One-Time License Amendment Request Unit 3 Train B Diesel Generator

Palo Verde Nuclear Generating Station

December 20, 2016

Agenda

- Event Description
- Palo Verde AC Power System
- Operating Experience
- Event Investigation
- Response Plan
- Risk Assessment
- License Amendment Request
- Regulatory Options

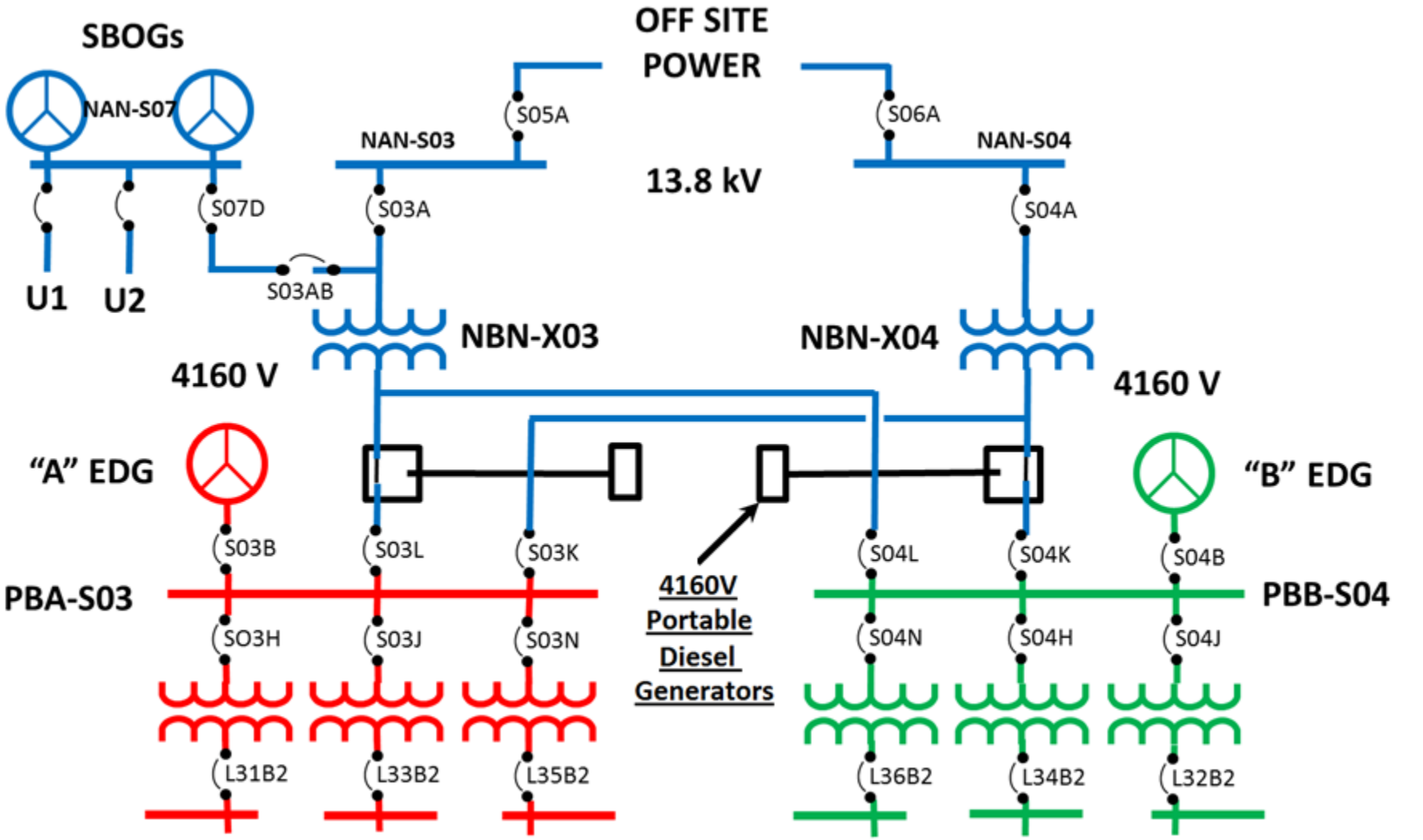
Event Description

- On 12/15/16 at 03:02, Unit 3 Train B (3B) Diesel Generator (DG) was started for routine surveillance testing
- At 03:56, 3B DG was operating at 2.5 MW and a loud bang was heard and the 3B DG tripped on low lube oil pressure
- At 04:10, Alert classification (EAL HA2.1) was declared (explosion with visible damage to 3B DG, ENS 52435)
- At 06:36, the Alert was terminated

Palo Verde AC Power System

- Seven, independent offsite power transmission lines
- Two, redundant, class 1E emergency diesel generators per unit
- Two station blackout generators (SBOGs)
- Two 4160V portable diesel generators

Palo Verde AC Power System



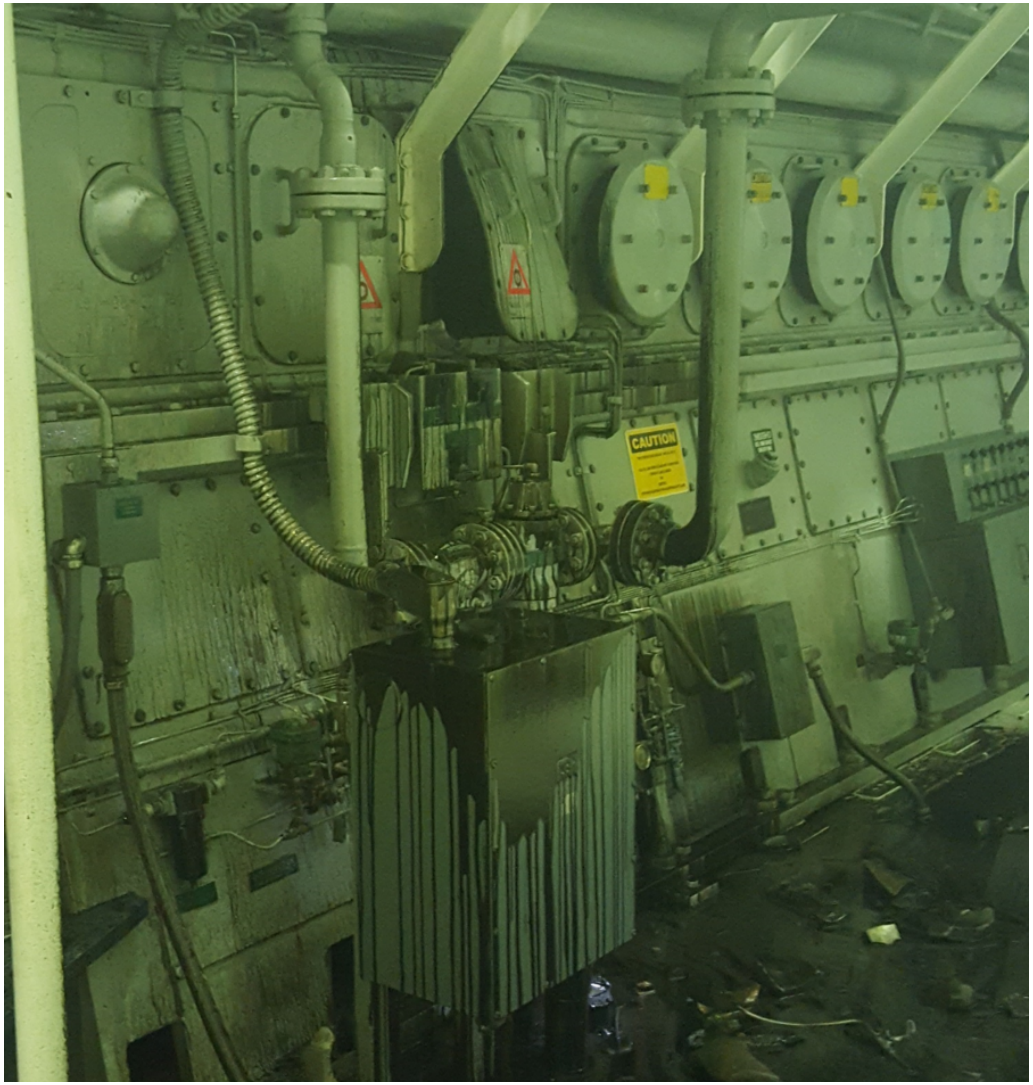
Palo Verde AC Power System

- Diesel Generator Design
  - Cooper-Bessemer Model KSV-20
  - 20 cylinder engine with vee configuration
  - 5.5 MW continuous output
  - 6.05 MW output for 2 hours out of 24 hours

Operating Experience (OE)

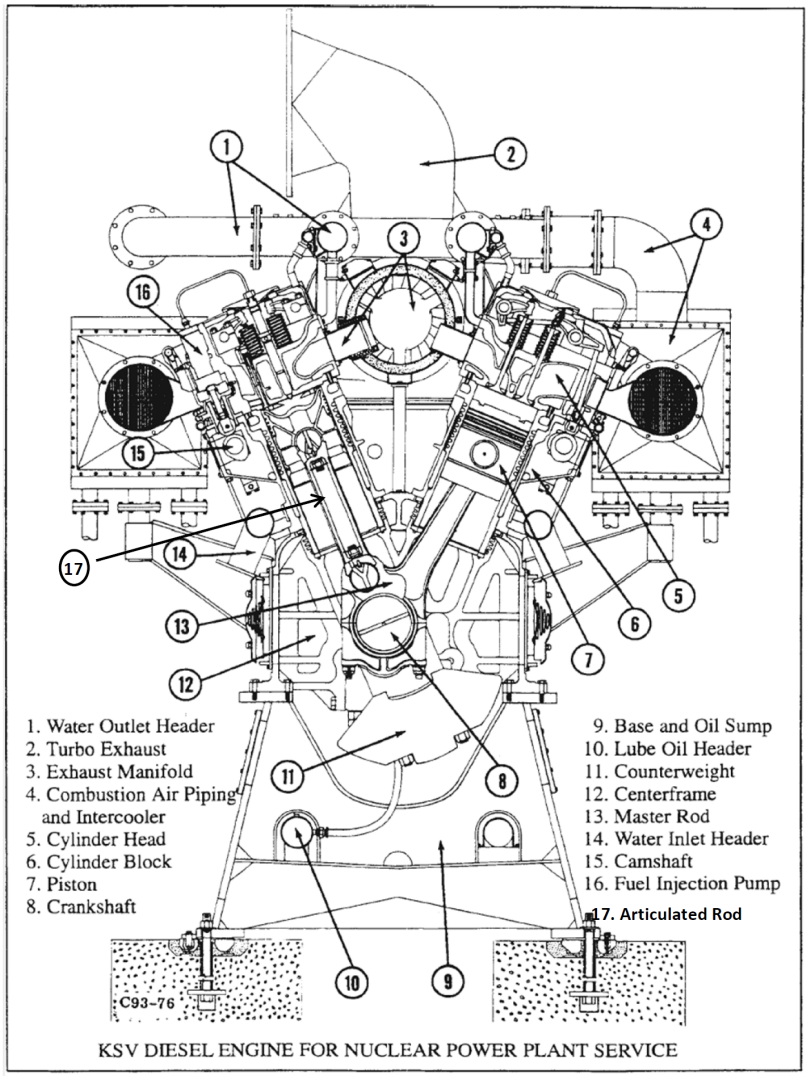
- Cooper-Bessemer KSV-20 OE
  - 1986 – Palo Verde 3B DG connecting rod (9R) failure during unit startup testing program
  - 1989 – South Texas Project DG 22 connecting rod failure during a surveillance test
  - 2003 – South Texas Project DG 22 connecting rod failure during a surveillance test (one-time LAR using a two-phased approach to extend allowable outage time to 113 days)
  - 2016 – Palo Verde 3B DG connecting rod (9R) failure during a surveillance test

Event Investigation

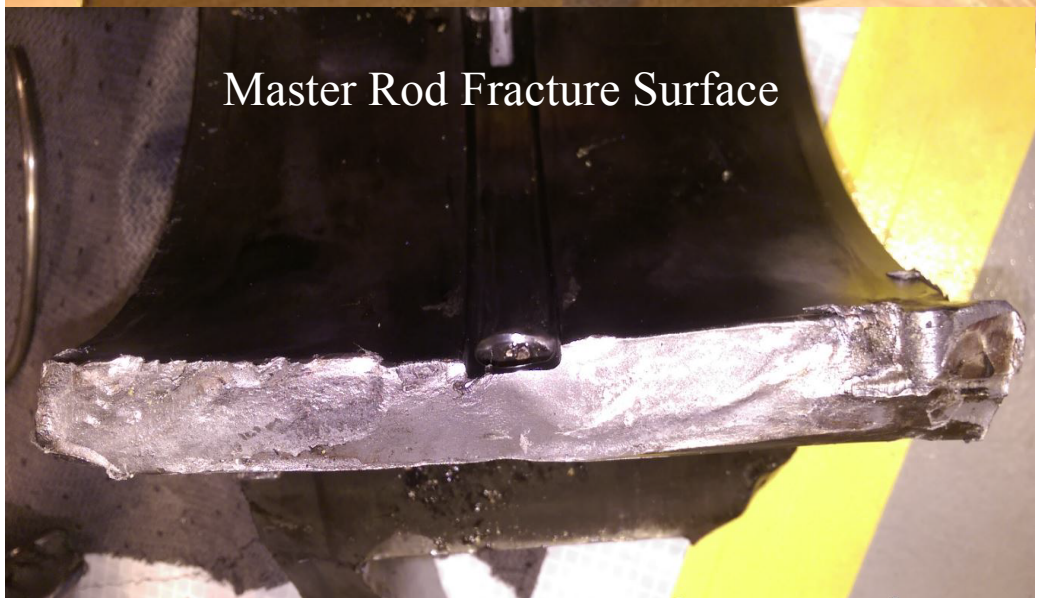


Event Investigation

- Identified damage
  - Power cylinders
    9-Right, 9-Left,
    8-Right, and 8-Left
  - Crankshaft and connecting rods
  - Left and right cylinder blocks
  - Centerframe
  - Crankcase floor and lube oil headers



Event Investigation



Event Investigation

- Evidence of high cycle fatigue on master connecting rod
- Second major failure of DG 3B (9R)
- Additional evidence needed to fully evaluate cause and potential for common mode failure
  - Analysis of parts as engine is dismantled
  - Forensics plan established
  - Strong focus on 1986 repairs
- Partnerships established with MPR, Goltens, Structural Integrity, EPRI, and the Cooper-Bessemer Owners Group

Assessment of DG 3A

- 3A DG test run following 3B DG failure
- Comparative analysis of 3A/3B DGs performed
  - Lubrication history
  - Vibration history
  - System parameter reviews (temperatures, pressures)
  - Maintenance history
  - Run times

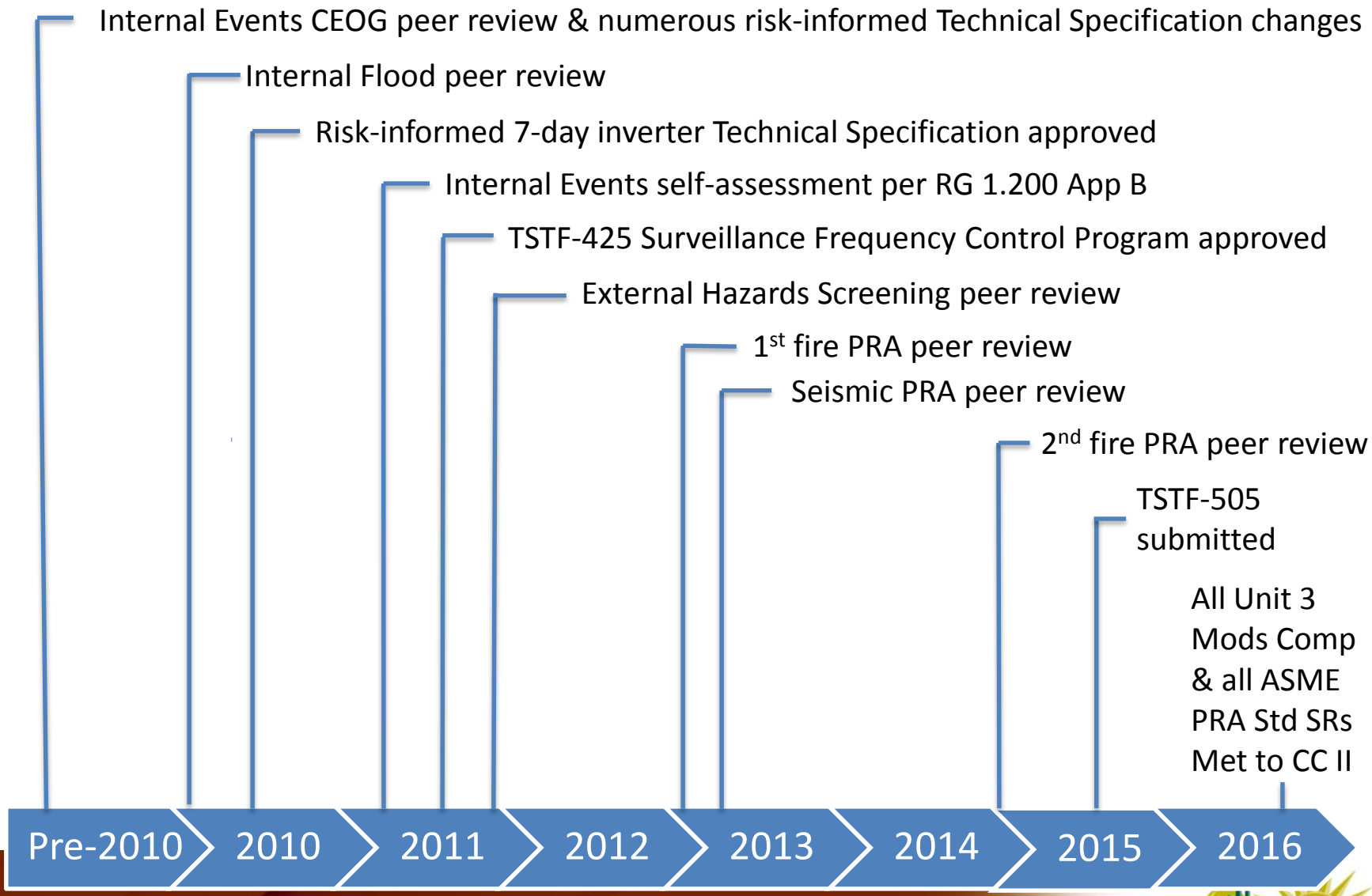
Response Plan

- South Texas Project and vendor expert involvement
- Outage Control Center activated and staffed 24/7
- Current repair plan includes:
  - Visual inspection, damage assessment and parts recovery
  - Crankshaft and internal parts removal
  - 3-dimensional laser scan of DG internals
  - Engine block repair
  - Install new and refurbished components including crankshaft
  - Engine assembly and alignment
  - Retest and restoration of Operability
- Response plan shows additional time (beyond 10-day completion time) will be required to perform repairs and testing
- Parts are available to perform repairs

Risk Assessment

- PRA models for
  - Internal Events
  - Internal Flood
  - Internal Fire
  - Seismic
- Other hazards screened out

PRA Model and Risk-Informed Application Model History



Palo Verde is Special and Unique

- Six 100% capacity SG makeup pumps all supplied by onsite power sources
  - Only one of these powered by DG B if loss of offsite power
- RCP seal LOCAs negligible – ECCS significance minimal in loss of offsite power events
- No Pressurizer power-operated relief valves
- Very low internal events CDF and LERF - consistent with STP and Millstone 3
- Only shared systems in PRA are SBOGs and firewater
- Dedicated fire department staff and equipment
- Risk significant FLEX connections outside of unit
- Did not need to implement NFPA-805 to address multiple spurious operations

Risk Assessment

- Defense-in-Depth Evaluation
  - Unavailability does not reduce the amount of available equipment to a level below that necessary to mitigate a design basis accident
- Safety Margin Evaluation
  - No significant reduction in margin of safety
- Regulatory Guide 1.200, Revision 2 compliant
- Regulatory Guide 1.177, Revision 1 compliant
- Regulatory Guide 1.174, Revision 2 compliant

Risk Assessment

Unit 3 Baseline Average Annual CDF/LERF

Hazard	CDF (per year)	LERF (per year)
Internal events	1.3E-6	4.3E-8
Internal flooding	4.1E-7	1.9E-8
Seismic	2.8E-5	5.3E-6
Internal Fire	2.1E-5	2.1E-6
Total	5.1E-5[1]	7.5E-6[2]

Notes:
1. Meets Regulatory Guide 1.174 acceptance criteria of < 1E-4/yr
2. Meets Regulatory Guide 1.174 acceptance criteria of < 1E-5/yr

Risk Assessment

ICCDP and ICLERP for One-Time Technical Specification Change

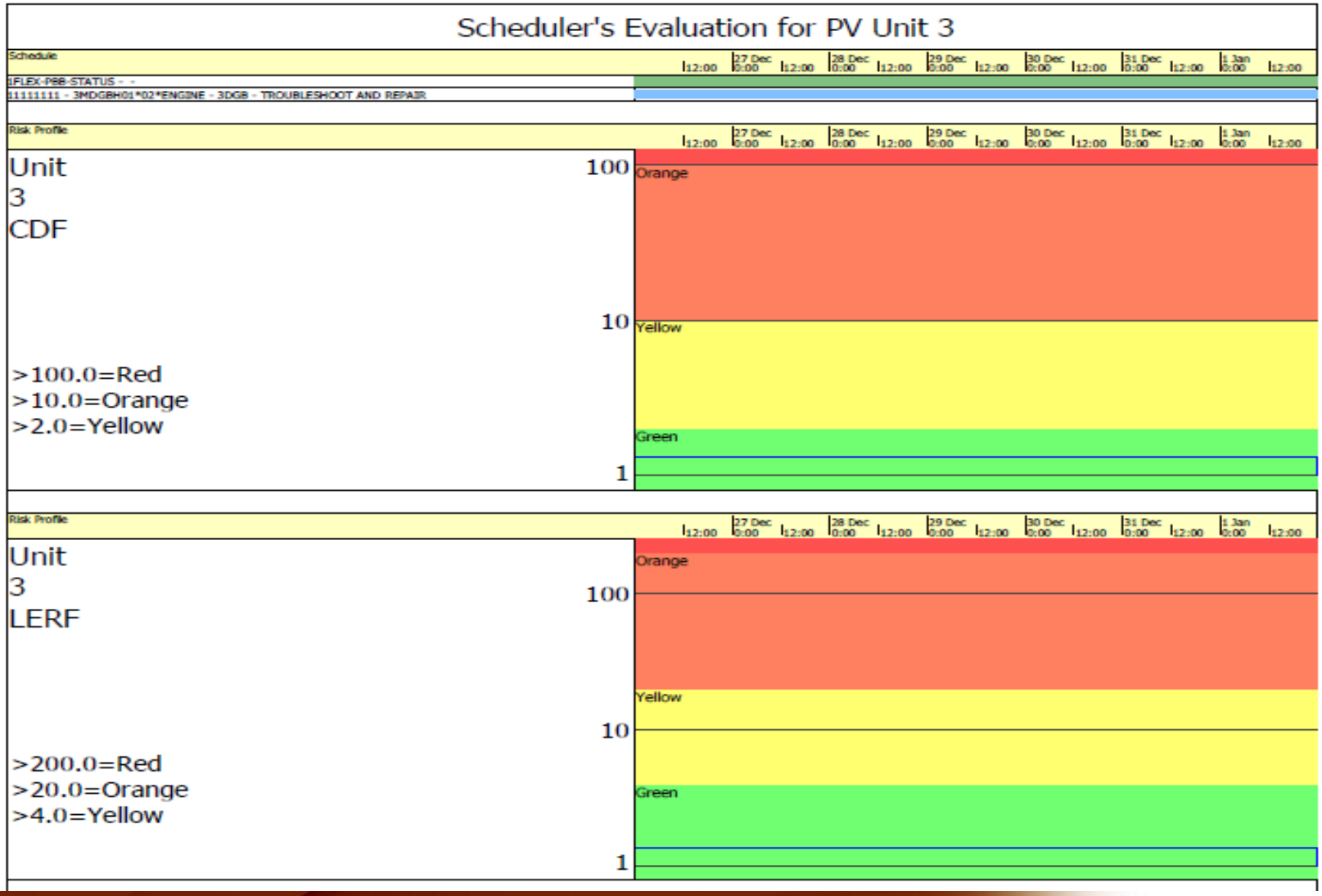
Hazard	ICCDF (per year)	ICCDP (11 days)	ICLERF (per year)	ICLERP (11 days)
Internal events	1.2E-6	3.6E-8	5.5E-8	1.7E-9
Internal flooding	2.2E-8	6.6E-10	5.0E-10	1.5E-11
Seismic	3.0E-5	9.0E-7	7.3E-7	2.2E-8
Internal Fire	2.8E-4	8.4E-6	4.5E-6	1.4E-7
Total	3.1E-4	9.3E-6[1]	4.9E-6	1.56E-7[2]

Notes:
1. Meets Regulatory Guide 1.177 acceptance criteria of < 1E-5
2. Meets Regulatory Guide 1.177 acceptance criteria of < 1E-6

Compensatory Measures

- 15 compensatory measures will be established during extended completion time, including:
  - Two, 2 MW portable DGs staged, test run and hooked-up to Unit 3 FLEX 4.16KV connections
  - Diesel driven FLEX Steam Generator make-up pump staged in Unit 3
  - Suspension of discretionary maintenance on SBOGs, Switchyard, Safety Systems
  - Establish protected equipment controls for Train A equipment, SBOGs, portable equipment
- Additional measures to reduce fire risk will stringently control transient combustibles and limit performance of hot work

Risk Profile During Repairs



License Amendment Request

- Request one-time extension of Technical Specification 3.8.1 Condition B.4 Completion Time from current 10 days to 21 days
- Request on Emergency Basis
- Risk-Informed Submittal
- To be submitted Wednesday, December 21
- Requesting approval by Sunday, December 25, prior to 3:56 am
- A two-phased approach will be used with a second LAR to request additional extension to completion time

Conclusion

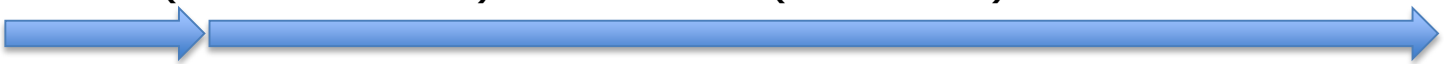
- Palo Verde continues to have diverse and redundant sources of AC power and steam generator makeup
- PRA risk acceptable in accordance with Regulatory Guides 1.174 and 1.177
- No significant hazards consideration criteria satisfied
- Second submittal expected upon further completion of the causal evaluation

Regulatory Options

Current AOT is 10 days, extended AOT times to be determined

- LAR 1 (risk - 11 days)----------LAR 2 (risk total)

- LAR 1 (deterministic)------LAR 2 (risk total)



- NOED----------LAR 1 (risk total)

- NOED---LAR 1 (risk)---LAR 2 (risk total)

Questions?