Deterministic evaluation of L132 girth weld fitness for service in soil liquefaction zones

Redacted PE

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Background

- PG&E is conducting internal video inspection (IVI) of selected pipelines to characterize the seam, view and record stencils and markings, and document the approximate length of each pipe section.
- While conducting the IVI PG&E has observed lack of penetration in girth welds, requiring a process to evaluate fitness.

Scope

- Mission: Evaluate whether girth welds in L132 are able to withstand seismic event in soil liquefaction zones
- Inputs:
  - Applied strains from geotechnical study by Kleinfelder, Honneger
  - Weld ductility and mechanical properties tests by EWI
  - Characteristic weld quality based on sampled inspection data
- Determine critical flaw sizes using accepted standards

Weld Sampling

- 7 weld samples gives high confidence that material properties tests are representative
- With observed variation, confidence level is near 99%
- Sampling met requirements of applicable fitness for service standards

Material test results

	CTOD (in.)	YS (ksi)	UTS (ksi)
Minimum	0.0026	48.9	70.1
Average	0.00767	50.4	75.6
Maximum	0.0166	52.3	80.1

Material test results interpretation

- CTOD results show ductile fracture behavior can be expected so welds have good flaw tolerance
- Brittle fracture is unlikely so welds are superior to acetylene welds
- Weld metal strength is similar to or better than the line pipe

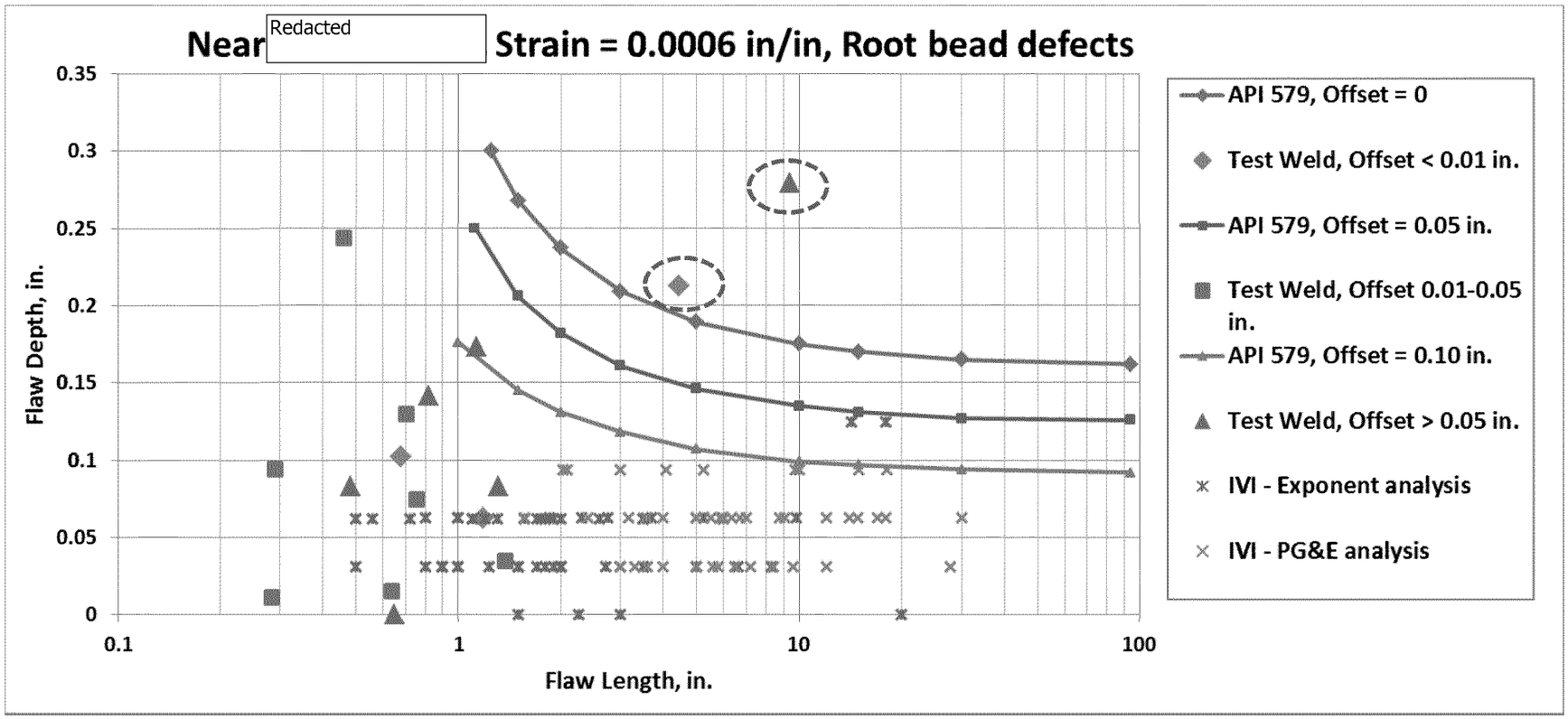
Applied stresses

- Operating stresses:
  - 2,400 psi at 200 psig internal pressure
  - 8,775 psi for 45 F thermal expansion
- Two seismic event cases considered:
  - At Redacted strain = 0.0006 in/in
  - Remote from creek, strain = 0.0004 in/in
- Total applied stress in the event of soil liquefaction:
  - Redacted stress = 29,175 psi = 56.1% SMYS
  - Other areas, stress = 23,175 psi = 44.6% SMYS

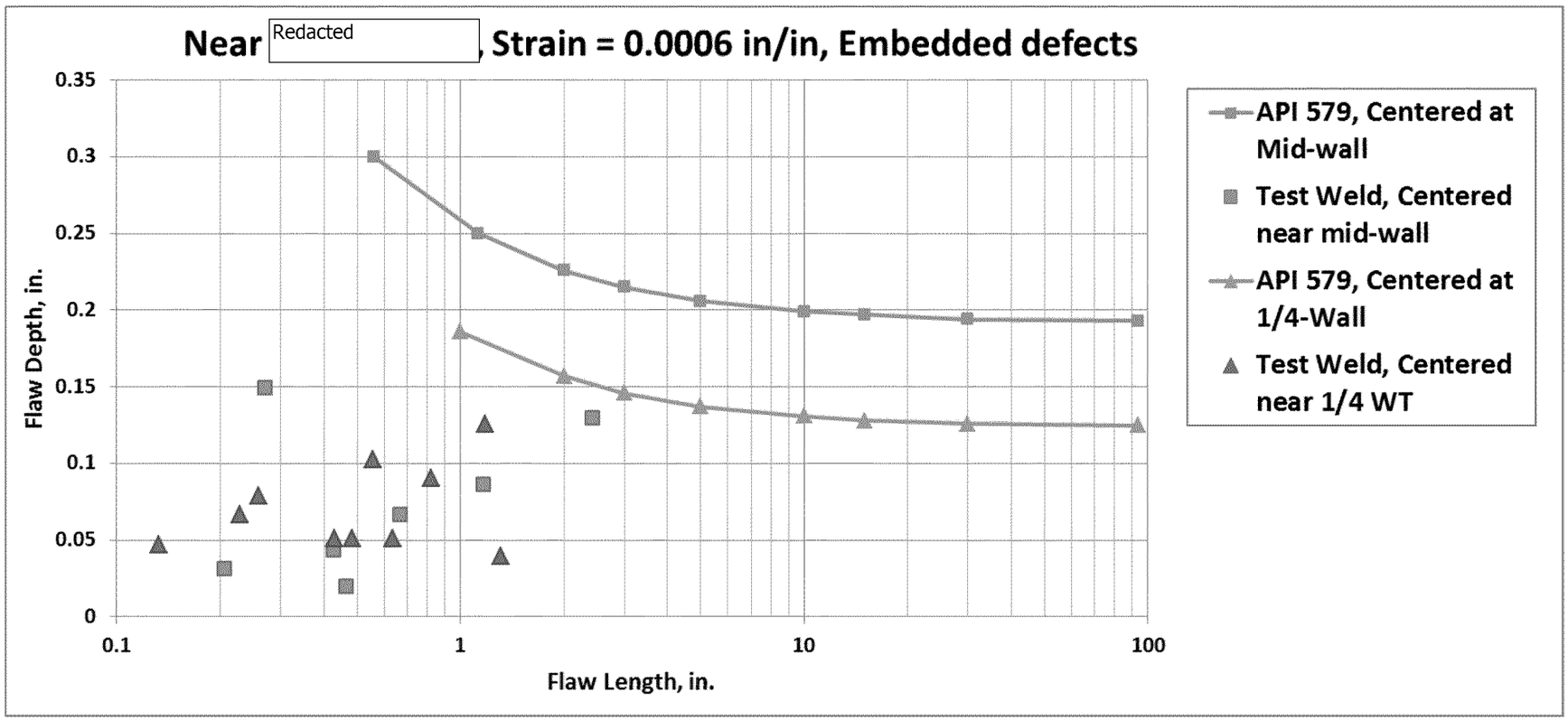
Critical flaw size criteria

- API 1104, Appendix A alternative welding workmanship standard
- API 579, Level 2 fitness for service standard
- API 579 is more rigorous and conservative and therefore was used in final assessment
- Confirmatory analyses performed using circumferential defect models in engineering literature

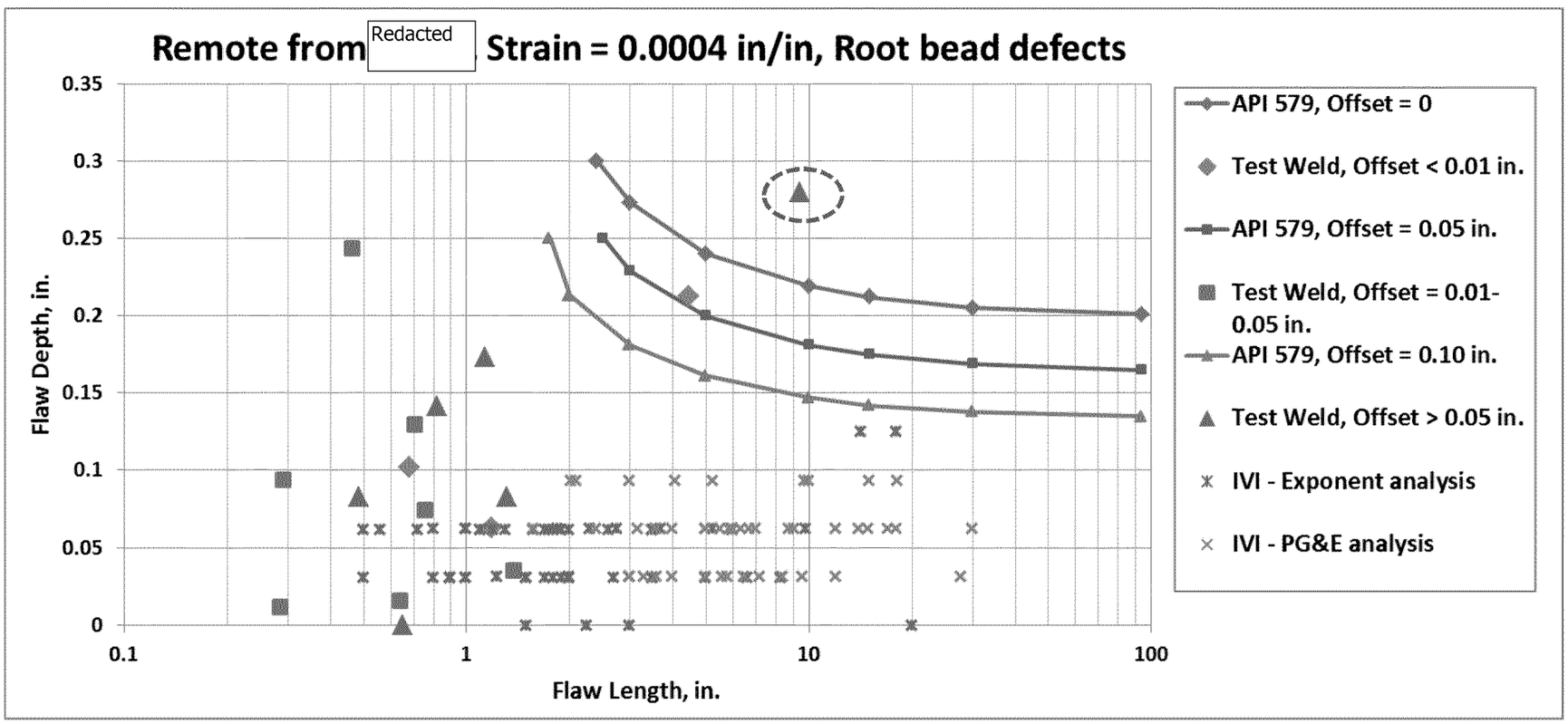
Adjacent to Redacted
Root bead IP and burn-through



Adjacent to Redacted
Embedded flaws



Remote from Redacted
Root bead IP and burn-through



Remote from Redacted
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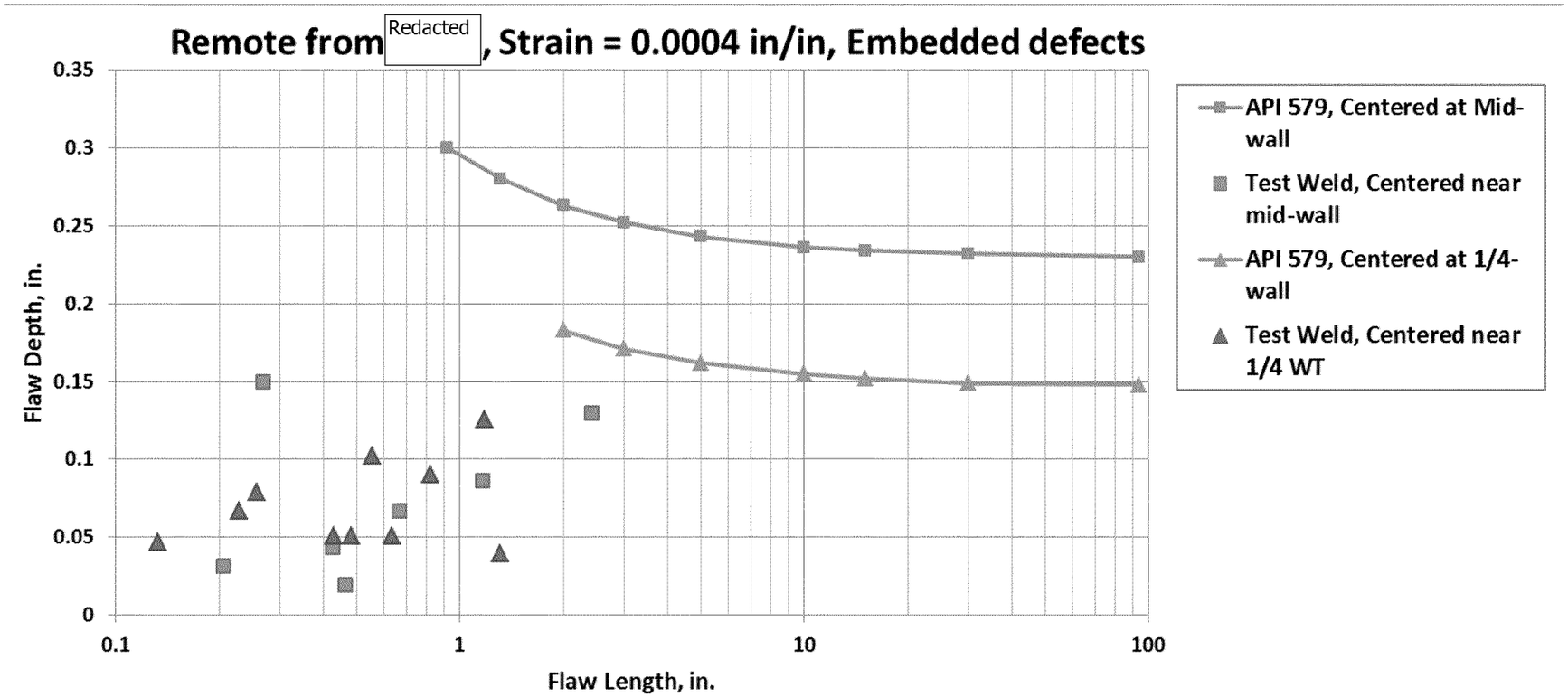

Results

- Analysis showed that critical defect sizes are governed by weld metal strength, not toughness properties.
- Results considered lowest weld strength.
- Embedded flaws are not governing, so IVI can be used to detect potentially critical flaws.

Results

- Two outliers discovered in L132 might not perform as required during an event.
- Outliers were removed and confirmation that no similar conditions remain in welds near creek can be obtained by IVI.
- Welds with flaws similar to the rest of those discovered would be expected to perform as required during an event.
- No weld concern exists if no seismic event occurs.