

The background of the slide features a stylized globe with a grid of latitude and longitude lines. Overlaid on the left side of the globe is the logo for Southwest Research Institute (SWRI), which consists of the letters 'S', 'W', 'R', and 'I' stacked vertically in a large, bold, sans-serif font. The letters are white with a blue outline and are set against a blue and white geometric background.

Metallurgical Analysis of Failed Valve

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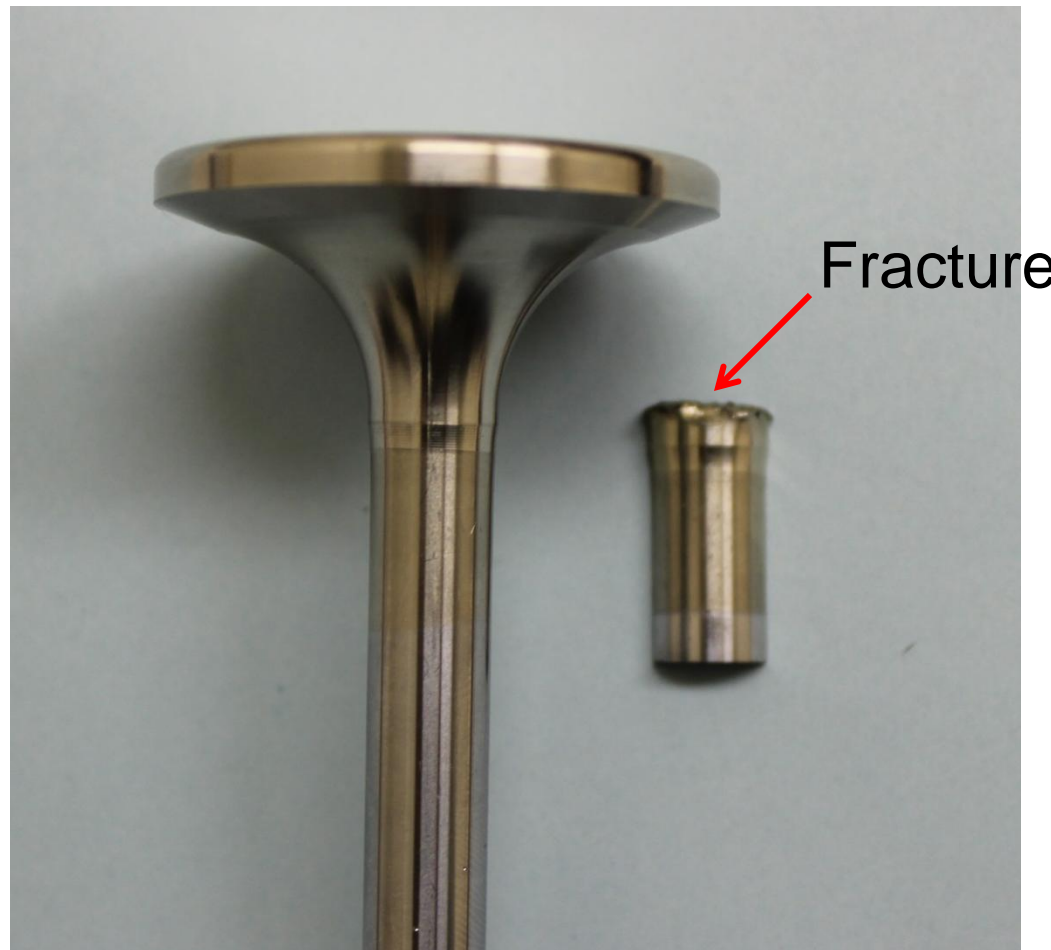
San Antonio, TX





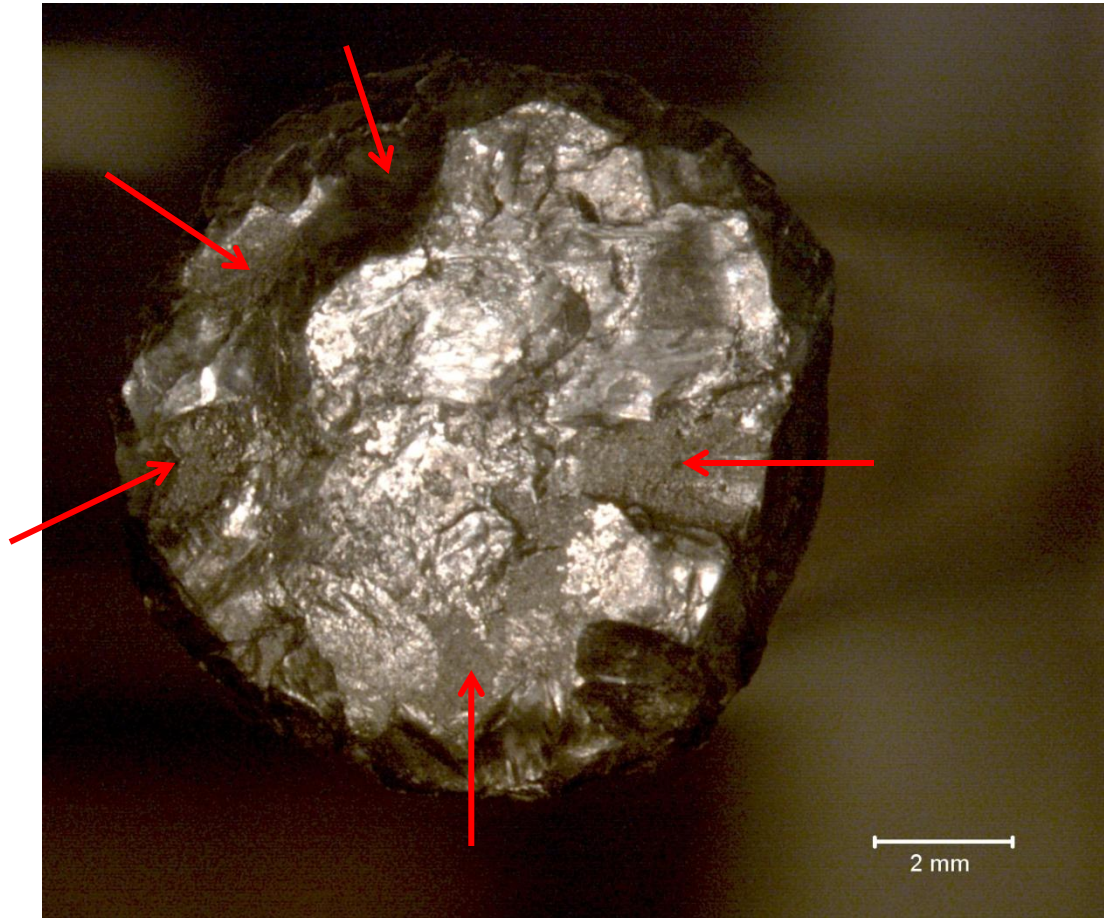
Fracture Location

Fracture separated the valve from the stem approximately 0.16" above the transition



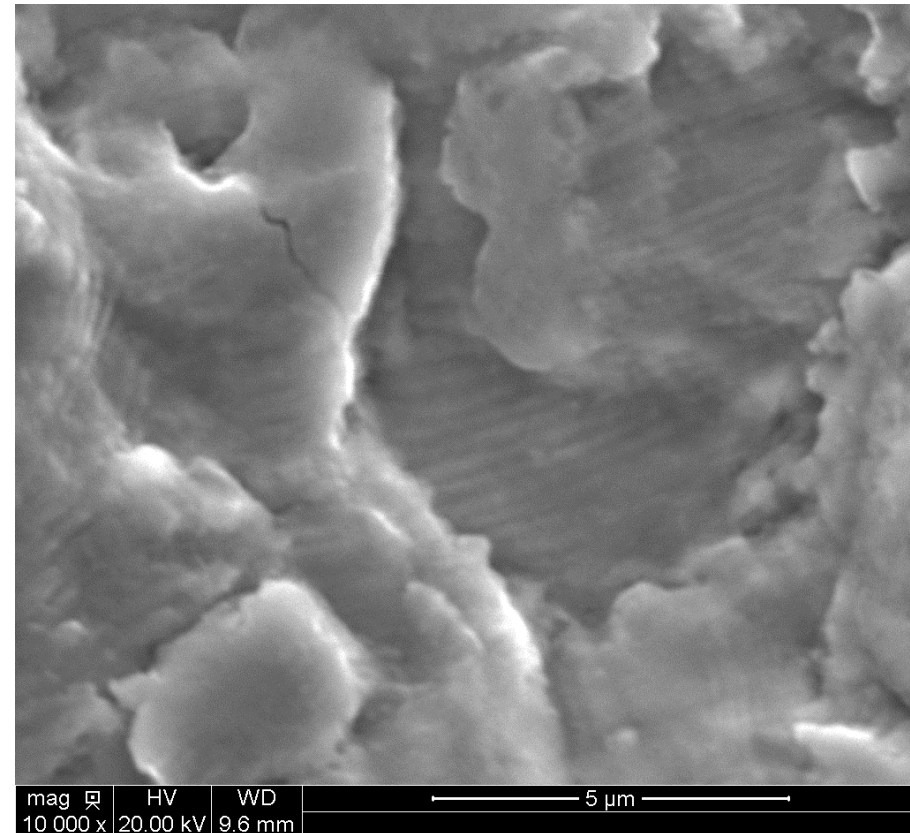
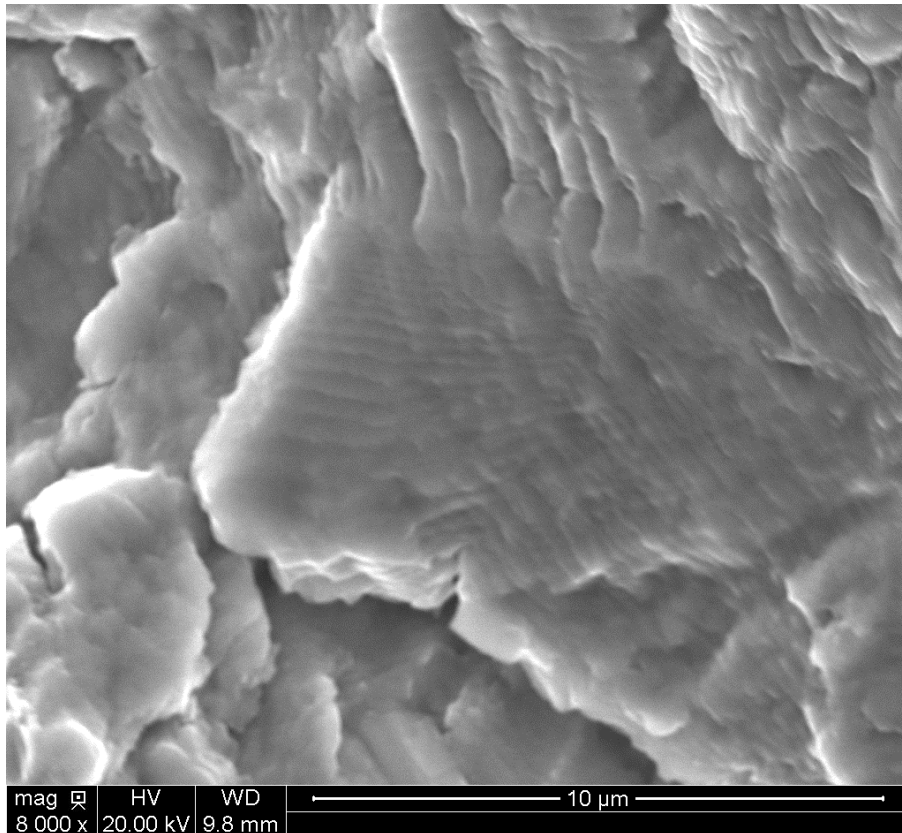
Valve Stem Fracture Surface

- Most of the fracture surface features had been destroyed by repeated contact following fracture
- Some recessed regions avoided this contact damage



SEM Fractography

Fatigue striations were present on areas of the fracture that had not been affected by repeated contact following fracture





Fractography Summary

- Extensive post fracture contact damage made it impossible to identify crack growth directions and the crack initiation site(s)
- Therefore, it was not possible to determine if material or geometric defects contributed to crack initiation
- The fracture morphology that was present in the areas that did not experience post fracture damage (fatigue striations) indicated that failure was by high cycle fatigue



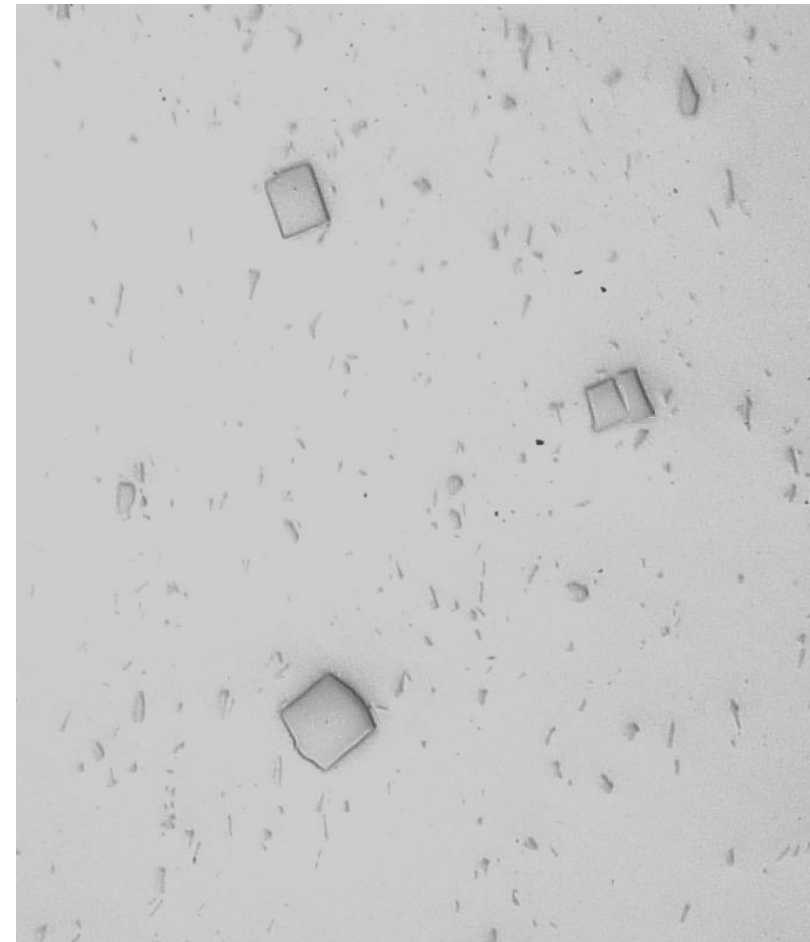
Metallography

Metallographic sections were prepared from the fractured valve and from unused valves from the same batch as the fractured valve and from a batch that has not experienced any failures

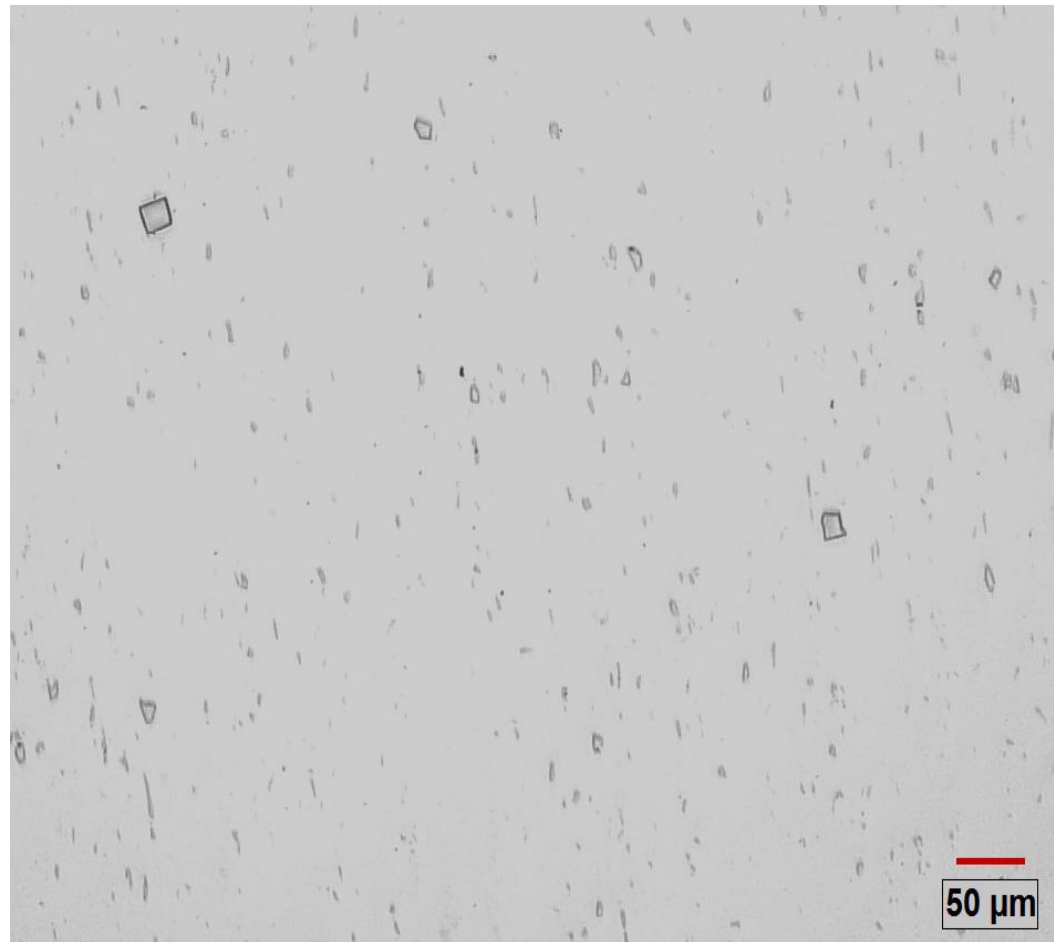




Metallography – Large Carbides



Fractured
Valve



Fractured
Batch



Metallography – Large Carbides Absent

Blocky carbides were absent on the section from the good batch



50 μm



Metallography – Transition Region



Fractured
Valve

Fractured
Batch

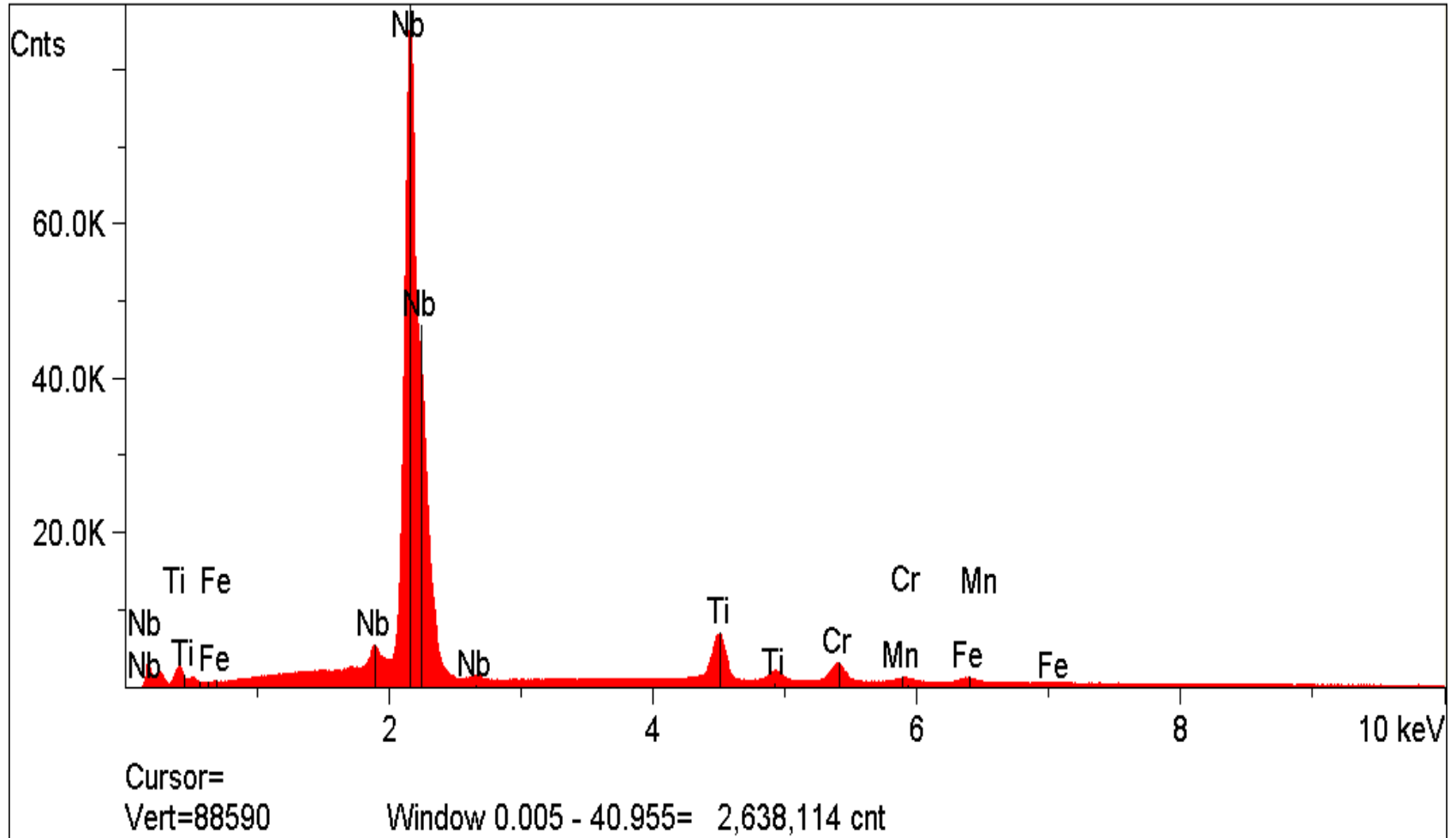
Good
Batch

50 μm



Metallography

EDS indicated blocky carbides were rich in Niobium





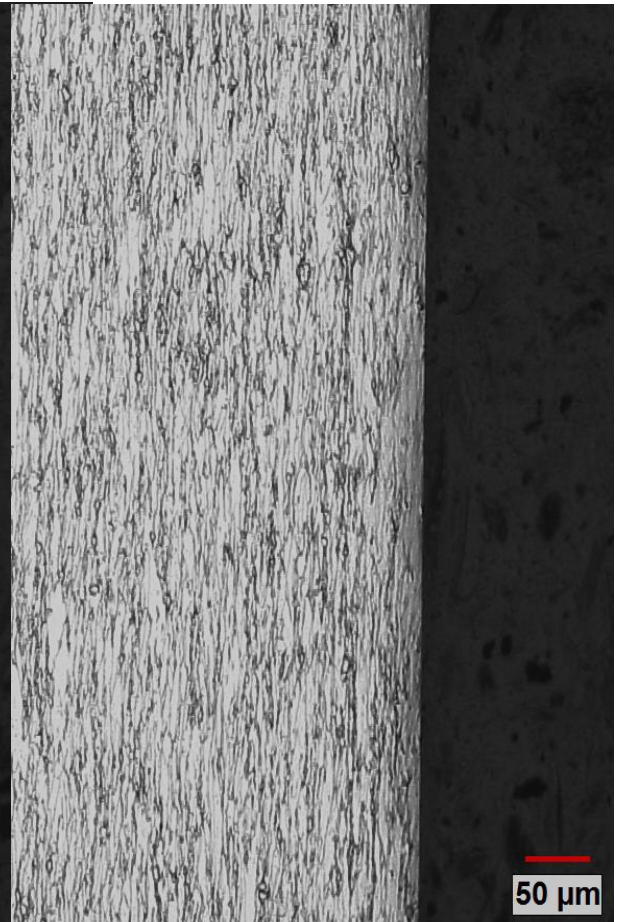
Metallography – Stem OD



Fractured
Valve



Fractured
Batch



Good
Batch

50 µm



Chemical Composition

Minor composition differences between batches

Fractured batch

Elt.	Line	Intensity (c/s)	Atomic %	Conc	Units	
Si	Ka	29.42	1.04	0.53	wt.%	
Cr	Ka	1,317.43	22.18	20.72	wt.%	
Mn	Ka	478.28	9.77	9.64	wt.%	
Fe	Ka	2,537.54	61.94	62.13	wt.%	
Ni	Ka	91.88	3.25	3.43	wt.%	
Nb	La	114.16	1.51	2.52	wt.%	
W	La	8.19	0.31	1.03	wt.%	
			100.00	100.00	wt.%	Total

Good batch

Elt.	Line	Intensity (c/s)	Atomic %	Conc	Units	
Si	Ka	21.07	0.71	0.36	wt.%	
Cr	Ka	1,415.27	22.53	21.04	wt.%	
Mn	Ka	468.48	9.06	8.94	wt.%	
Fe	Ka	2,700.60	62.51	62.71	wt.%	
Ni	Ka	104.98	3.52	3.71	wt.%	
Nb	La	110.92	1.39	2.32	wt.%	
W	La	7.63	0.28	0.91	wt.%	
			100.00	100.00	wt.%	Total



Metallography Summary

- Large Niobium carbides are present in both the fractured valve stem and in the intact stem from the same batch but not in the intact stem from the good batch
- Many of these carbides are located along, or near, the OD surface.
- A difference in the amount of recrystallization along the OD edge is also present
- These microstructural differences suggest a difference in the processing between the valve batches



Conclusions

- The presence of fatigue striations indicates that the valve stem failure was by high cycle fatigue
- Post-fracture damage to the fracture surface precluded identification of the fracture initiation site and examination of the role of possible defects
- Large Niobium carbides were present in the failed stem and a second intact valve from the same batch but were absent from an intact stem from a batch that has not exhibited any failures
- These large carbides, particularly if located near the surface, could act as local stress concentrators, thereby facilitating fracture initiation and decreasing the stem's resistance to fatigue failure