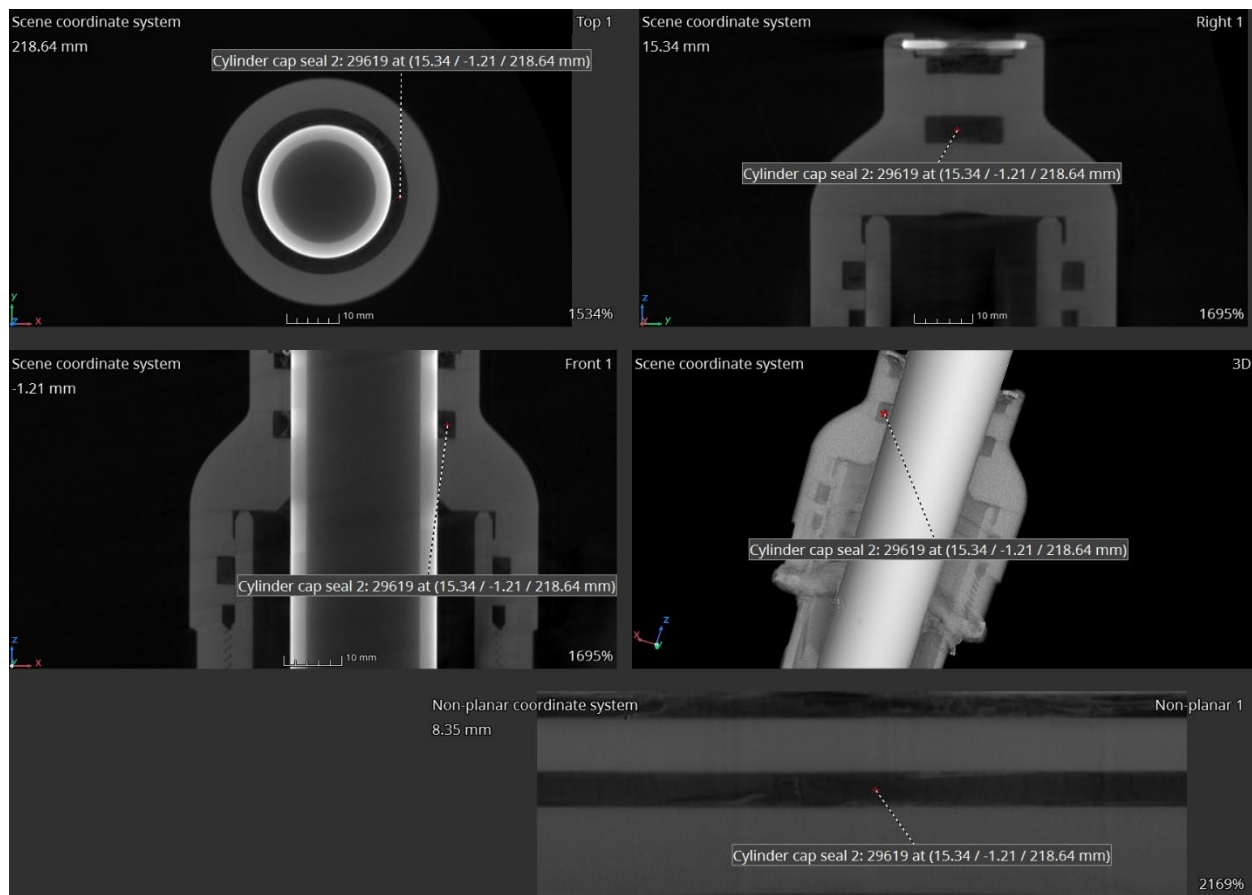


Figure 92. Right lateral actuator - cylinder assembly - cylinder cap seal 2. (225 kV)

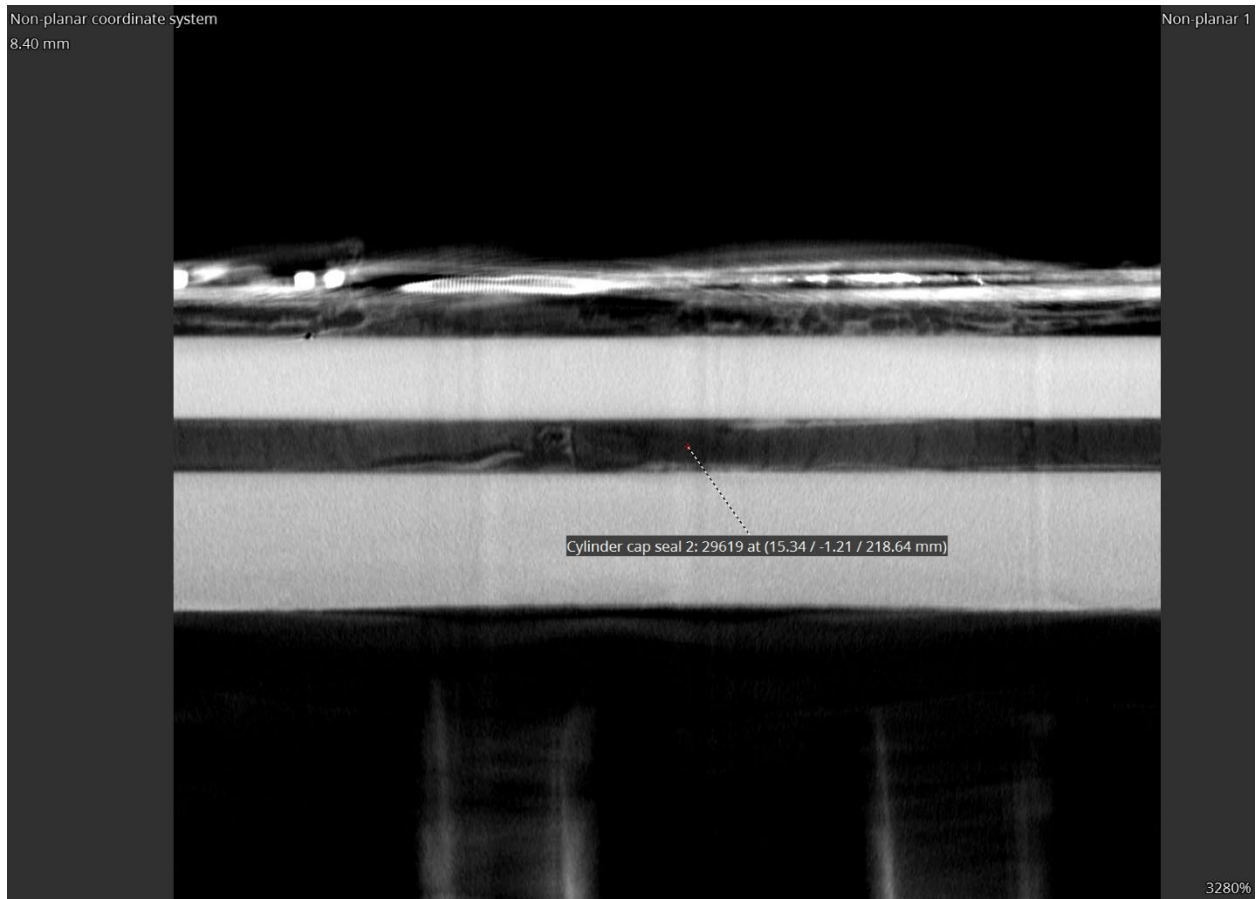


Figure 93. Right lateral actuator - cylinder assembly - cap seal 2 unrolled. (225 kV)

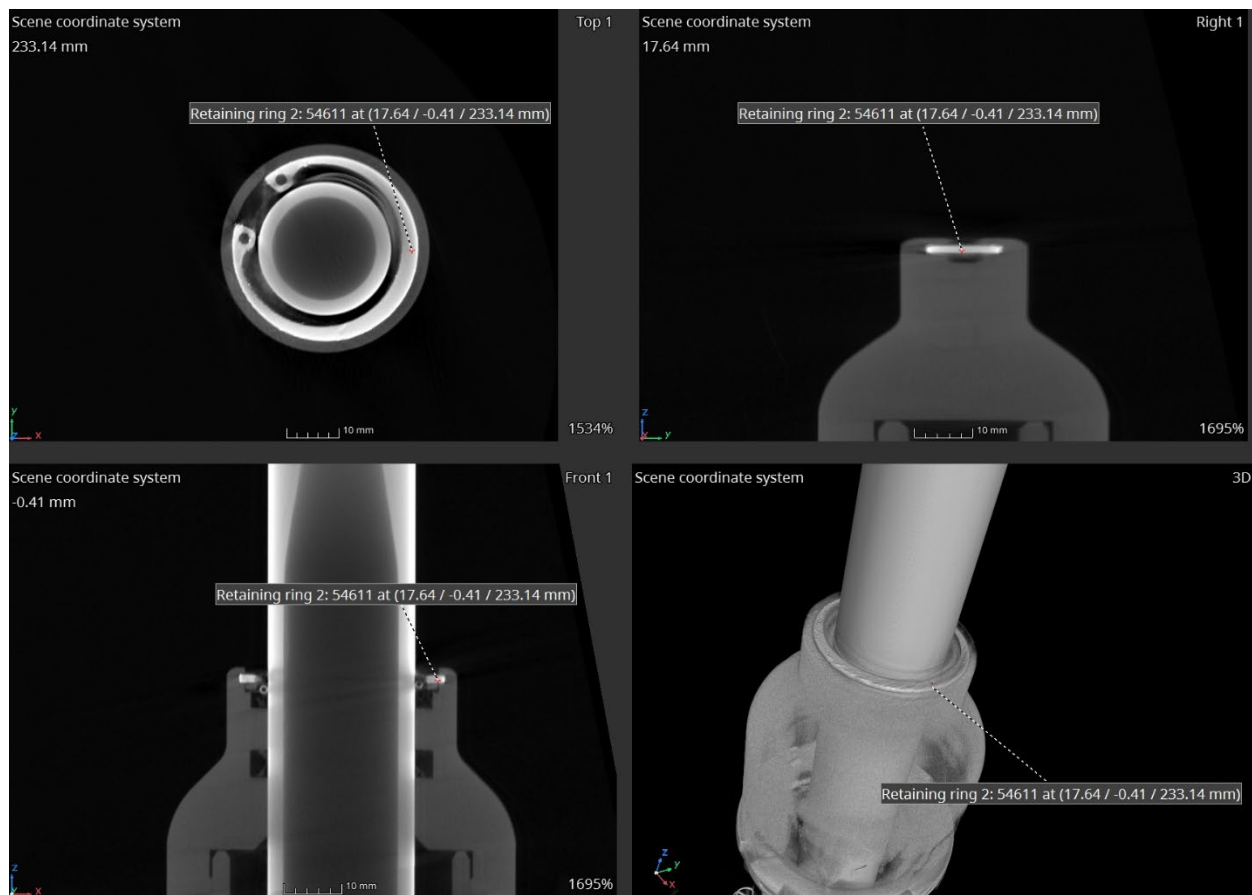


Figure 94. Right lateral actuator - cylinder assembly - retaining ring 2. (225 kV)

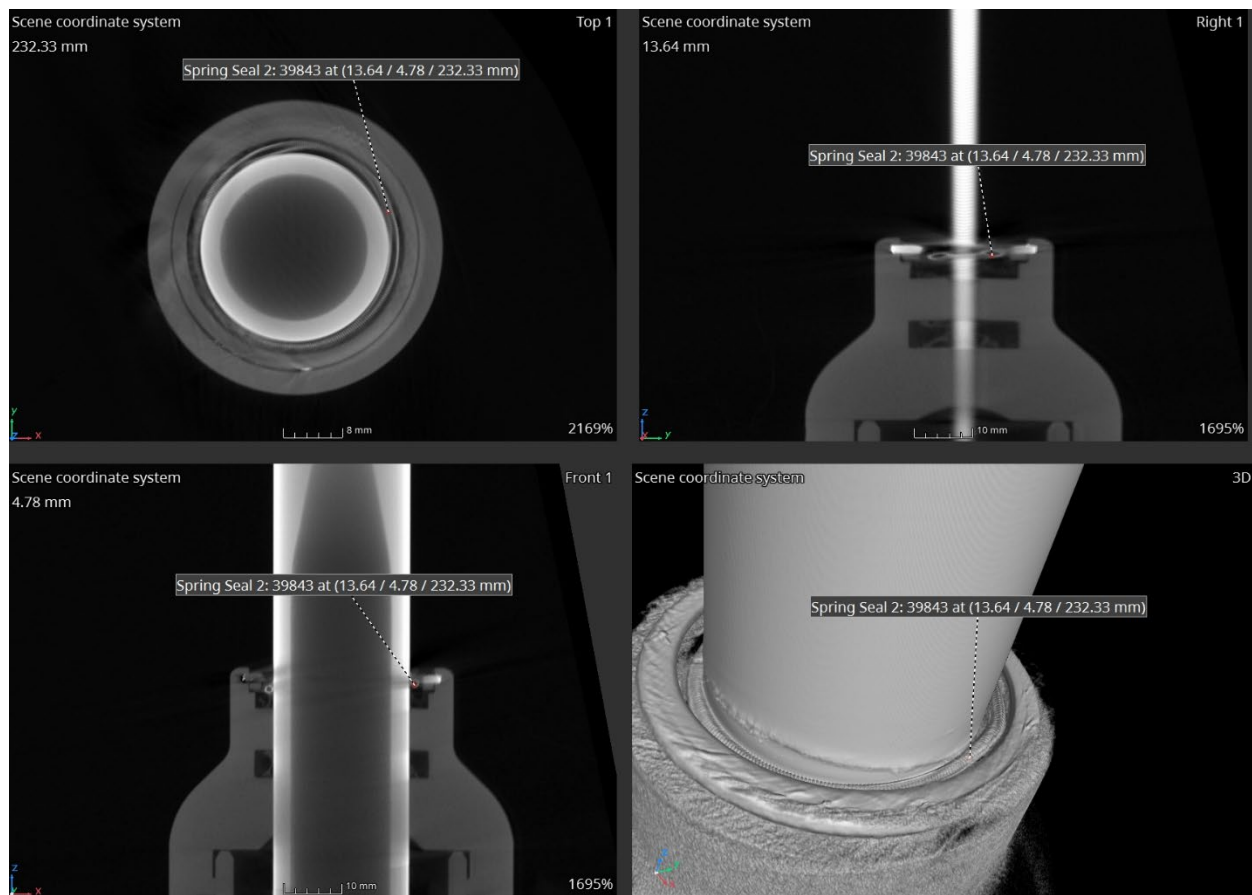


Figure 95. Right lateral actuator - cylinder assembly - spring seal 2. (225 kV)

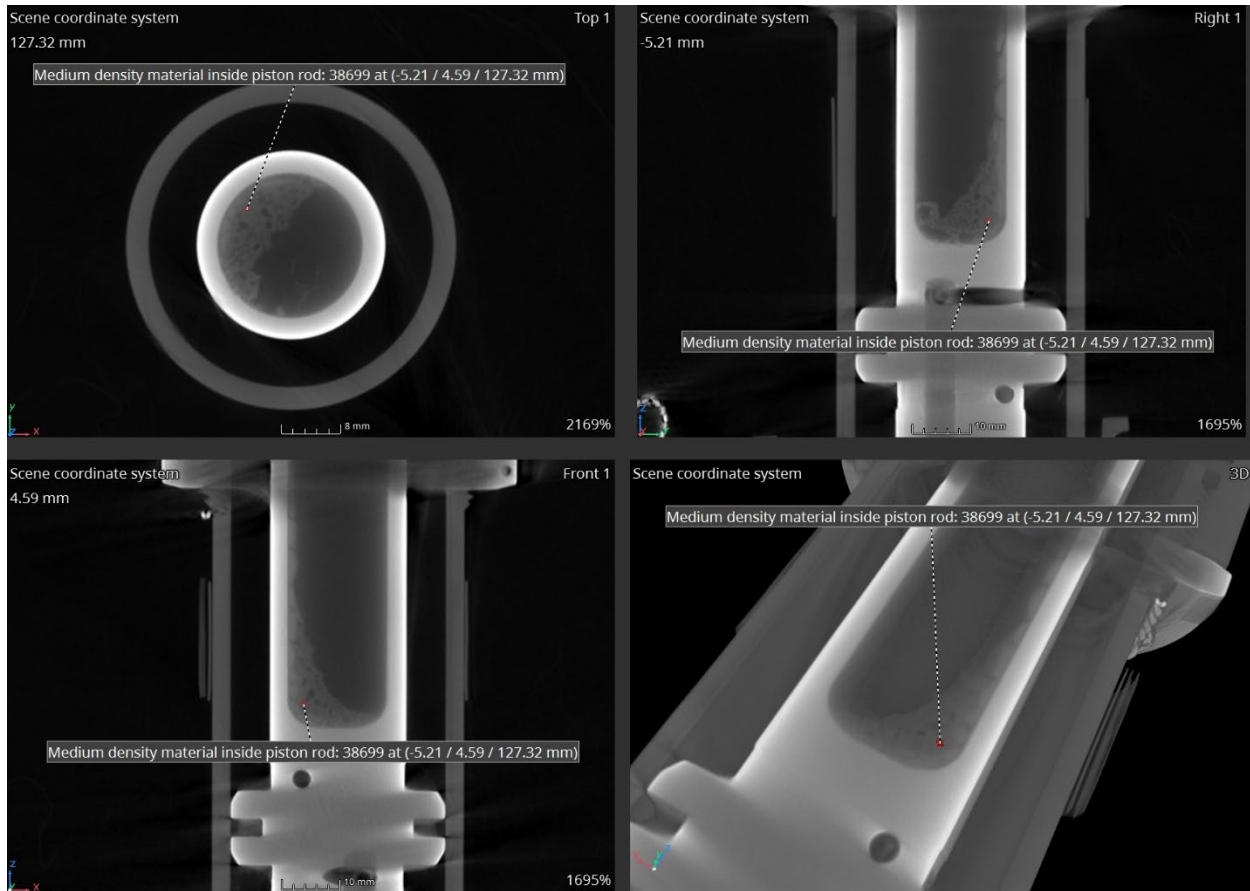


Figure 96. Right lateral actuator - cylinder assembly - medium density material inside piston rod. (225 kV)

3.3 Left Lateral Actuator Cylinder Assembly

The computed tomography (CT) results for the left lateral actuator are shown in Figures 97 through 125. Review of the images indicated that, when the scans were conducted, the following indications were noted:

1. There were indications of medium and high density particles and/or material in several locations within the left lateral actuator. (Figures 104, 105, 109, 110, 111, 112, 113, 124, and 125)
2. There were indications of gaps and distortions in the seals in the cylinder cap within the left lateral actuator. (Figures 114, 115, 116, and 117)
3. There were indications of cracks in the cylinder cap. (Figures 120, 121, 122, and 123)

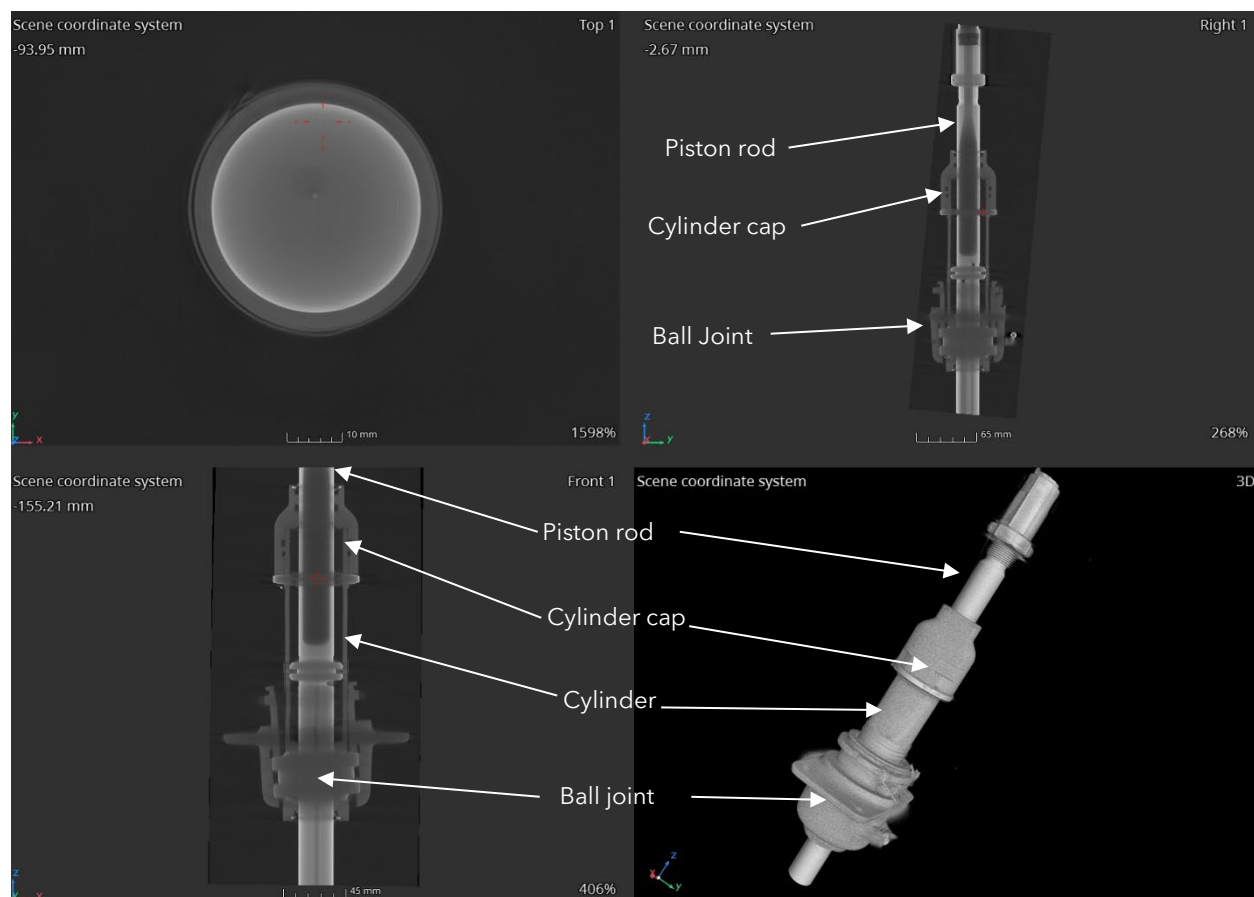


Figure 97. Left lateral actuator - overview.

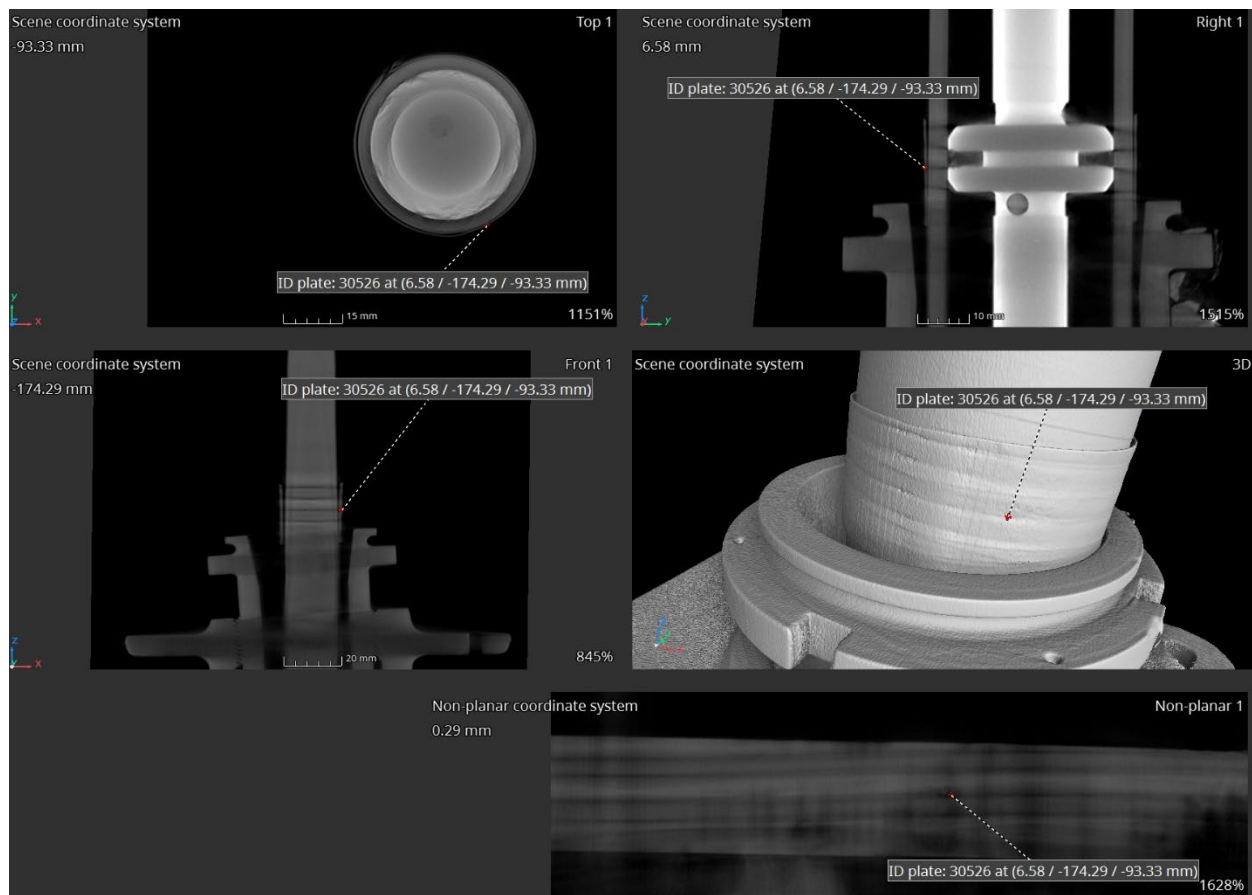


Figure 98. Left lateral actuator - cylinder assembly - ID plate.

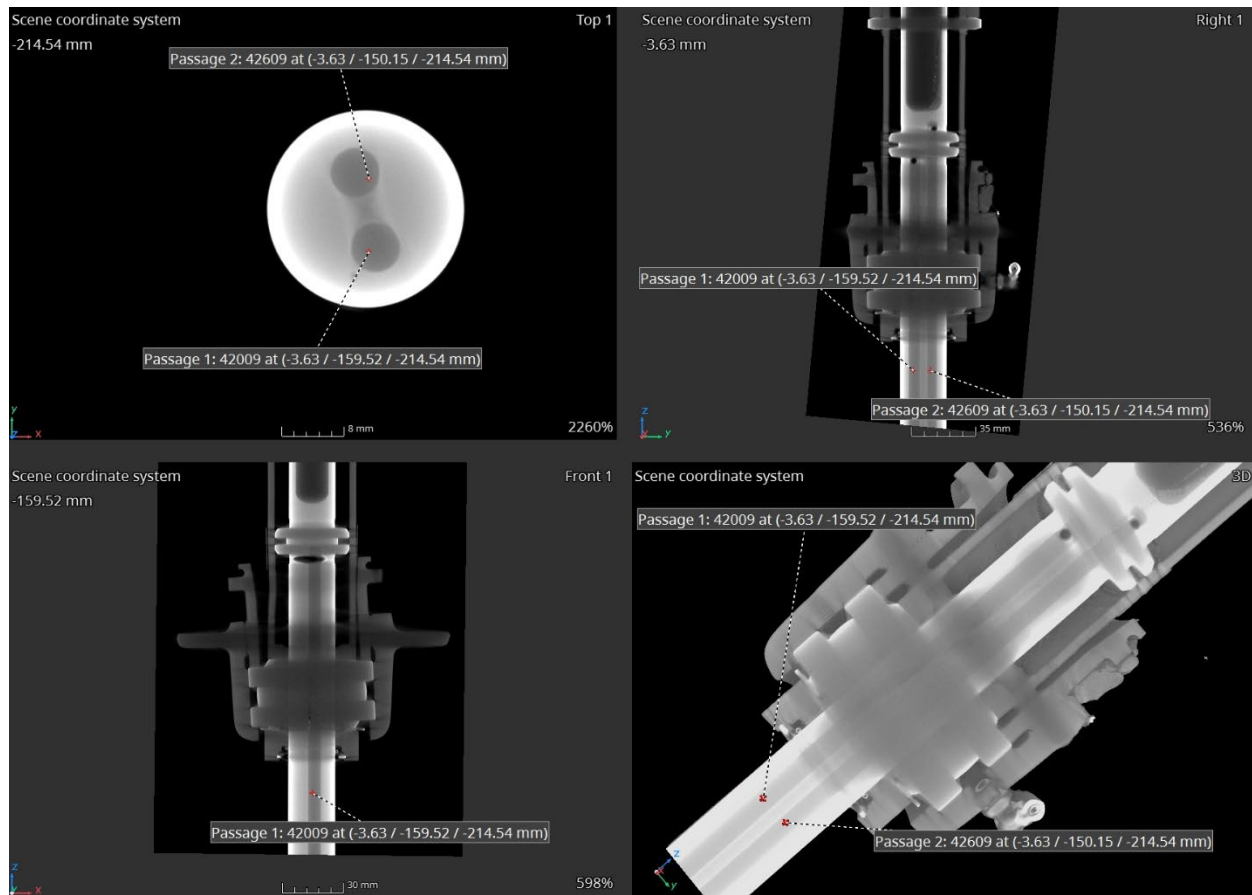


Figure 99. Left lateral actuator – cylinder assembly - hydraulic passages.

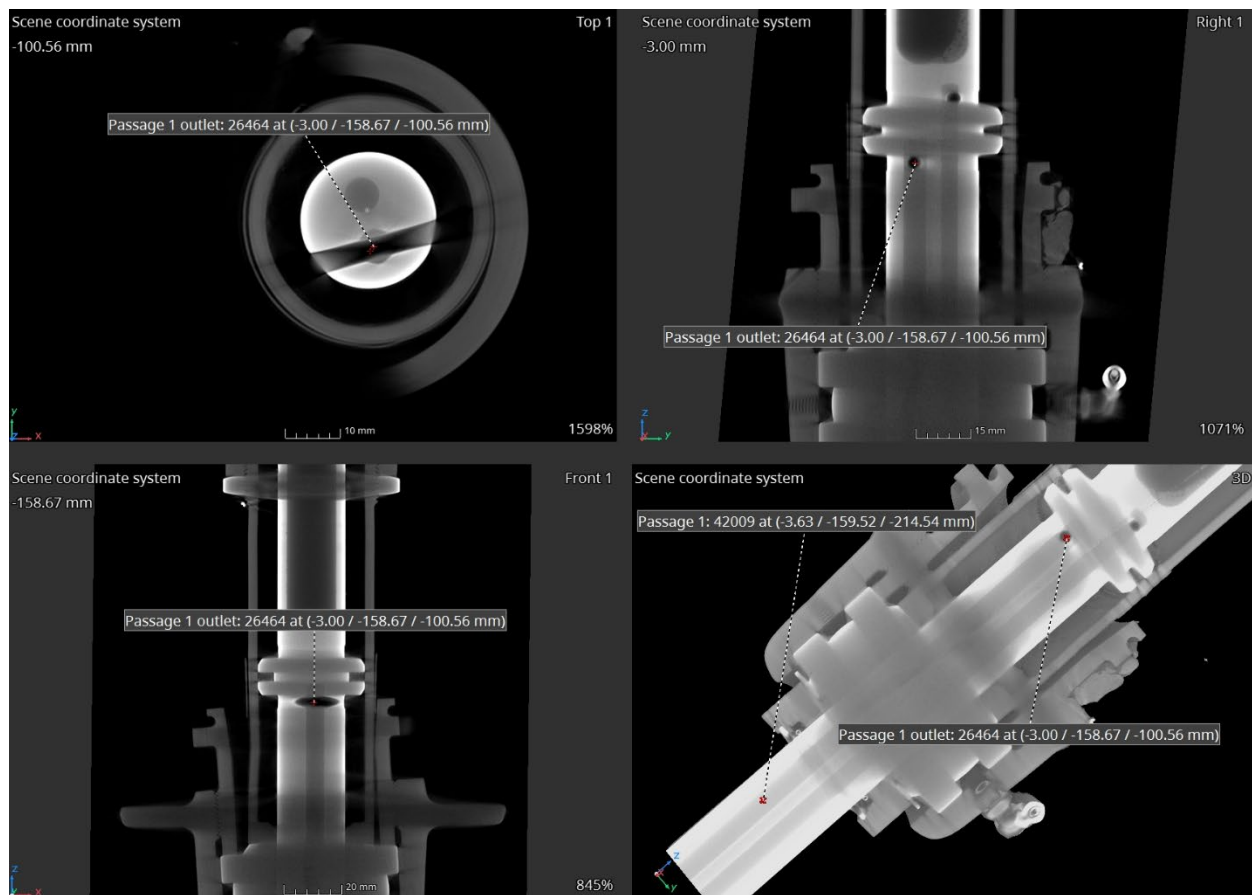


Figure 100. Left lateral actuator - cylinder assembly - passage 1 outlet.

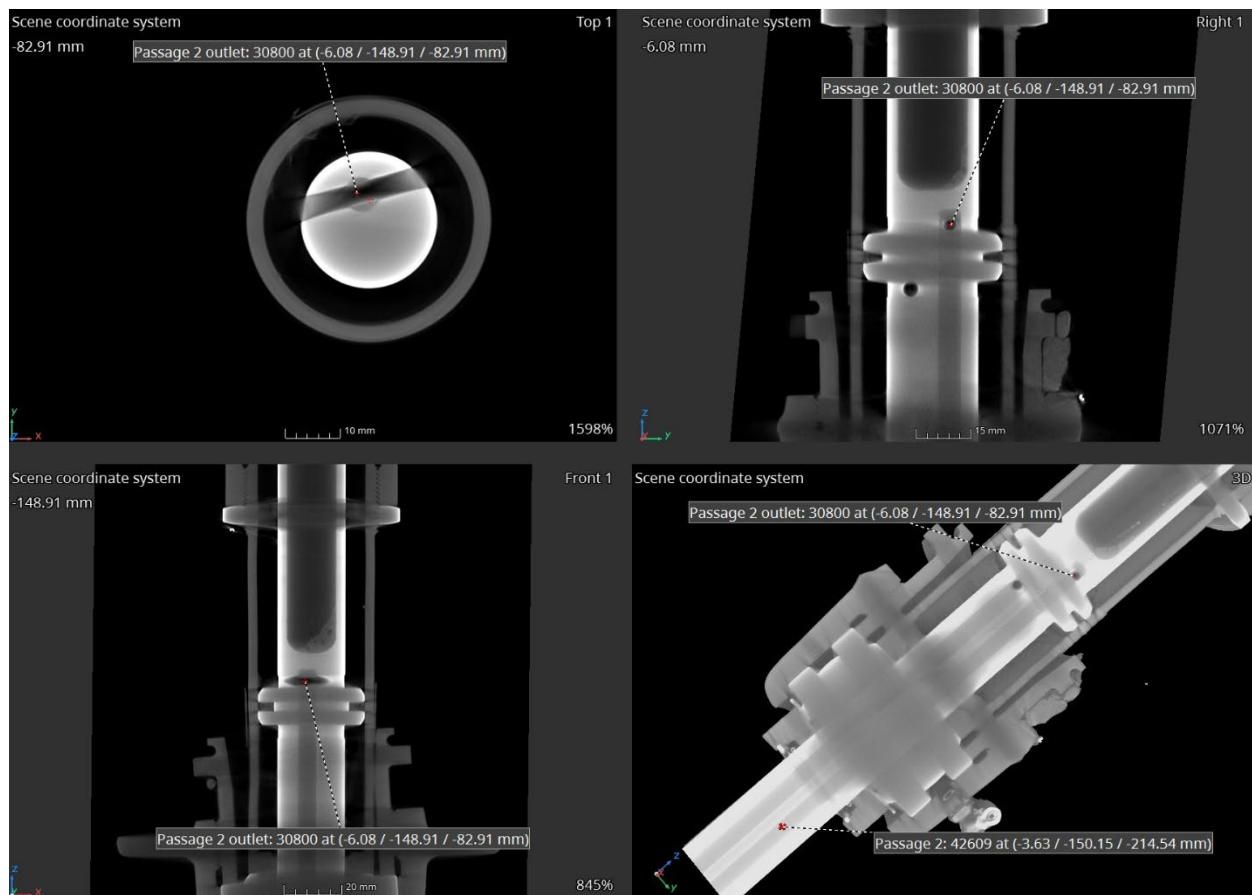


Figure 101. Left lateral actuator - cylinder assembly - passage 2 outlet.

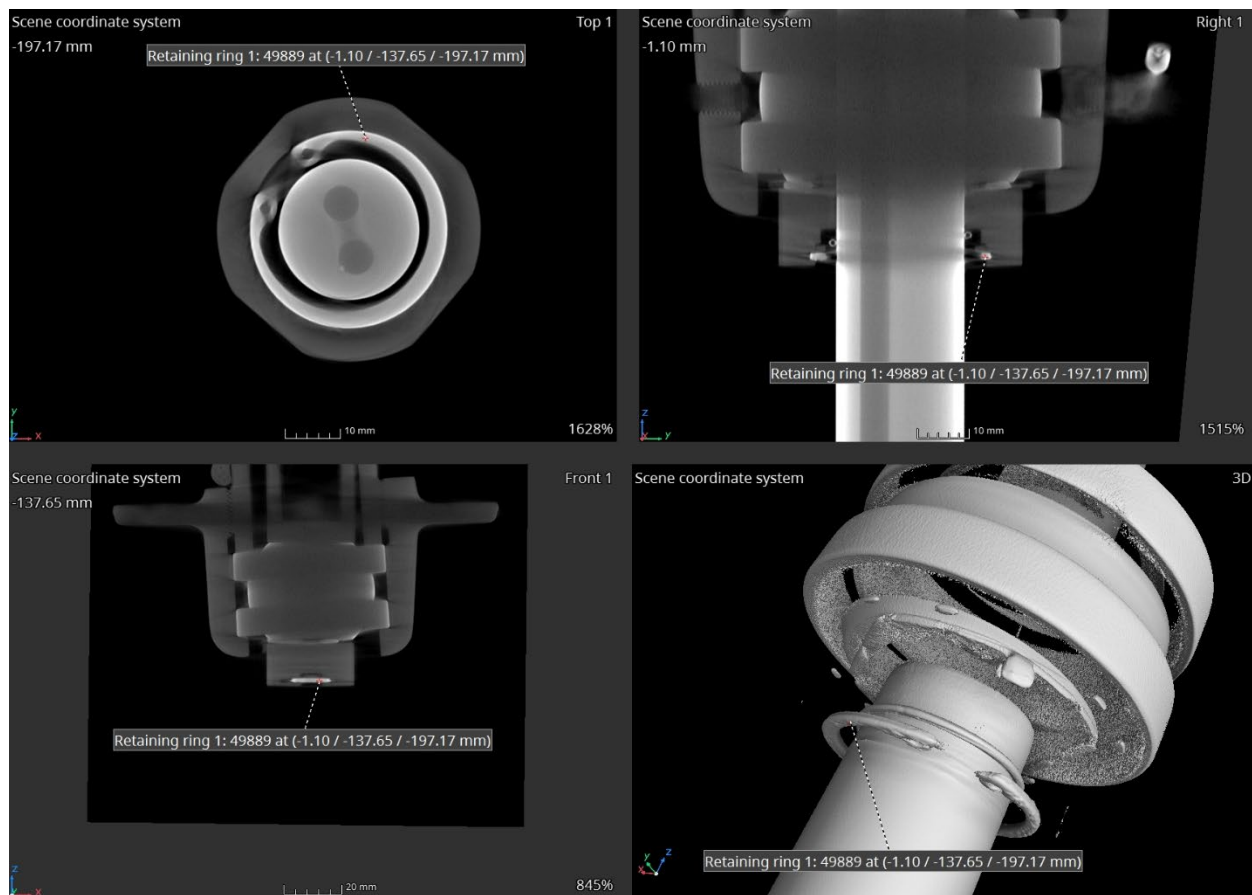


Figure 102. Left lateral actuator - cylinder assembly - retaining ring 1.

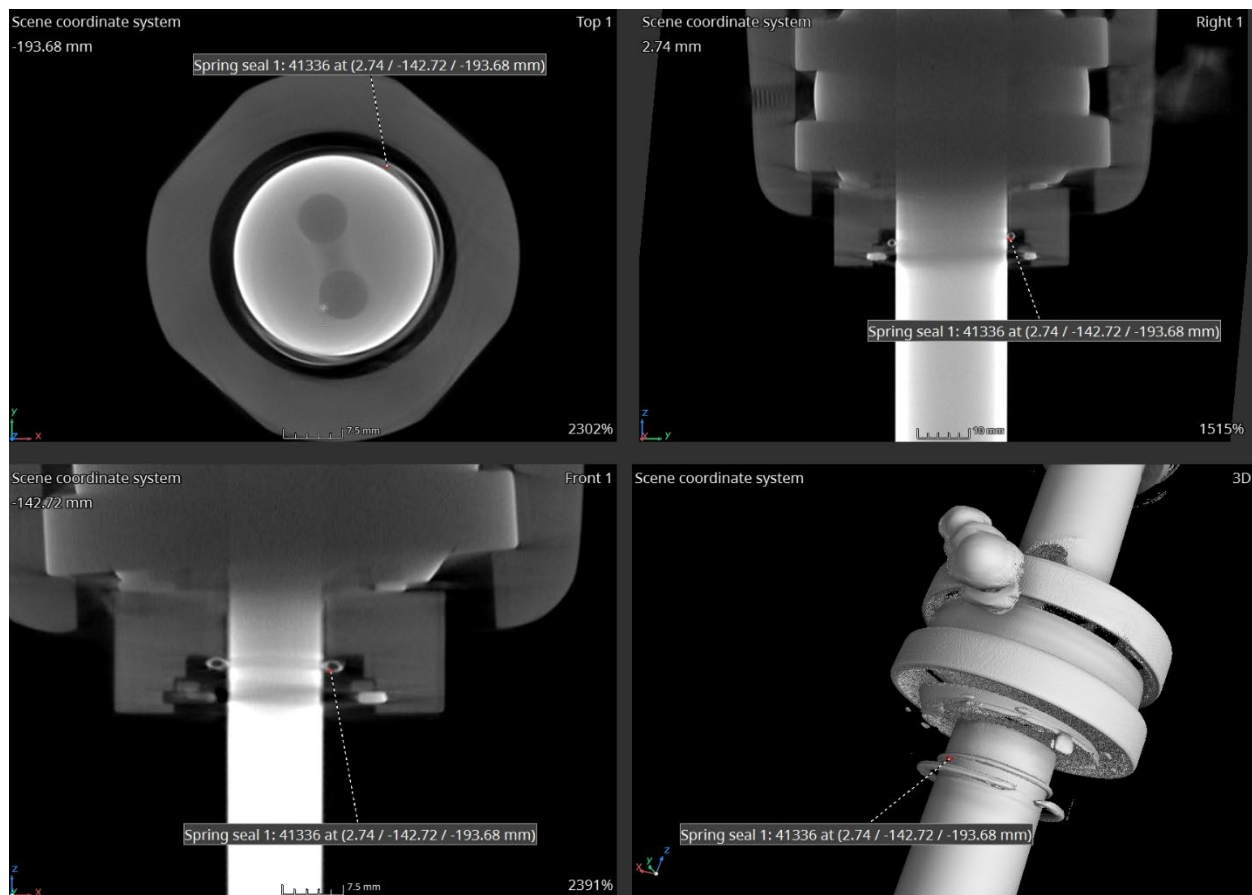


Figure 103. Left lateral actuator - cylinder assembly - spring seal 1.

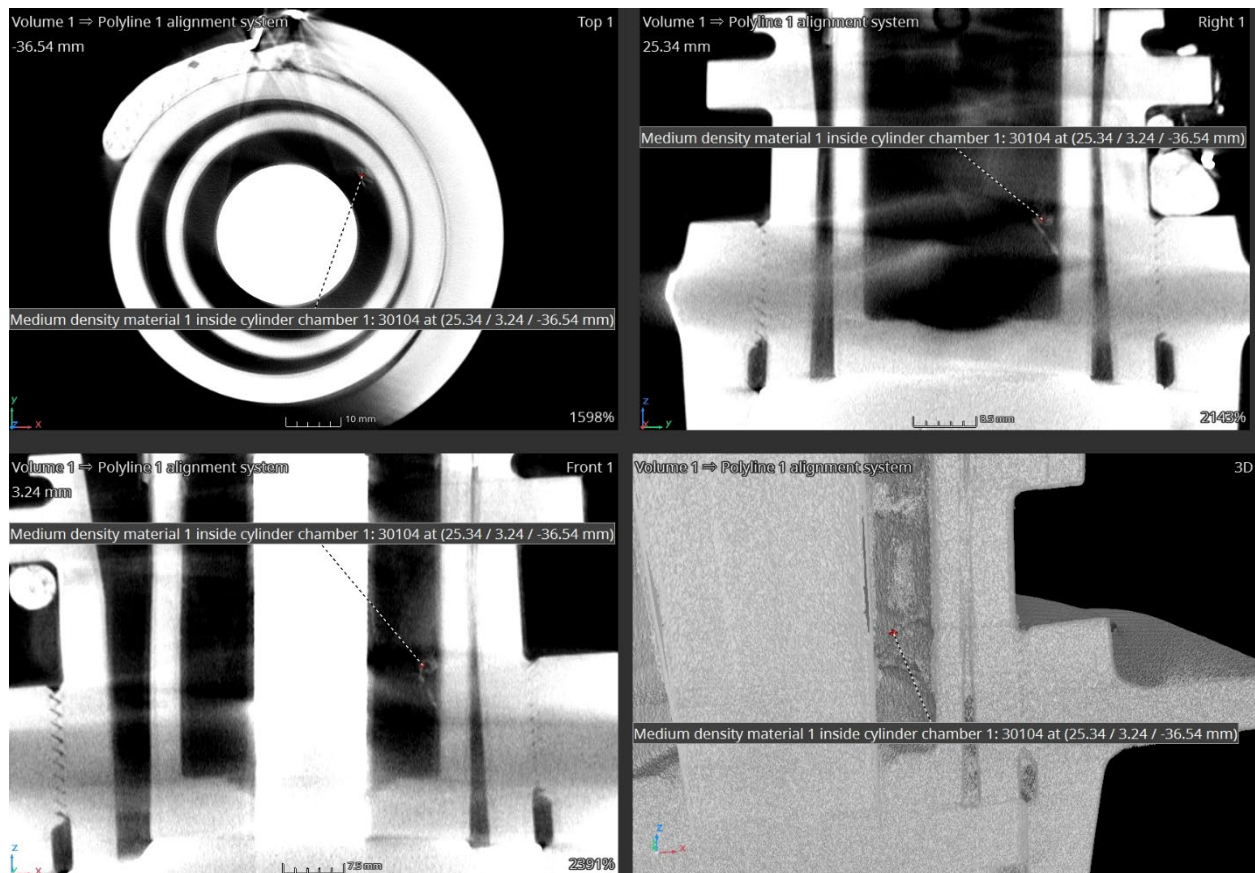


Figure 104. Left lateral actuator - cylinder assembly - medium density material inside cylinder chamber 1.

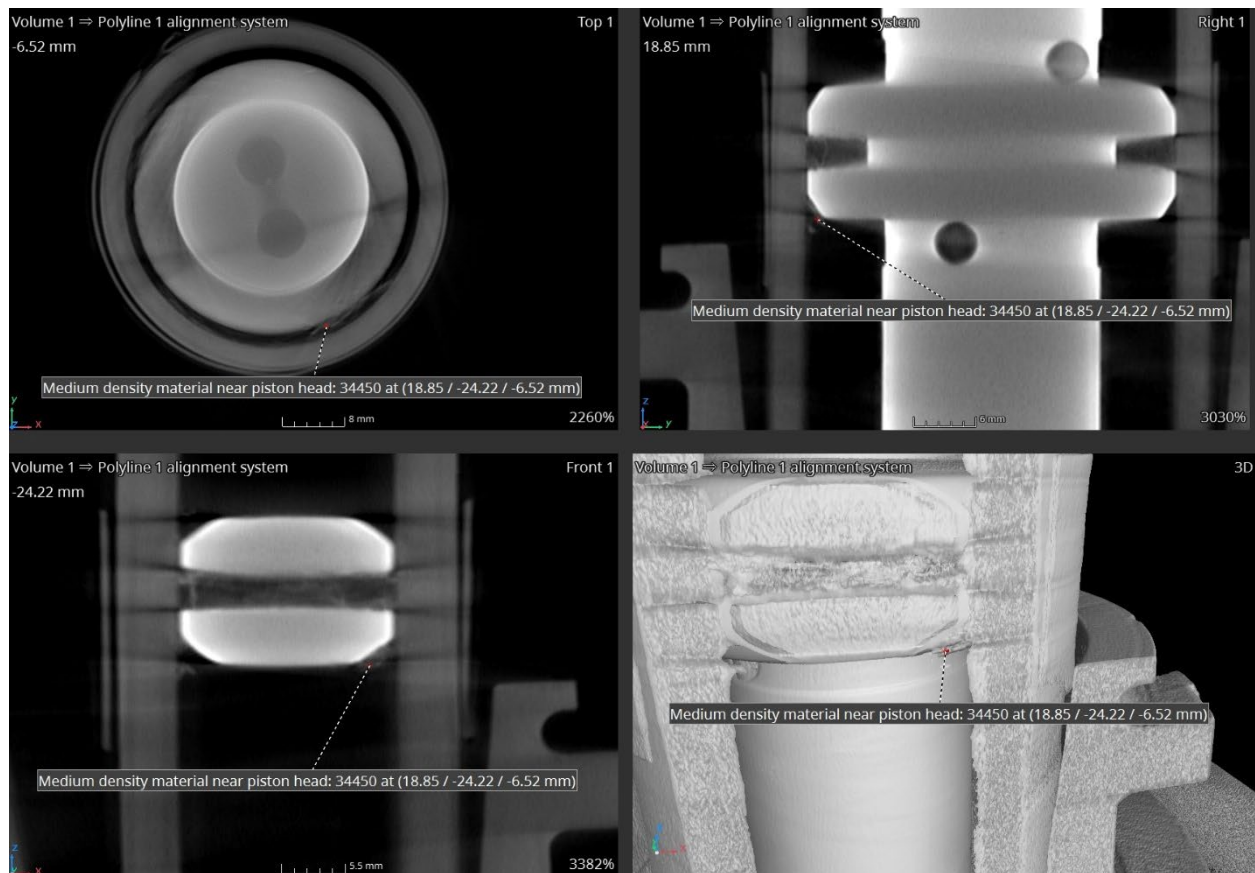


Figure 105. Left lateral actuator - cylinder assembly - medium density material near piston head inside cylinder chamber 1.

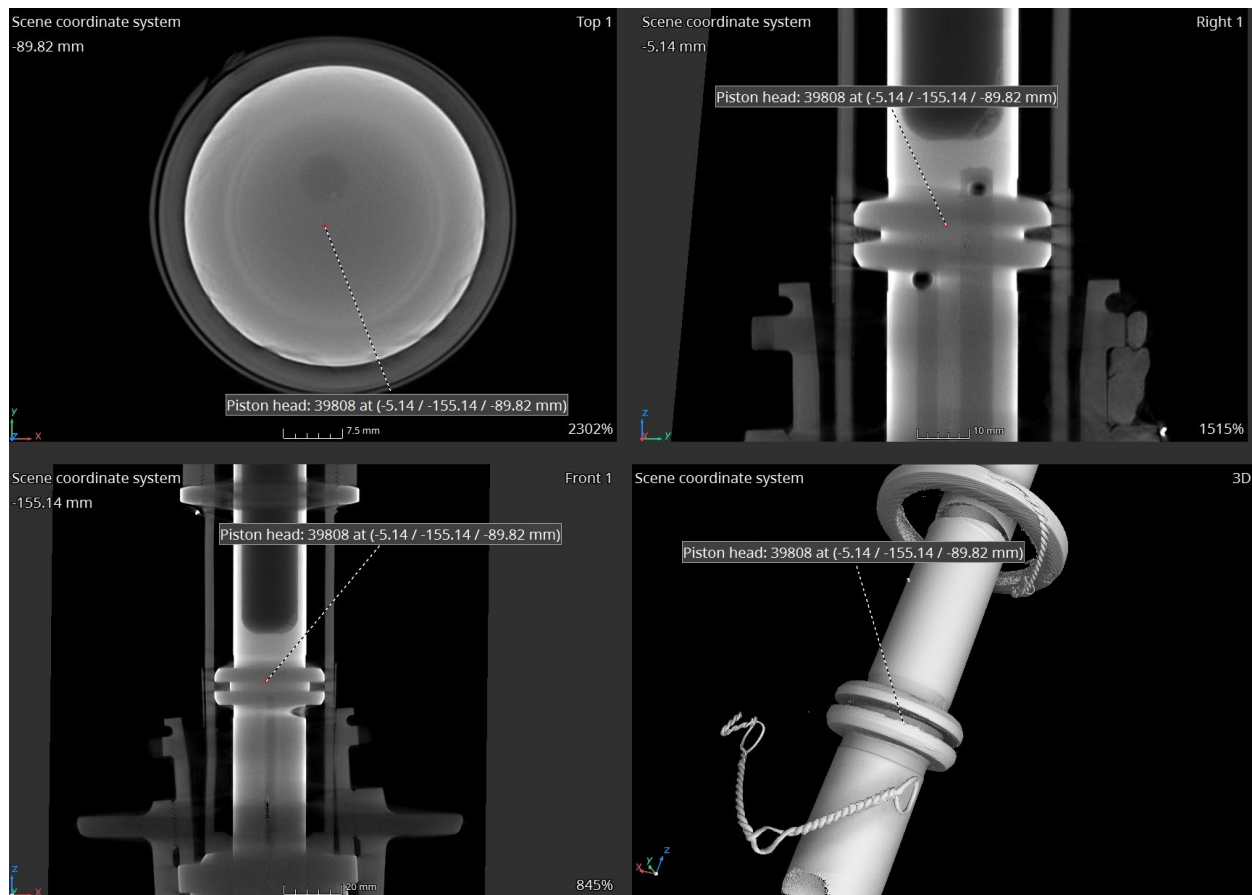


Figure 106. Left lateral actuator - cylinder assembly - piston head.

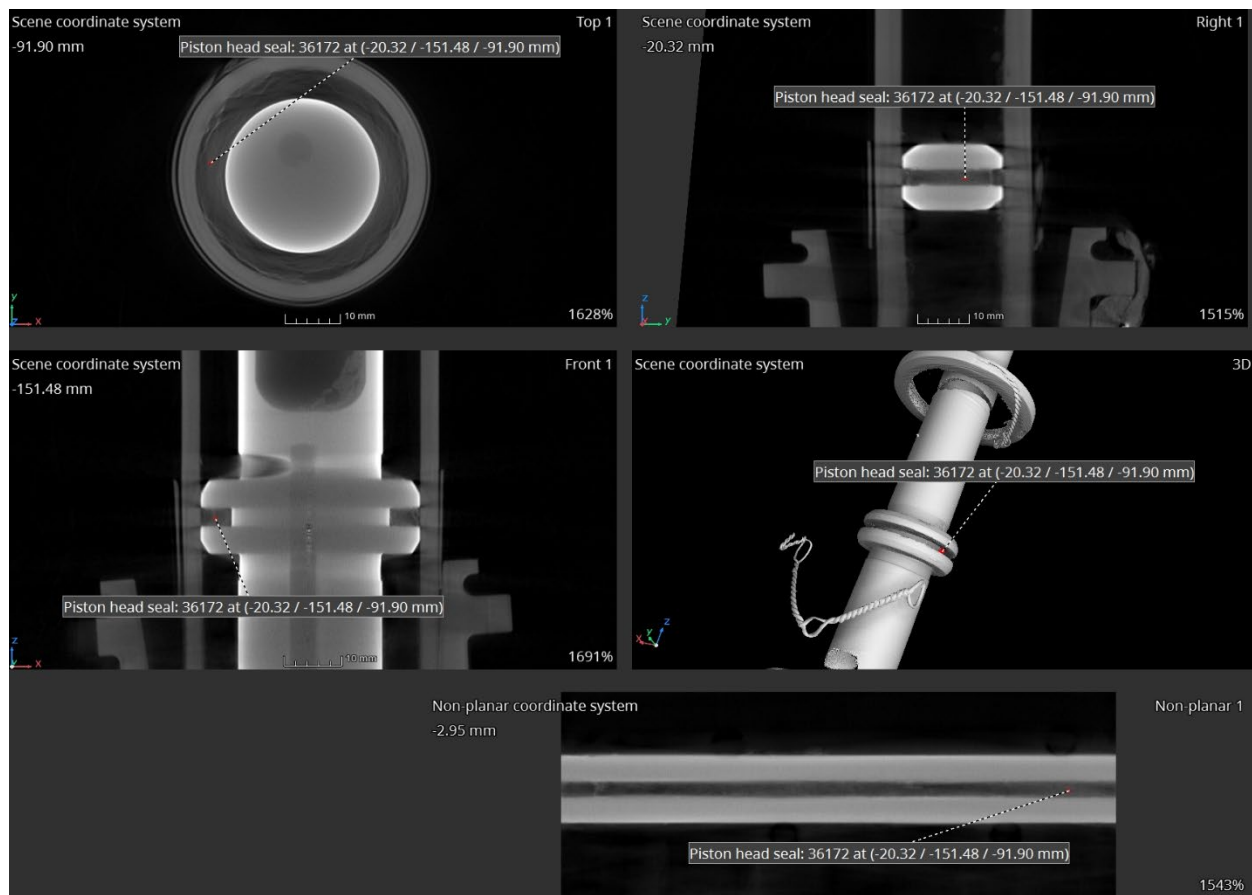


Figure 107. Left lateral actuator - cylinder assembly - piston head seal.



Figure 108. Left lateral actuator - cylinder assembly - piston head seal unrolled.

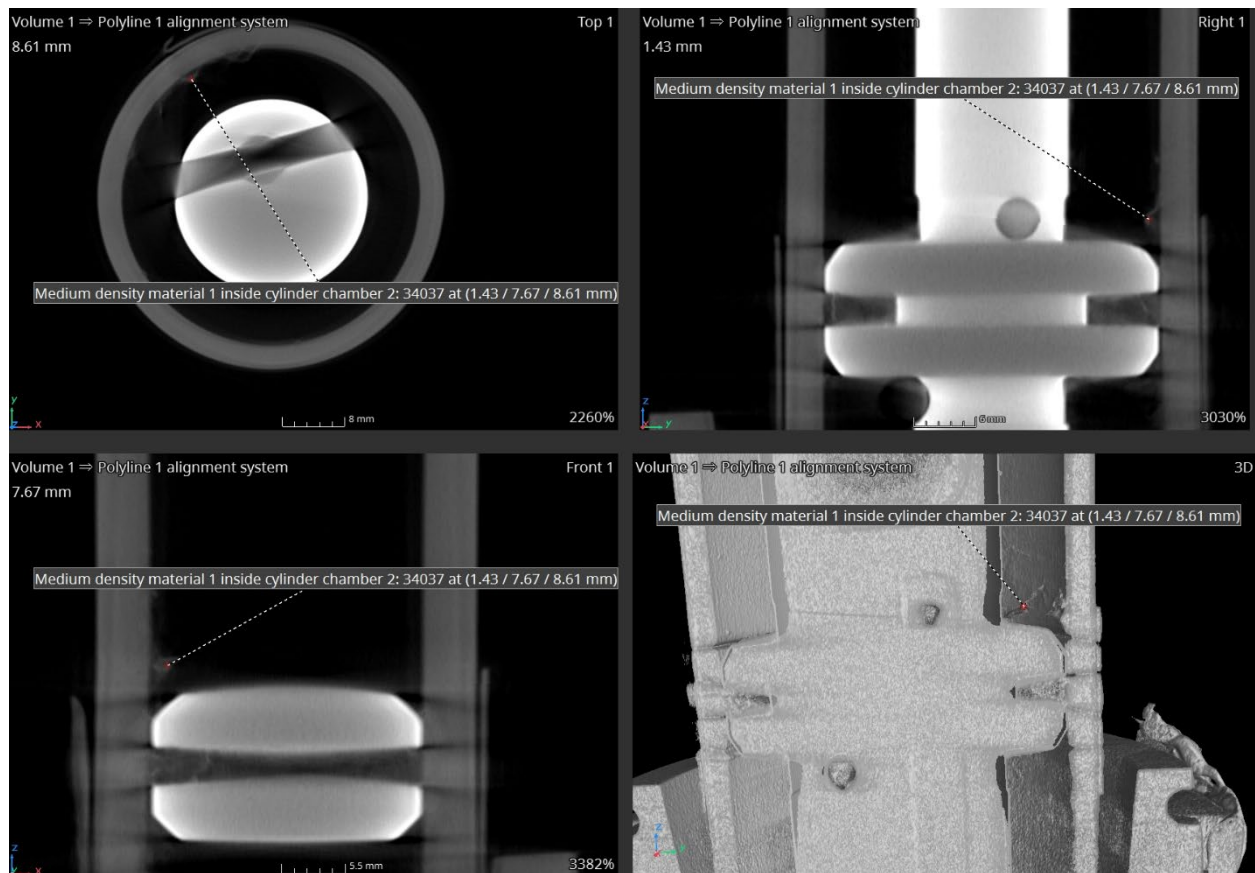


Figure 109. Left lateral actuator - cylinder assembly - medium density material 1 inside cylinder chamber 2.

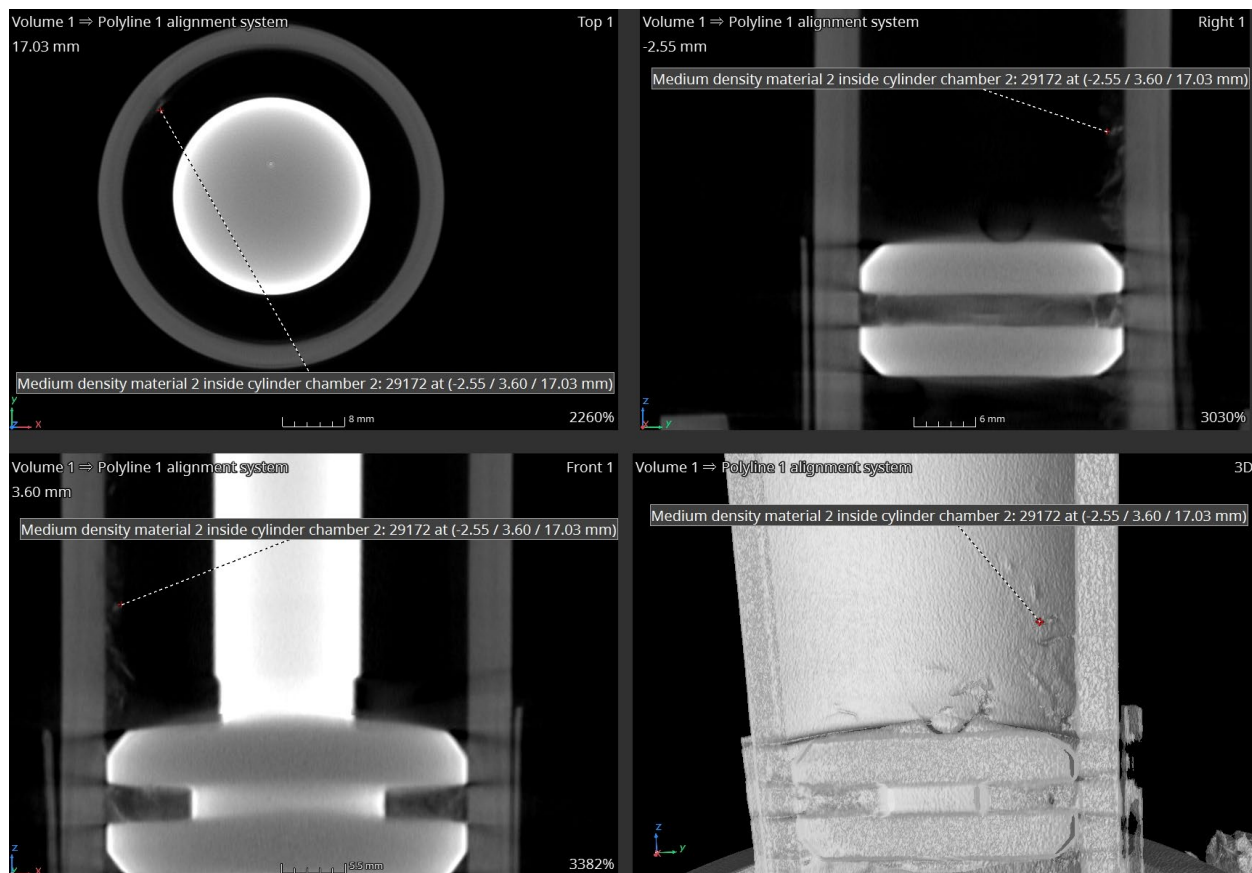


Figure 110. Left lateral actuator - cylinder assembly - medium density material 2 inside cylinder chamber 2.

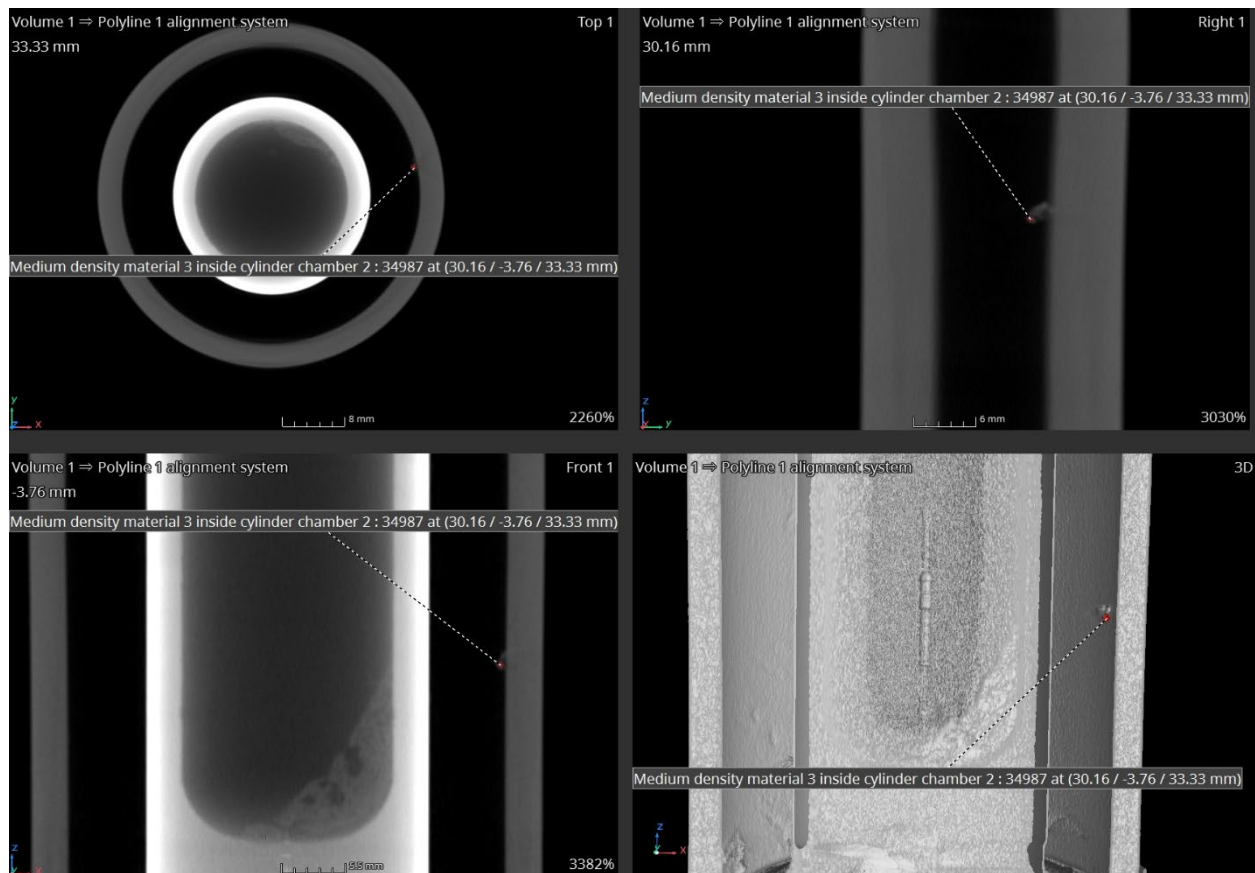


Figure 111. Left lateral actuator - cylinder assembly - medium density material 3 inside cylinder chamber 2.

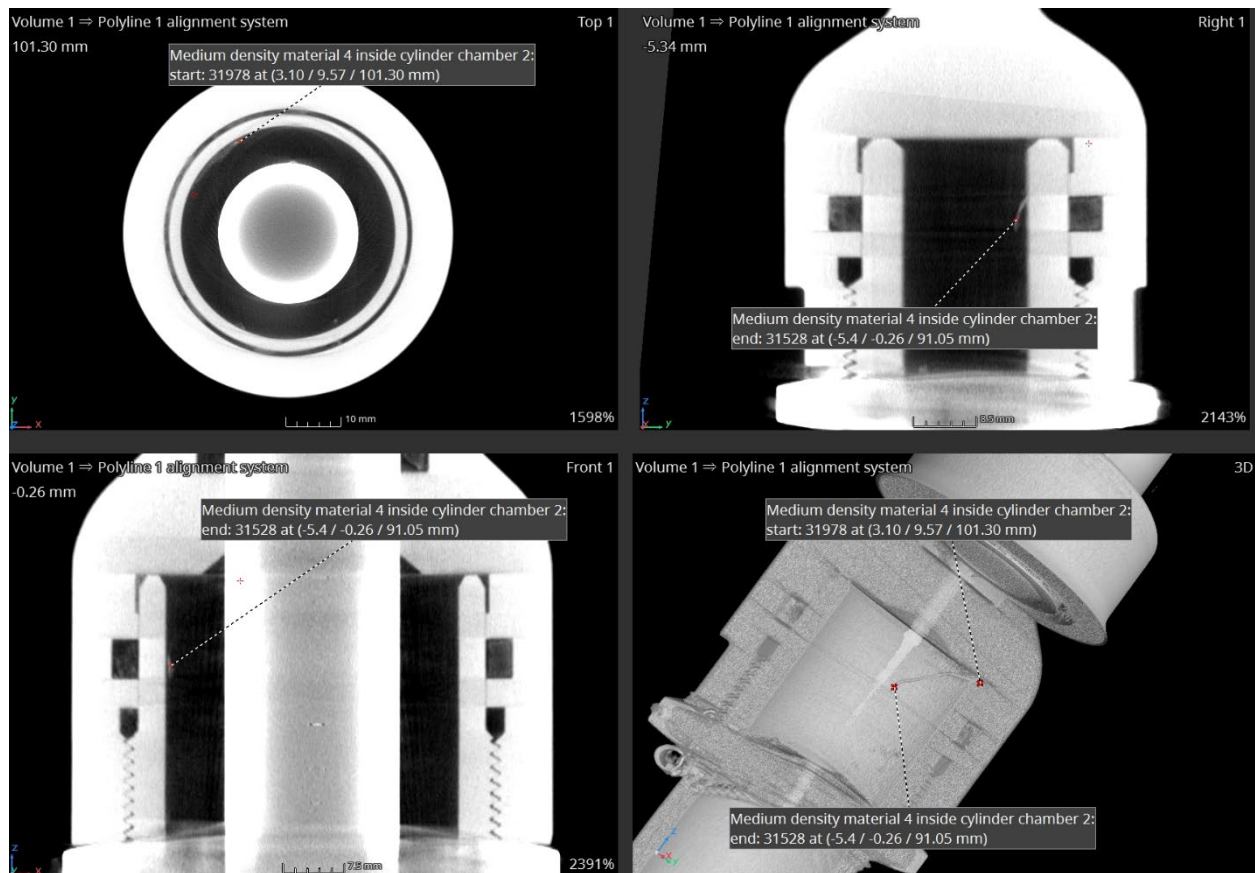


Figure 112. Left lateral actuator - cylinder assembly - medium density material 4 inside cylinder chamber 2.

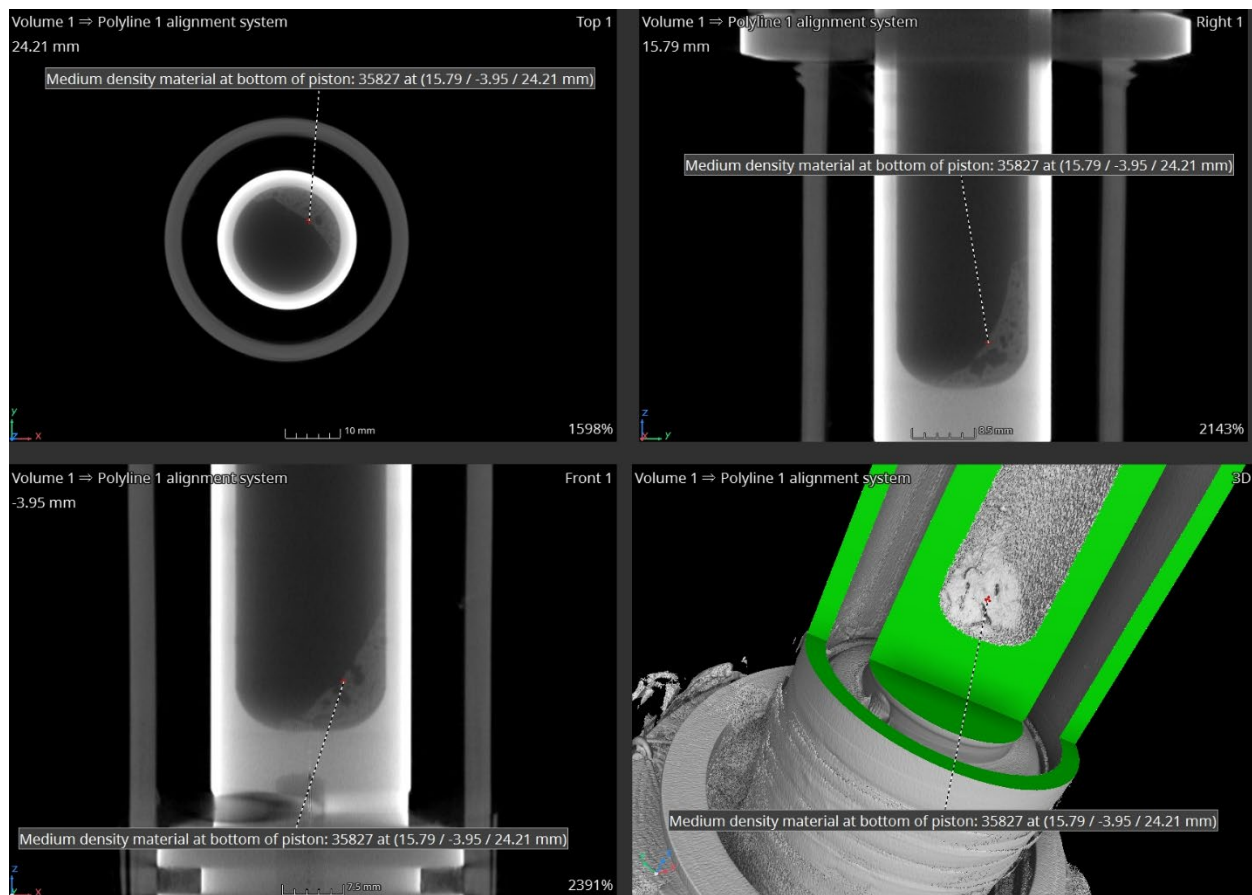


Figure 113. Left lateral actuator - medium density material at bottom of piston.

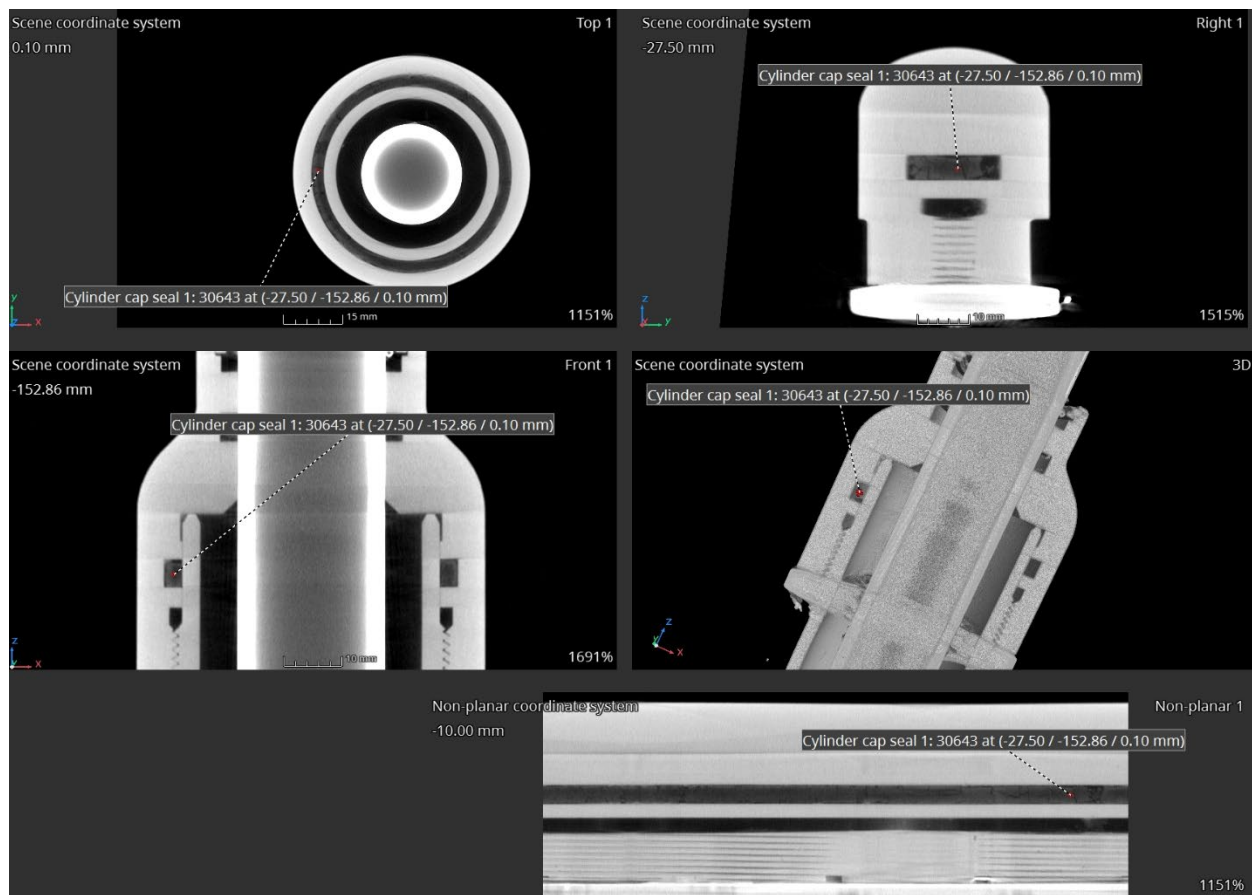


Figure 114. Left lateral actuator - cylinder assembly - cylinder cap seal 1.

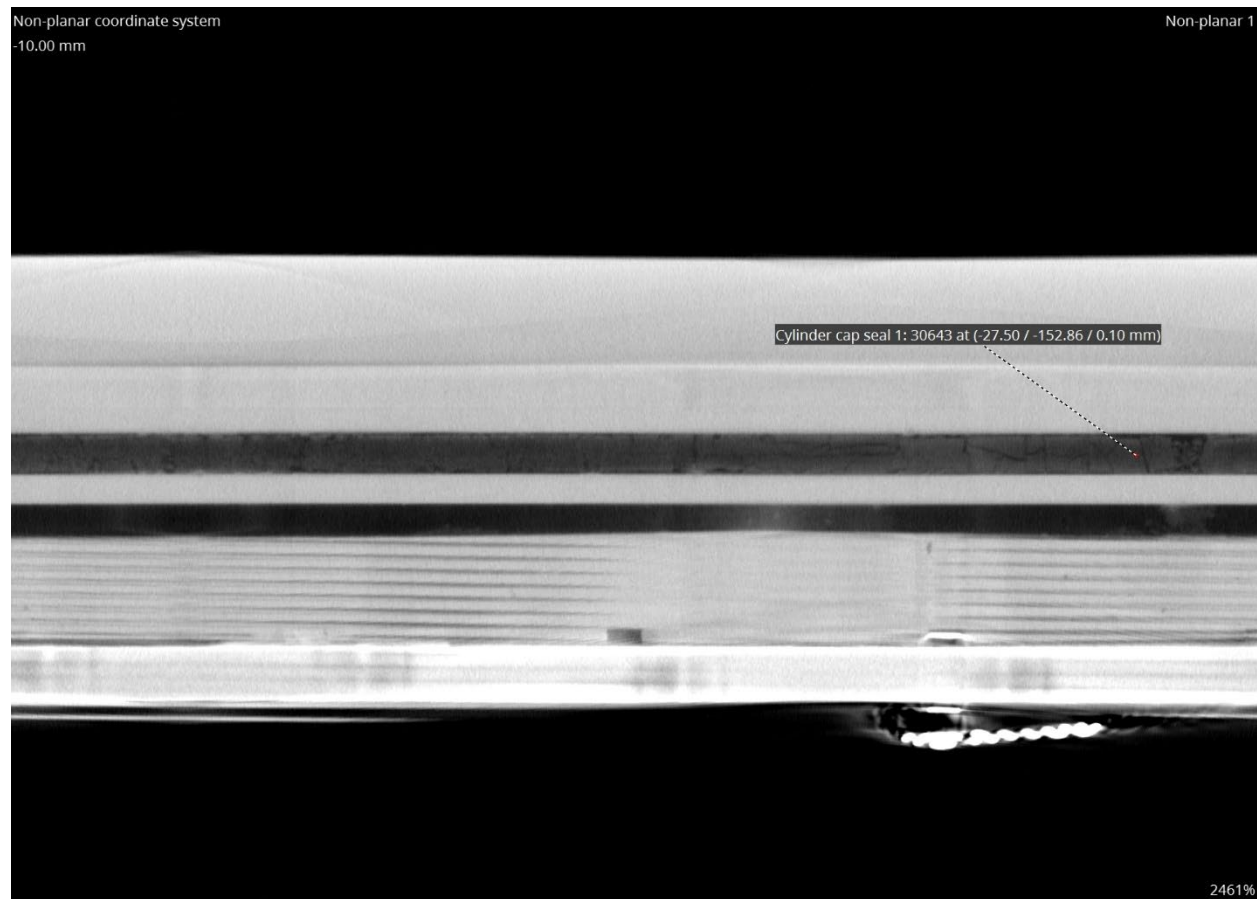


Figure 115. Left lateral actuator - cylinder assembly - cylinder cap seal 1 unrolled.

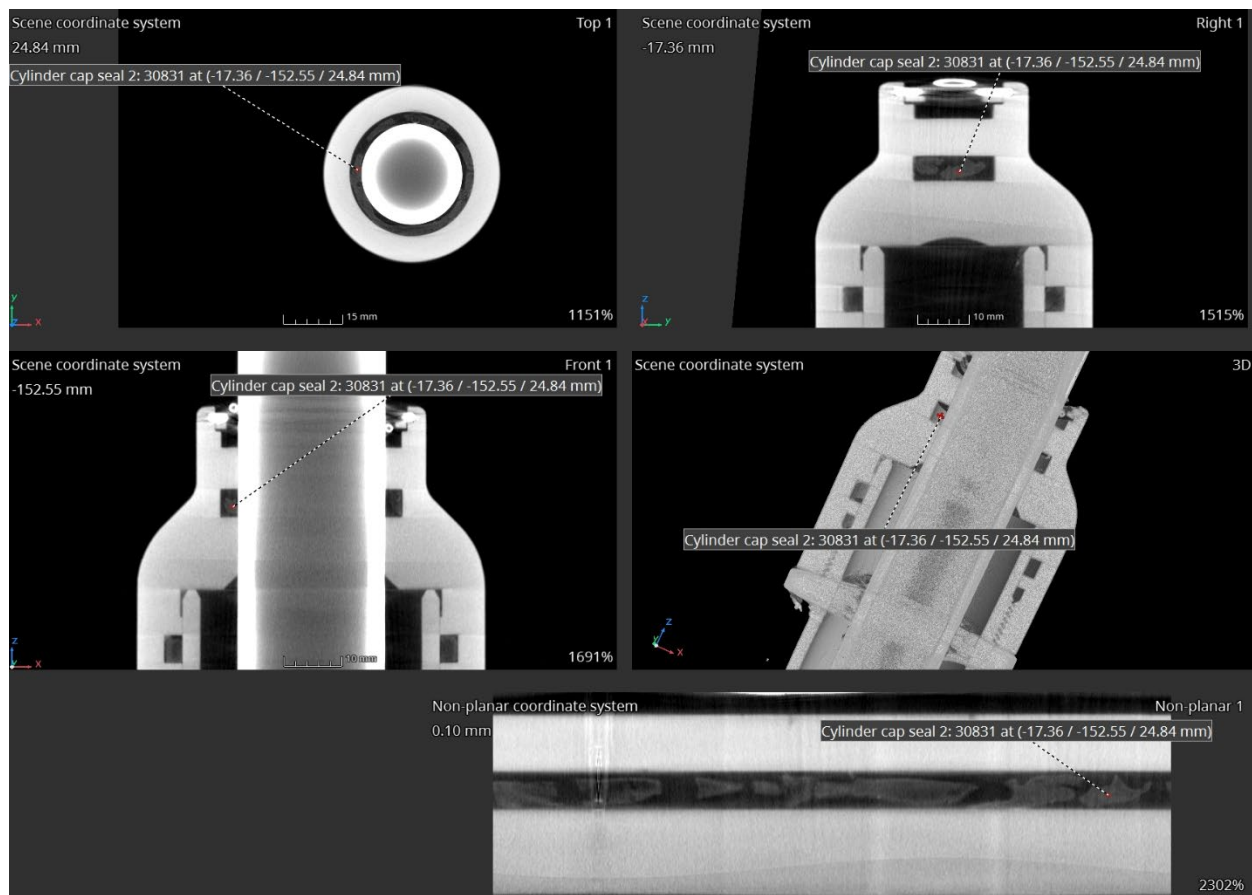


Figure 116. Left lateral actuator - cylinder assembly - cylinder cap seal 2.

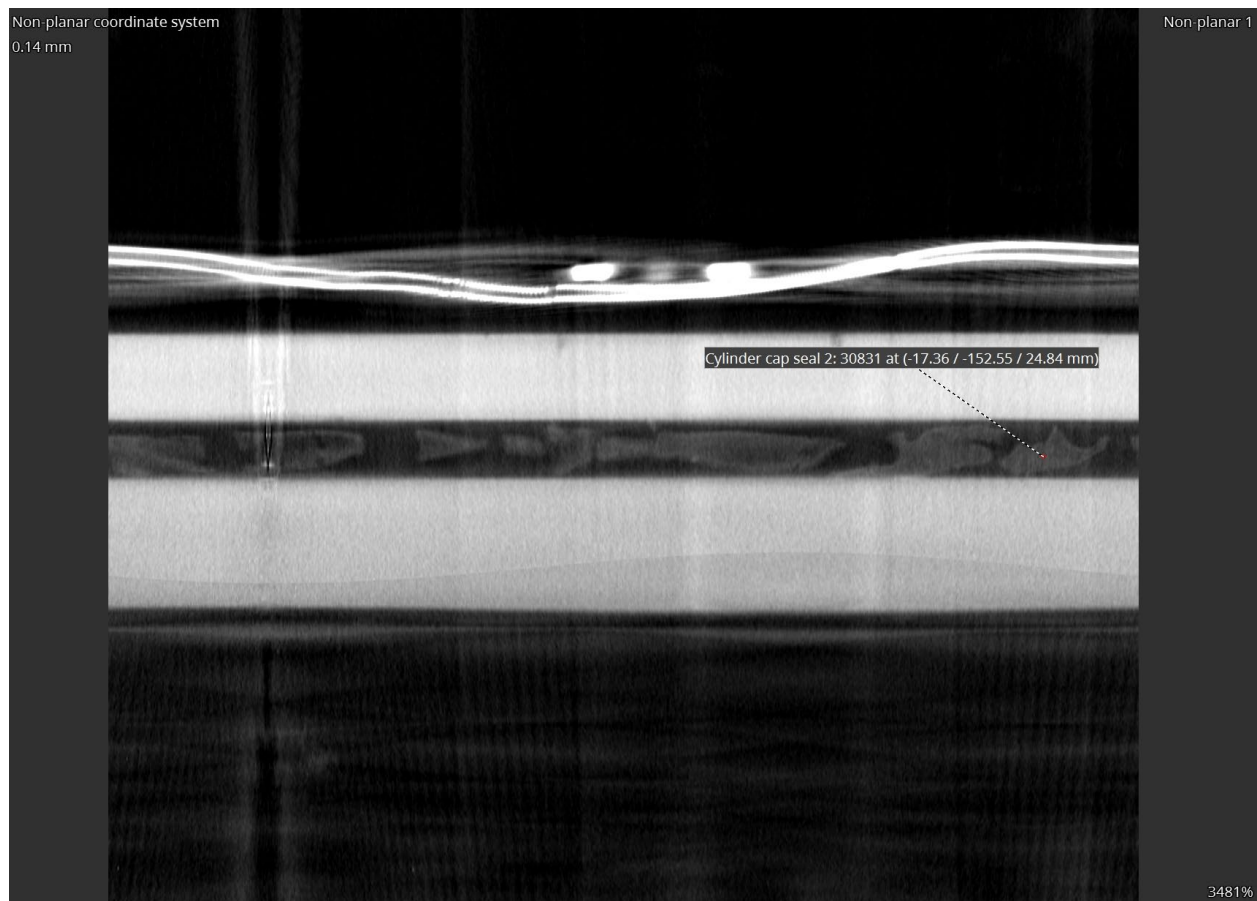


Figure 117. Left lateral actuator - cylinder assembly - cylinder cap seal 2.



Figure 118. Left lateral actuator - cylinder assembly - retaining ring 2.

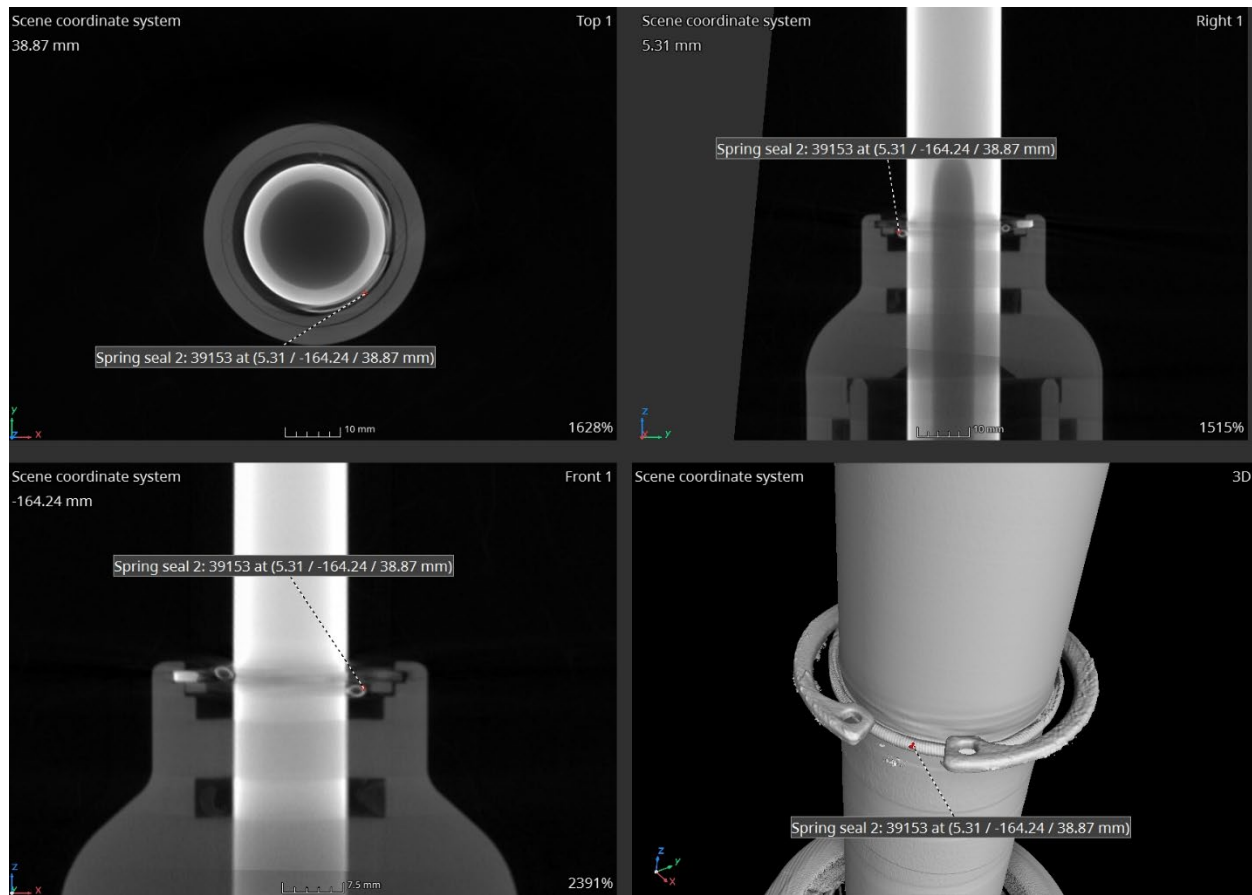


Figure 119. Left lateral actuator - cylinder assembly - spring seal 2.

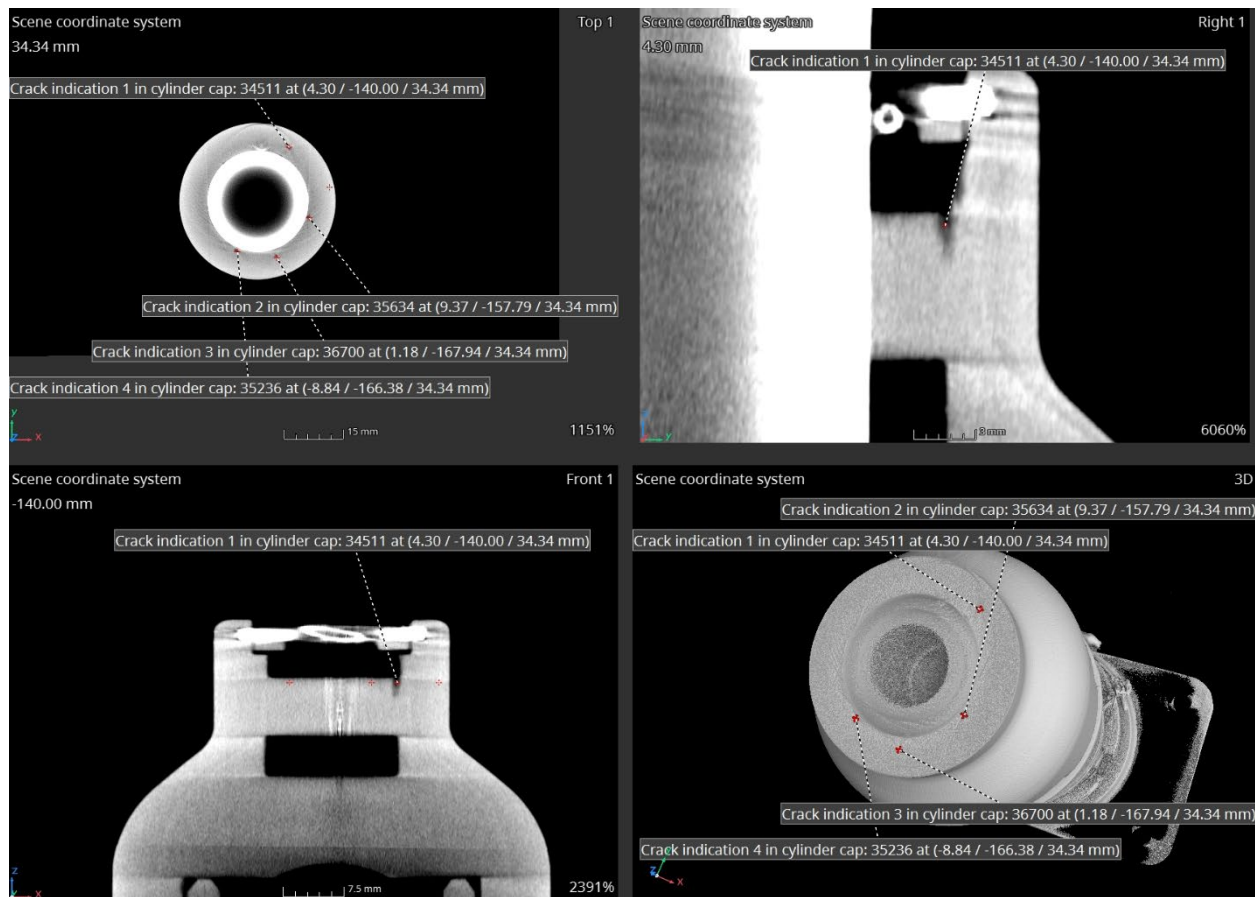


Figure 120. Left lateral actuator - cylinder assembly - crack indication 1 in cylinder cap.

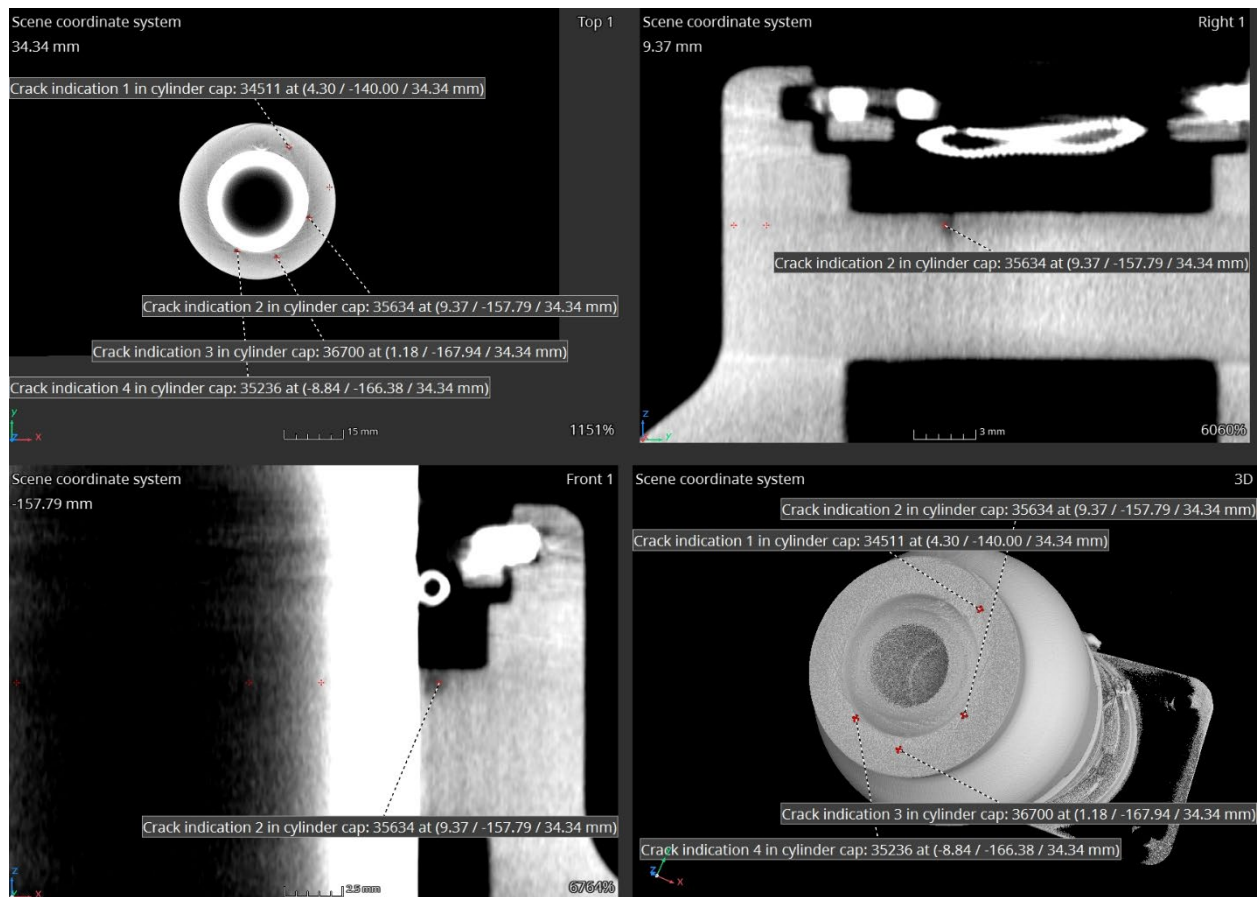


Figure 121. Left lateral actuator - cylinder assembly - crack indication 2 in cylinder cap.

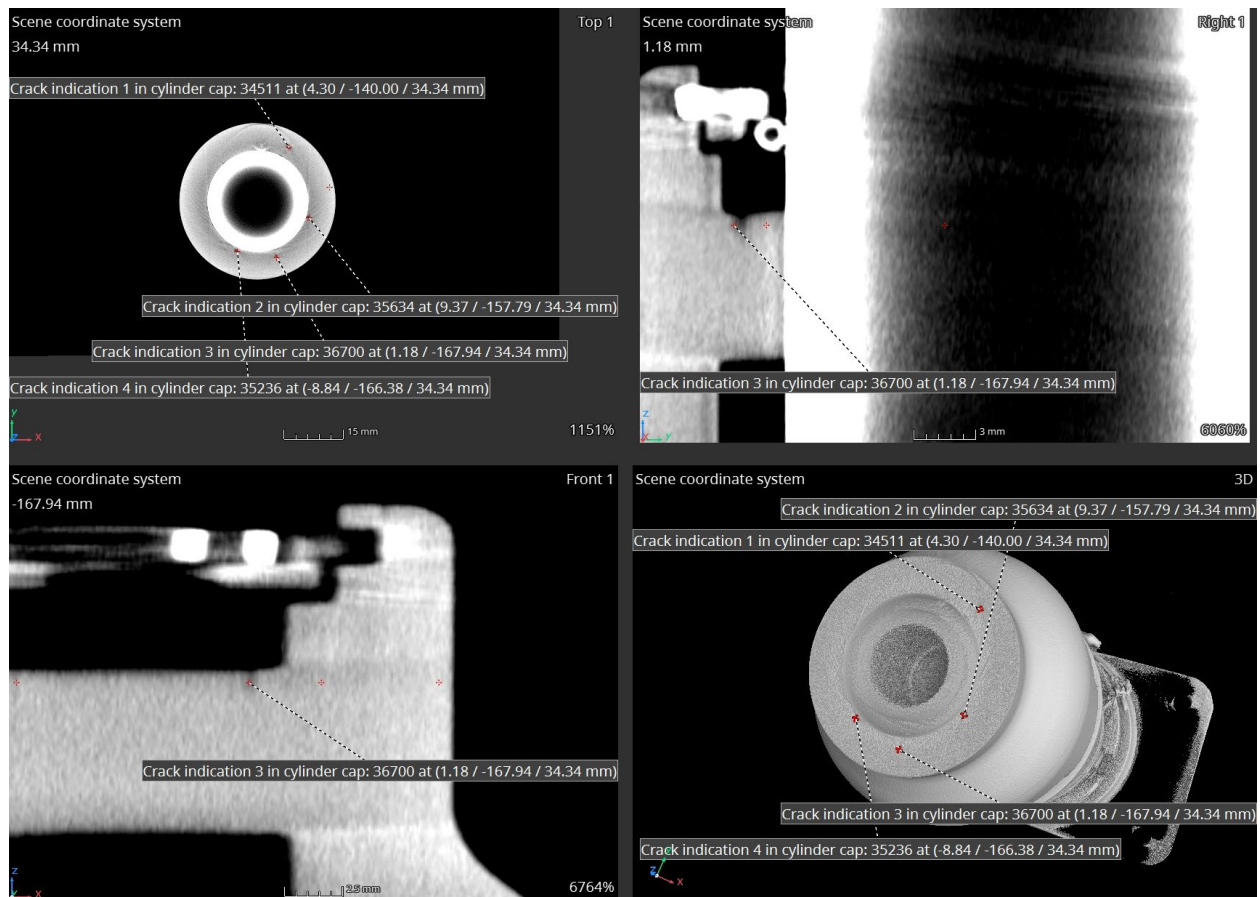


Figure 122. Left lateral actuator - cylinder assembly - crack indication 3 in cylinder cap.

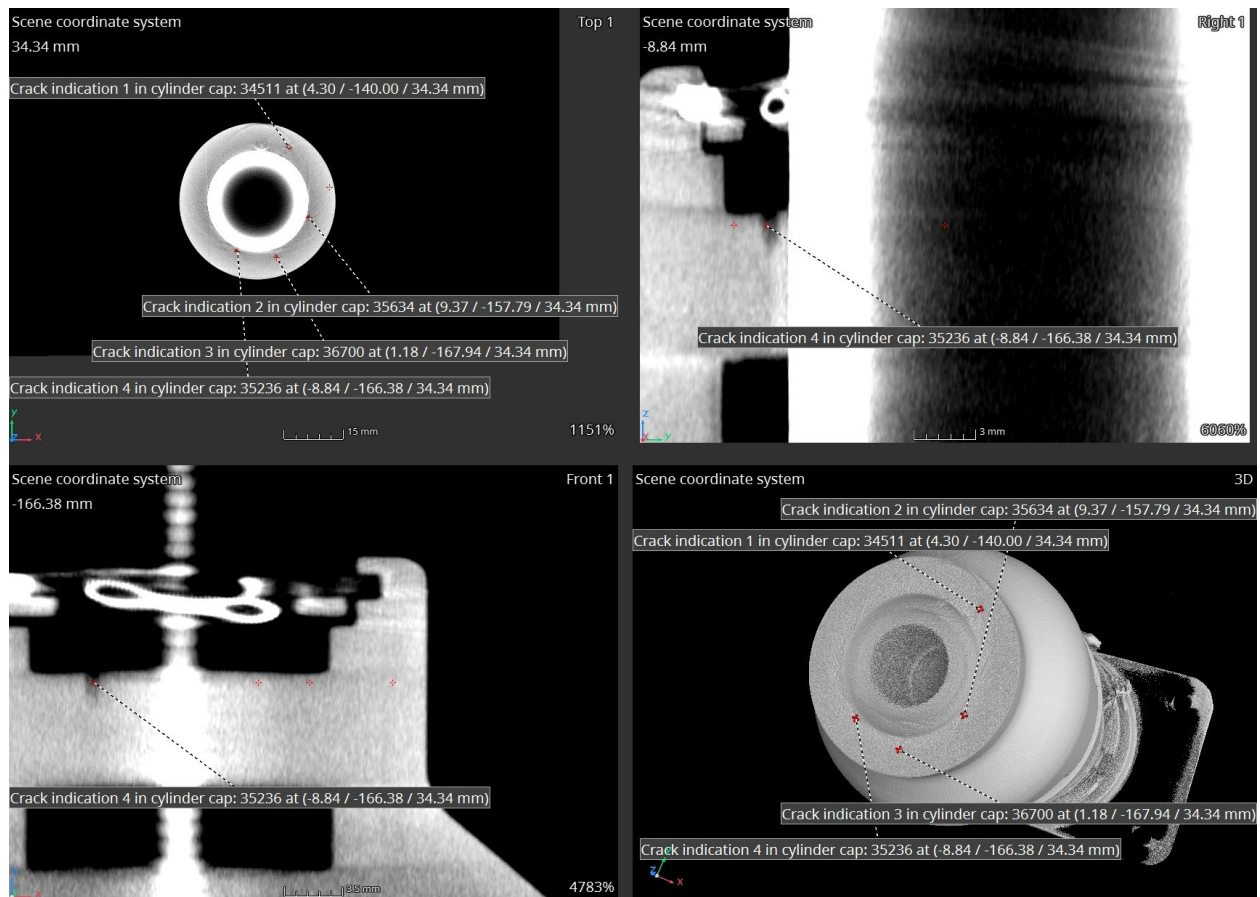


Figure 123. Left lateral actuator - cylinder assembly - crack indication 4 in cylinder cap.

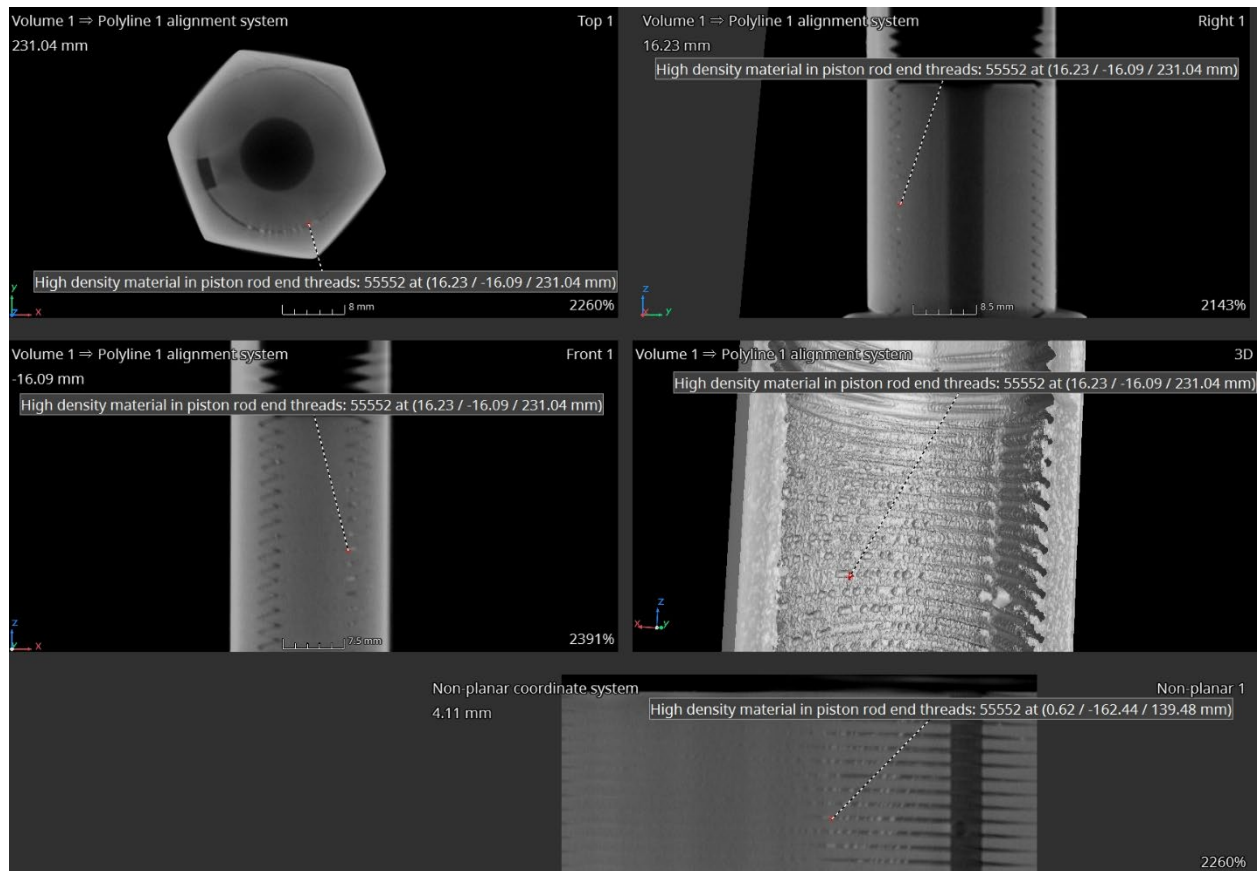


Figure 124. Left lateral actuator - cylinder assembly - high density material in the piston rod threads.

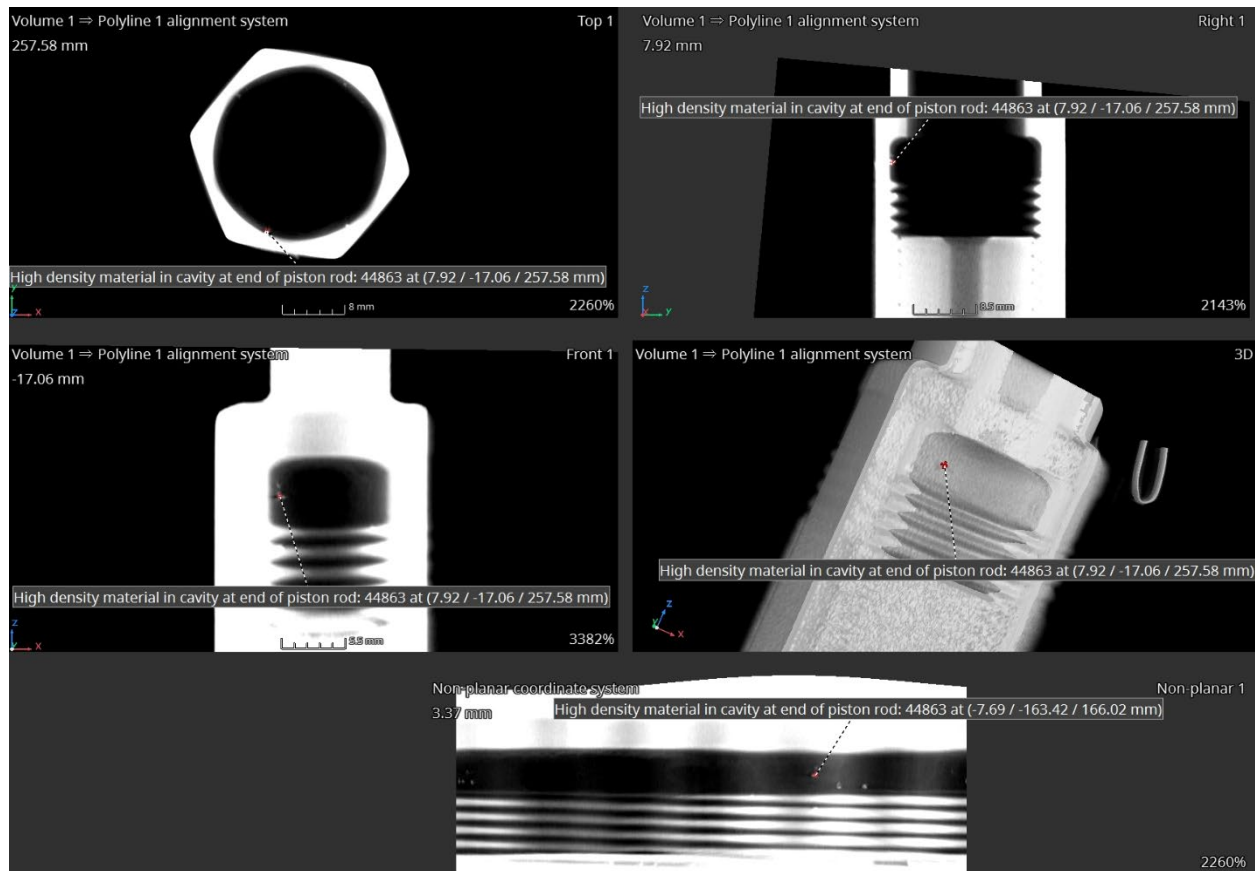


Figure 125. Left lateral actuator - cylinder assembly - high density material in cavity at the end of the piston rod.

3.4 Left Lateral Actuator Irreversible Valve

The CT results for the left lateral actuator irreversible valve are shown in Figures 126 through 160. Review of the images indicated that, when the scans were conducted, the following indications were noted:

1. The irreversible valve housing was deformed with cracks visible or indications of cracks. (Figures 127, 128, 149, and 151)
2. The pressure and return fittings were crushed and deformed. (Figures 129 and 130)
3. There were indications of low and/or medium density particles and/or material near the sequence valve, near the check valve cap, near the plug between the thermal relief valve and differential pressure relief valve, in the cylinder pressure port, and in the accumulator inlet port. (Figures 133, 134, 138, 144, 146, 155, and 156)

4. There were indications of a bulging cap for the sequence valve and the thermal relief valve of the irreversible valve assembly. (Figures 135 and 140)
5. There were indications of a void in the poppet assembly of the thermal relief valve. (Figure 139)
6. The cylinder pressure port fitting was damaged. (Figure 147)
7. There were indications of cracks in the irreversible valve housing near the accumulator spring end. (Figure 151)
8. The accumulator retainer and retaining ring for the accumulator retainer are out of position. (Figure 152)
9. The seal in the accumulator retainer (spring end) appears to be missing. (Figures 153 and 154)
10. There were indications of cracks in the accumulator piston. (Figure 157)
11. There were indications of wear or damage to the bore of the accumulator and the accumulator springs were not fully extended. (Figures 158, 159 and 160)

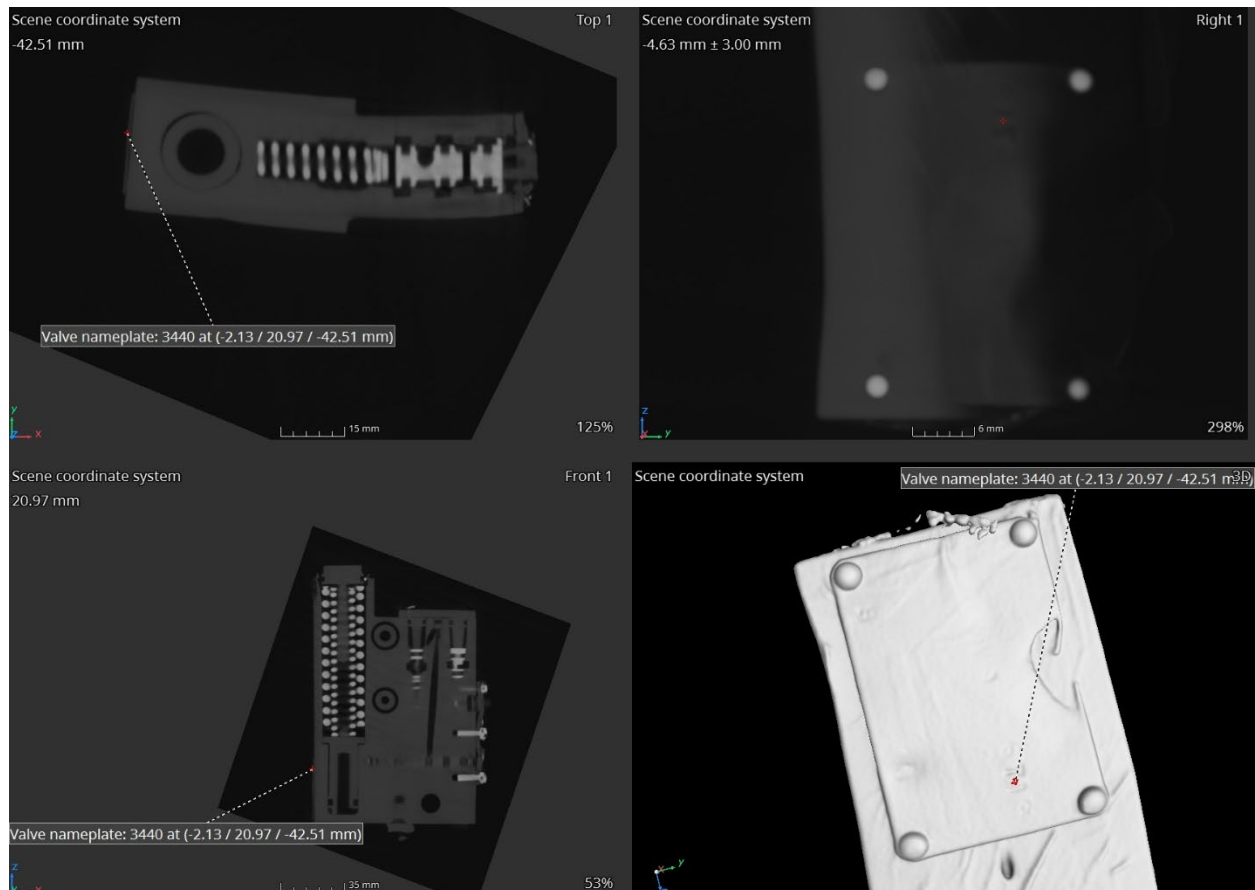


Figure 126. Left lateral actuator - irreversible valve - nameplate. (450 kV)

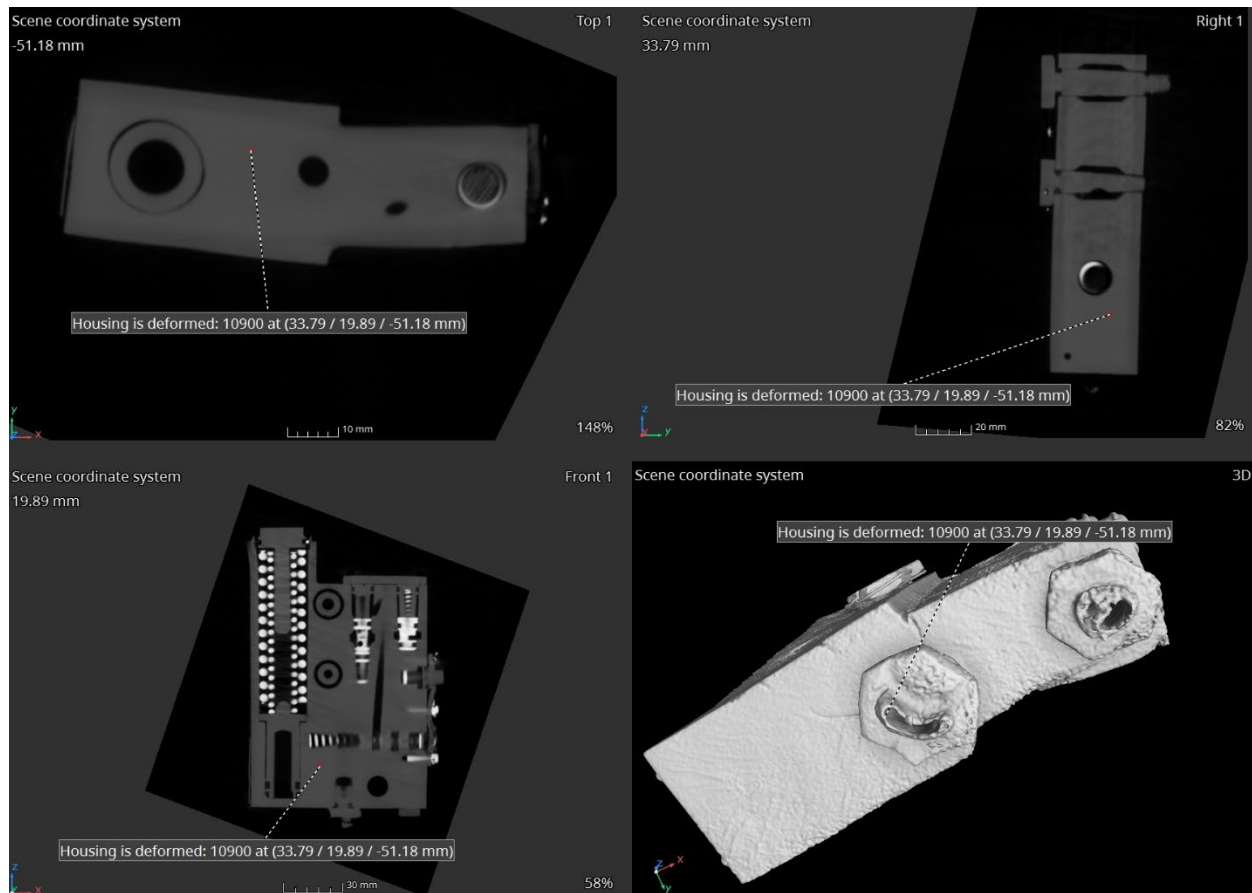


Figure 127. Left lateral actuator - irreversible valve - housing. (450 kV)

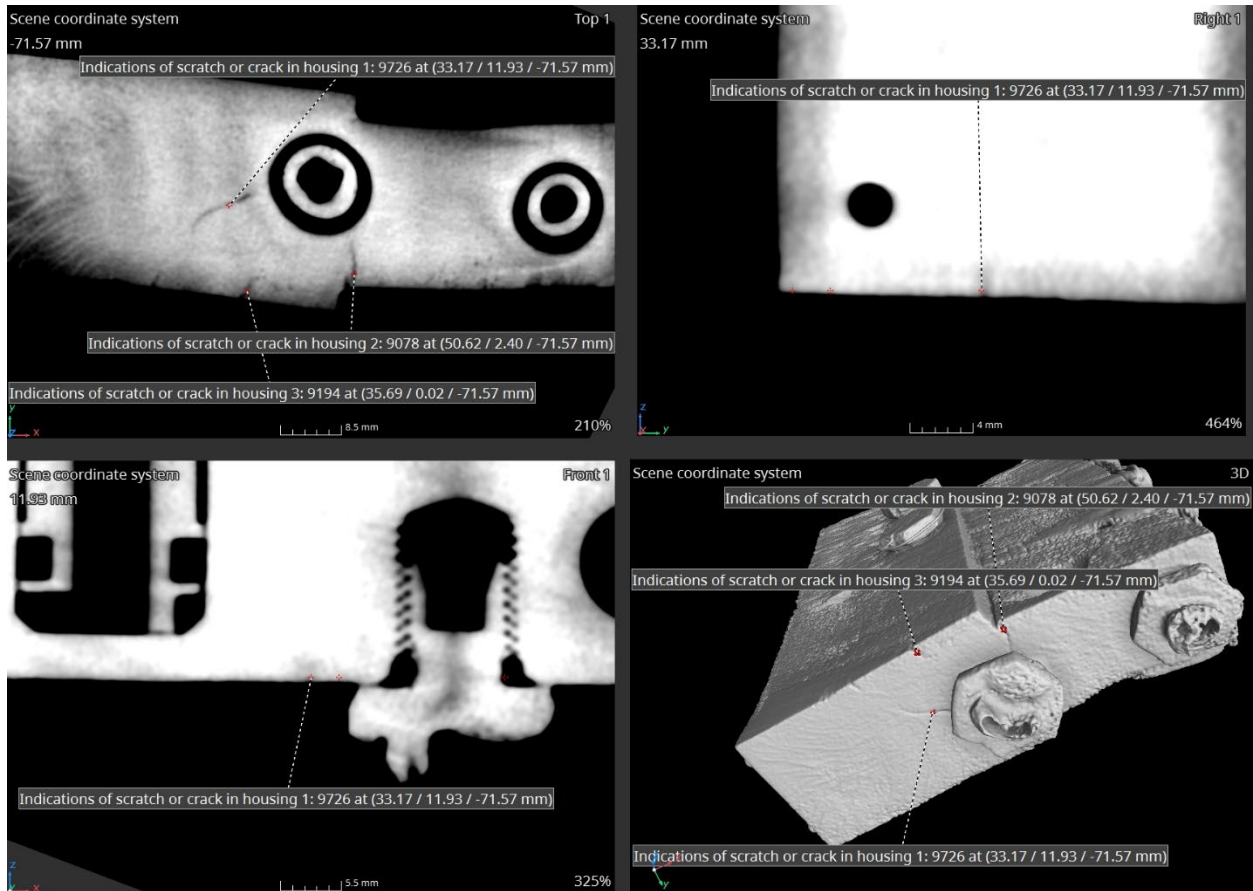


Figure 128. Left lateral actuator - irreversible valve - housing - possible cracks. (450 kV)

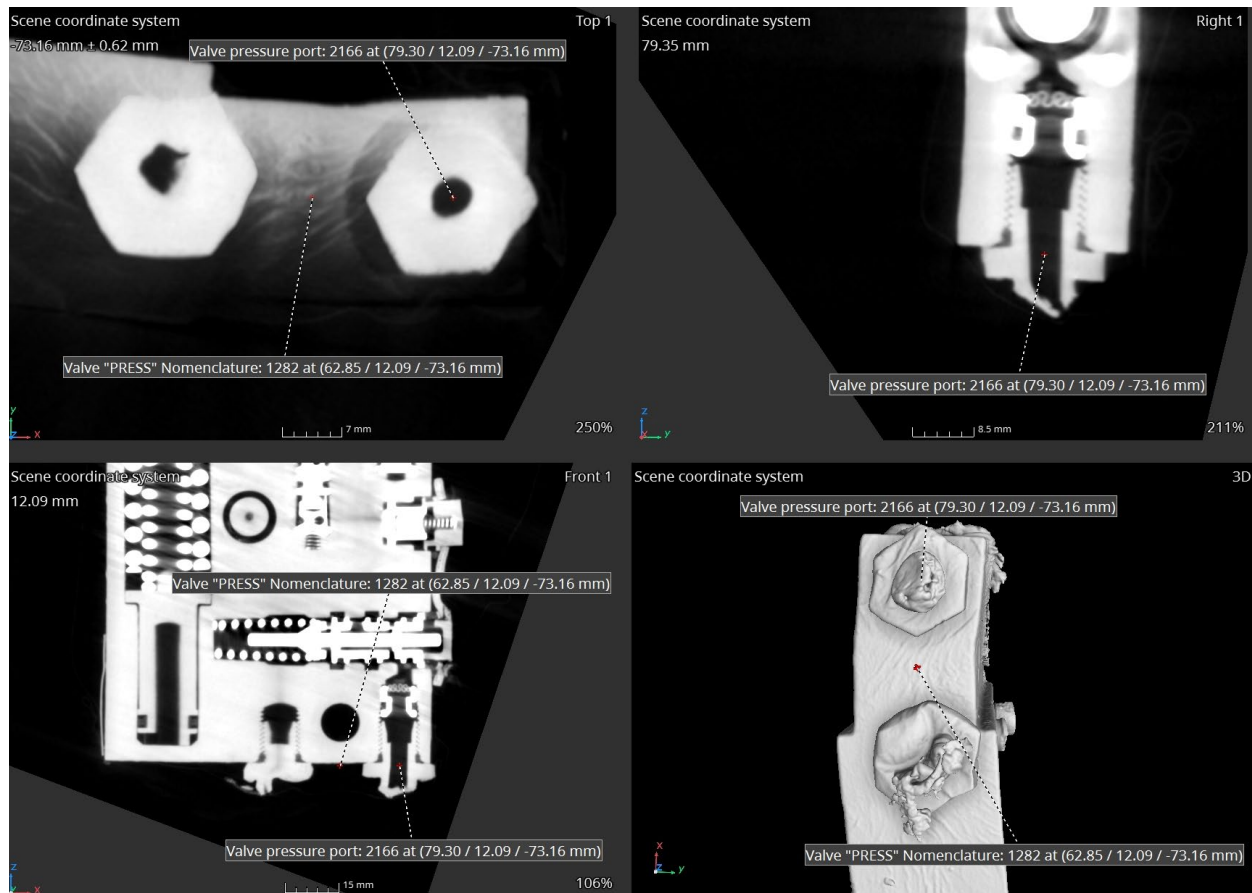


Figure 129. Left lateral actuator - irreversible valve - pressure port and nomenclature. (450 kV)

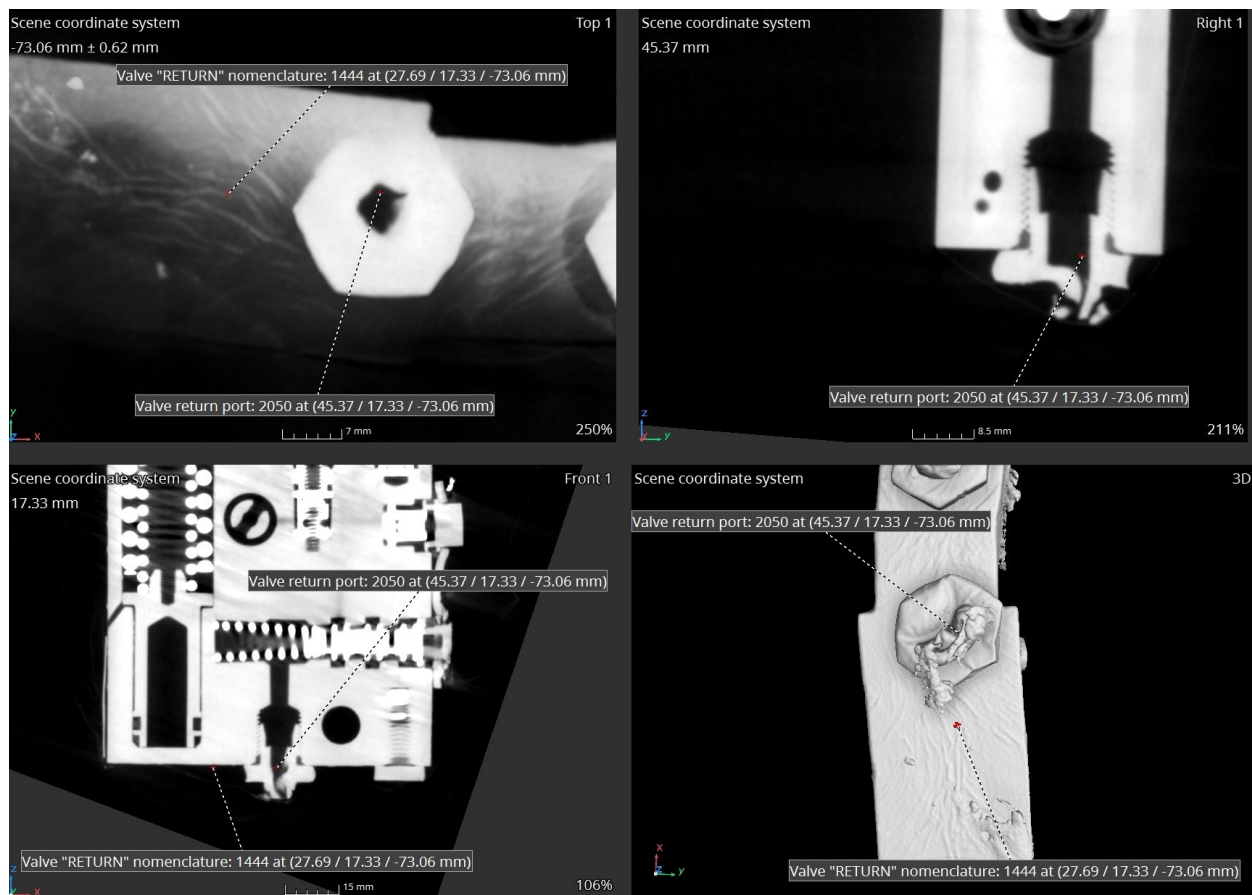


Figure 130. Left lateral actuator - irreversible valve - return port and nomenclature. (450 kV)

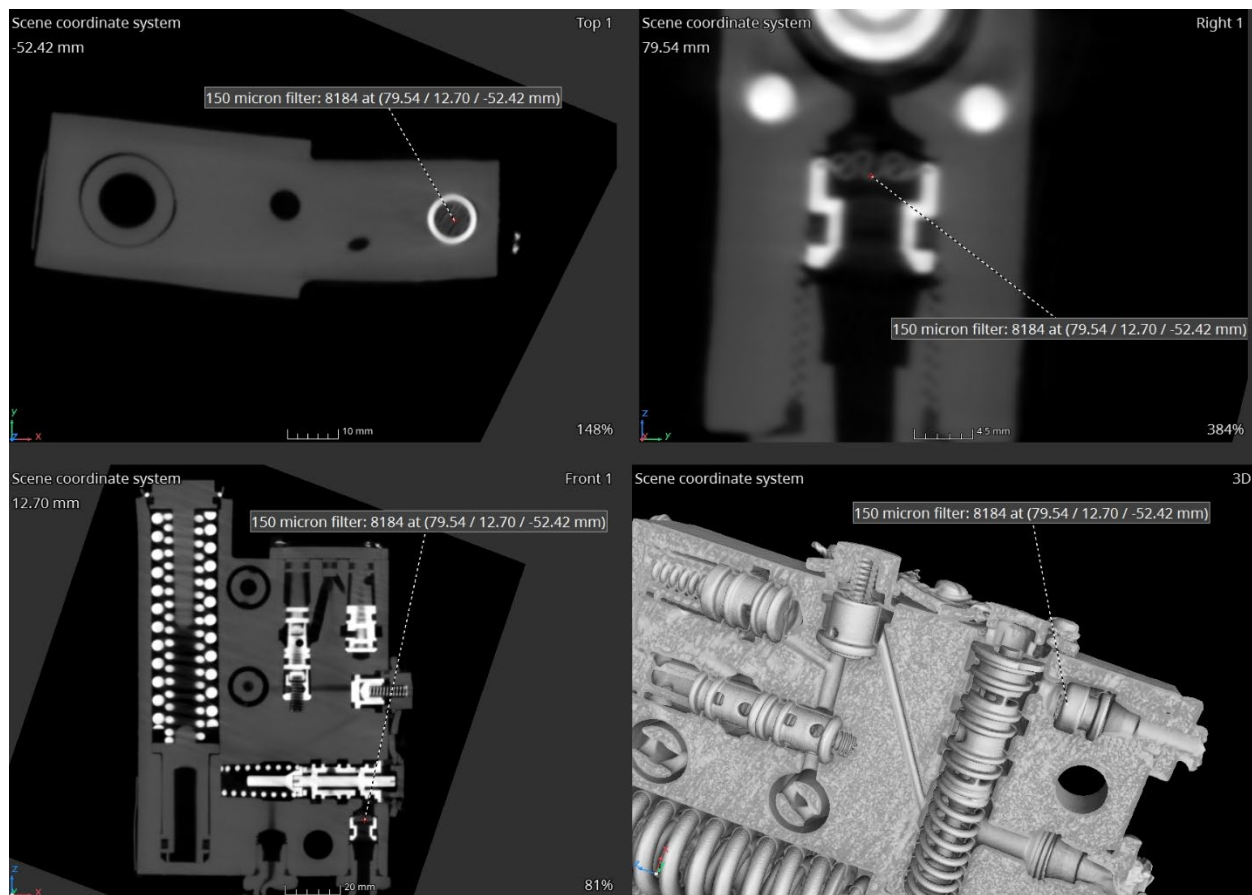


Figure 131. Left lateral actuator - irreversible valve - 150 micron filter. (450 kV)

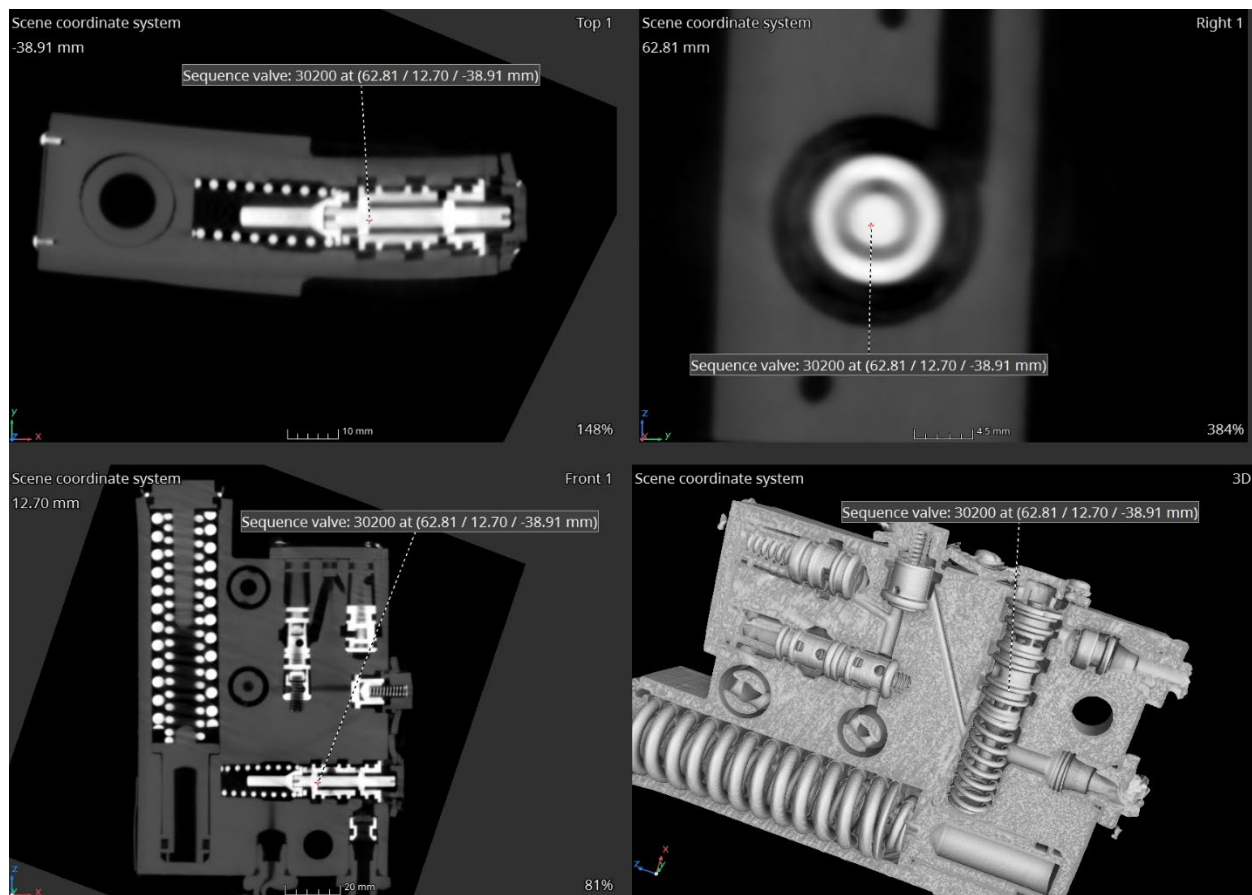


Figure 132. Left lateral actuator - irreversible valve - sequence valve. (450 kV)

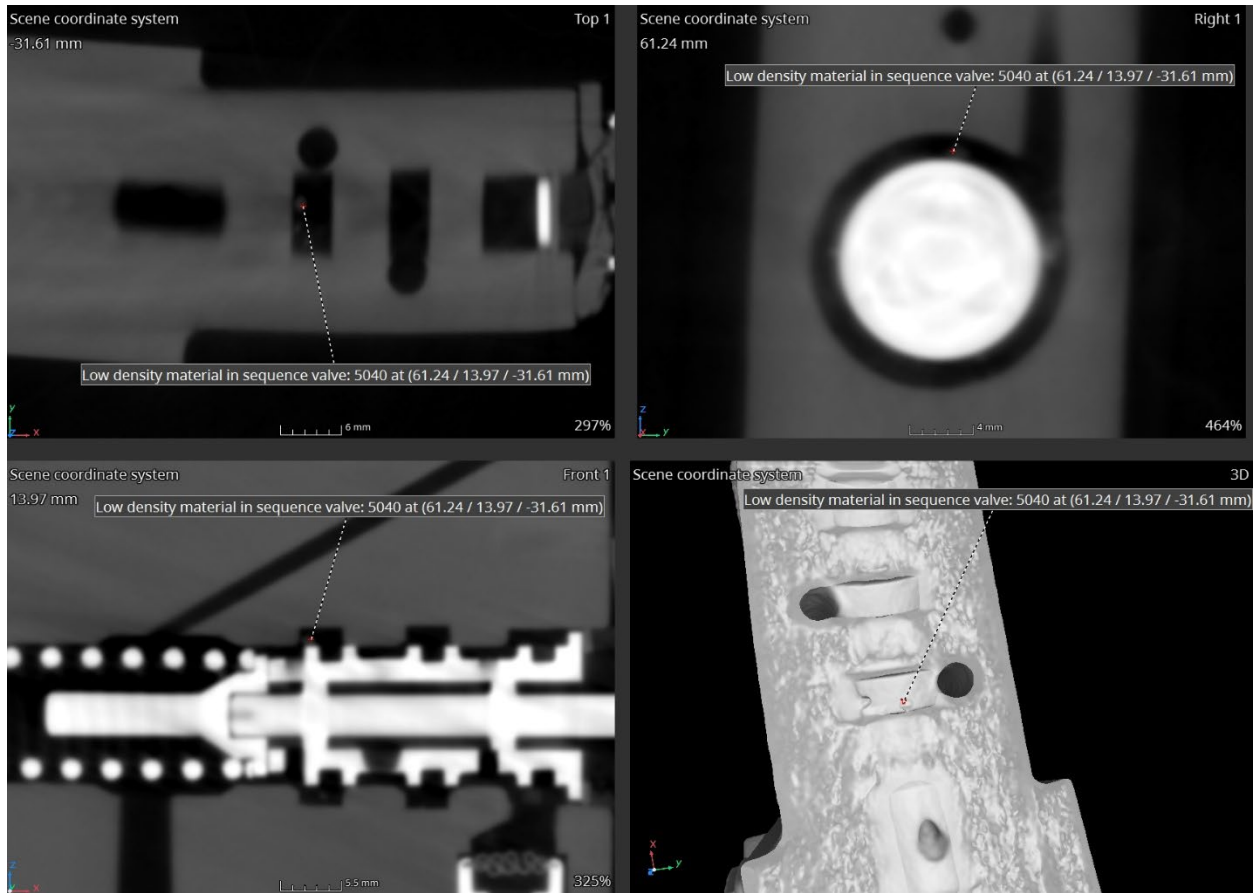


Figure 133. Left lateral actuator - irreversible valve - sequence valve - low density material. (450 kV)

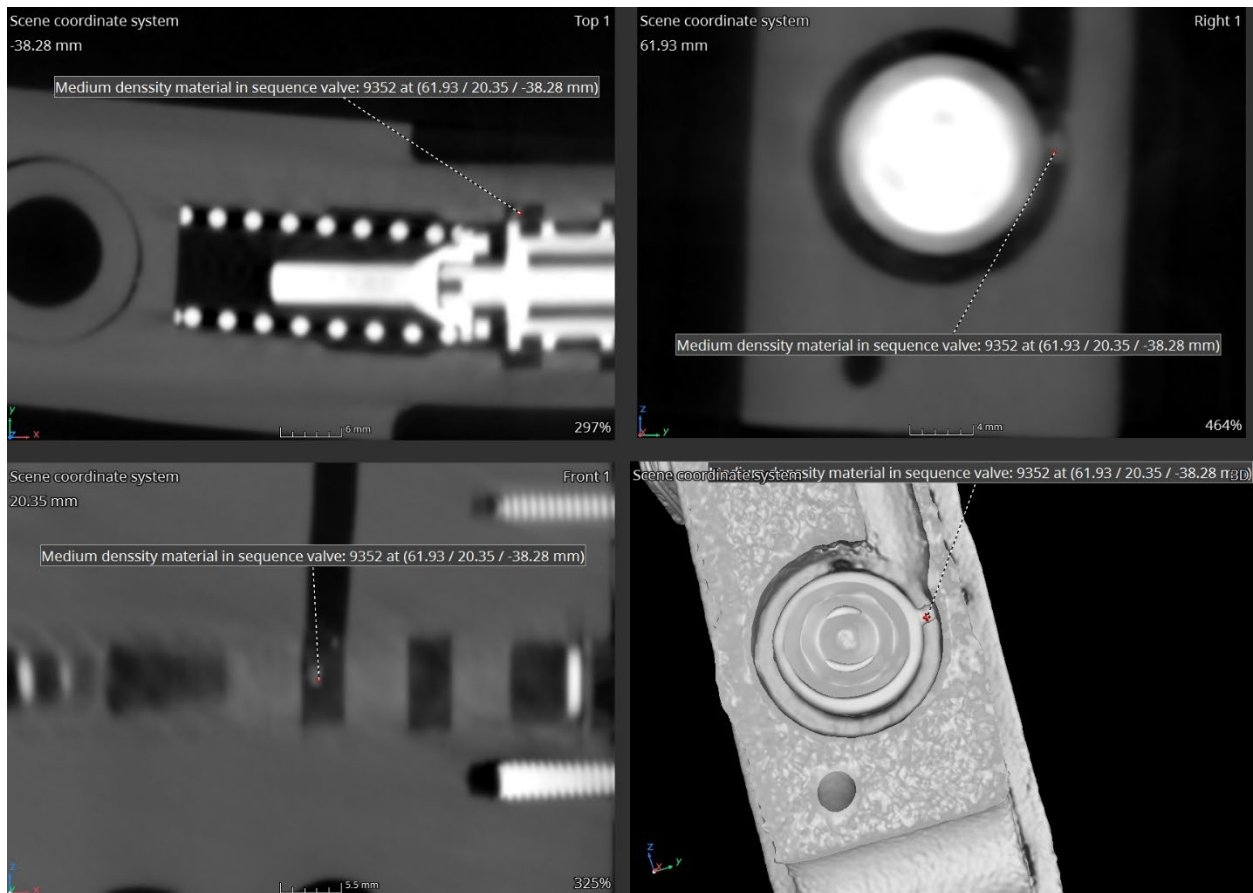


Figure 134. Left lateral actuator - irreversible valve - sequence valve - medium density material. (450 kV)

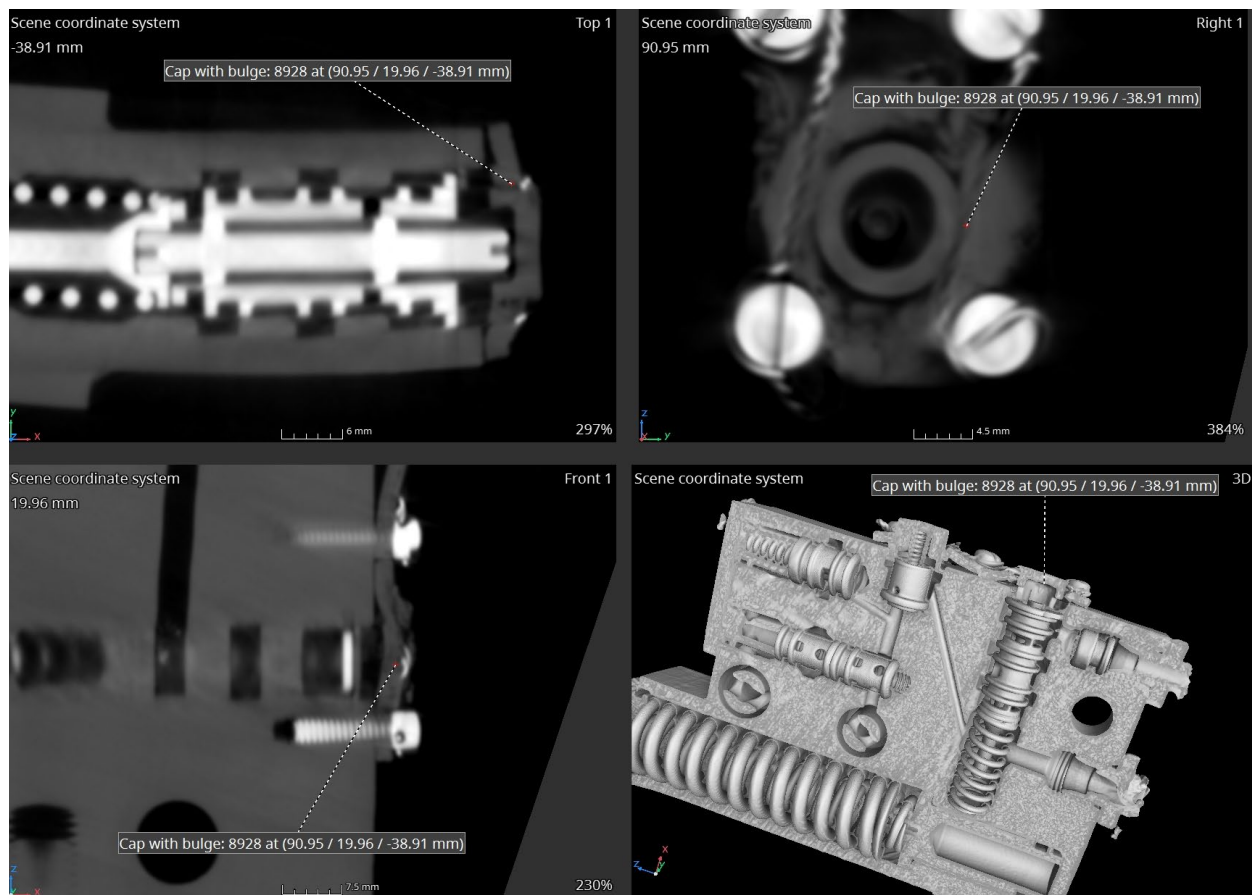


Figure 135. Left lateral actuator - irreversible valve - sequence valve cap with bulge. (450 kV)

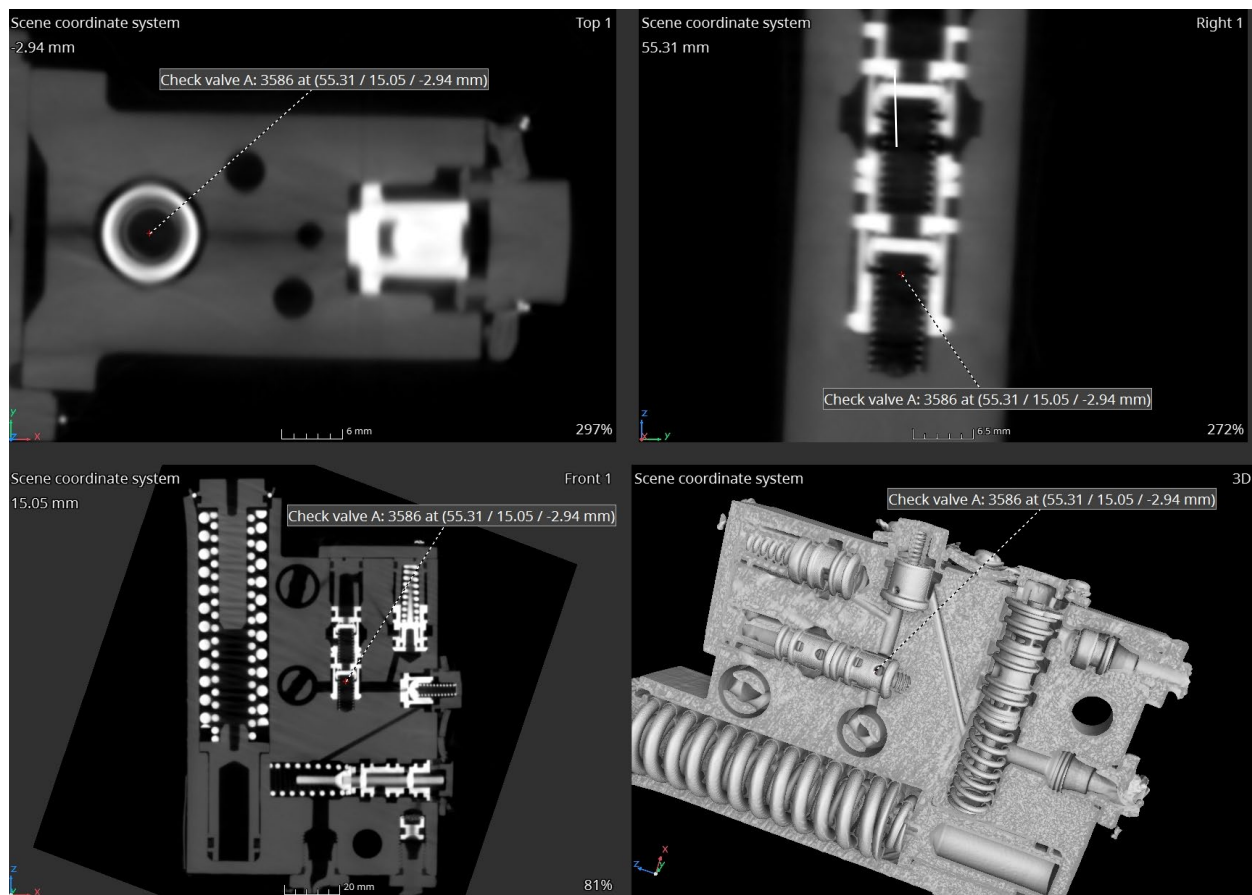


Figure 136. Left lateral actuator - irreversible valve - check valve A. (450 kV)

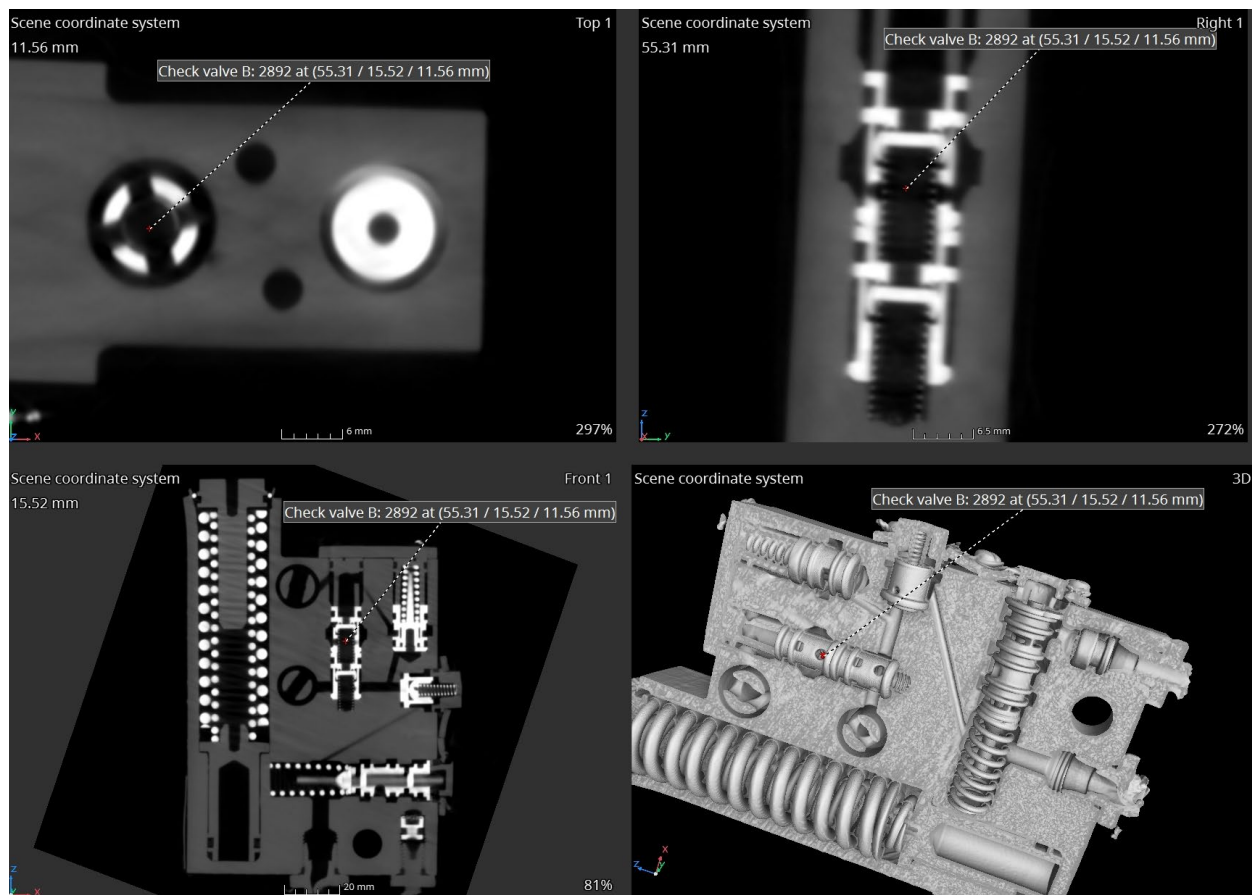


Figure 137. Left lateral actuator - irreversible valve - check valve B. (450 kV)



Figure 138. Left lateral actuator - irreversible valve - check valve B - medium density material. (450 kV)

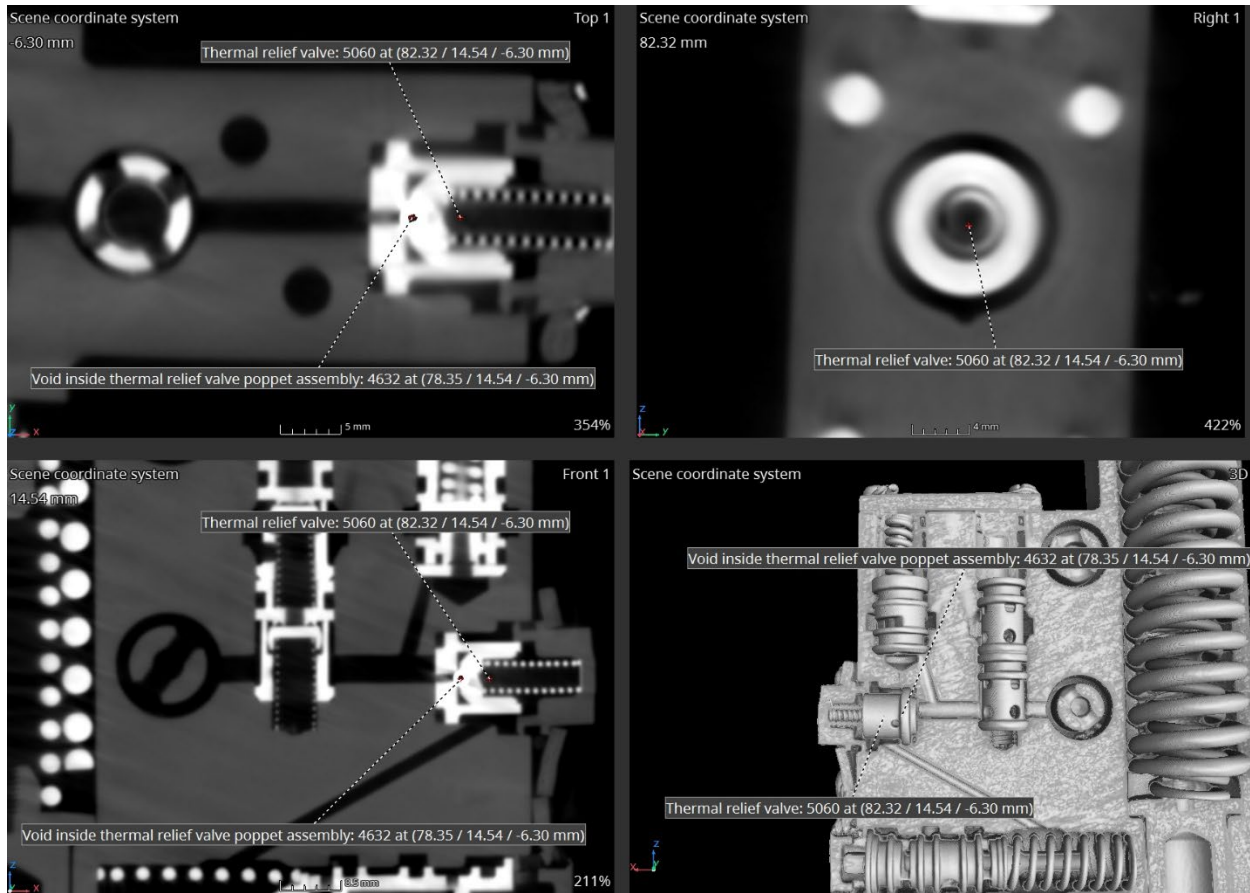


Figure 139. Left lateral actuator - irreversible valve - thermal relief valve. (450 kV)

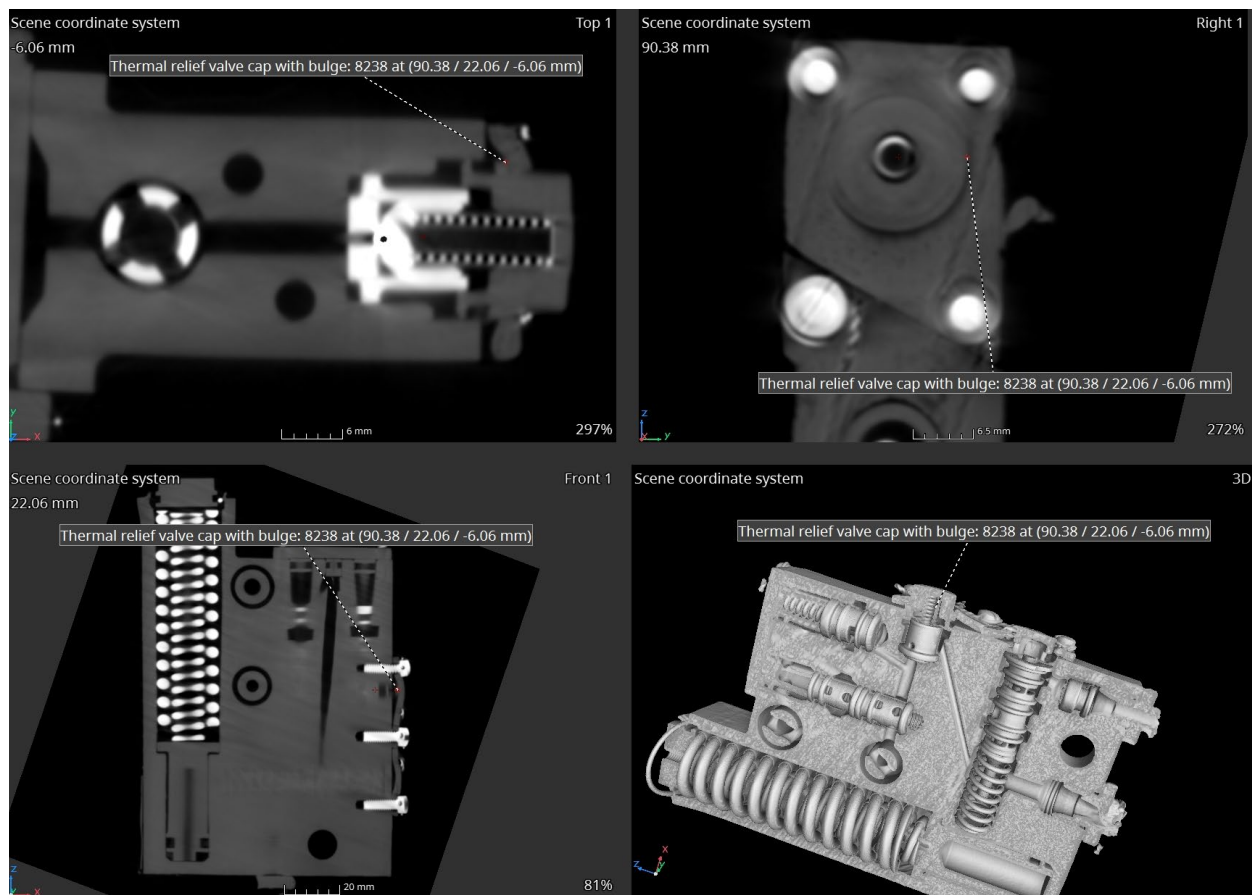


Figure 140. Left lateral actuator - irreversible valve - thermal relief valve cap with bulge. (450 kV)

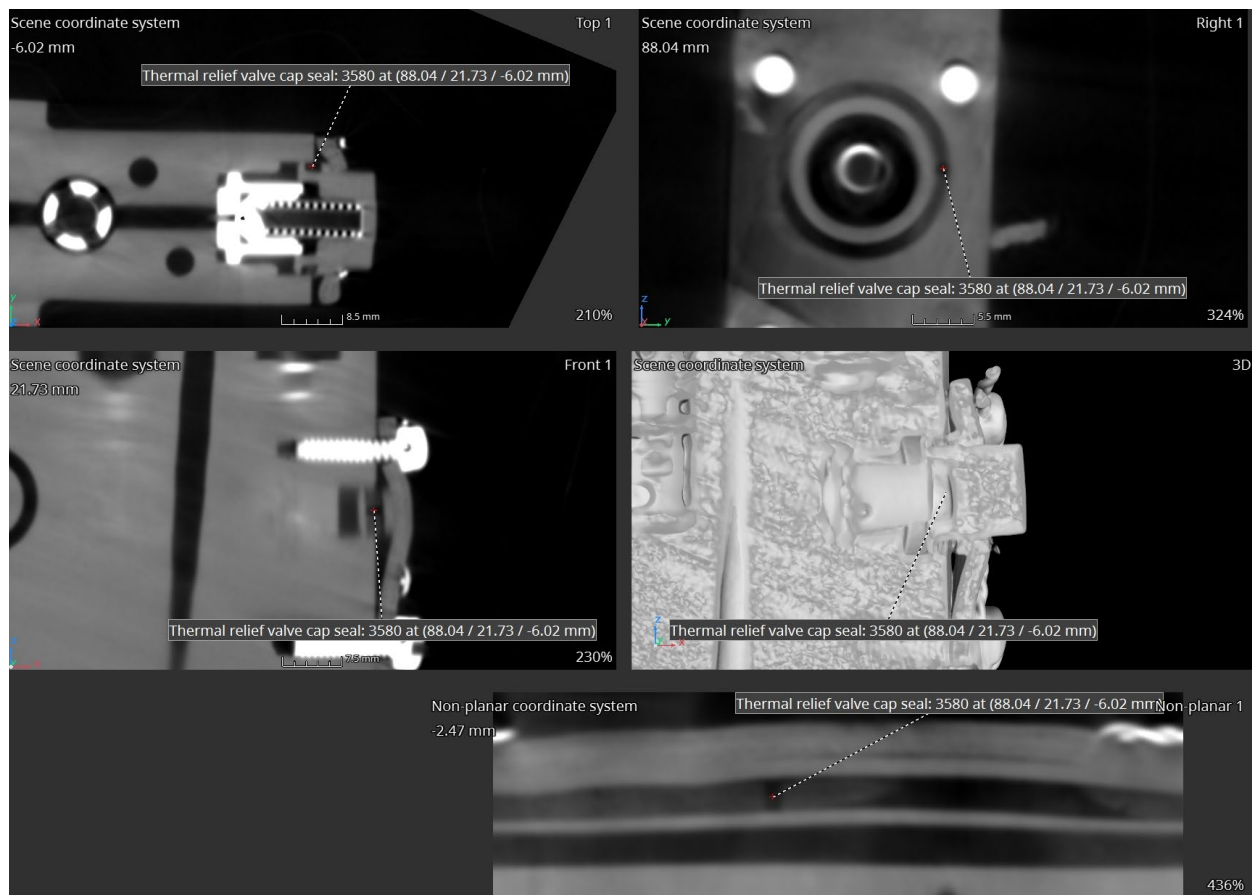


Figure 141. Left lateral actuator - irreversible valve - thermal relief valve cap seal. (450 kV)

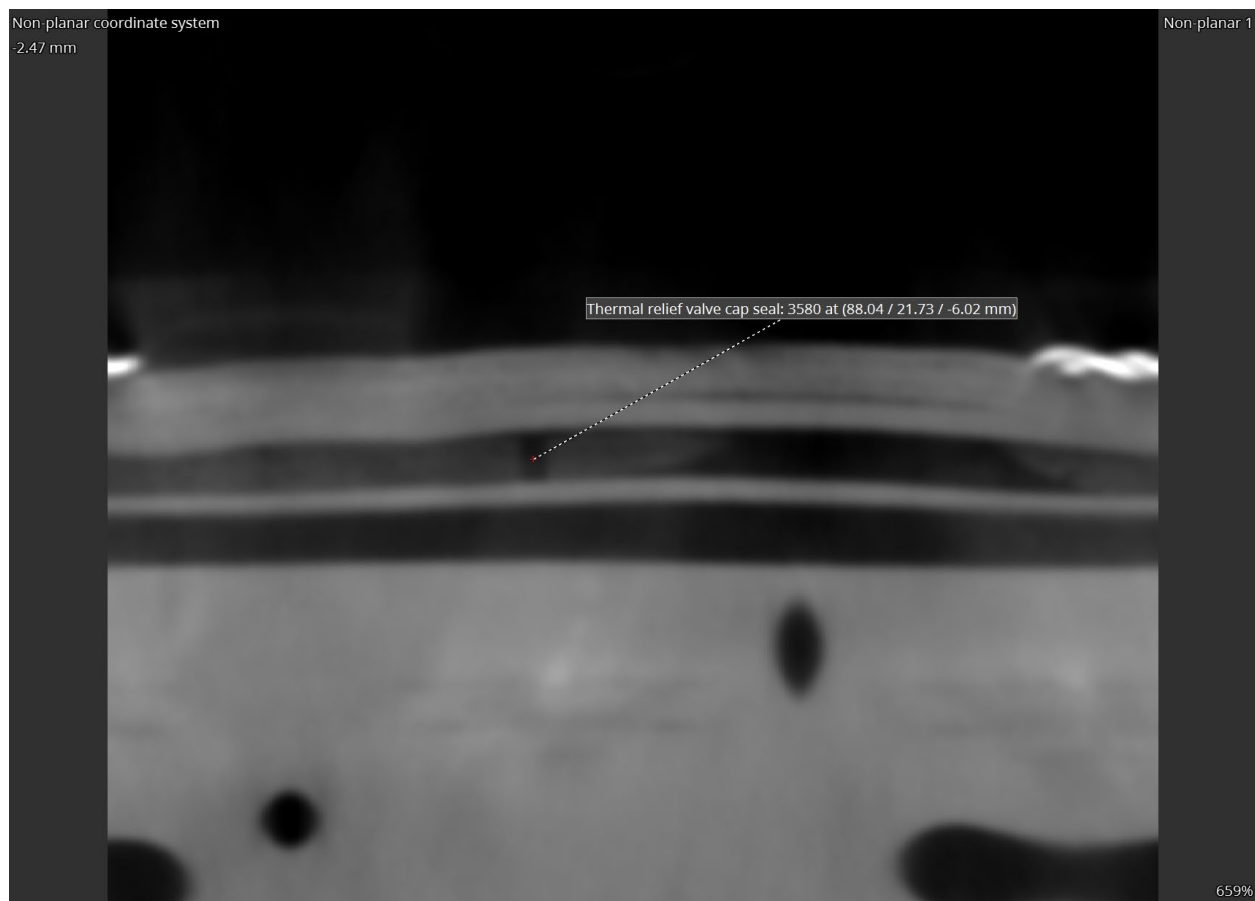


Figure 142. Left lateral actuator - irreversible valve - thermal relief valve cap seal unrolled.. (450 kV)

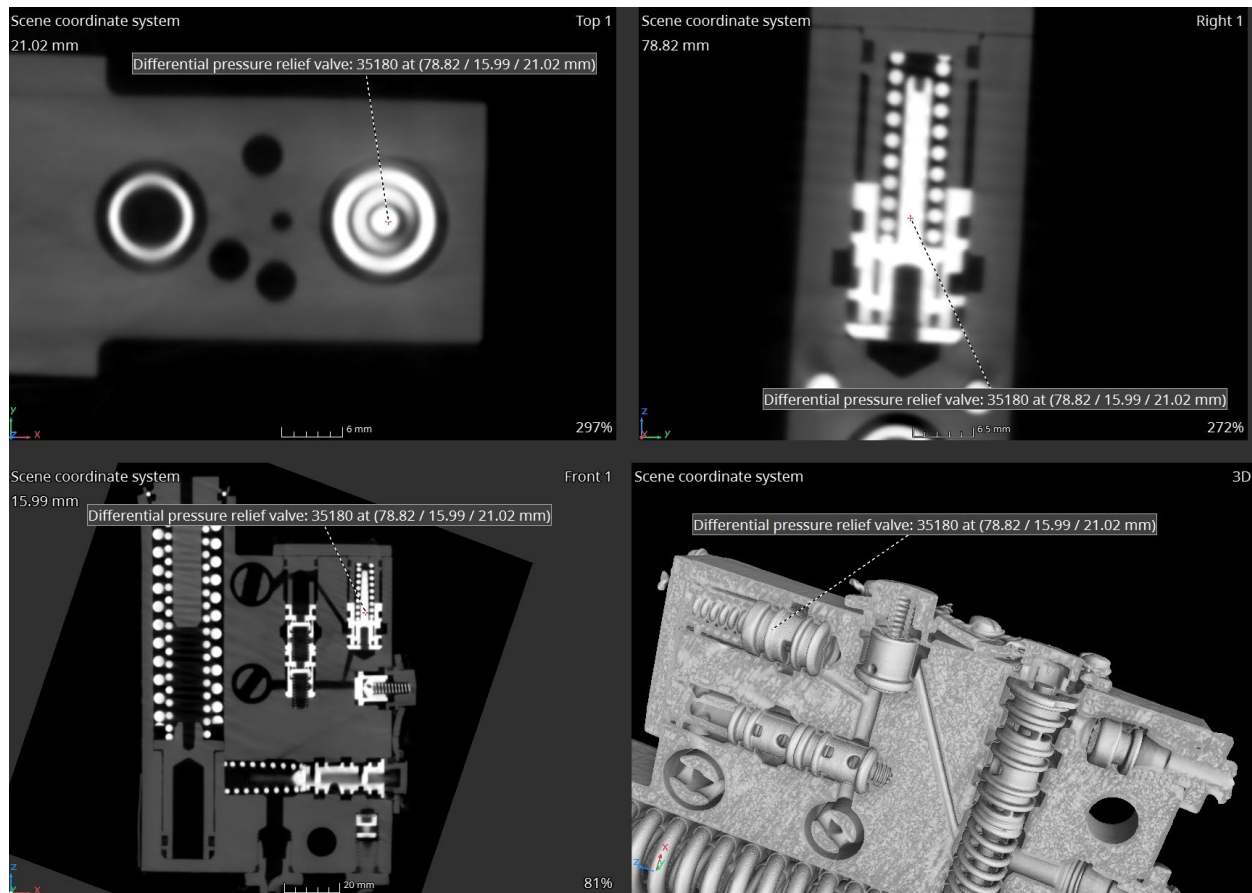


Figure 143. Left lateral actuator - irreversible valve - differential pressure relief valve. (450 kV)



Figure 144. Left lateral actuator - irreversible valve - low density material near plug between the differential pressure relief valve and the check valves. (450 kV)

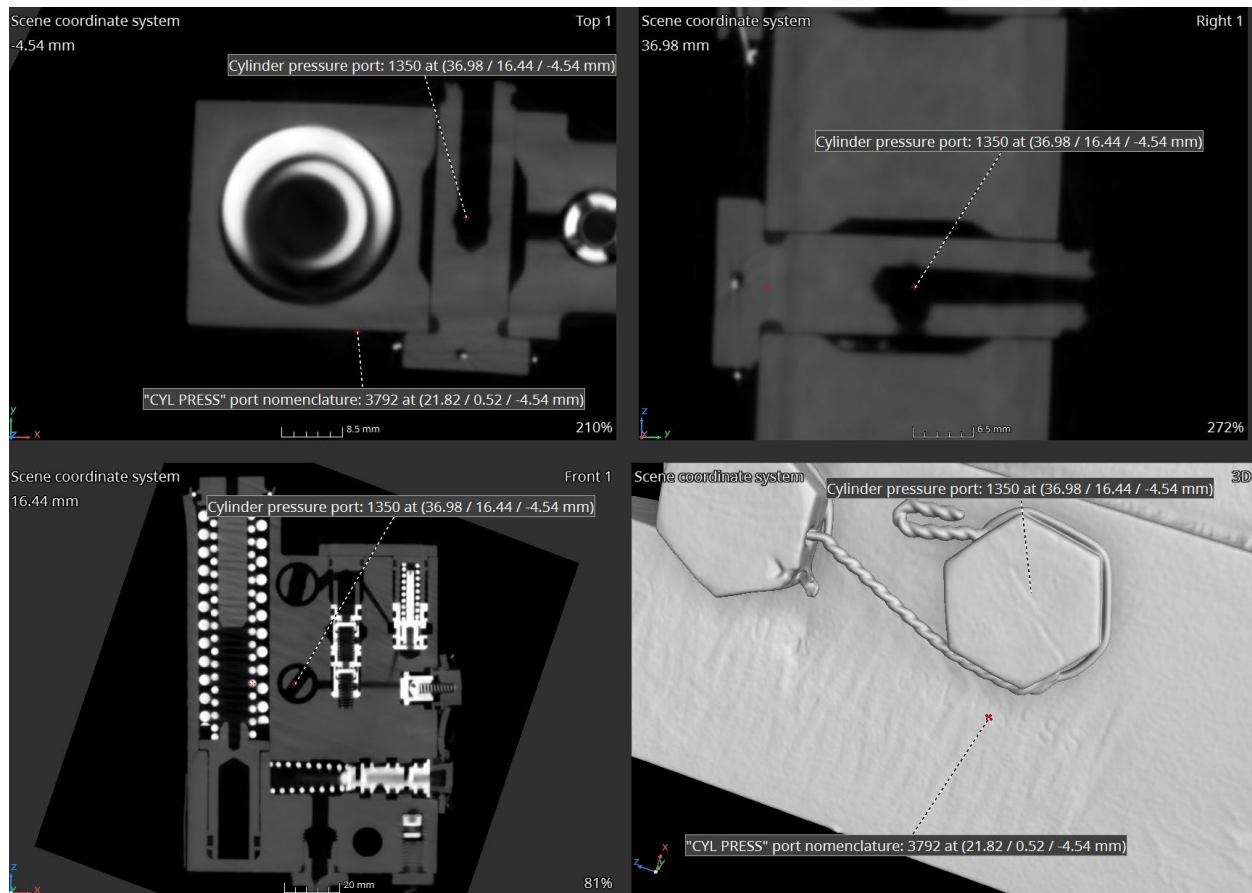


Figure 145. Left lateral actuator - irreversible valve - cylinder pressure port and nomenclature. (450 kV)

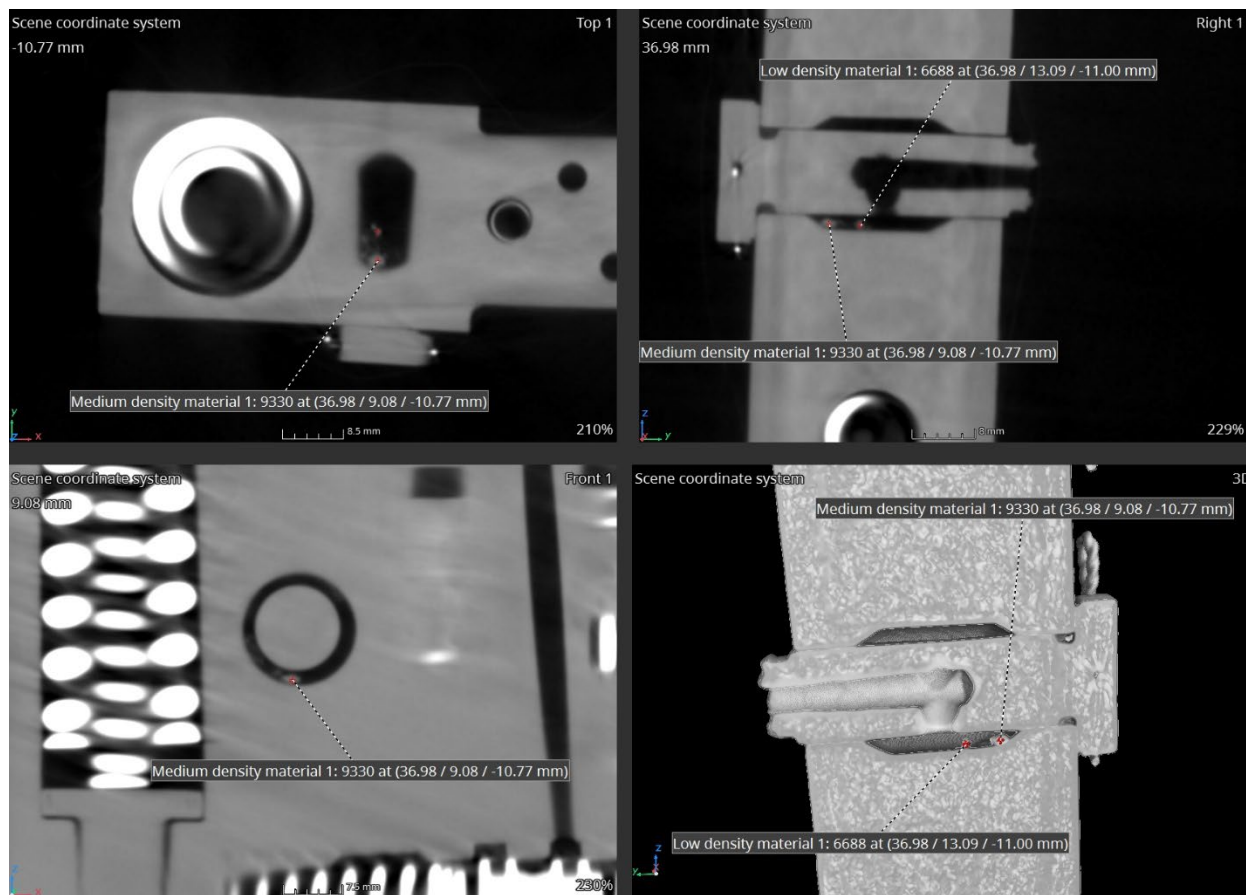


Figure 146. Left lateral actuator - irreversible valve - cylinder pressure port low and medium density material. (450 kV)

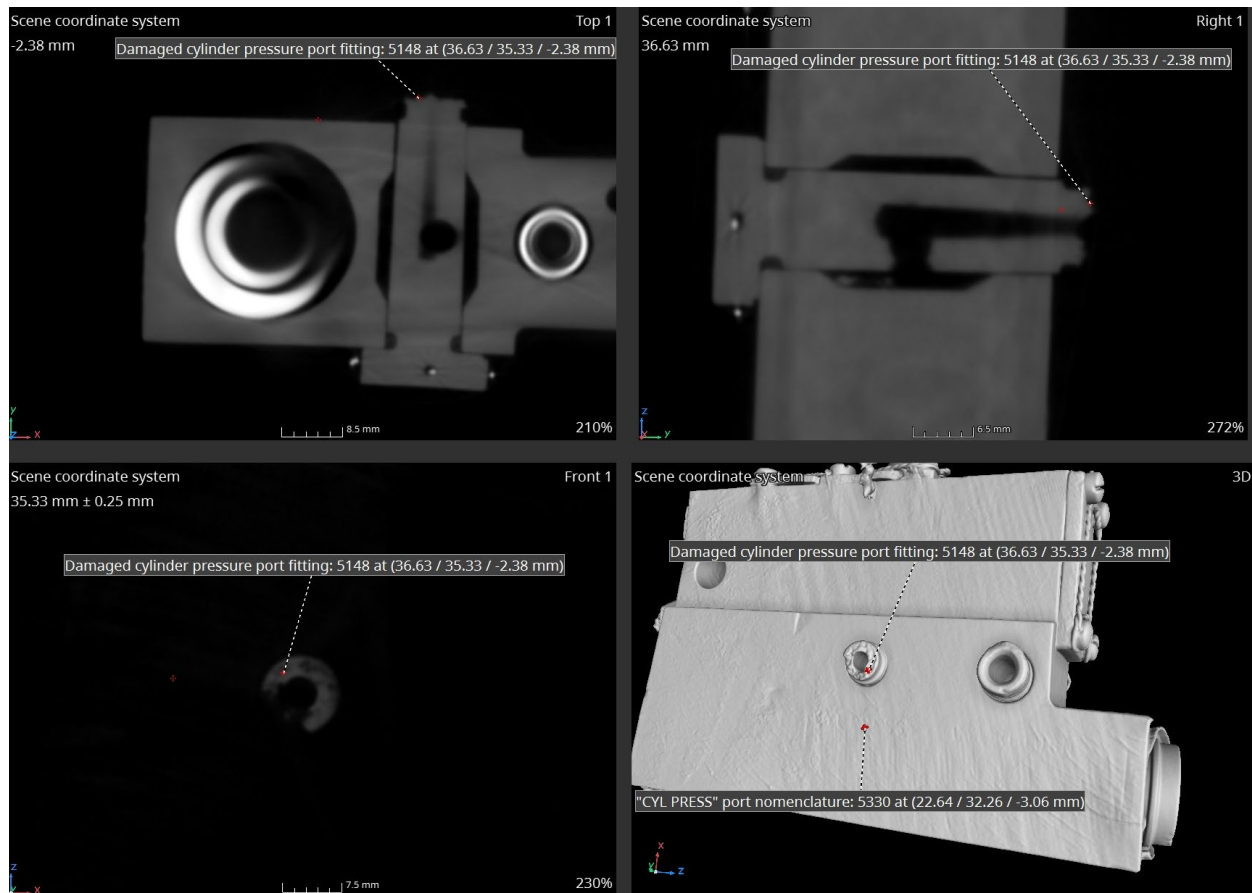


Figure 147. Left lateral actuator - irreversible valve - cylinder pressure port damaged fitting. (450 kV)

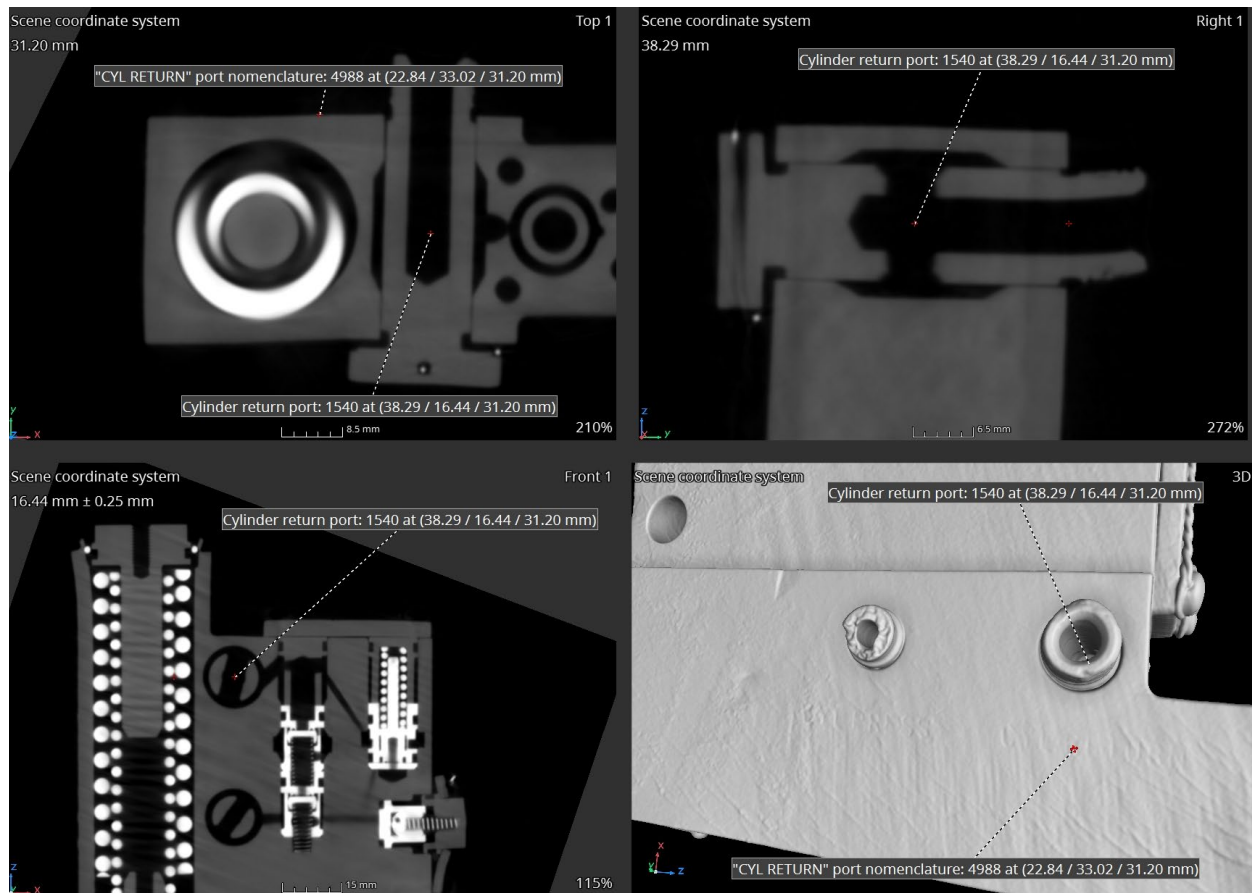


Figure 148. Left lateral actuator - irreversible valve - cylinder return port and nomenclature. (450 kV)

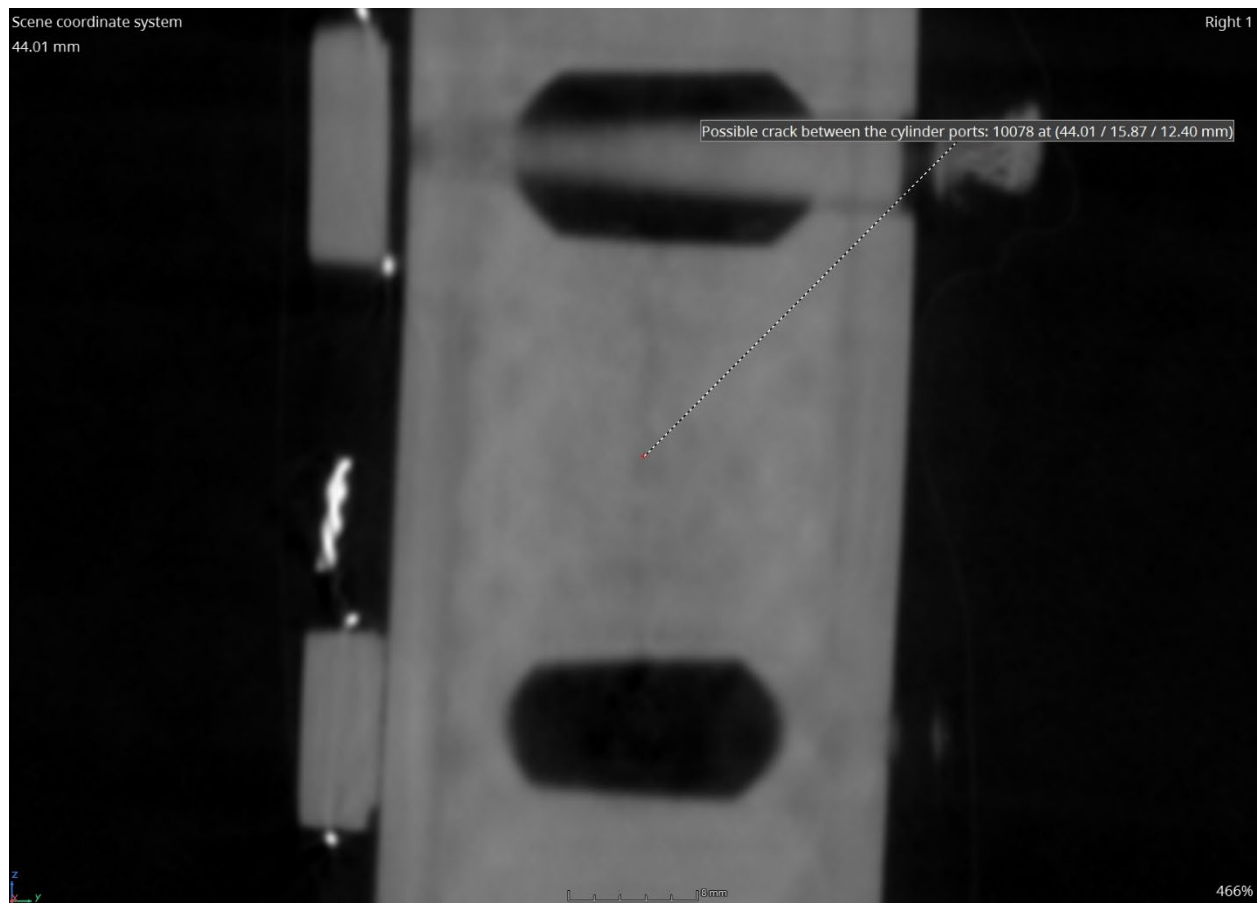


Figure 149. Left lateral actuator - irreversible valve - possible crack between cylinder ports. (450 kV)

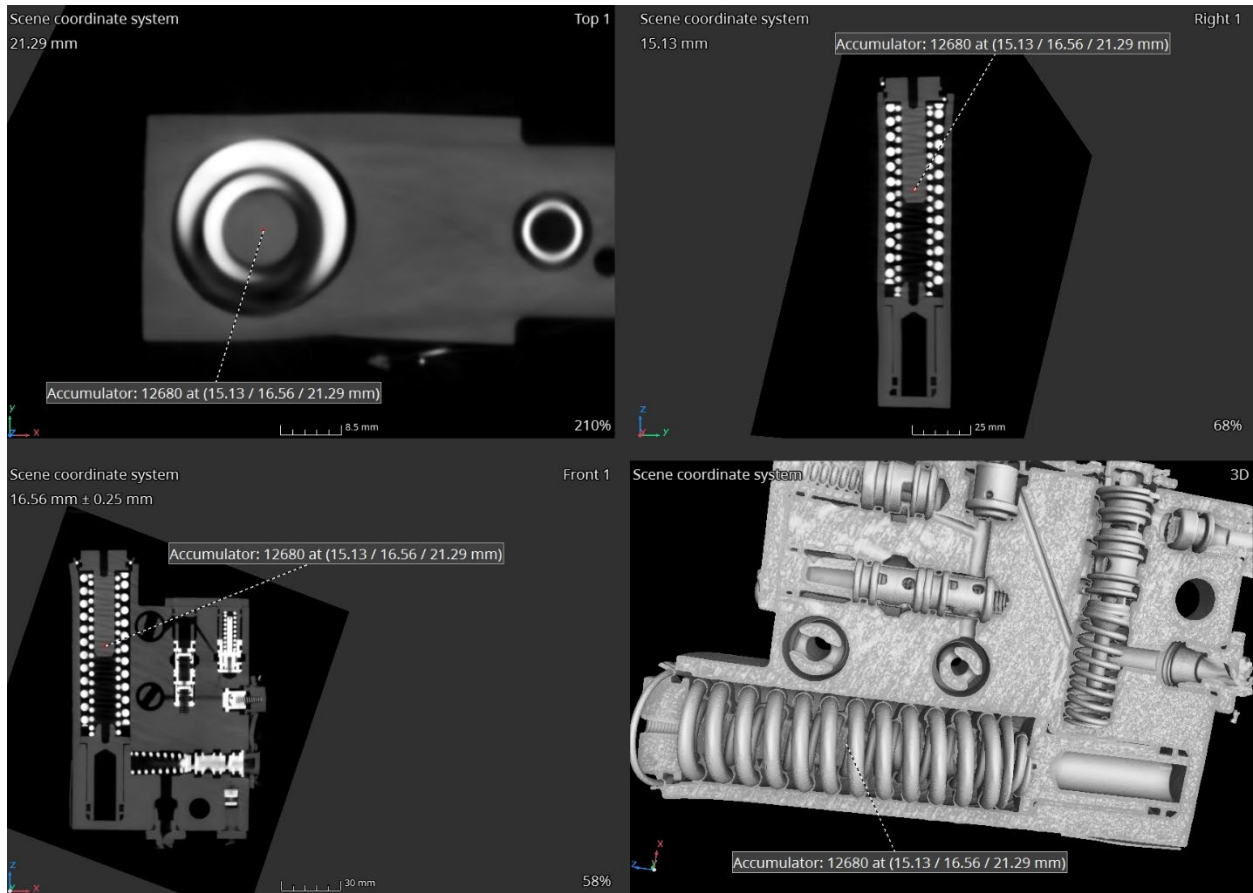


Figure 150. Left lateral actuator - irreversible valve - accumulator. (450 kV)

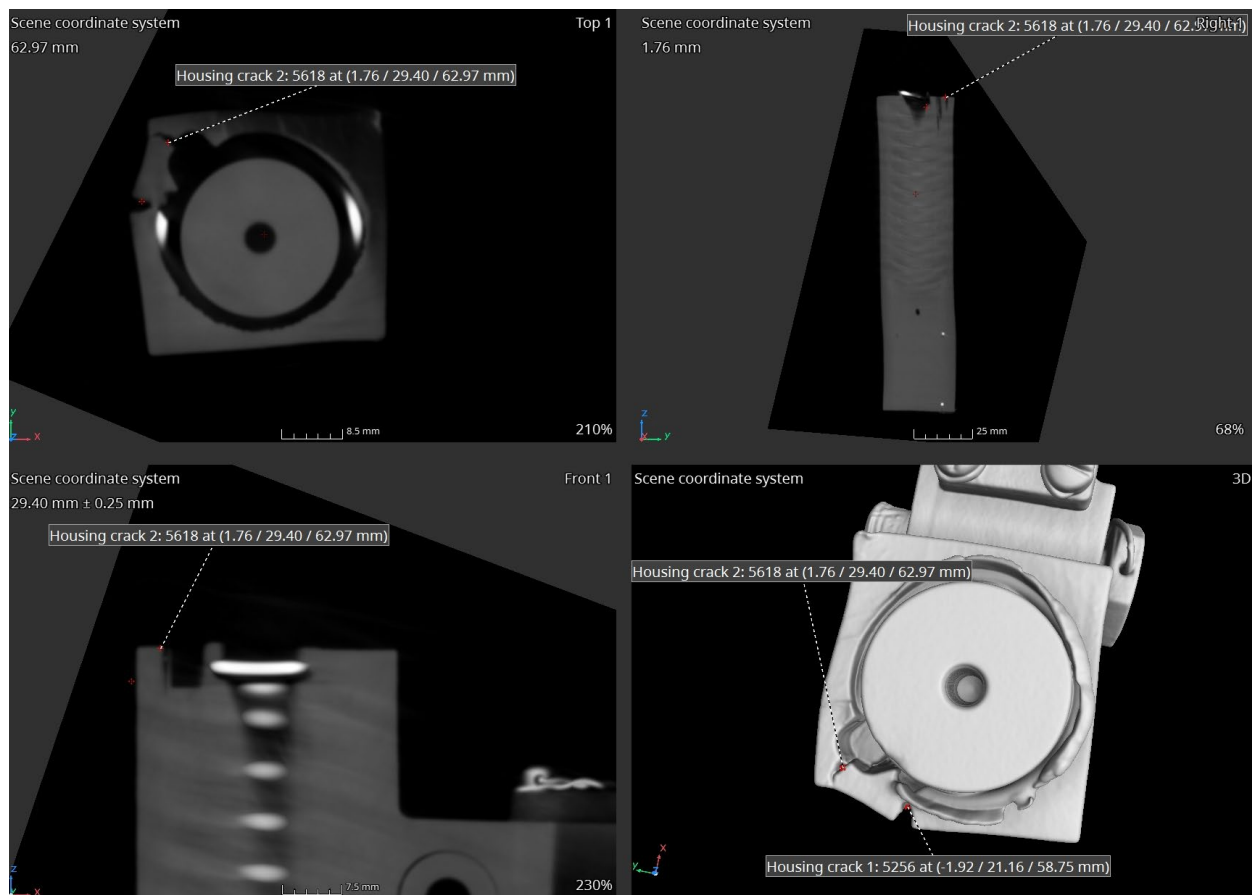


Figure 151. Left lateral actuator - irreversible valve - cracks in housing near the accumulator. (450 kV)

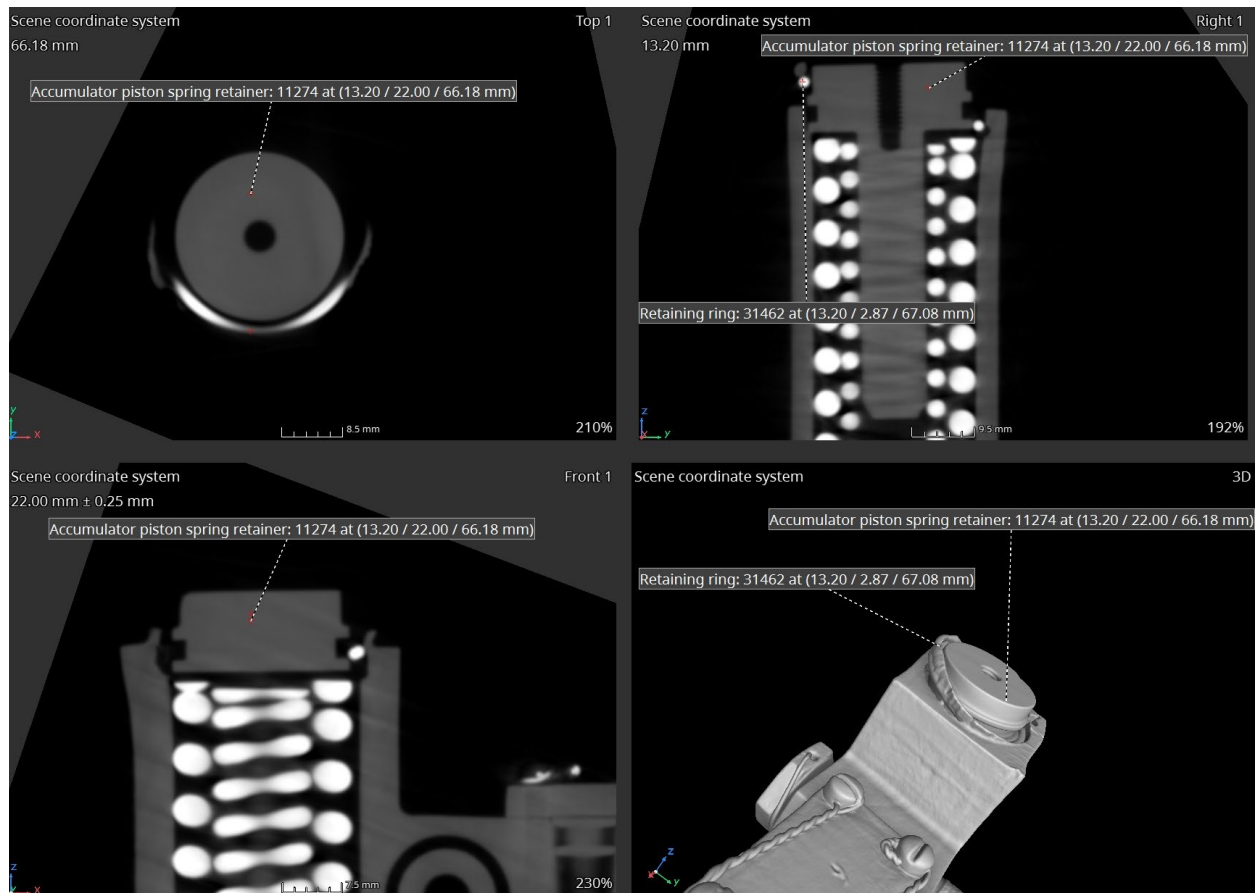


Figure 152. Left lateral actuator - irreversible valve - accumulator retaining ring and retainer. (450 kV)

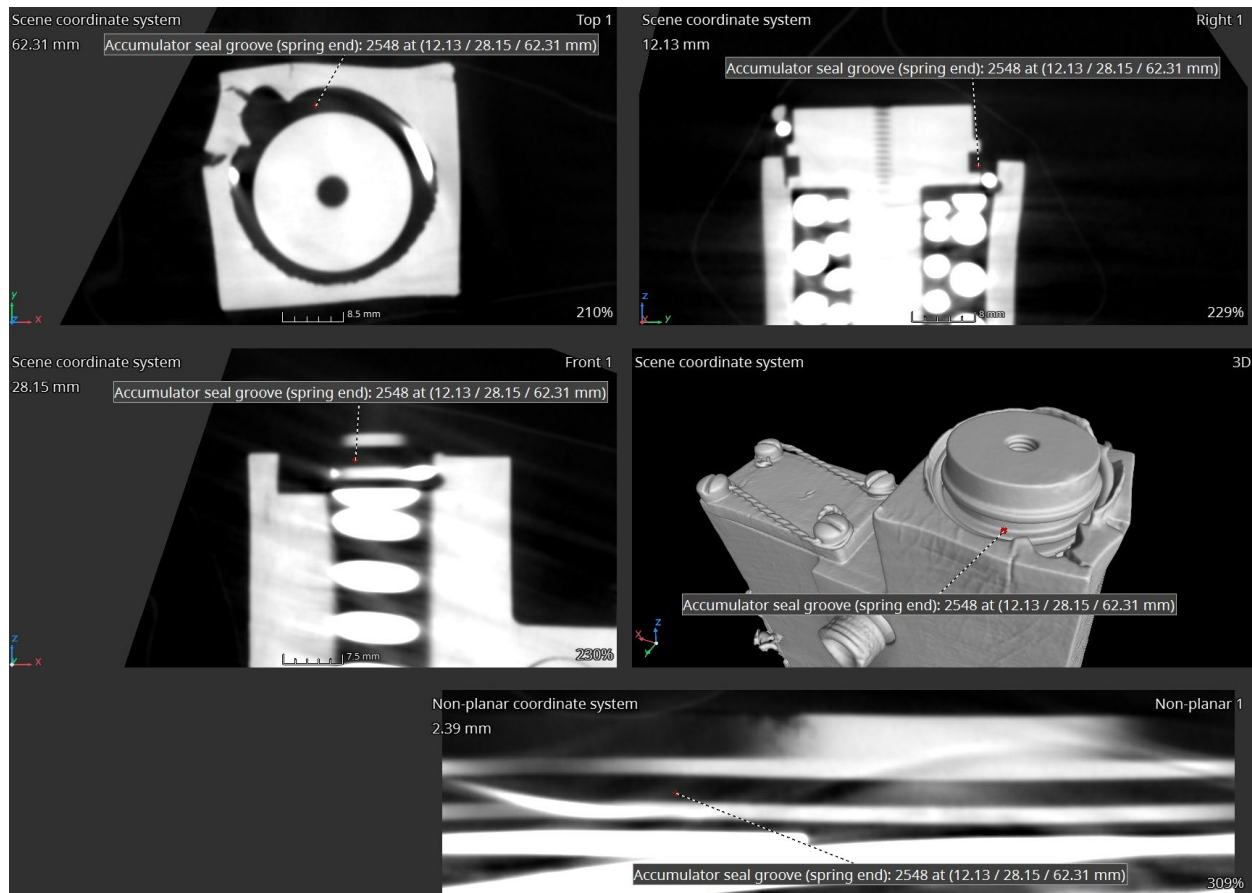


Figure 153. Left lateral actuator - irreversible valve - accumulator seal at spring end. (450 kV)



Figure 154. Left lateral actuator - irreversible valve - accumulator seal groove unrolled at spring end.
(450 kV)

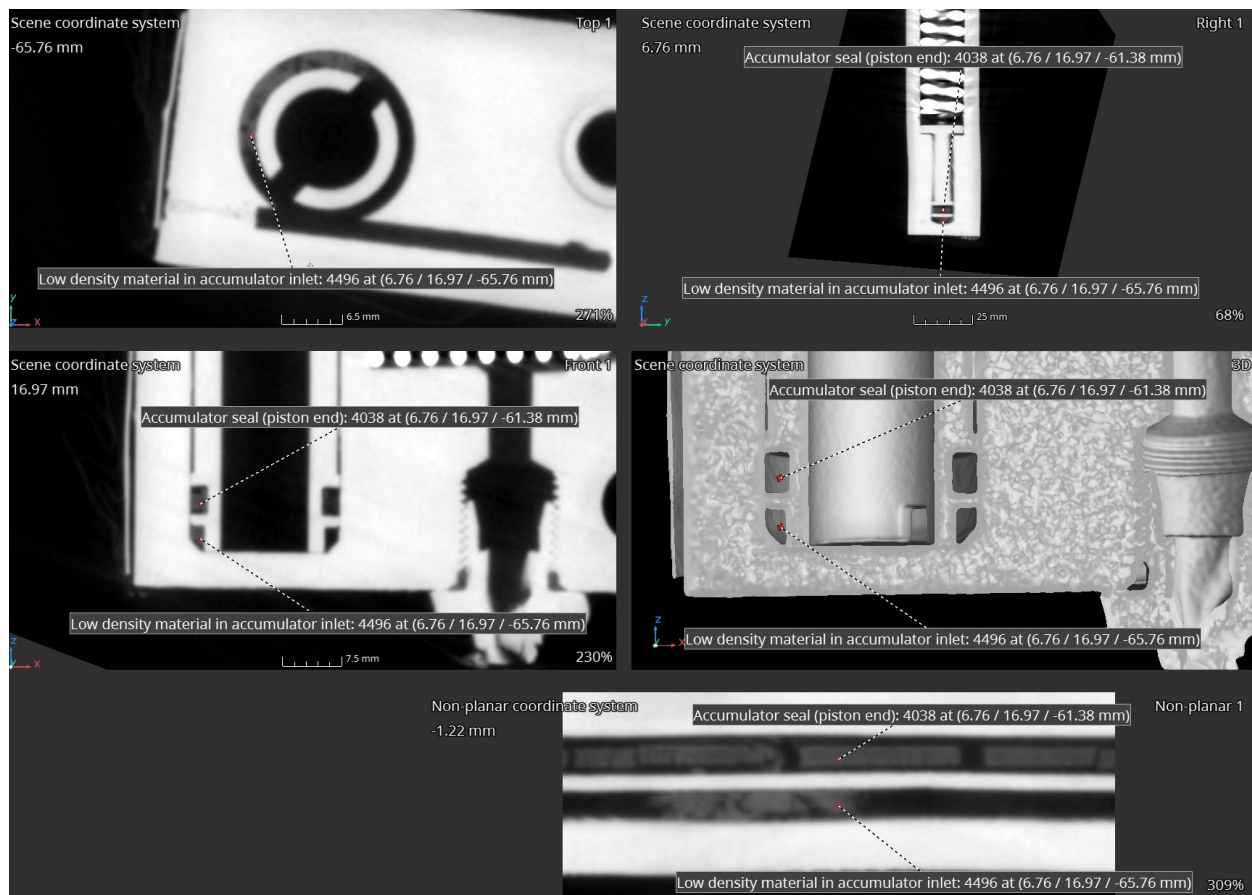


Figure 155. Left lateral actuator - irreversible valve - accumulator seal at piston end. (450 kV)

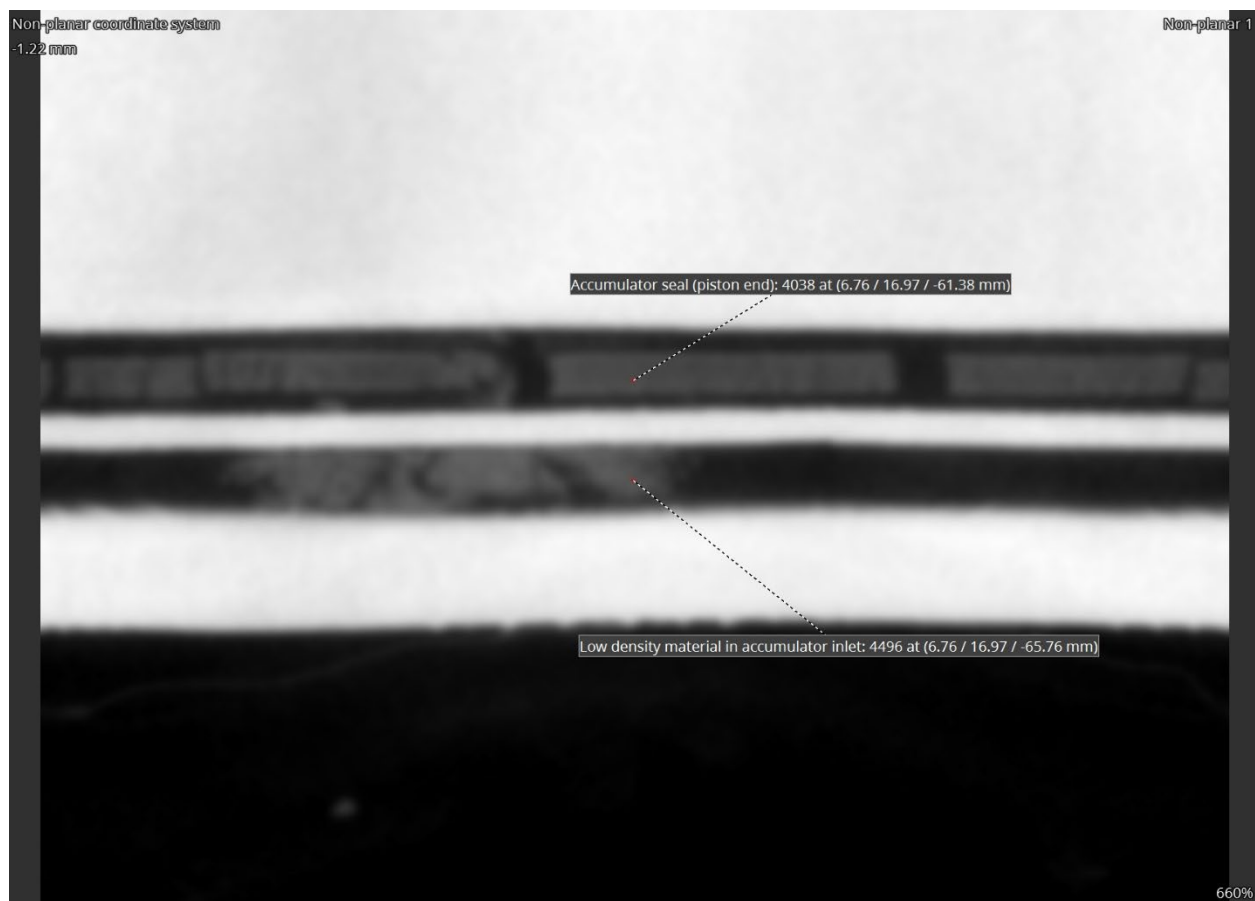


Figure 156. Left lateral actuator - irreversible valve - accumulator seal unrolled at piston end. (450 kV)

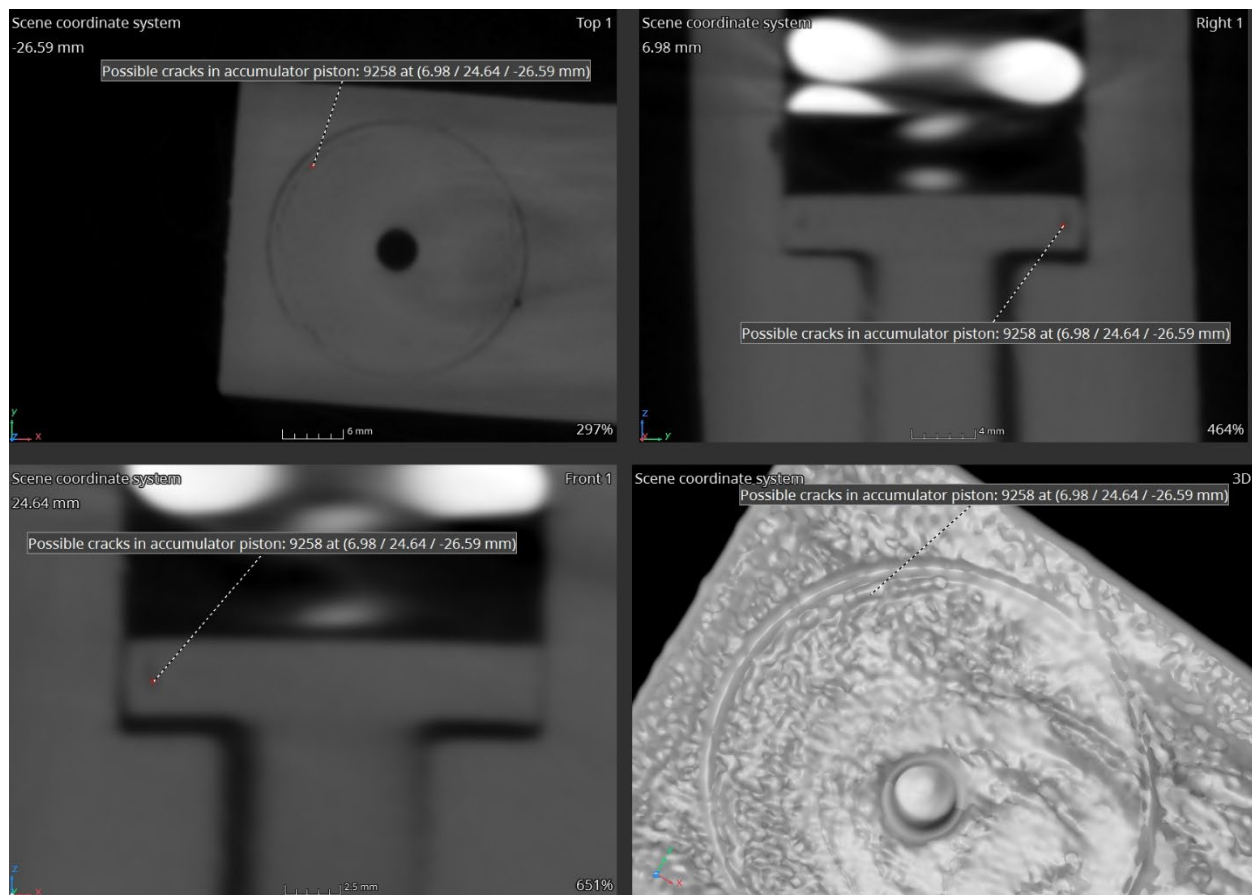


Figure 157. Left lateral actuator - irreversible valve - accumulator piston. (450 kV)

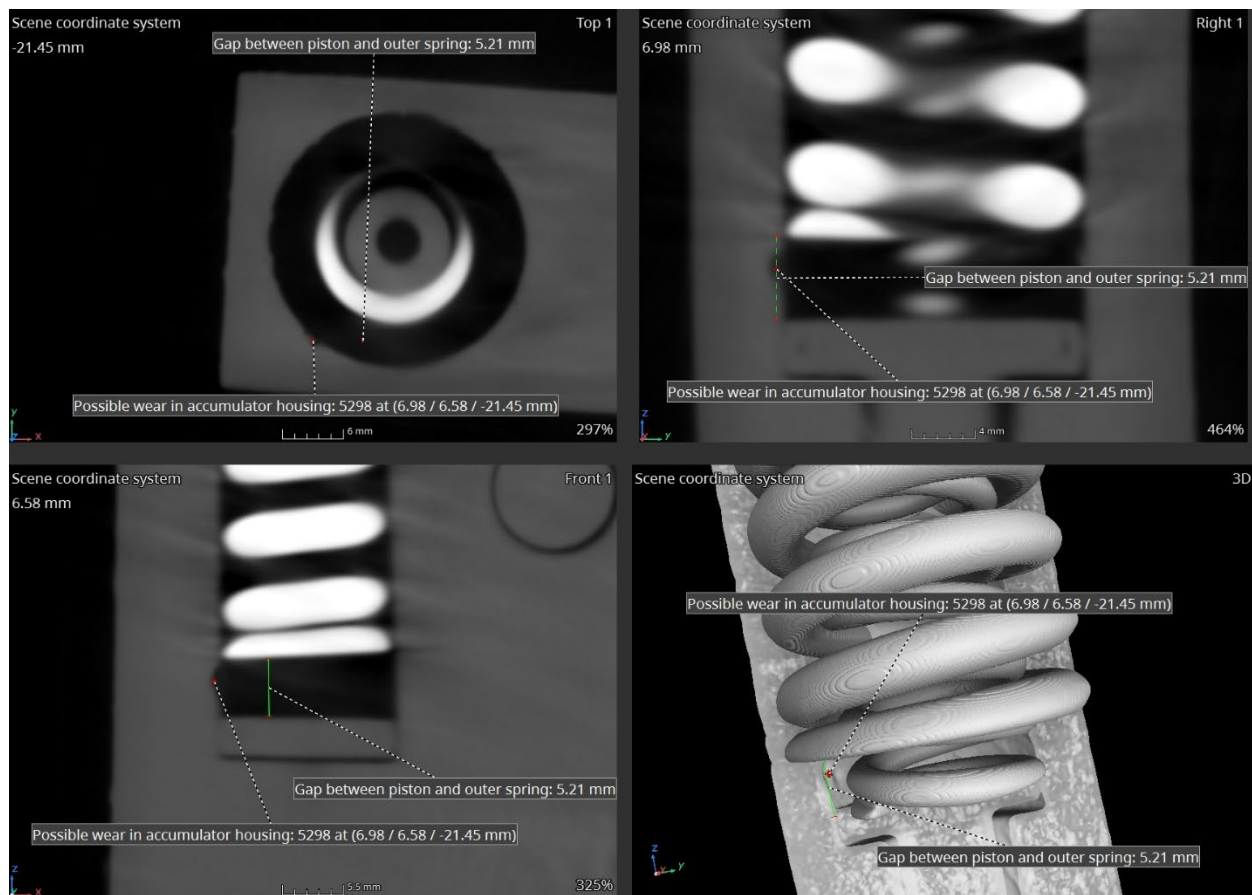


Figure 158. Left lateral actuator - irreversible valve - showing outer spring is not seated against the piston and possible wear in housing. (450 kV)

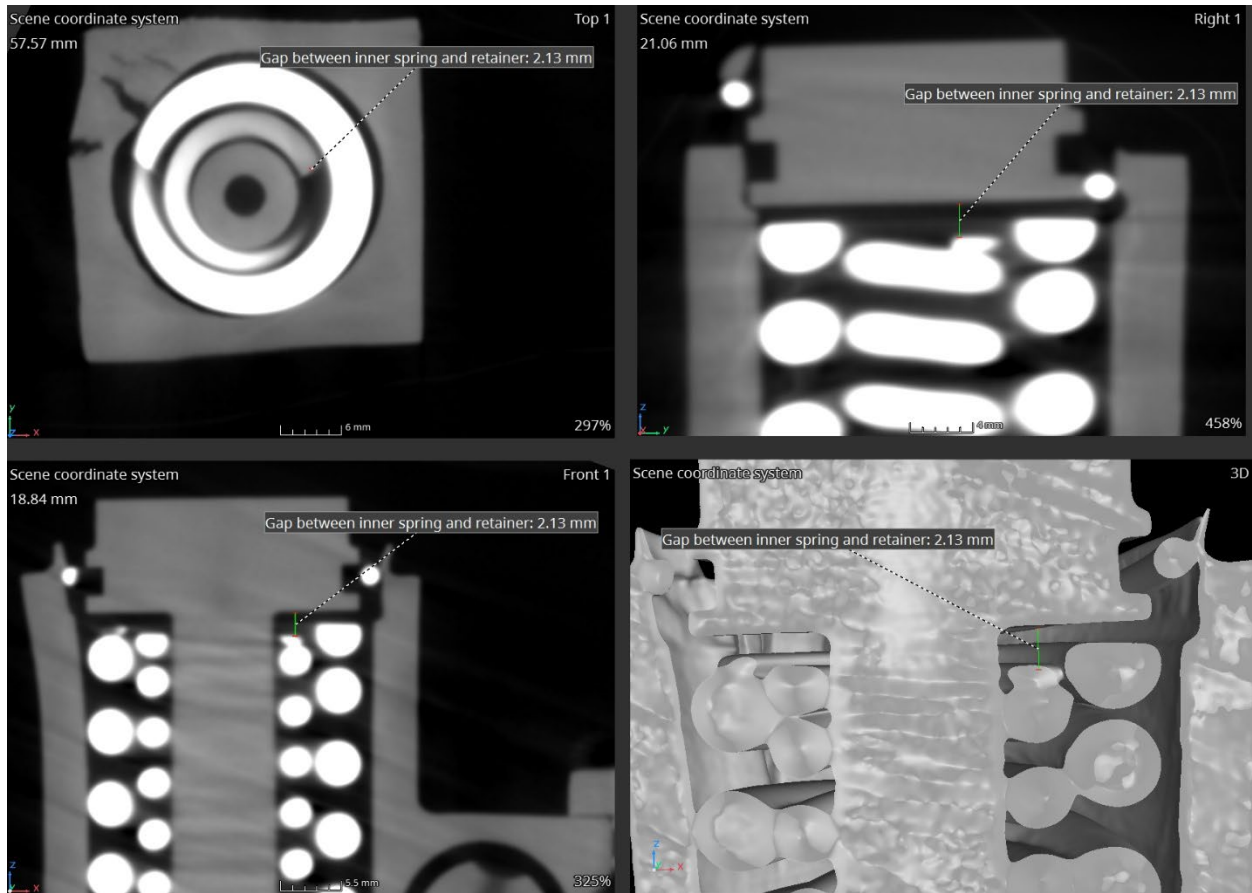


Figure 159. Left lateral actuator - irreversible valve - showing inner spring is not seated against the piston spring retainer. (450 kV)

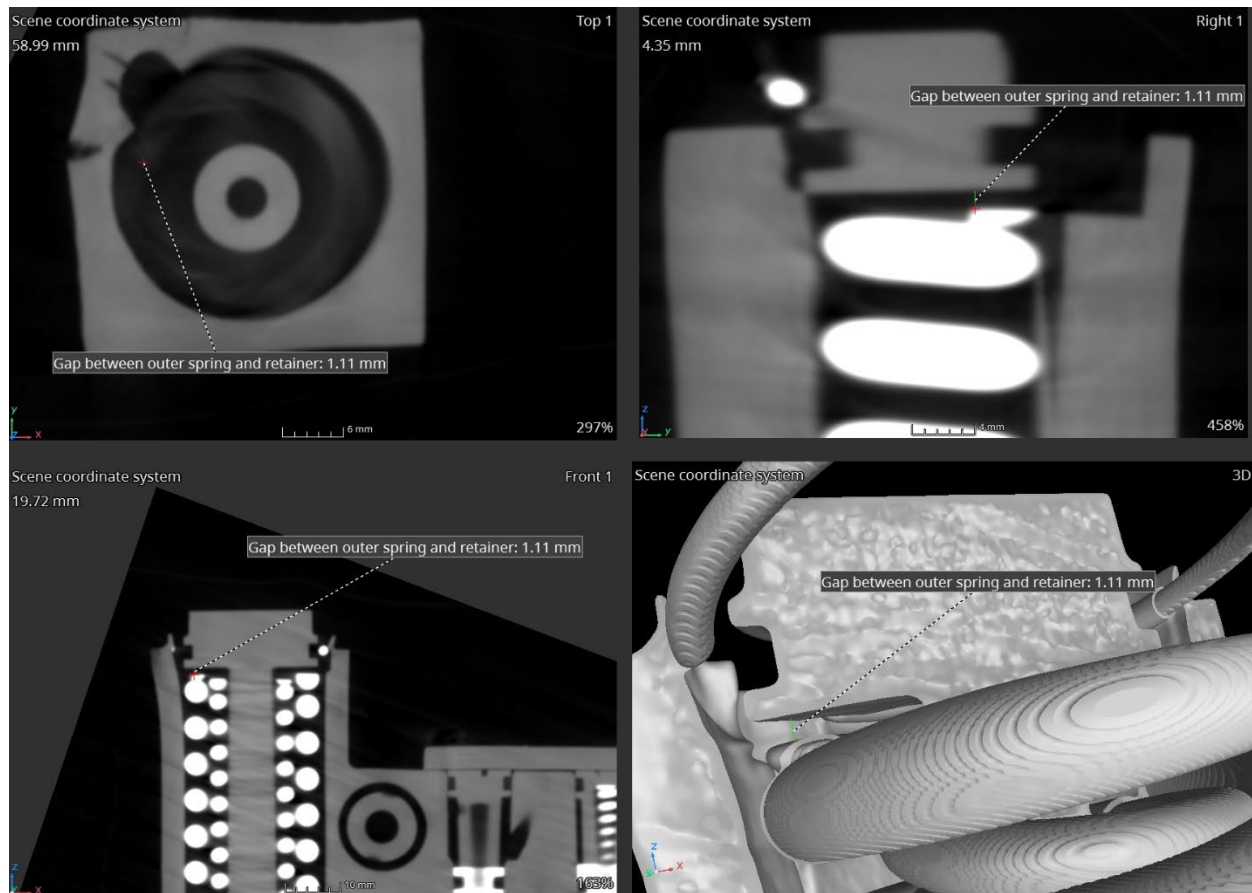


Figure 160. Left lateral actuator - irreversible valve - showing outer spring is not seated against the piston spring retainer. (450 kV)

Submitted by:

John Flynn
Aerospace Engineer