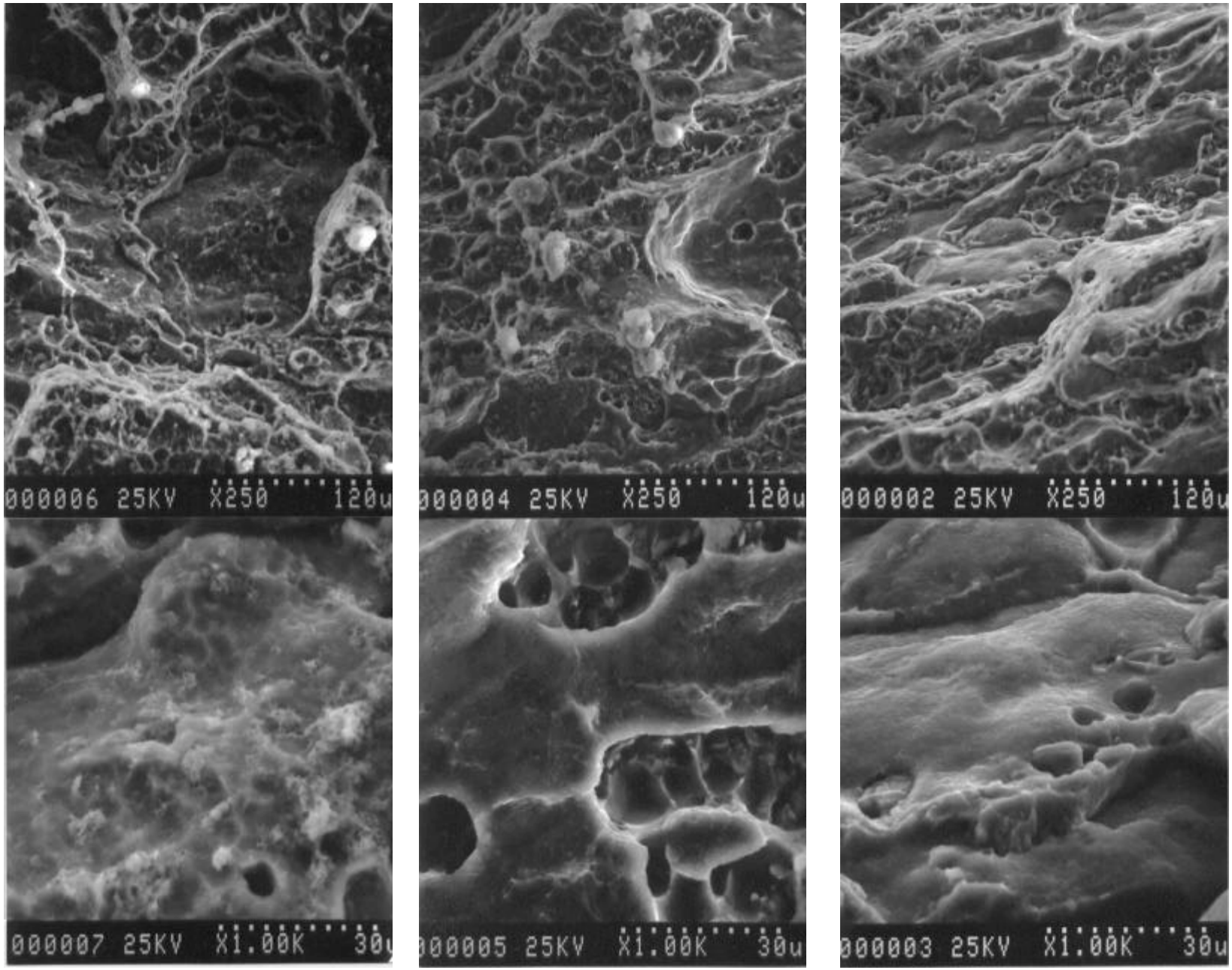
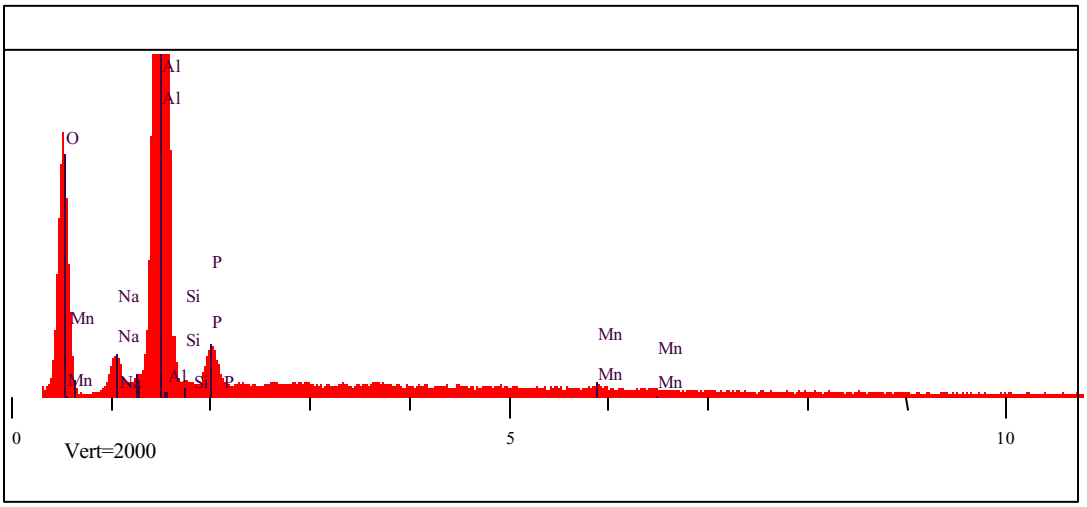


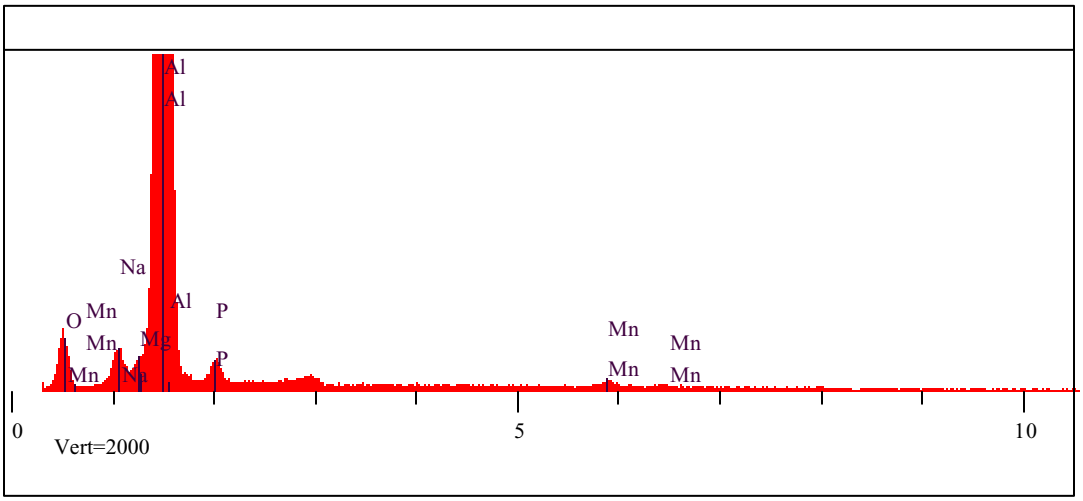
(a) Region I (dark area) (b) Region I (at transition) (c) Region I (beyond transition)

Figure 16. SEM fractographs from regions shown in Figure 14.

(a)



(b)



(c)

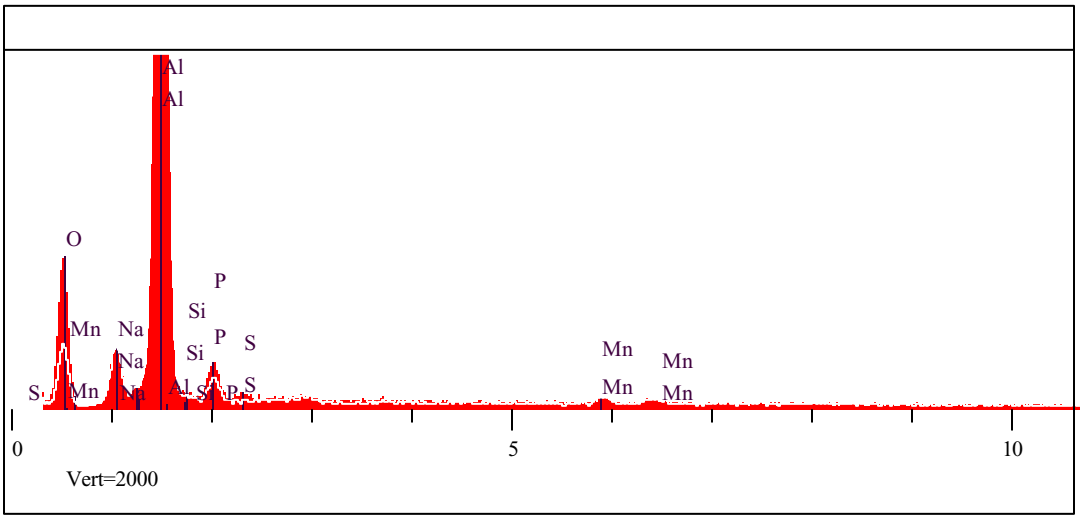


Figure 17: EDS results from 1-1-2 fracture surface.
(a) Region F (b) Region G (c) Region I
Plots show the spectra from the dark area (Figure 14) with the spectrum from the area beyond the beach mark superimposed in white. Note the lower S, O, and P peaks in the superimposed spectrum.

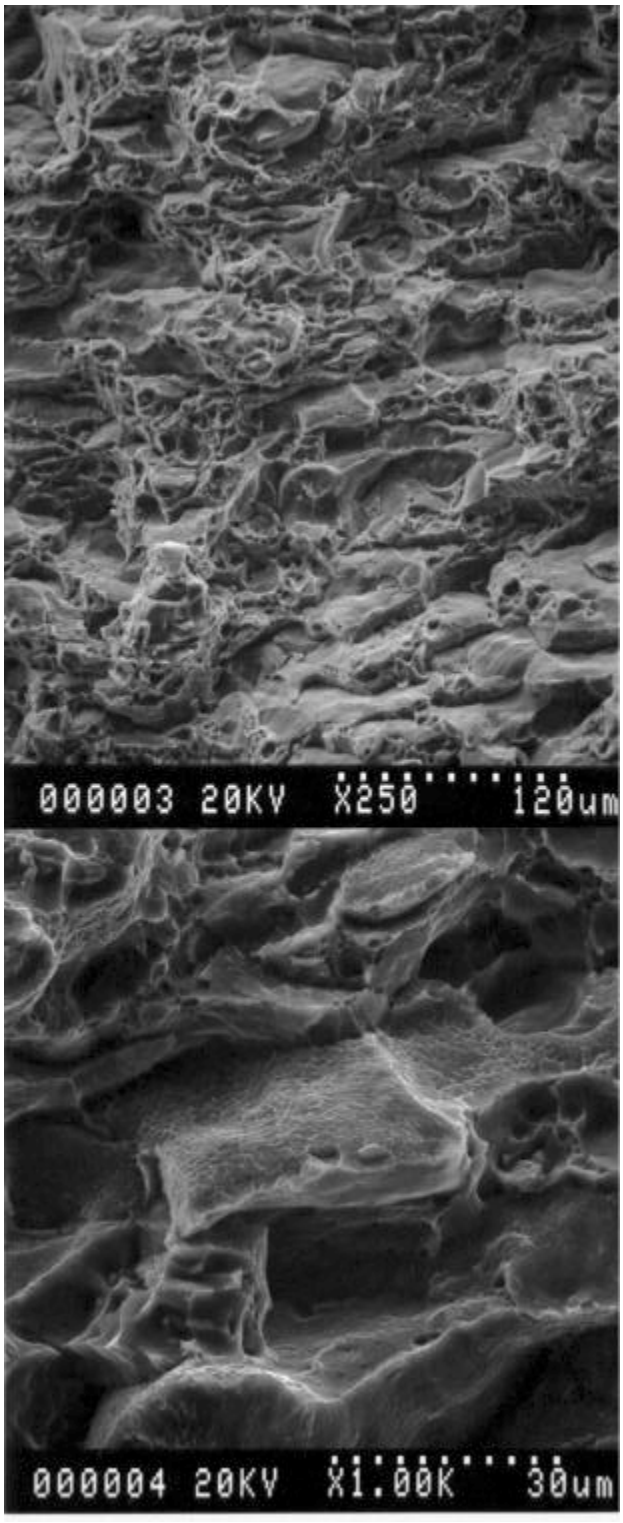


Figure 18. SEM fractographs of tensile specimen 1-2-1.

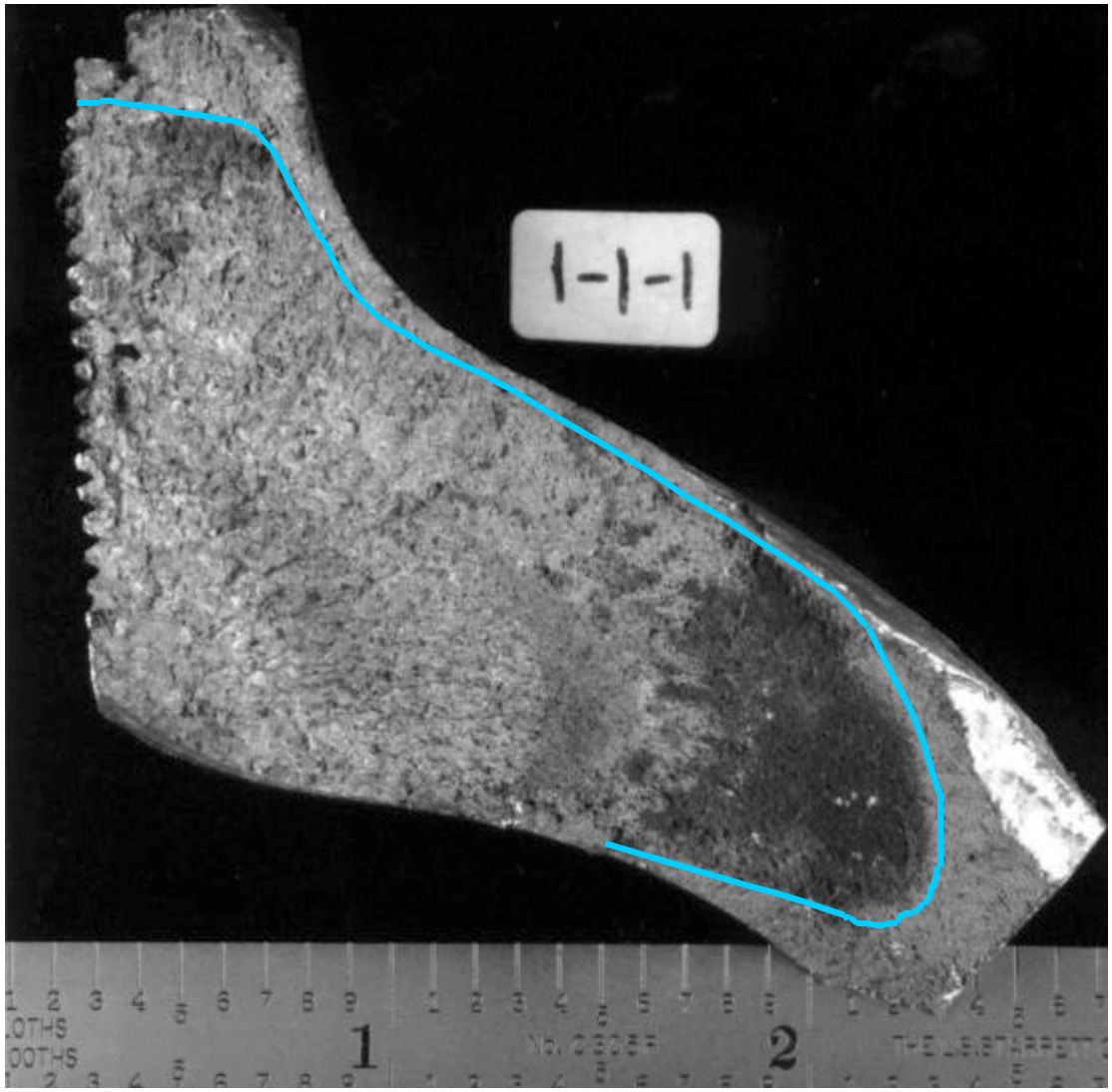


Figure 19: Approximate extent of subcritical crack growth on the 1-1-1 fracture surface.

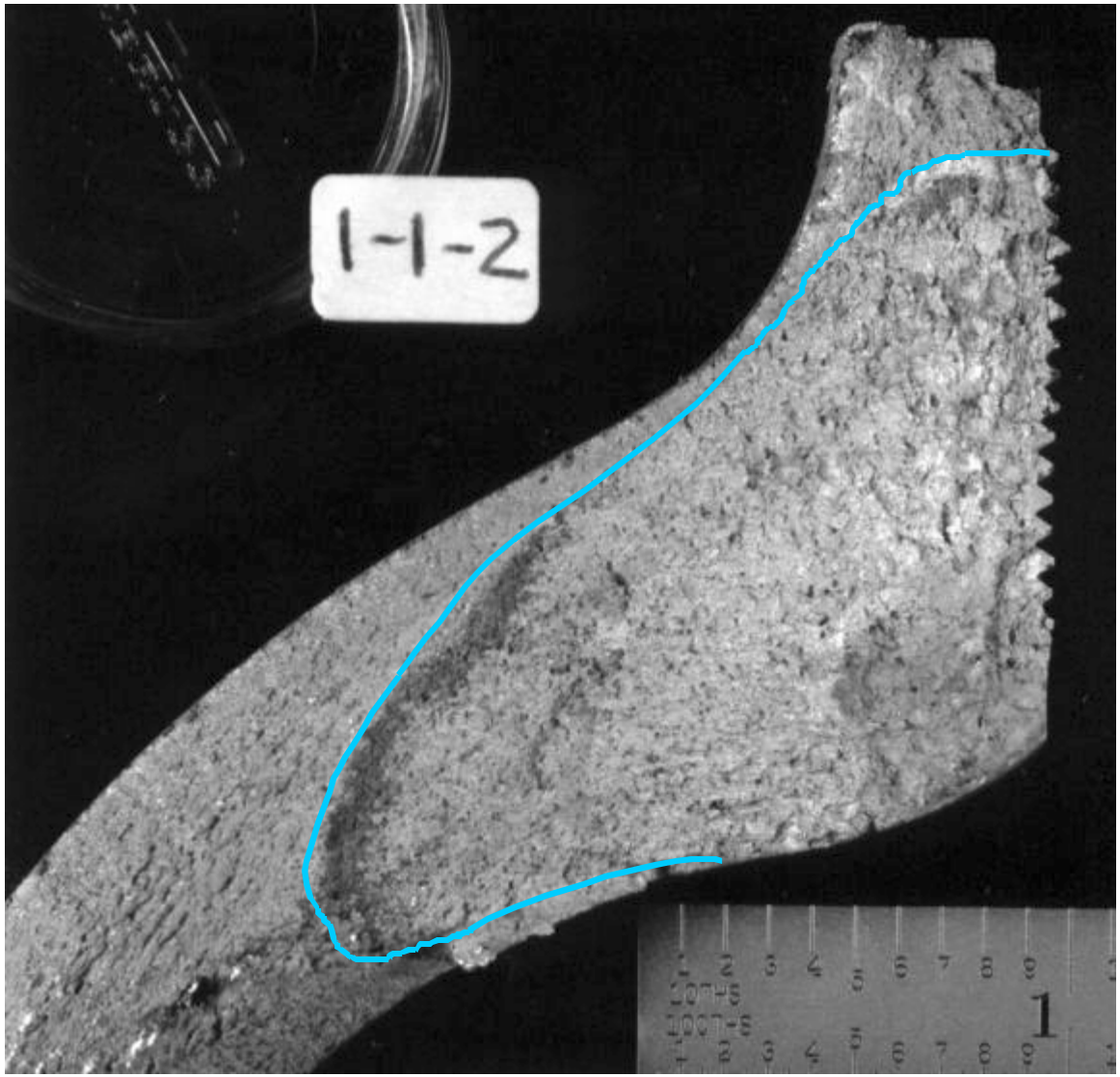


Figure 20: Approximate extent of subcritical crack growth on the 1-1-2 fracture surface.

Appendix A: Recommended Scope of Work

Recommended Scope of Work for Metallurgical Evaluation of Walter Kidde Aluminum SCUBA Cylinder

1. Photodocumentation. Prior to any destructive examination of this cylinder, it will be photodocumented to illustrate its "as-received condition". All stampings on the cylinder will be photodocumented. After each cutting operation needed to remove samples for testing or evaluation (such as required for chemical samples) the cylinder and sample will be photodocumented to illustrate the sample location. Photodocument the primary fracture surface as well as any secondary cracks that may be present. Any corrosion deposits or other visible surface contaminates should also be photodocumented

2. Corrosion. Testing for corrosion product should be done prior to any extensive cutting or handling of the cylinder remains. Swipe samples or cuttings of material containing any such potential corrosion products should be taken. When cutting is performed, care should be used to minimize contamination of the cylinder surfaces. Swipe samples or samples containing potential corrosion products should first be analyzed by scanning electron microscopy and energy dispersive spectroscopy (SEM/EDS).

3. Chemical Analysis. The cylinder aluminum alloy will be analyzed for chemical composition to compare with materials specifications. Material from the neck region, side wall and cylinder bottom will be analyzed to check for alloy homogeneity. The analysis will also determine the concentration of potentially detrimental trace elements, such as lead and bismuth.

4. Macroetching. A thin slice of material will be removed from the neck of the cylinder, including some sidewall material. This slice will be macroetched to show the grain macro/microstructure in this area.

5. Fractography. Fractures will be examined by SEM and stereo-microscopic techniques. Particular attention should be focused in the regions where the fracture originated. Any indications of fatigue, stress-corrosion cracking, ductile rupture, inter/intra-granular fracture features, etc., should be photodocumented.

6. Dimensional Checking. Prior to extensive cutting, the cylinder wall thickness at various locations and other cylinder features, such as threads, cylinder internal diameter, inlet hole diameter should be documented. Measurements done should be sufficient to determine the minimum wall thickness as well as to document any extensive plastic tearing that may have resulted in the failure event.

7. Secondary Cracking. A section of the primary fracture surface near the crack origin should be metallographically polished. Any secondary cracking near the failure origin should be evaluated. These sections should be first examined in the unetched condition and photodocumented to look for crack branching. The sample should then be etched, re-examined and photodocumented.

8. Material Hardness. The material hardness shall be evaluated by means of macrohardness testing according to ASTM standards.

9. Physical Testing.
Mechanical testing will be carried out following the procedure proscribed in 49 CFR, 178.46-13

10. Report. The report should contain a description of all tests performed and the results obtained. If possible, the location of the crack origin, mode of fracture, and likely cause of failure will be stated.

Appendix B: Detailed Photodocumentation of Cylinder

Photo ID: DC18344-R1E8

Photo ID: DC18344-R1E10

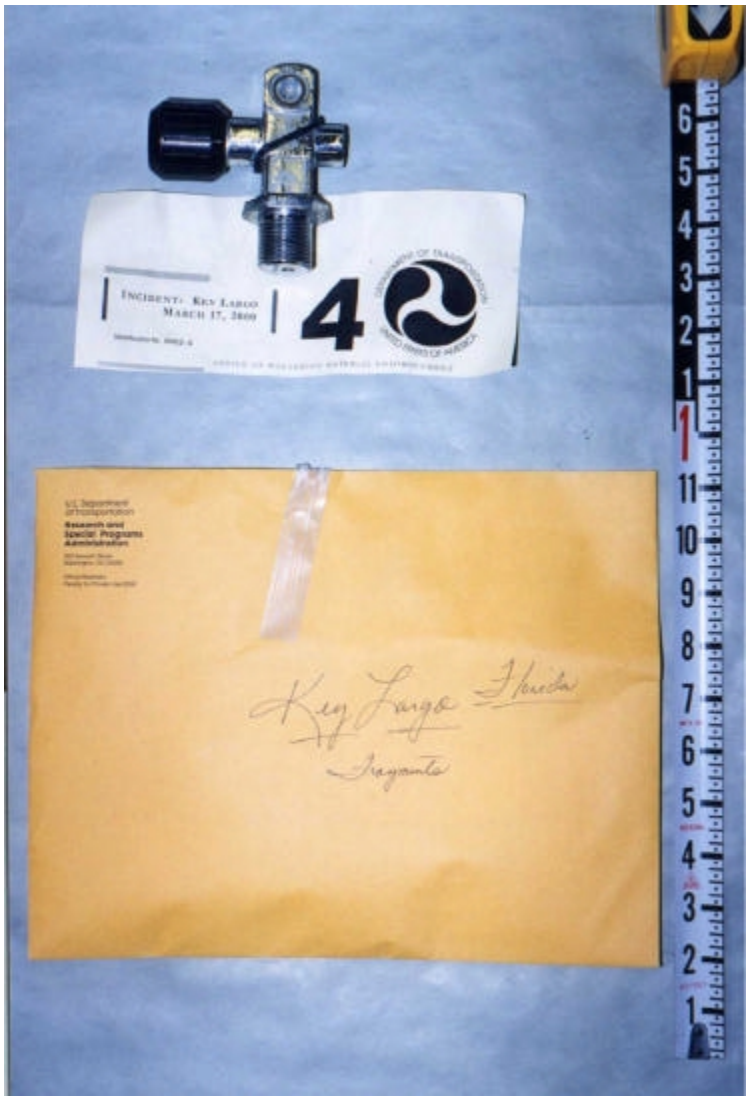


Photo ID: DC18344-R1E12

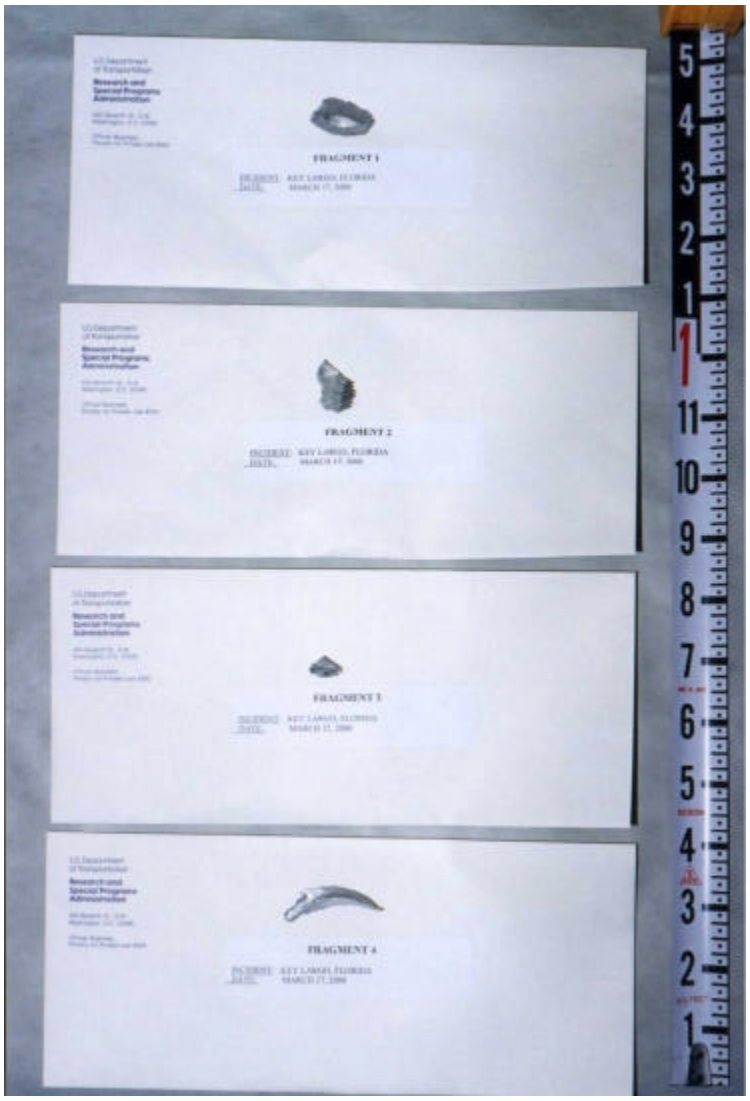


Photo ID: DC18344-R1E15