



# New Development of LBB Concept and Practices in US PWR Fleet

**SMiRT-19: What is New in LBB? -  
Industry and Regulatory Perspective**  
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# EPRI MRP Technical Analysis of LBB

- Completed technical evaluation in 2005 addressing:
  - PWSCC is an active cracking degradation mechanism,
  - PWSCC leakage path is more tortuous than fatigue cracks used in previous LBB evaluations
- LBB evaluation of circumferential flaws in pressurizer dissimilar metal welds (fleet implications of Wolf Creek indications)

# MRP LBB Evaluation Effort Overview (MRP-140)

- Reviewed population of Alloy 82/182 welds with LBB
- Evaluated most highly stressed Alloy 82/182 LBB locations for each piping system within each reactor type
- Determine margins between critical flaw sizes and leakage flaw sizes including crack morphology effects
- Investigated expected crack shape for Alloy 82/182 cracking
- Evaluated the time available for plant action from leakage detection to failure

# Conclusions

## The technical basis for LBB remains strong:

- PWSCC observed in Alloy 82/182 butt welds in several plants has been primarily axial in nature
  - Long part-through wall circumferential flaws not likely
- Adequate time between leakage detection and growth to critical flaw size to allow safe shut down
- Adequate margin remains considering alternative leak rate calculation methodologies
- Increased plant sensitivity to unidentified leakage
  - Response to leak rates less than 1 gpm (Tech Spec Limits) improved
  - Generally the unidentified leakage is trended

# WC Inspection Results and Evaluation

## Indication Characterization – October 2006

Nozzle	Circumference (in)	Outside Diameter (in)	Thickness (in)	Inside Diameter (in)	2006 Indications				
					OD Length (inches)	Arc Length (2) (deg)	Maximum Depth (1) (%)	Depth (in)	Aspect Ratio (3)
Safety C	25.0	7.96	1.32	5.32	3.75	54	23	0.30	8
Relief	25.0	7.96	1.32	5.32	11.50	166	26	0.34	22
Surge	47.0	14.96	1.45	12.06	1.00	8	<10 (4)	---	---
	47.0	14.96	1.45	12.06	2.75	21	25	0.36	6
	47.0	14.96	1.45	12.06	5.00	38	31	0.45	9
Surge Nozzle Totals =>					8.75	67			

Highlighted data represents values reported to the NRC by Wolf Creek. Other values are calculated by geometry.

- (1) Average depth from 45 and 60 degree angle UT probes at maximum depth location.
- (2) Calculated from OD length and circumference.
- (3) Calculated from ID arc length and depth.
- (4) Indication found but no measurable depth could be determined.

# MRP Crack Growth Evaluation

## Wolf Creek Relief Nozzle

- 4.4 years to through-wall (NRC 1.9-2.6 years) primarily due to refinement of stress intensity factor solution in FEM
- Due to semi-elliptical flaw and axisymmetric residual stress assumption, calculations show little margin between onset of leakage and rupture
- Realistic treatment of residual stress distribution and crack shape would result in significant time between leakage and rupture

# Project Approach

## *Key Project Activities*

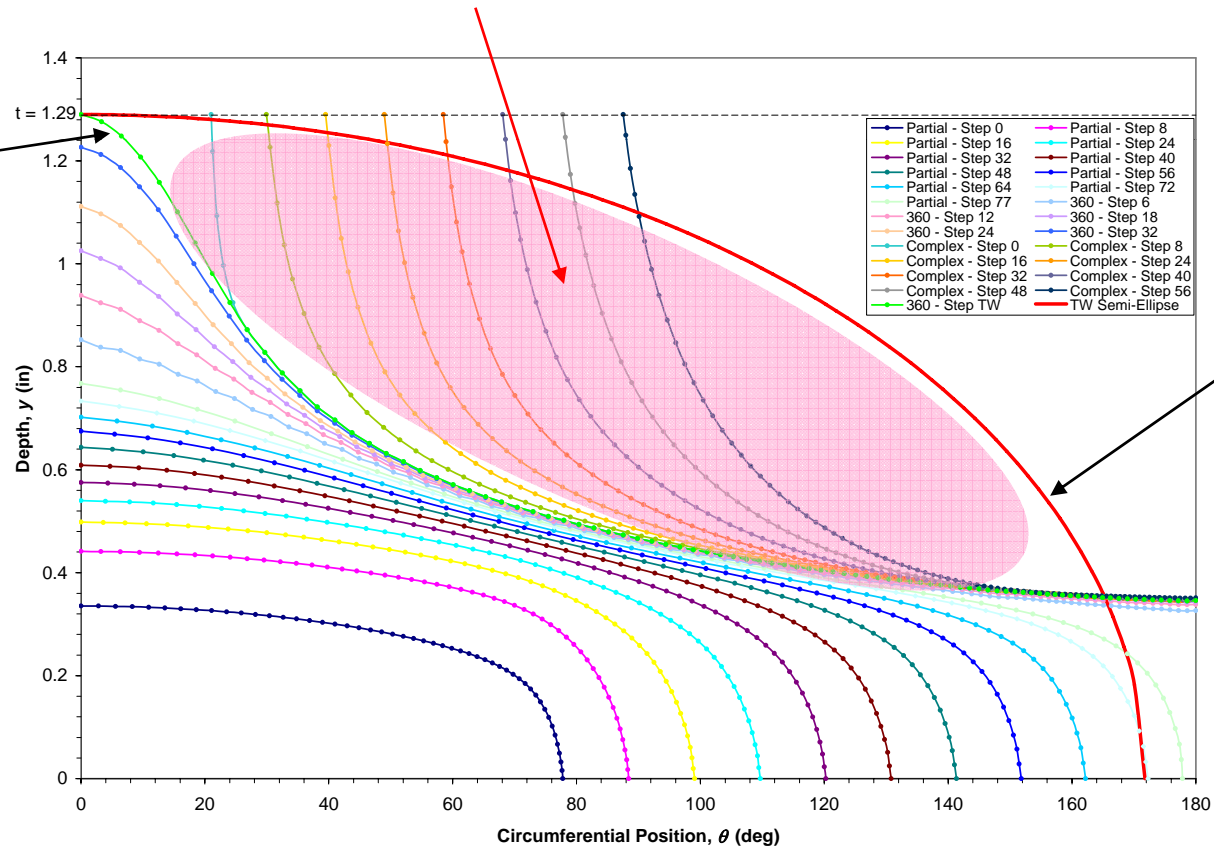
- Software capability development within FEACrack
- Develop and execute an analysis parametric sensitivity case matrix
  - Develop and apply a sensitivity matrix of welding residual stress (WRS) profiles, including weld repairs
  - Crack growth calculations for custom crack shape
- Critical crack size calculations to define the end point for the crack growth calculation
- Leak rate calculations - PICEP and SQUIRT models
- Software verification and benchmarking
- Validation
- Expert panel input and review throughout the project

# Project Approach

## Artificial Conservatism of Semi-Elliptical Crack Assumption

Semi-ellipse assumption over predicted extent of cracked material in this zone vs. the arbitrary shape methodology for the Wolf Creek nozzle benchmark run

Arbitrary Crack Shape at Initial Through Wall  
Growth at each point on the crack front as a function of the stress intensity factor calculated at that point



Semi-Ellipse Crack Shape at Initial Through Wall

# Evaluation Criteria

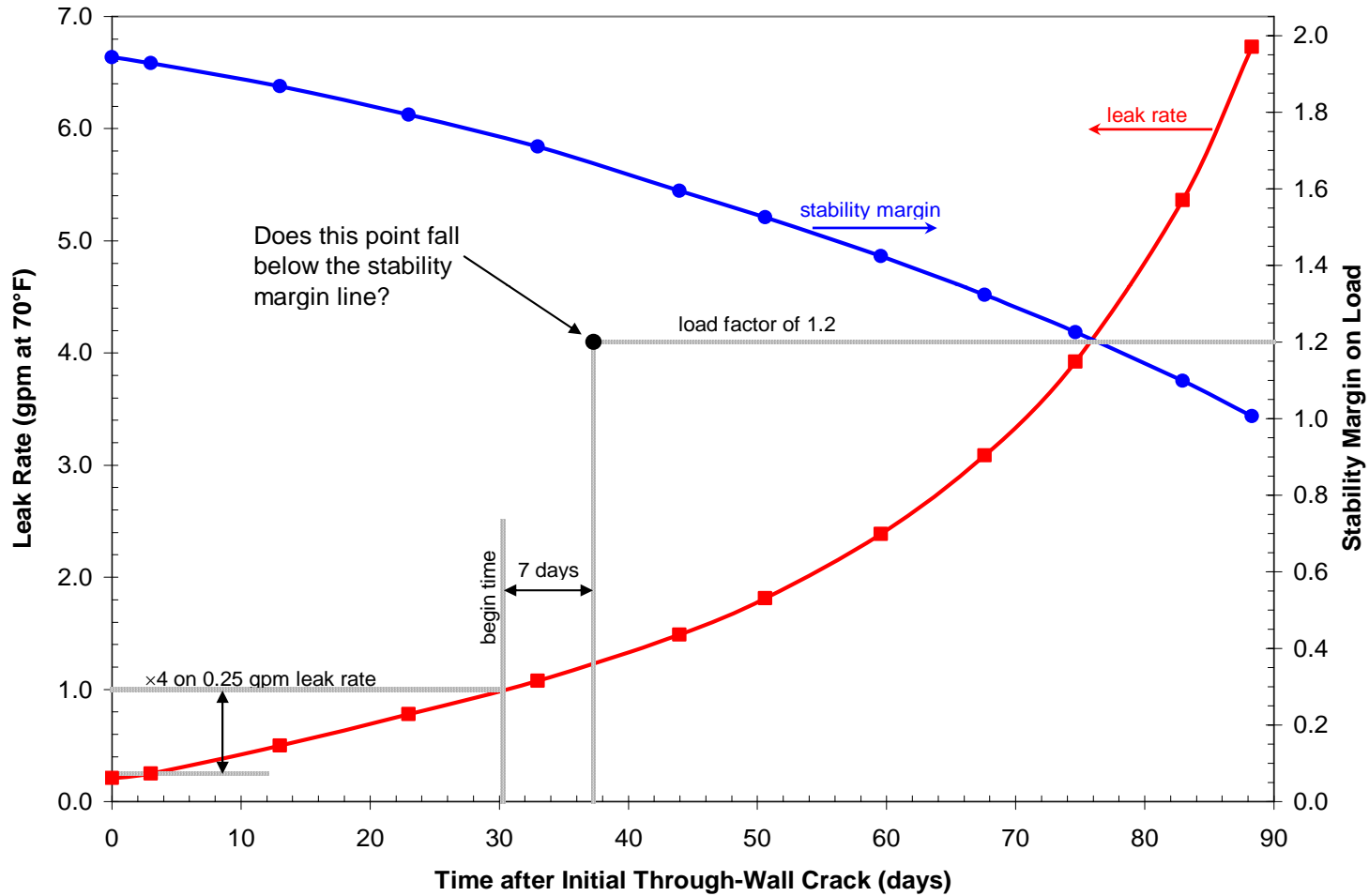


Illustration of Approach for Hypothetical Leakage and Stability Data

# Conclusions

- Assumption of semi-elliptical flaw shape shown to result in large unnecessary overconservatism
- Results show tendency of circumferential surface cracks to show stable arrest
- In summary, this study demonstrates the viability of leak detection to preclude the potential for rupture for the pressurizer nozzle DM welds in the group of subject PWRs
  - This type of analysis could be used by an individual plant to analyze a found indication.