Southern Nuclear / Westinghouse Proposed Test Plan to Demonstrate the Benefit of Zinc Addition to Mitigate PWSCC

Mike Stinson

August 25, 2005

SOUTHERN COMPANY

Energy to Serve Your World℠

Purpose

SOUTHERN COMPANY
Energy to Serve Your World™

To determine if test data from the proposed program can be used to make informed decisions with respect to regulatory requirements.

Agenda

- Farley 2 background
- Overview of test plan
- Test design & expectations
- Benefits
- Feedback & discussion

Description of Farley 2

SOUTHERN COMPANY
Energy to Serve Your World™

- Three-loop, Westinghouse PWR
  910 megawatts
- Initial Ops: 1981
- Renewal license expiration: 2041

Farley 2
Pilot Plant for Zinc Addition

SOUTHERN COMPANY
Energy to Serve Your World™

- Laboratory and test reactor experiments indicated reduced general corrosion and PWSCC mitigation benefits of zinc addition
- EPRI sponsored demonstration plant
- Zinc injection began June 12, 1994
- RCS zinc concentration
  - 30 ppb Cycles 10, 12 - 14
  - 15 ppb Cycles 15 – 17 (post SG replacement)

Farley 2
Zinc Addition Experience

SOUTHERN COMPANY
Energy to Serve Your World™

- Sig. Radiation benefit observed after S/G Replacement

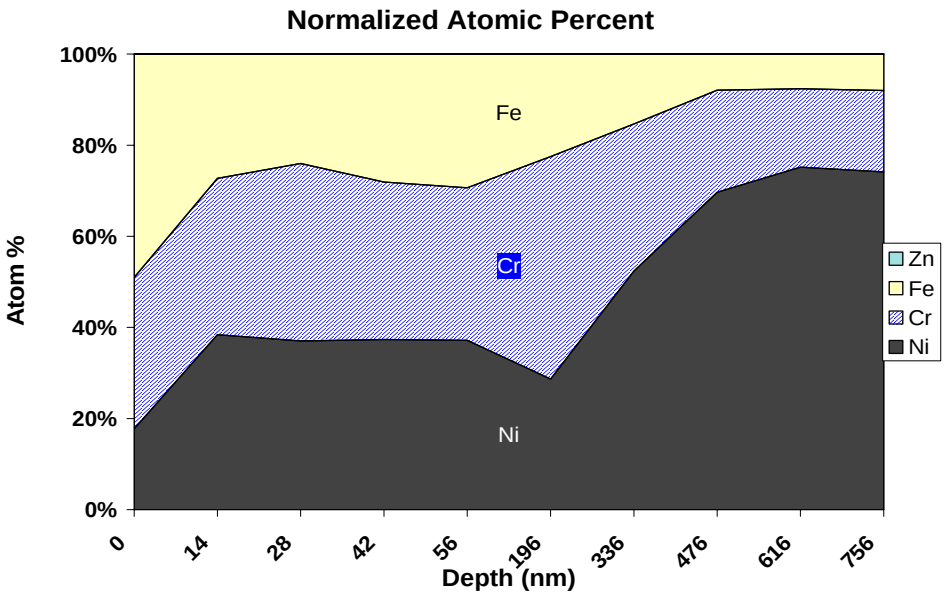
Plant	EFPY	Channel head dose rate (R/hr)
Farley 2	1.3	0.34
Watts Bar	1.15	2.3
Cook 2	1.11	3.0
Indian Point 3	1.07	3.1
No. Anna 1	1.36	5.0
Ringhals 2	1.34	4.0

Ref: EPRI TR-107566

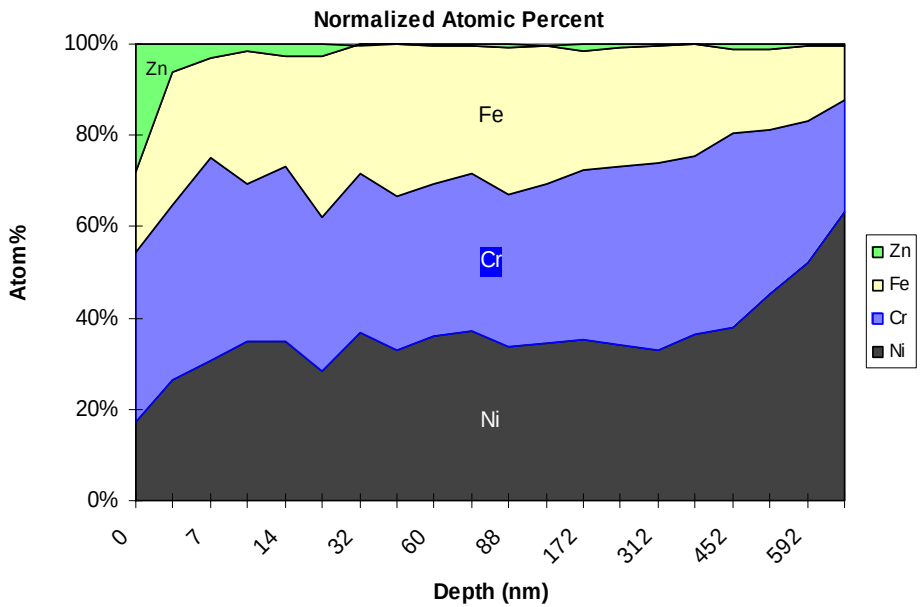
Farley 2 Oxide Films

SOUTHERN COMPANY
Energy to Serve Your World™

- Pulled SG tube film characterization



Cycle 9



Cycle 10

Ref: EPRI TR-106358-V1

Farley 2
Zinc Addition Experience

SOUTHERN COMPANY
Energy to Serve Your World℠

- Difficult to assess PWSCC benefit.

Alloy 600 / 82 / 182 Inspections			
	2002 2R15	2004 2R16	2005 2R17
CRDM (EA-03-009)	Volumetric (UT) + BMV	Volumetric (EC + UT) + BMV	Replace
RPV nozzles (ISI Program)			BMV
RPV BMI (BL 2003-02)		BMV	BMV
PRZ nozzles (BL 2004-01)	Volumetric + surface (1 nozzle)	BMV	BMV (top) Volumetric + surface (2 nozzles)

Farley 2
CRDM Penetration Material

SOUTHERN COMPANY
Energy to Serve Your World™

- B&W Tubular Products heat M3935
- Less than optimum annealing heat treat
- Heat M3935 used in penetrations of five RPV heads:
  - Farley 2
  - Davis-Besse
  - Oconee 3
  - Beaver Valley
  - ANO 1

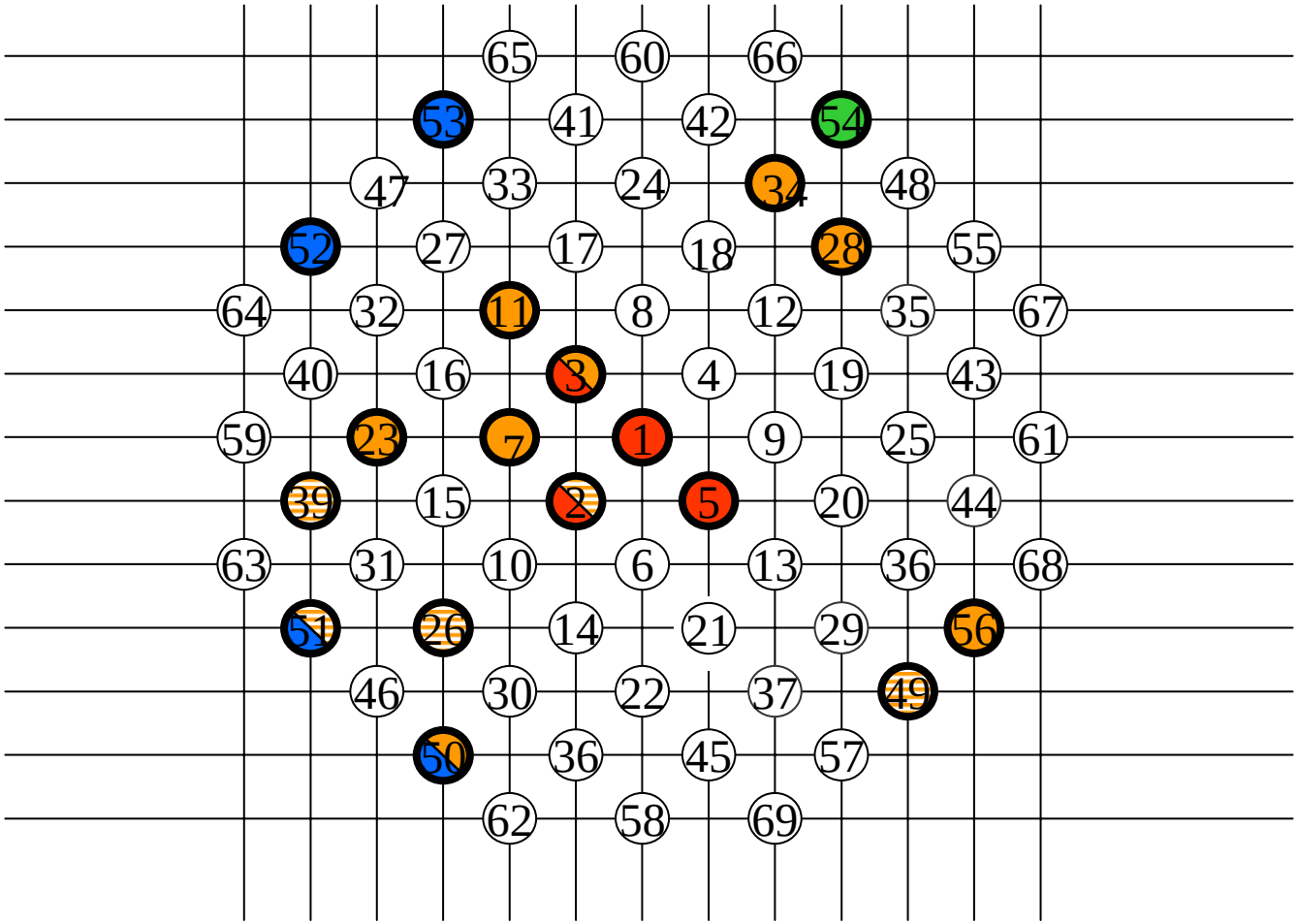
Heat M3935 Industry Experience

SOUTHERN COMPANY
Energy to Serve Your World™

Plant name	# of nozzles heat no. M3935	% in industry heat no. M3935	# inspected by UT	# required repair	% of M3935 in RV head with defect
Oconee 3	68	49%	68	14	20%
Davis-Besse	5	4%	5	3	60%
ANO 1	1	<1%	1	1	100%
Beaver Valley 1	4	3%	4	4	100%
Farley 2	61	44%	61	**0**	**0%**
Total	**139**		**139**	**22**	
%			100%	16%	

Heat M3935 - Industry Locations that req'd repair

SOUTHERN COMPANY
Energy to Serve Your World™



Orange
Oconee 3 (Spr 2001)

Orange striped
Oconee 3 (Fall 2001)

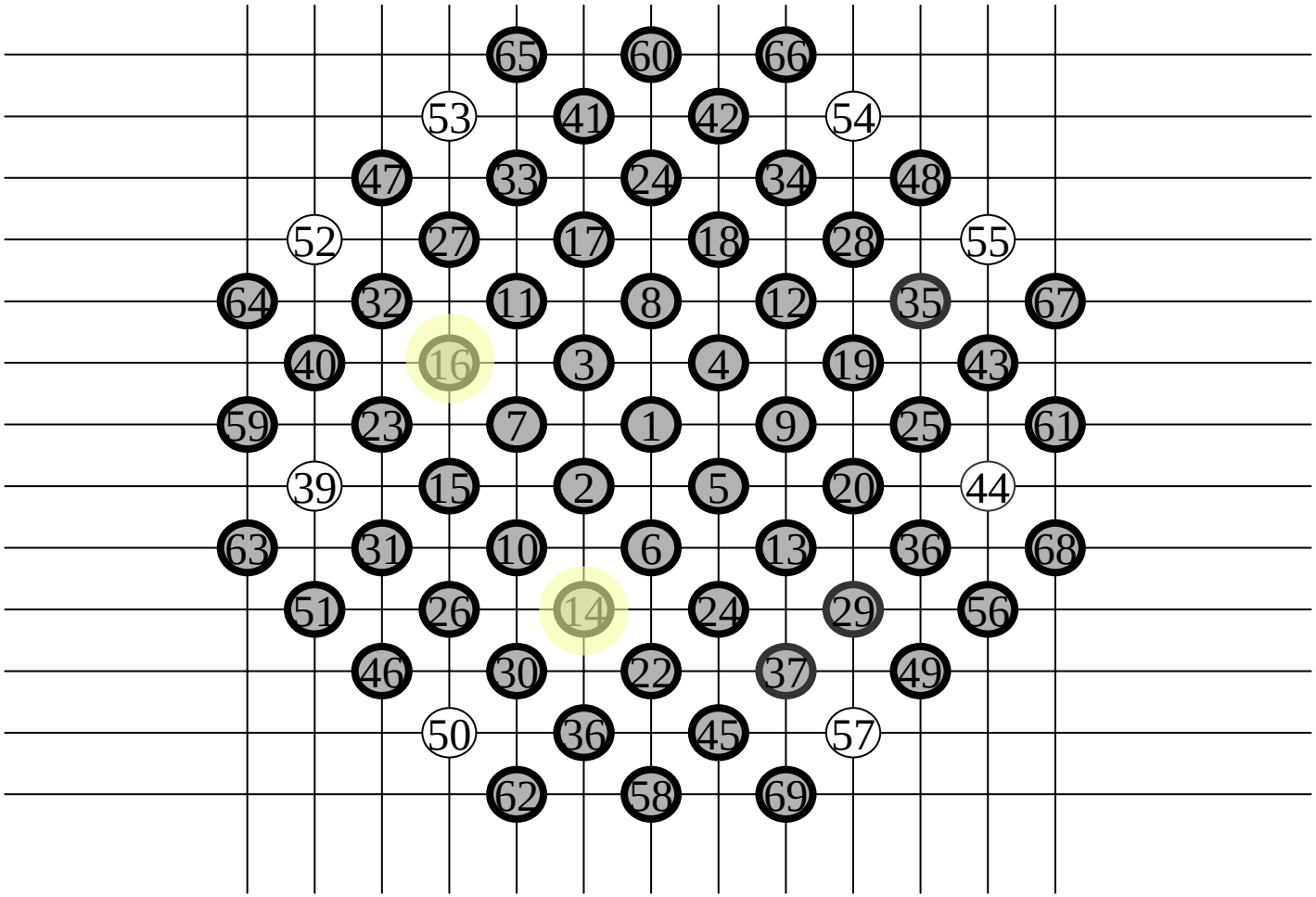
Red
Davis-Besse (Spr 2002)

Green
AN0 1 (Fall 2002)

Blue
Beaver Valley 1 (Spr 2003)

Heat M3935
Farley Unit 2 Locations

SOUTHERN COMPANY
Energy to Serve Your World™



- M3935 locations

-Proposed sample locations

What's different?

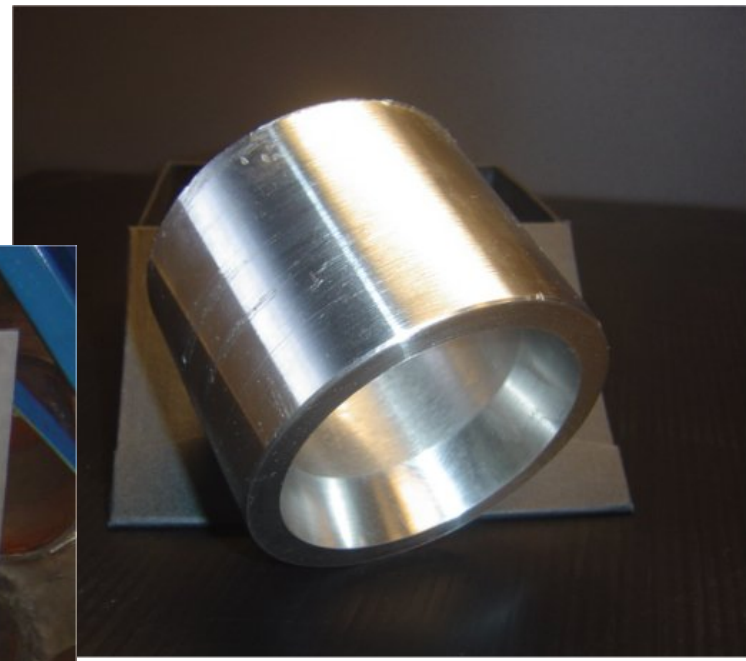
SOUTHERN COMPANY
Energy to Serve Your World™

- Farley 2 is the only RPV head with heat M3935 that has not experienced cracking
- Farley 2 is the only plant that operated with heat M3935 and significant zinc chemistry
  - Beaver Valley 1 started to add zinc in 2002 and noted SCC in M3935 in Spring 2003 (~20 ppb-mo.)

How can we determine what makes Farley 2 RPV head different?

Mock-up of Sample Removal

SOUTHERN COMPANY
Energy to Serve Your World℠



Test Program Goal

SOUTHERN COMPANY
Energy to Serve Your World™

- Demonstrate that zinc addition makes the surfaces of Alloy 600 more resistant to PWSCC.
- Quantify the improvement in life provided by zinc additions.

What is significant about the Farley 2 Alloy 600?

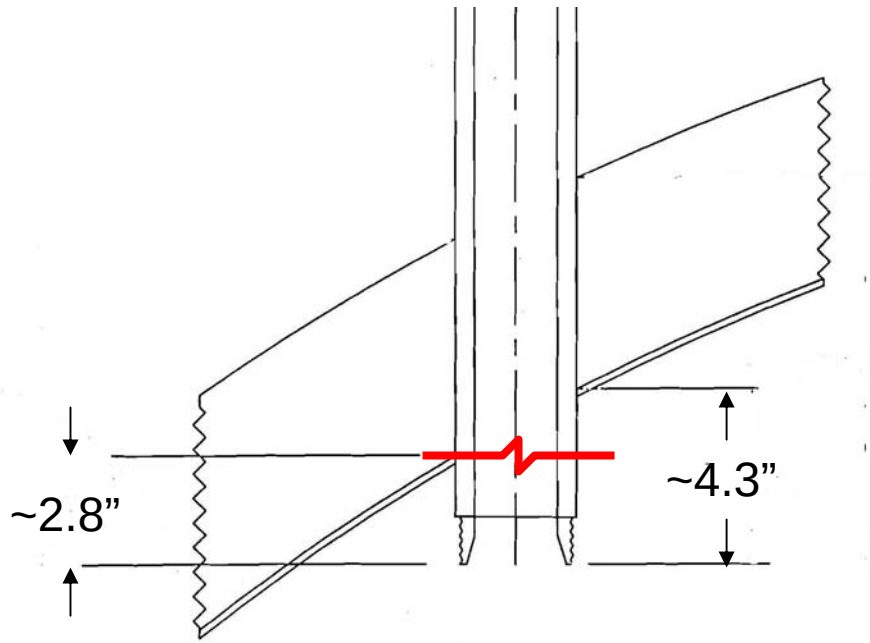
SOUTHERN COMPANY
Energy to Serve Your World™

- Exposed to zinc in the primary coolant since 1994
  - Integrated zinc exposure 1600 ppb-months at last inspection
  - Integrated zinc exposure 1900 ppb-months at RV head replacement
  - High susceptibility heat allows comparison testing to show the beneficial effects of zinc

Farley U2R17
RV Head Replacement

SOUTHERN COMPANY
Energy to Serve Your World™

- Plan to collect two penetration samples
  - penetrations # 14 and # 16
- M3935 base material



Proposed Program Objectives

SOUTHERN COMPANY
Energy to Serve Your World℠

- Harvest Alloy 600 Heat M3935 material from the Farley 2 reactor vessel head.
- Characterize surface chemistry
- Assess crack initiation by performing lab tests of segments containing the Zn conditioned material
- Compare samples with and without zinc in film
- Demonstrate benefits of Zn additions

Characterize the incorporation of -zinc

SOUTHERN COMPANY
Energy to Serve Your World℠

- Can compare depth of zinc infiltration in films
  - With Cycle 9 exam (pre-zinc)
  - With Cycle 10 exam, (310 ppb-months exposure)
- Key questions
  - What is the current surface zinc concentration
  - How deep has the zinc diffused into the oxide film
  - What are the film characteristics
- Can provide limited material to other organizations

Prove benefit regarding crack initiation

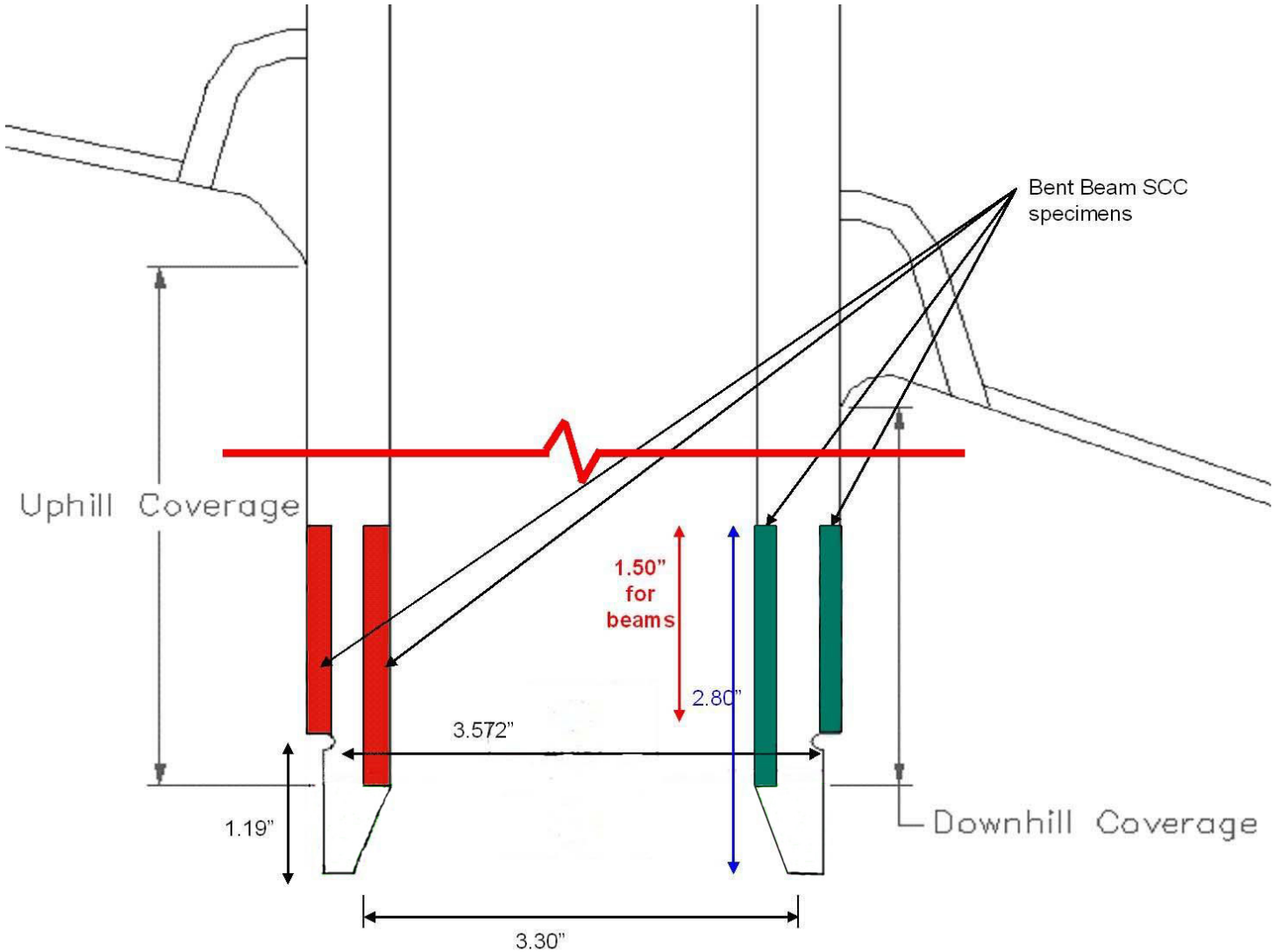
SOUTHERN COMPANY
Energy to Serve Your World℠

Basic idea

- Fabricate test specimens keeping as-is surface films intact
- Divide specimens into two groups
- Carefully remove zinc from the surface films of one group
- Perform comparison testing

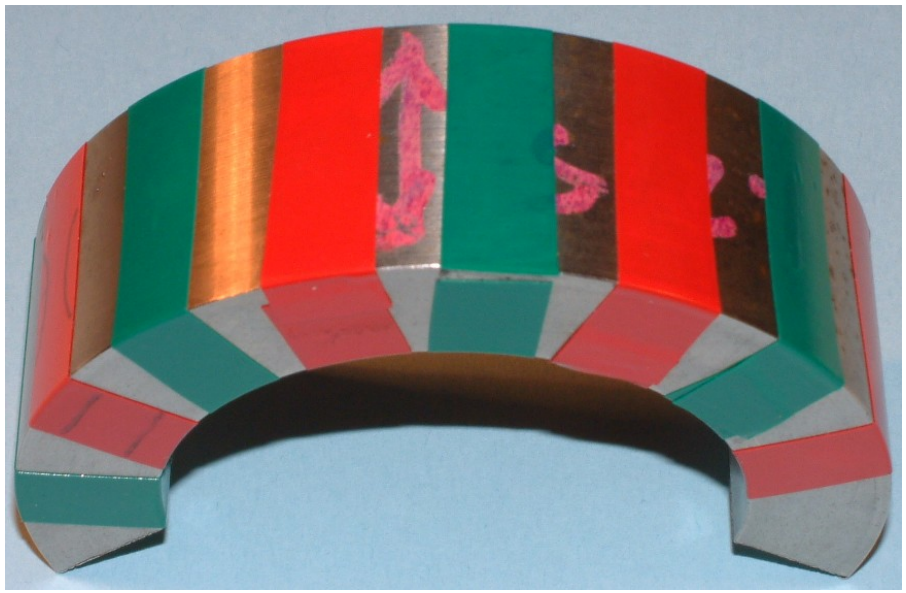
Harvest two Heat M3935 penetrations

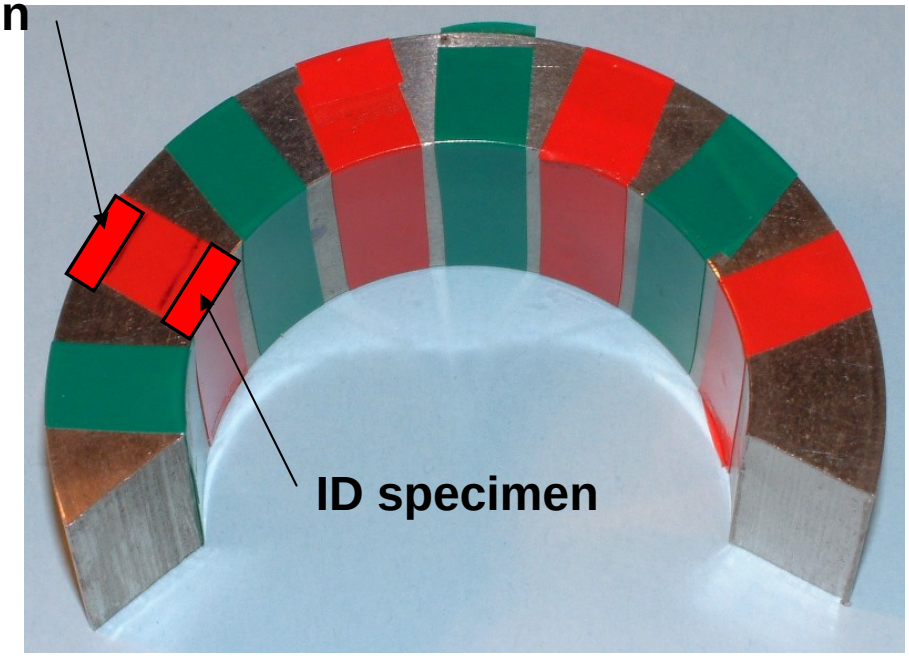
SOUTHERN COMPANY
Energy to Serve Your World™



Anticipated Geometry

SOUTHERN COMPANY
Energy to Serve Your World℠





Strips would be removed from the ID and OD surface of the Farley 2 material

- Assume “red” surfaces have zinc removed
- Assume “green” surfaces tested with zinc

Basic Approach to machine specimens

SOUTHERN COMPANY
Energy to Serve Your World™

With Zinc

- Carefully handle
- Preserve zinc in films
- Cold work (increase stress)
- Continue to test ***with*** typical concentrations of zinc in the water

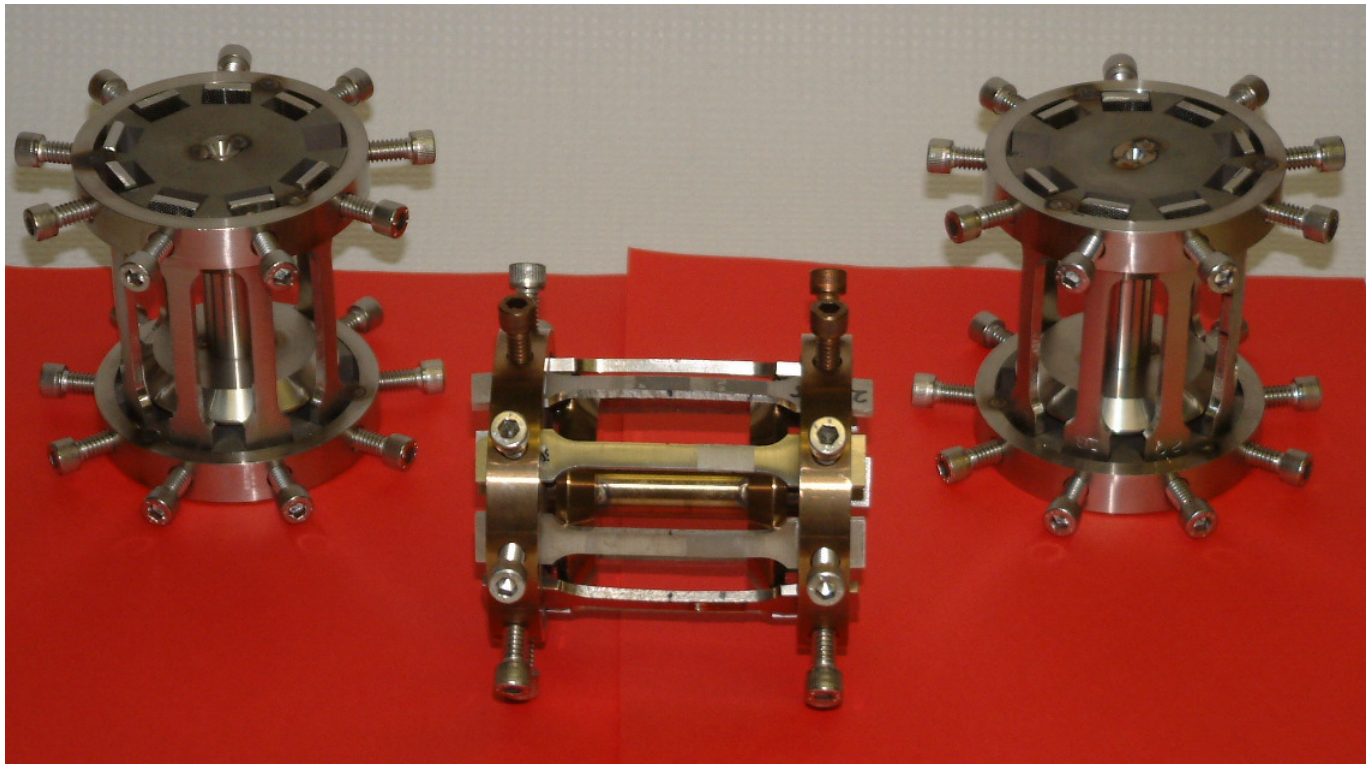
Without Zinc

- Carefully handle
- Remove zinc using a process w/o affecting oxide film (e.g. LOMI)
- Cold work (increase stress)
- Continue to test ***without*** zinc in the simulated primary water

Typical method for testing crack initiation behavior

SOUTHERN COMPANY
Energy to Serve Your World℠

- Westinghouse has used this configuration to test service & lab Alloy 600/182

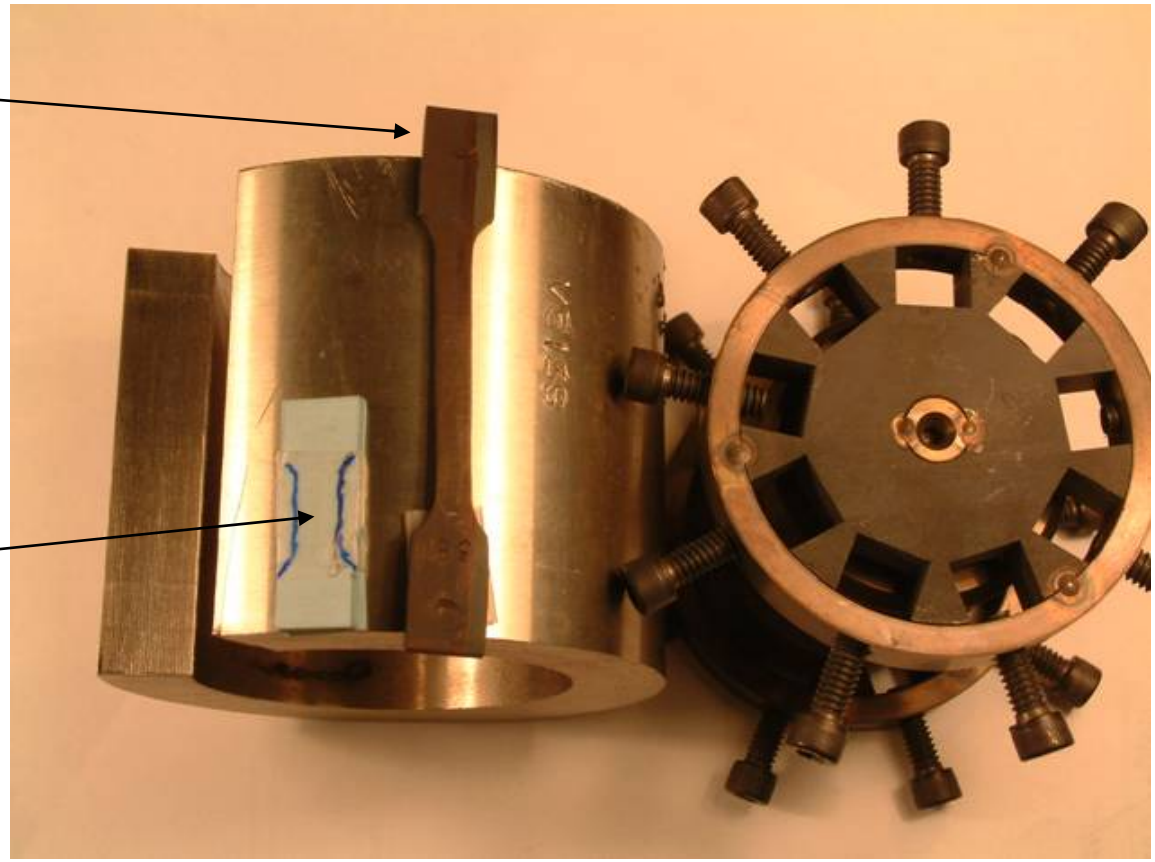


Sample size comparison

SOUTHERN COMPANY
Energy to Serve Your World℠

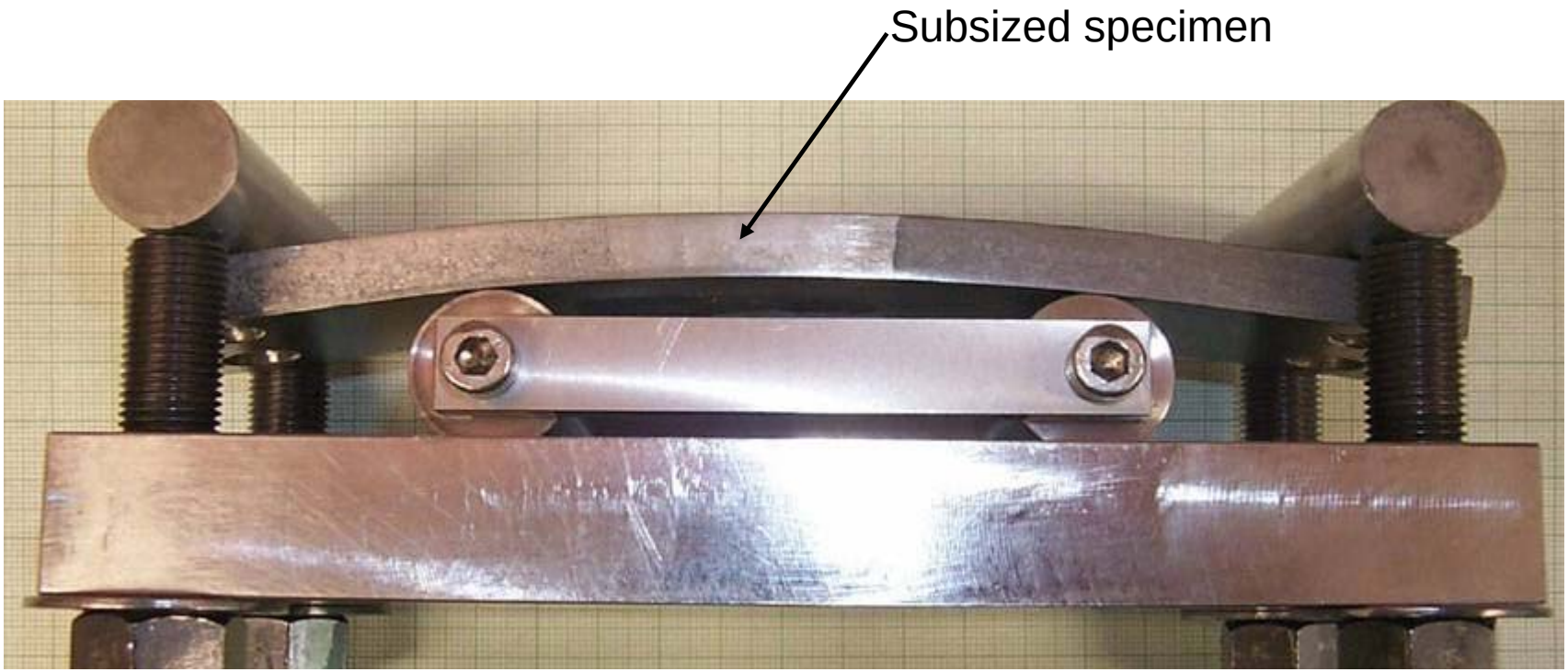
Size (L=3.7”) of Bent beam previously used.

Estimate specimens from Farley 2 would be ~1.5” long.



Anticipated specimen configuration

SOUTHERN COMPANY
Energy to Serve Your World℠



Westinghouse will shrink the test fixtures to test subsized specimens.

Key Challenges

SOUTHERN COMPANY
Energy to Serve Your World™

Constraints

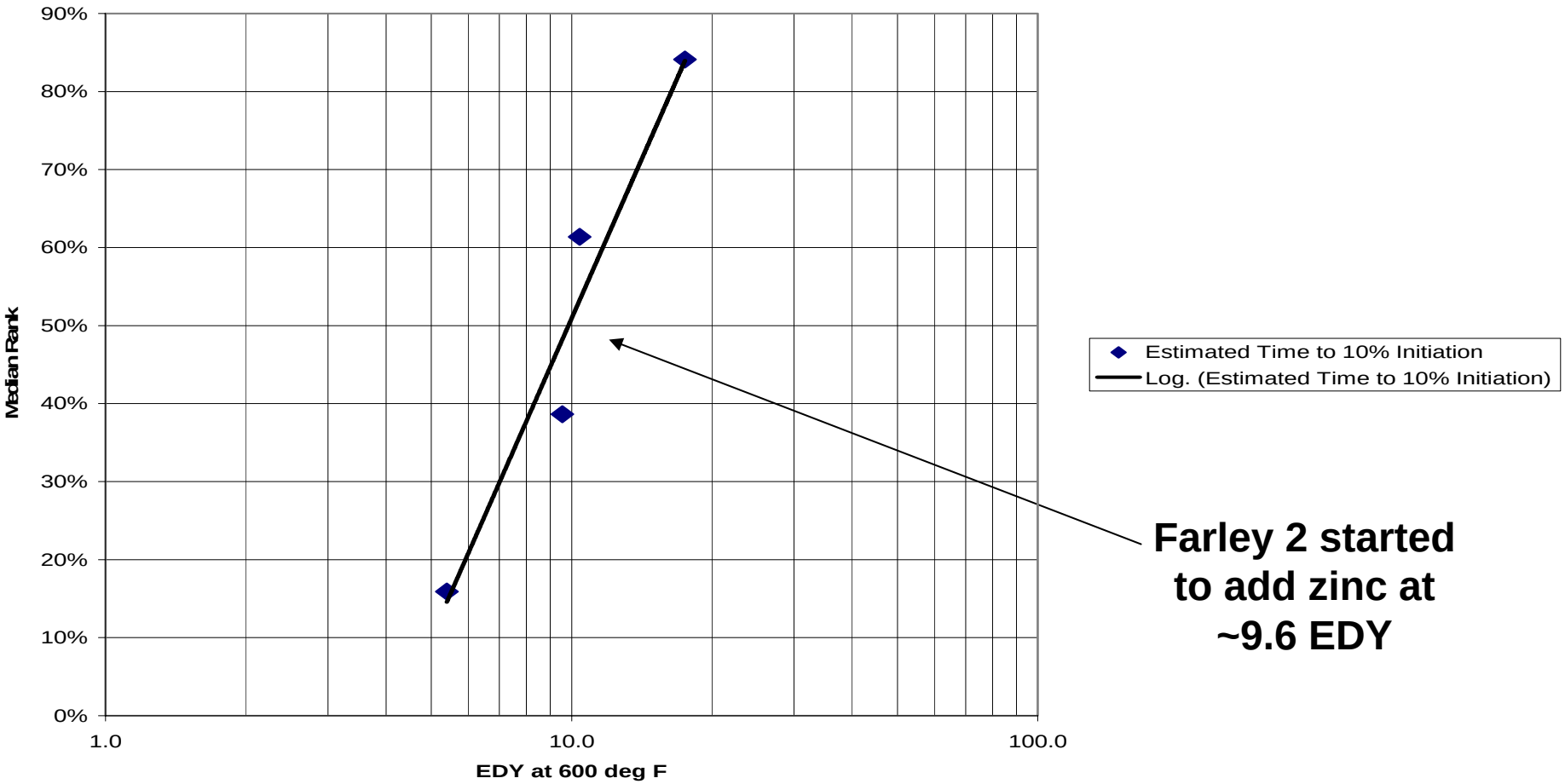
- Material that can be practically extracted from head penetrations is limited – requires subsized specimens
- The material surfaces will have significant radioactivity, >3R/hr (cannot be decontaminated)
- Testing is costly and time consuming

Risks

- Special subsized specimens and test fixtures need to be designed and demonstrated
- Subsized specimens may be difficult to handle
- May be difficult to compare subsized sample data with large sample data

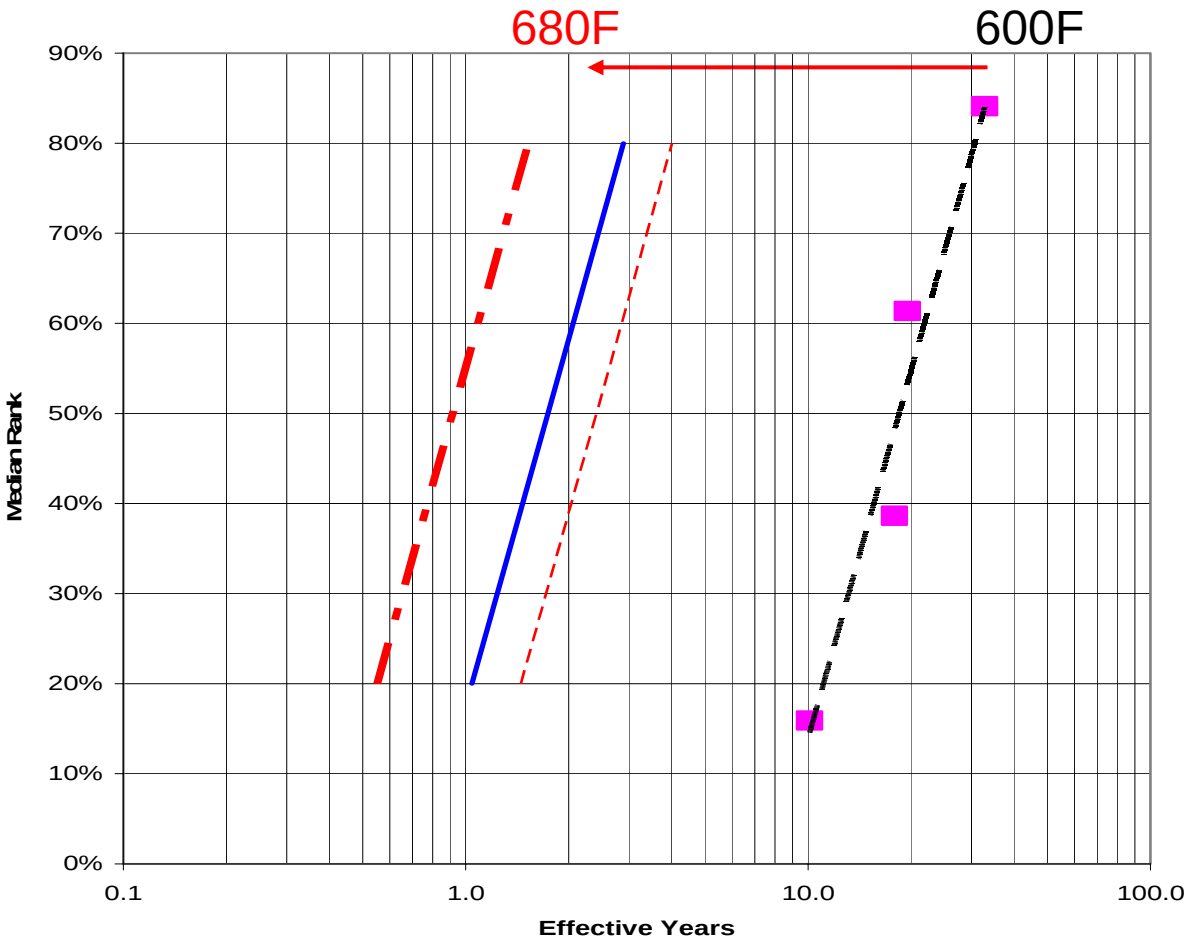
Heat M3935 Service Experience

SOUTHERN COMPANY
Energy to Serve Your World℠



Projected Performance at Elevated Temperature

SOUTHERN COMPANY
Energy to Serve Your World™

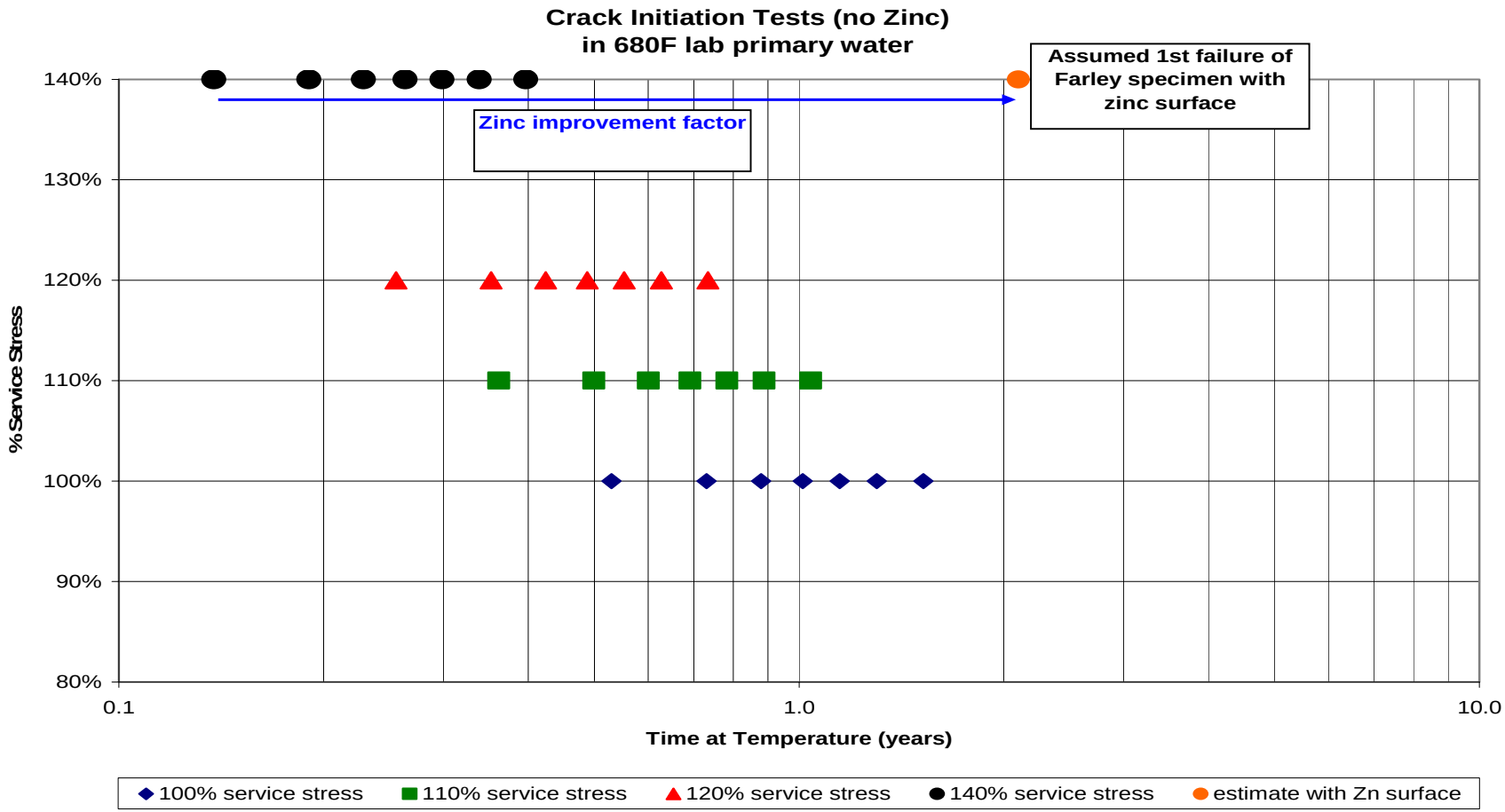


Need to accelerate cracking to demonstrate zinc effectiveness

High test temperatures will accelerate cracking

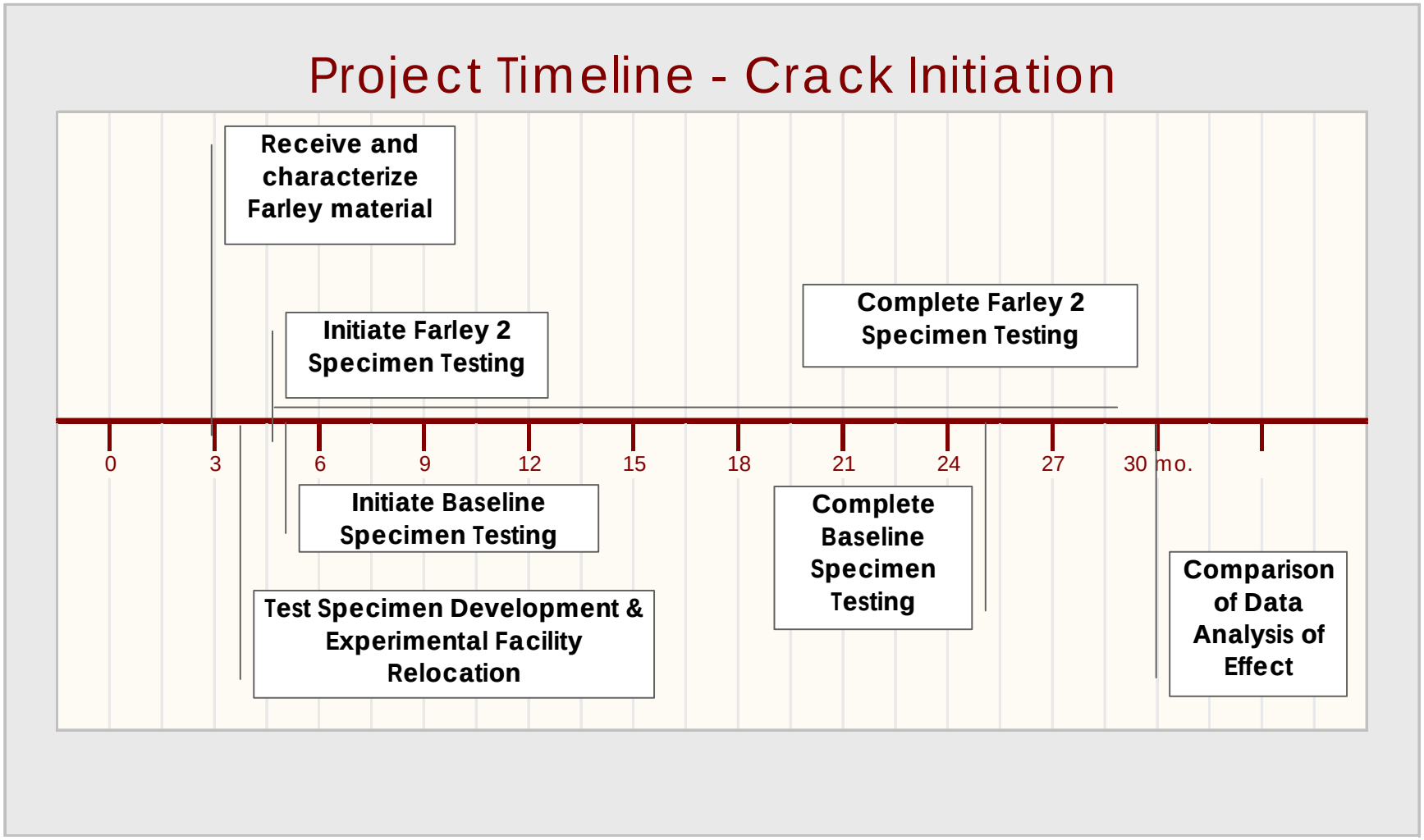
Anticipated Performance at Elevated Temp & Stress

SOUTHERN COMPANY
Energy to Serve Your World℠



Proposed Program – Tasks & Schedule

SOUTHERN COMPANY
Energy to Serve Your World℠



Expected Results & Implications

SOUTHERN COMPANY
Energy to Serve Your World™

- Zinc exposed surfaces of Heat M3935 will show reduced crack initiation compared to similar surfaces with the zinc removed
- Extended crack initiation duration relaxes the need for frequent inspections

Benefits

SOUTHERN COMPANY
Energy to Serve Your World™

- Inspection Requirements
  - CRDM Order EA-03-009
    - Replacement RV heads Alloy 690
  - RPV nozzles ASME XI – ISI Program
  - RPV BMI Bulletin 2003-02
  - PRZ nozzles Bulletin 2004-01
  - MRP Inspection Guidelines (e.g., MRP-139)

Feedback