Session C3: Research Activities: Materials Degradation

Detecting Material Degradation: Today and Looking Forward

Jim Lang

EPRI

USNRC Regulatory Information Conference

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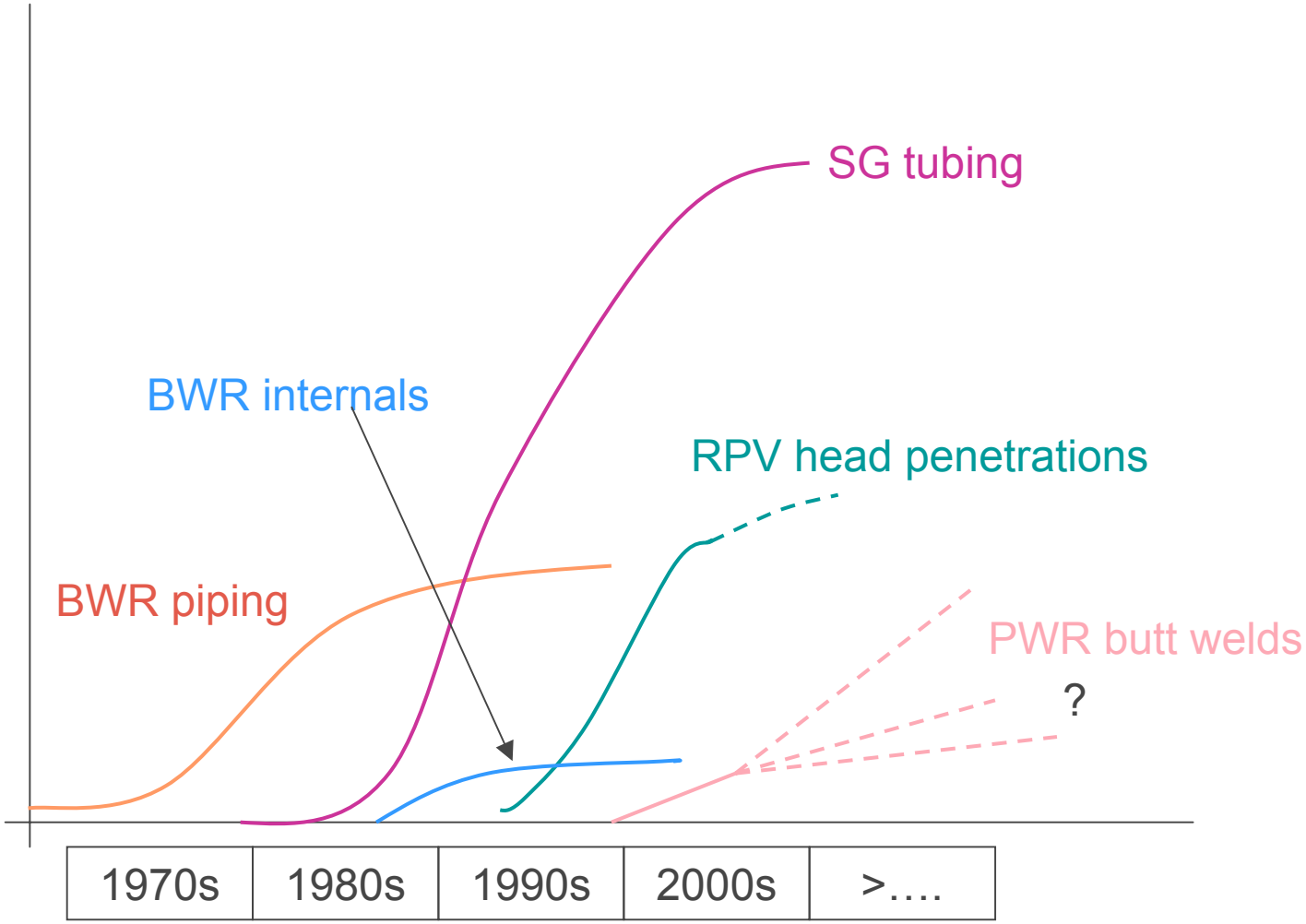
The Silver Lining: We Have Lots of Experience



With Experience We Have Refined Inspection Techniques

Leak Detection

Visual

Dye Penetrant

Magnetic Particle

Radiography

Electromagnetic

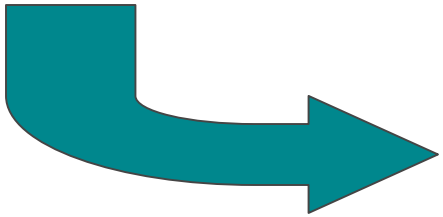
Acoustic Emission

Ultrasonic

Experience Also Provides The Basis For A Risk Informed Inspection Approach

RISK = (Core Melt Potential/Pipe Rupture) vs (Potential for Pipe Rupture)

Pipe Rupture Potential	Leak Conditions	Degradation Mechanisms To Which The Segment is Susceptible
HIGH	Large	Erosion Corrosion (FAC) Water Hammer Vibration Fatigue
MEDIUM	Small	Thermal Fatigue Corrosion Fatigue Stress Corrosion Cracking (IGSCC, TGSCC, PWSCC, ECSCC) Corrosion Attack (MIC, Crevice Corrosion and Pitting) Erosion/Cavitation
LOW	None	No Degradation Mechanisms Present

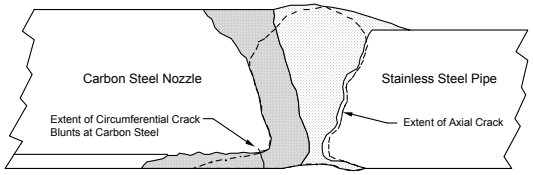


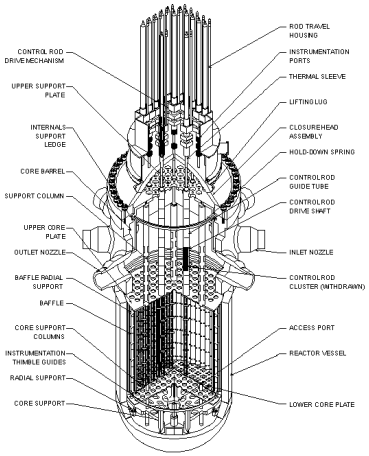
RISK REGIONS HIGH MEDIUM LOW	CONSEQUENCE CATEGORY Core Melt Potential for Limiting Break Size			
DEGRADATION CATEGORY Potential for Large Break/Rupture	NONE	LOW	MEDIUM	HIGH
HIGH	LOW RISK	MEDIUM RISK	HIGH RISK	HIGH RISK
MEDIUM	LOW RISK	LOW RISK	MEDIUM RISK	HIGH RISK
SMALL	LOW RISK	LOW RISK	LOW RISK	MEDIUM RISK

Inspect

Experience Has Clearly Identified Today's Material Degradation Issues

Nickel Based Alloy
Stress Corrosion Cracking





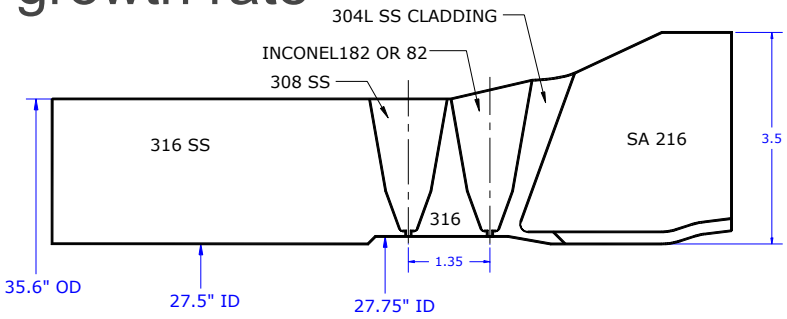
High Fluence in BWRs and PWRs

Steam Generator Tubing

Fuel Integrity

Experience Shows That NDE Is Reliable – But There Are Gaps

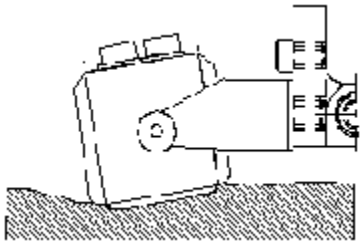
Detection & sizing of small defects given the projected fast crack growth rate



Accessibility for inspection

Rough/wavy surfaces

Complex configurations



Qualification of NDE – specific to configuration

Research Is Underway To Close The Gaps

- UT Probe development to handle real configurations
  - EMAT
  - Conventional
- UT Techniques
  - Phased array
  - SH wave
- Other methods
  - Eddy current
  - Radiography

- Database of as-built configurations
- Database & assessment of NDE performance
- Enhanced modeling
- Realistic samples for technique development & qualifications
- Intensive qualification effort

Tomorrow's Issues May Be Unknown – But We've Cataloged Our Vulnerabilities

PWR Component	Material	SCC SCC					Corrosion/Wear C & W				Fatigue Fat.			Reduction in Toughness RiT					
														Aging	*Irradiation*				
	[1]*Subdivision*→	IG	IA	TG	LTCP	PW	Wstg	Pit	Wear	FAC	HC	LC/Th	Env	Th	Emb	VS	SR	Th_n	Fl
PWR Pressurizer (Including Shell, Surge and Spray Nozzles, Heater Sleeves and Sheaths, Instrument Penetrations)	C&LAS	? e002	N	? e002	N	? e003	Y e004	N	N	Y e005	N	Y e006	Y e007	Y e008	N/A	N/A	N/A	N/A	N/A
	C&LAS Welds	? e002	N	? e002	N	? e003	Y e004	N	N	Y e005	N	Y e006	Y e007	Y e008	N/A	N/A	N/A	N/A	N/A
	Wrought SS	? e012	N	? e012	? e013	? e012	N	N	N	N	N	Y e014	Y e015	N	N/A	N/A	N/A	N/A	N/A
	SS Welds & Clad	Y e016	? e017	Y e018	? e013	? e019	N	N	? e020	N	N	? e014	Y e015	Y e022	N/A	N/A	N/A	N/A	N/A
	Wrought Ni Alloys	N	N	N	? e023	Y e023	N	N	N	N	Y e014	Y e014	Y e015	N	N/A	N/A	N/A	N/A	N/A
	Ni-base Welds & Clad	N	? e024	N	Y e023	Y e025	N	N	N	N	N	Y e014	Y e015	N	N/A	N/A	N/A	N/A	N/A

And We Know Where To Look

RISK REGIONS HIGH MEDIUM LOW		CONSEQUENCE CATEGORY Core Melt Potential for Limiting Break Size				
		NONE	LOW	MEDIUM	HIGH	
DEGRADATION CATEGORY Potential for Large Break/Rupture	HIGH	LOW RISK	MEDIUM RISK	HIGH RISK	HIGH RISK	Inspect
	MEDIUM	LOW RISK	LOW RISK	MEDIUM RISK	HIGH RISK	
	SMALL	LOW RISK	LOW RISK	LOW RISK	MEDIUM RISK