

# Sequoyah Nuclear Plant Reactor Coolant Pump Shaft Cracking

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(Thanks to Joel Whitaker for assembling data)

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# Introduction

- Sequoyah Nuclear Plant has recently found cracks on two reactor coolant pump shafts
- The first was on Unit 1 RCP#4 in Fall 2000
- The second was on Unit 2 RCP#1 in Spring 2002
- Both were showing abnormal signs of vibration
- BUT – the unit 2 shaft vibration was not severe

# History

- Reactor Coolant Pumps for SQN are part of pre-1974 manufactured pumps.
- Six out of 59 have had cracking incidents.
  - 1 Surry (Pre-1973 Failure)
  - 2 B&W Units (More severe duty cycle than Westinghouse plants)
  - 1 Prairie Island (1981)
  - 2 Sequoyah (2000 and 2002)

# History – Sequoyah U1 RCP4

- August 2000 - Upward vibration trend noticed - 8.5 mils
- September 15, 2000 - 10.4 mils & October 6, 2000 - 14.3 mils
- Decision to bring unit off-line and perform testing -17 mils with final test at 20 mils vibration.
- Decision to UT the motor shaft. (No Evidence of Cracking)
- Decision to perform UT of pump shafts from RCP#1 and #4. (Significant difference in UT signatures)
- UT sample expanded to include two from non-operating unit at Watts Bar for additional information.
- Decision made to replace RCP #4 rotating assembly.

# Metallurgical Evaluation

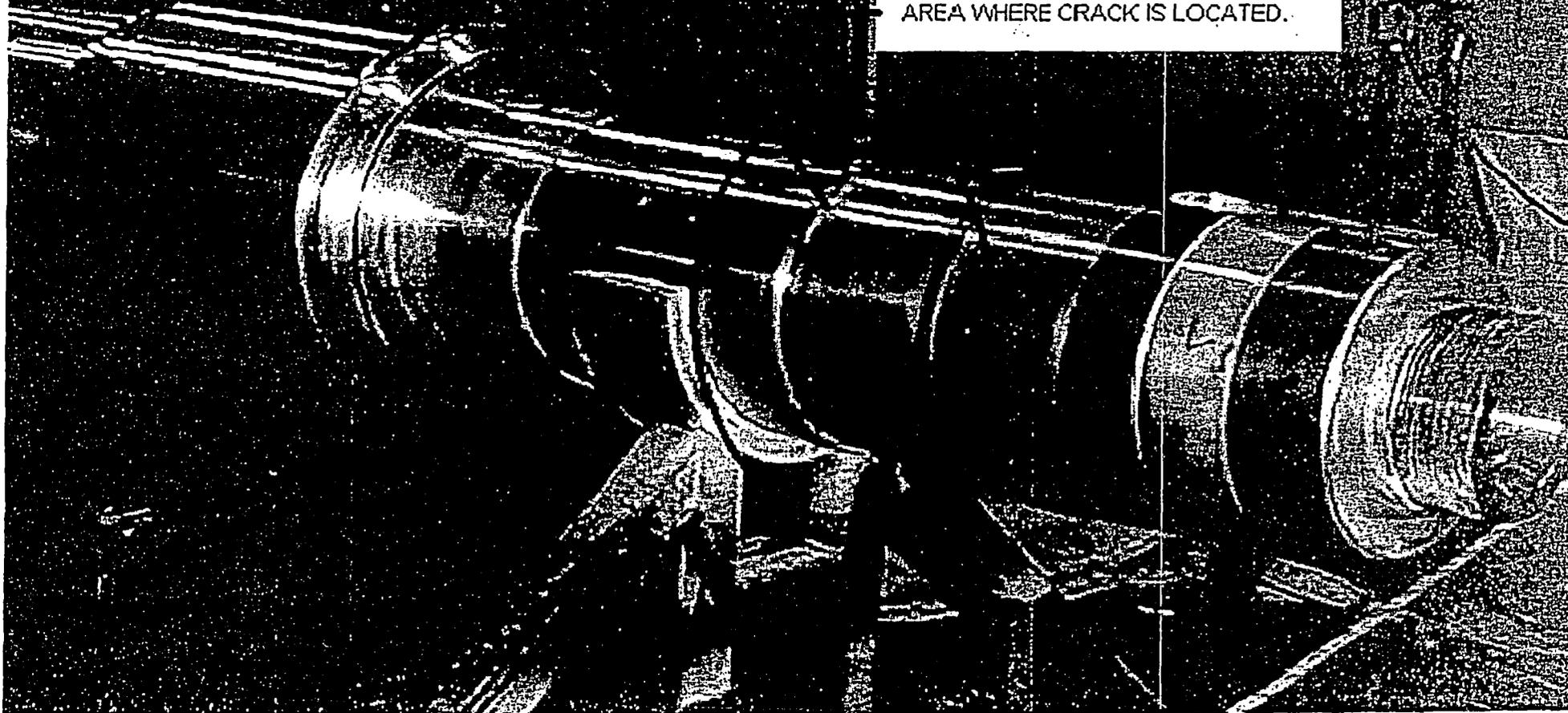
## U1 RCP4

- Pump 4 Shaft sent out for decontamination, disassembly, and inspection.
- Lateral run-out was measured at 2 mils which was indicative of a crack under the thermal sleeve.
- Thermal sleeve was removed and PT performed.
- Crack revealed in the pin hole plane. (approx. 252 degrees)
- Crack Initiation at the edge of the Pin Hole may have been promoted by:
  - Geometric stress concentration at this point.
  - Residual stresses due to welding of the pin.
  - Cold work due to manufacture.

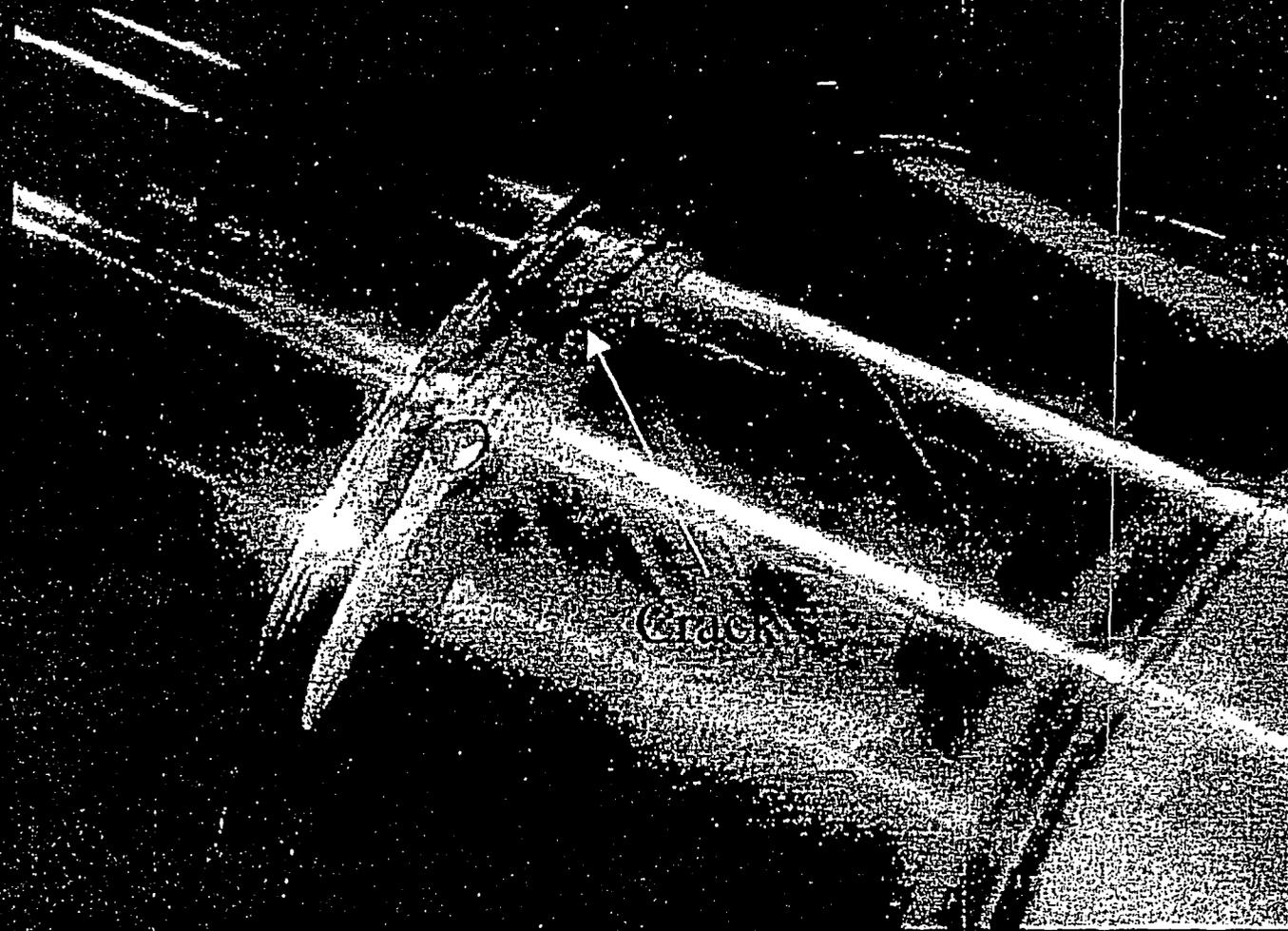
# U1 RCP4 Shaft

JOURNAL AREA.

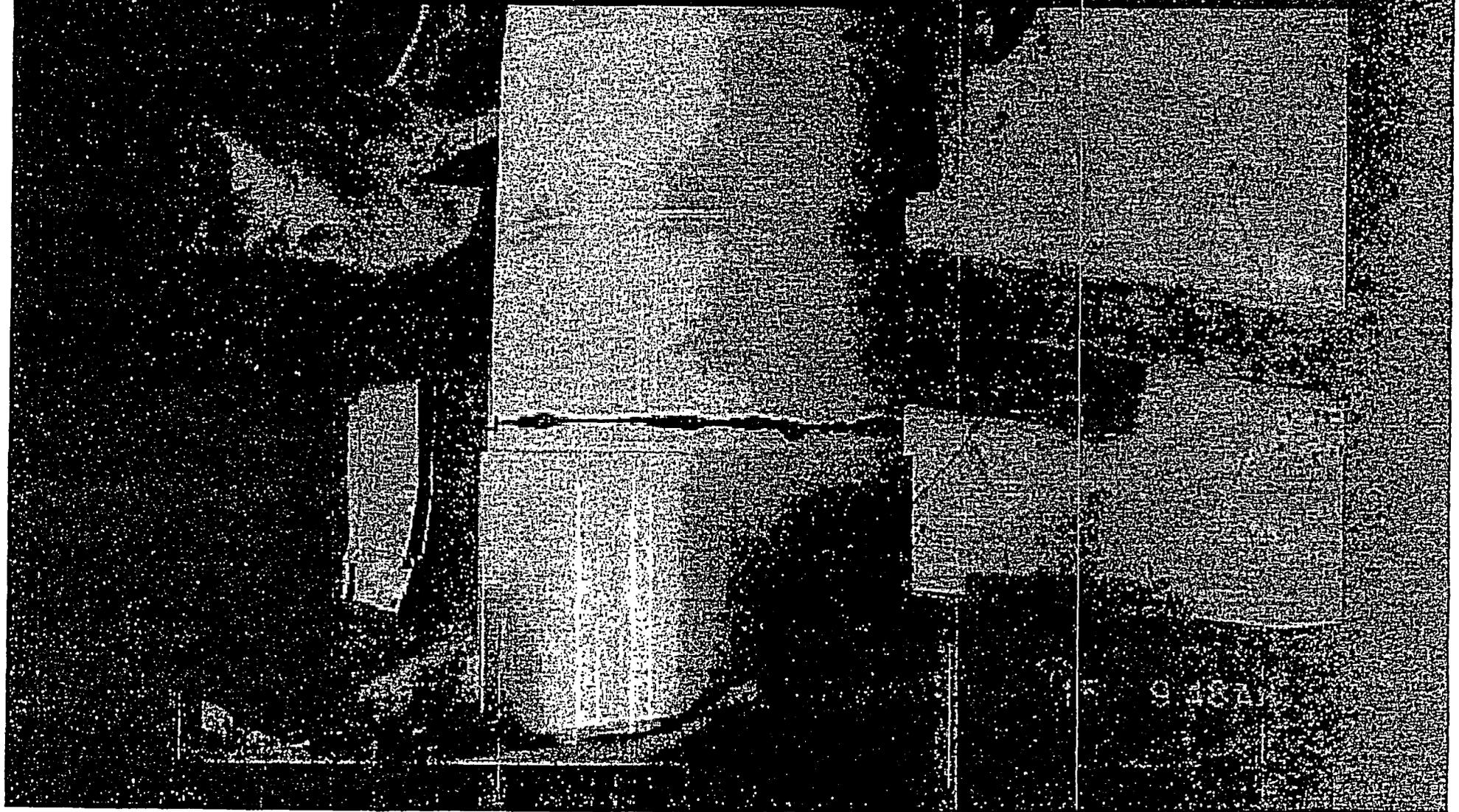
AREA WHERE CRACK IS LOCATED.



# U1 RCP4 Shaft



# U2 RCP1 - Shaft

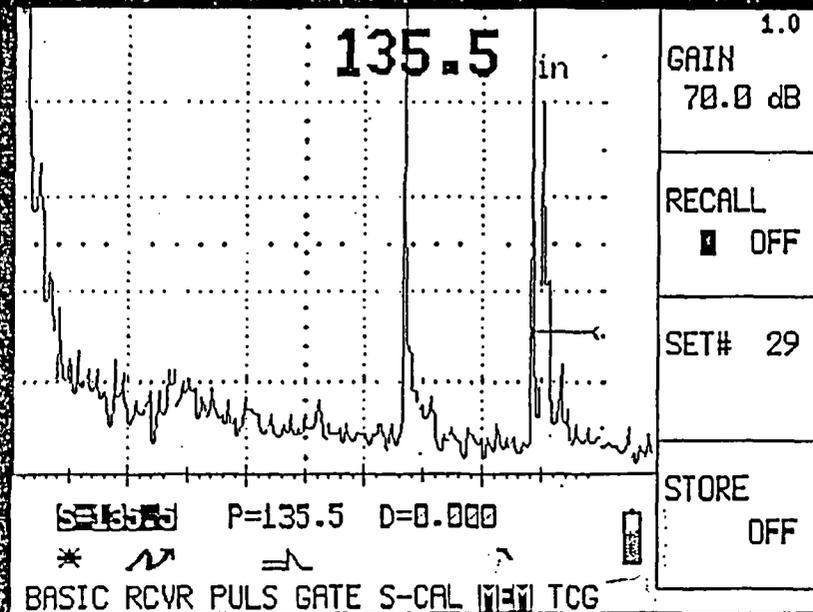


# TVA's Ultrasonic Technique

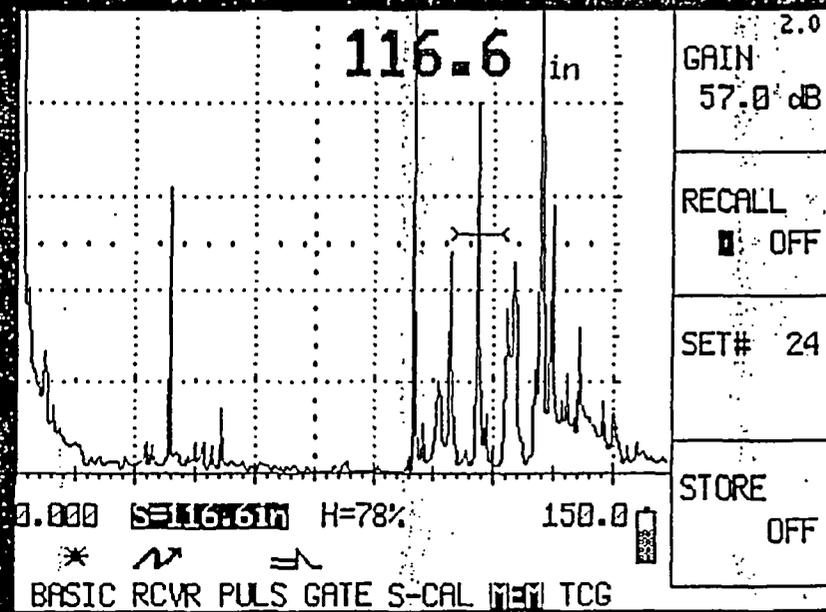
- Review drawings for anticipated geometry.
- USN-52 with 2.25 MHz search unit.
- Setup scope with stainless longitudinal values and 150 inch screen.
- Velocity can be fine tuned on part using landmarks at known distances (bottom of bearing journal, etc).
- Record Static Images at 4 locations (0, 90, 180, and 270) from Keyway.
- Ensure that gate is positioned over each signal and recorded while at each location.
- Down load images to computer and compare in an array.

# Typical UT Presentations

Good!



Cracked!



# Conclusion

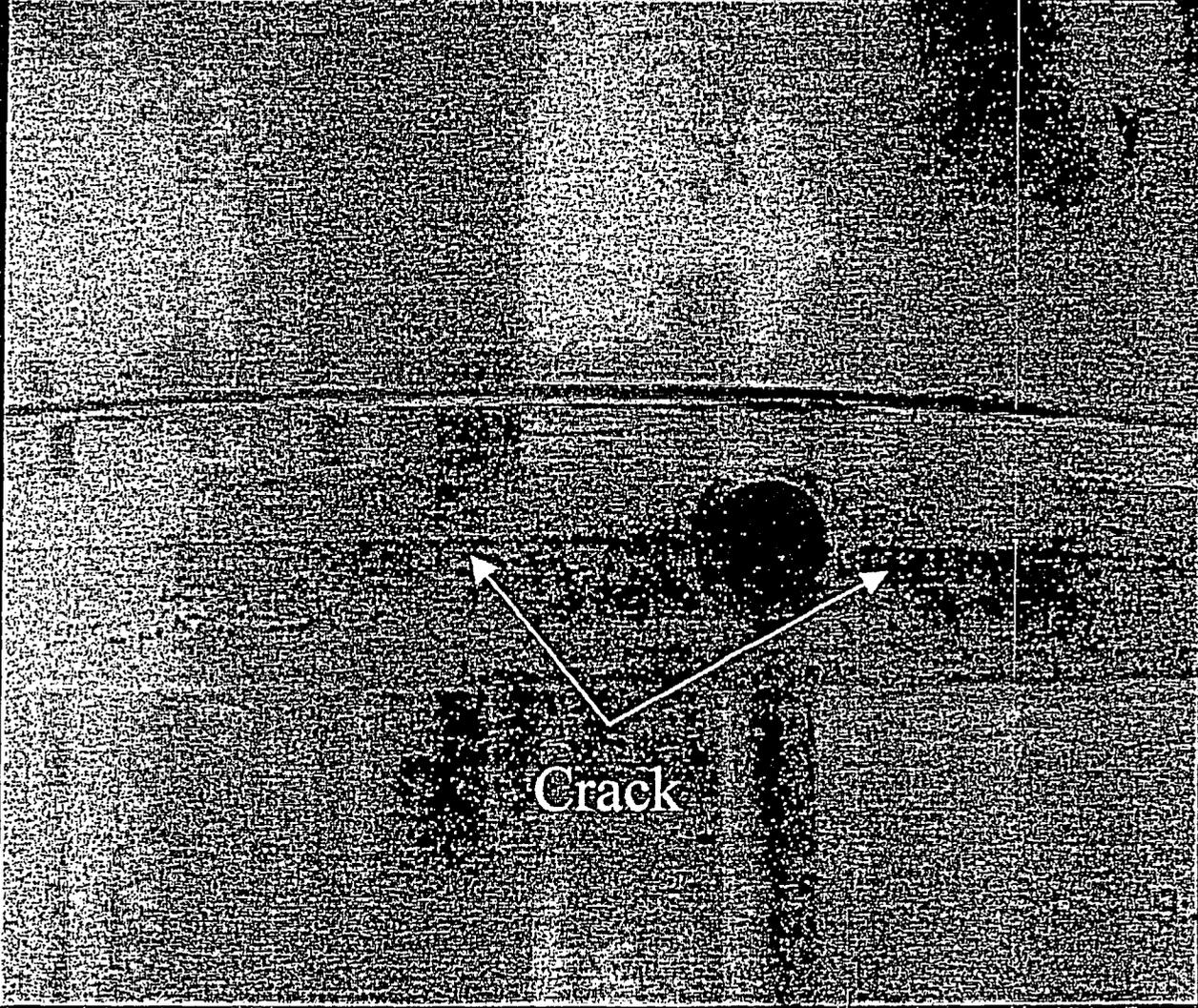
- Ultrasonic testing can be used to aid vibration studies for shaft cracking prior to alarm limits.
- Vibration analysis does not predict early shaft cracking (prior to 30 to 50% through-wall)
- Detail drawings are essential for geometry identification.
- Multiple pumps required for comparison studies.
- Upward vibration trends with ultrasonic studies are useful in shaft crack detection prior to failure.

# Recommendations

Ultimate goal is to detect cracking with UT early enough to plan replacements

- Utilities may want to consider a tailor collaboration (TC) activity or commit Subscriber Requested Assistance (SRA) funds to:
  - Quantify detection levels using ultrasonic testing for RCP shafts (and probably other pump shafts).
  - Determine flaw sizing capabilities on pump shaft cracking so predictions for change-out can be done in an efficient manner (i.e. detect cracking while small enough to run until a replacement could be efficiently scheduled and performed).

U2 RCP1



Crack