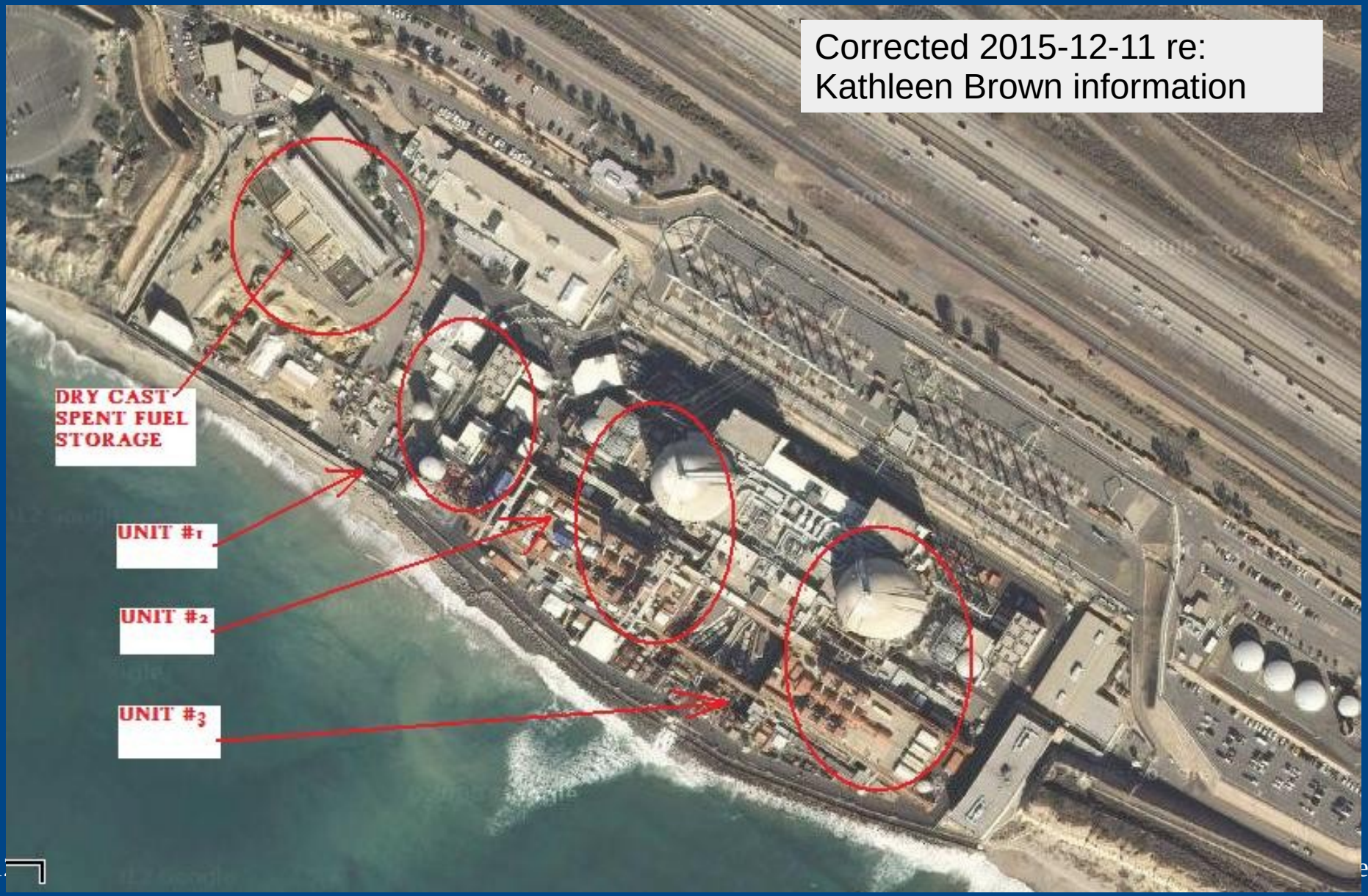
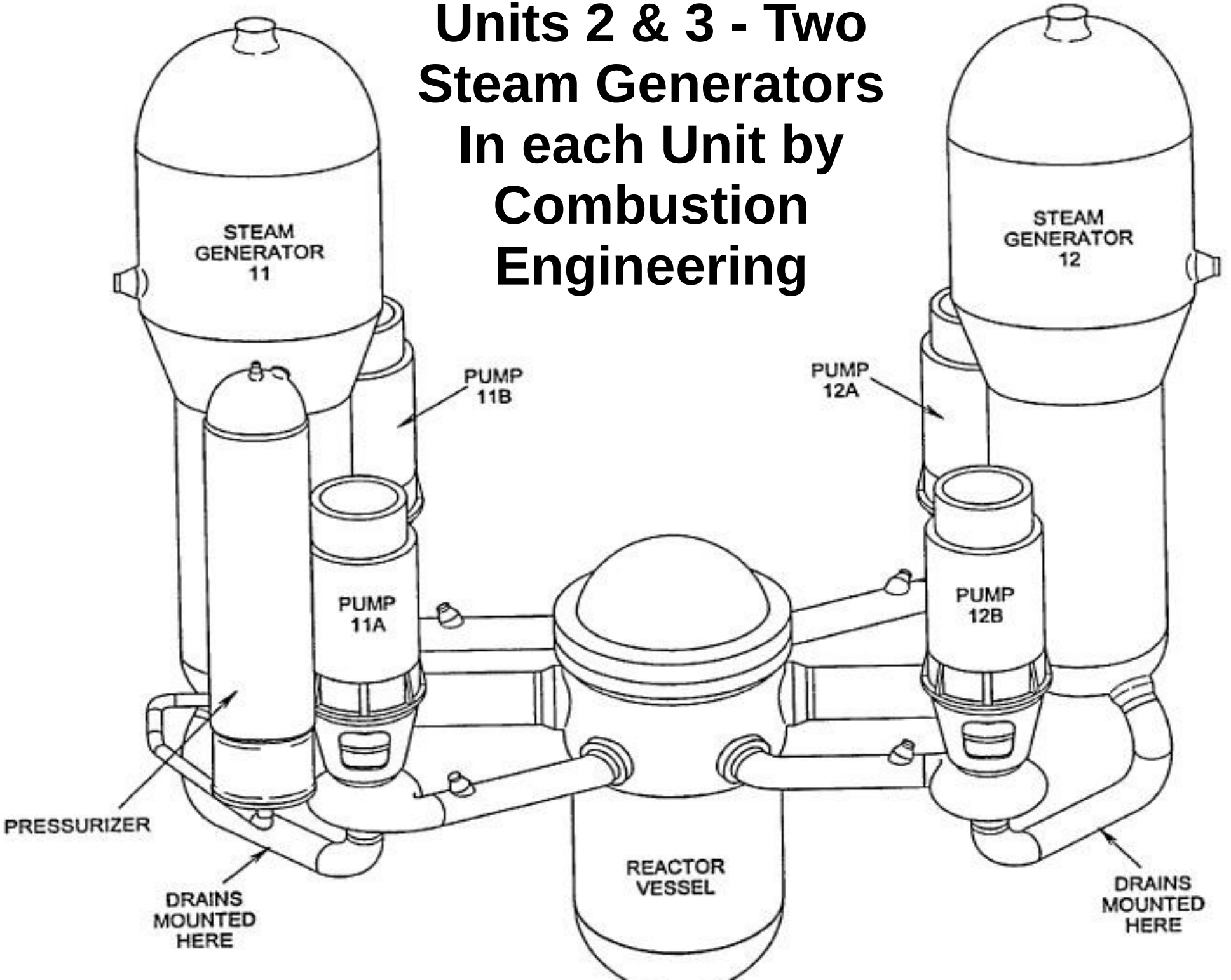
Anatomy of a Failure:
San Onofre Nuclear Generating Station (SONGS)
Ray Lutz, CitizensOversight.org 2015-11-23

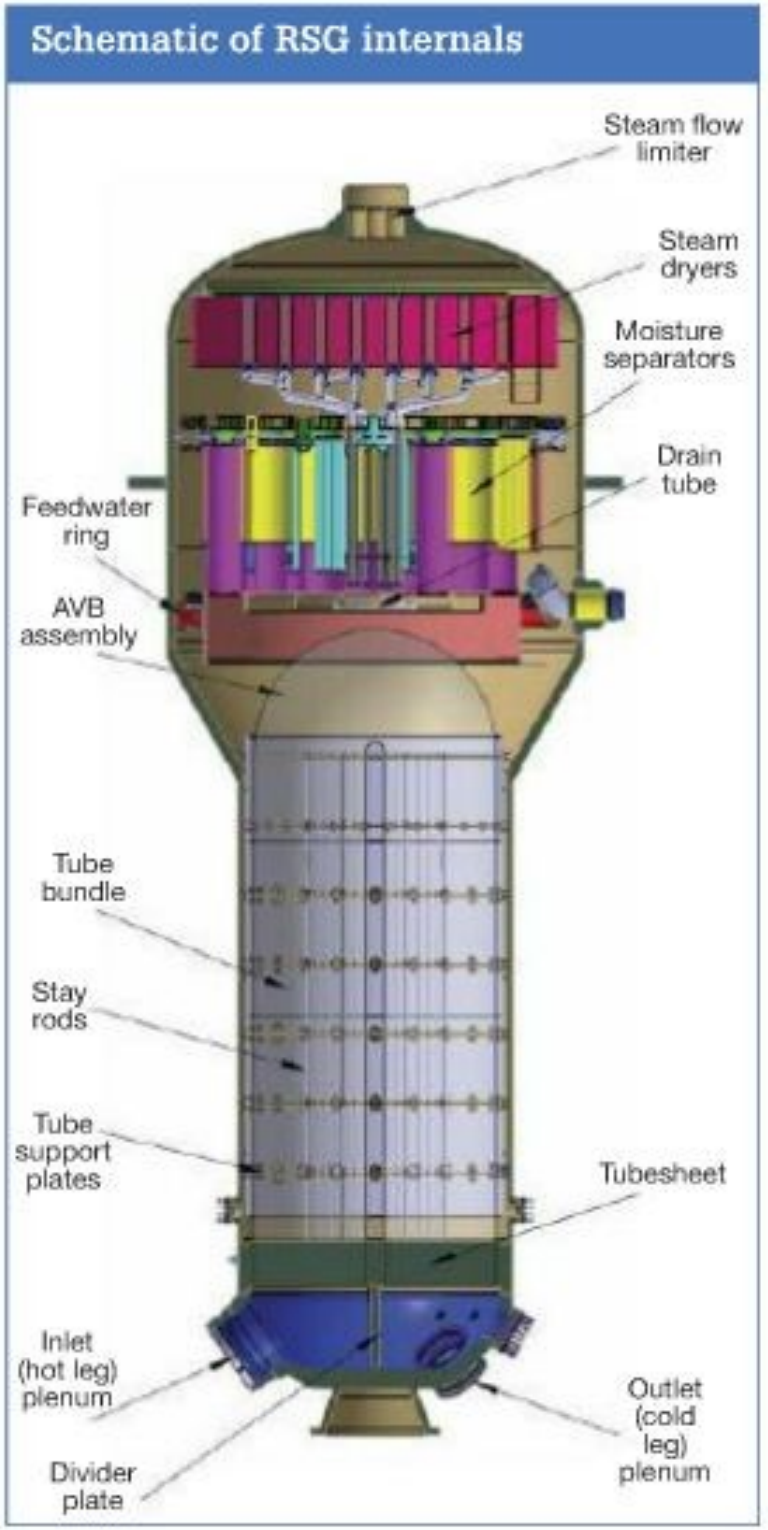


Units 2 & 3 - Two Steam Generators In each Unit by Combustion Engineering



Key Design Parameters (Design)

Total unit height:		**65.5**	**ft**
Primary Pressure		**2500**	**psia**
Primary Temperature		**650**	**°F**
Secondary Pressure		**1100**	**psia**
Secondary Temperature		**560**	**°F**
Steam pressure at outlet		**833**	**psia**
Tube plugging margin		**8**	**%**
Steam/Water weight @ 0% power		**270,460**	**lb**
Steam/Water weight @ 100% power		**171,250**	**lb**
Number of Tubes:	**OSG:9,350**	**RSG:9,727**	
Tube Diameter		**0.75**	**in**
Tube Spacing (center to center)		**1.00**	**in**
Tube Pattern		**Triangle**	
Nom. Tube Wall Thickness	**OSG**	**0.048**	**in**
	RSG	**0.043**	**in**



Generic PWR steam generator design (vertical type)

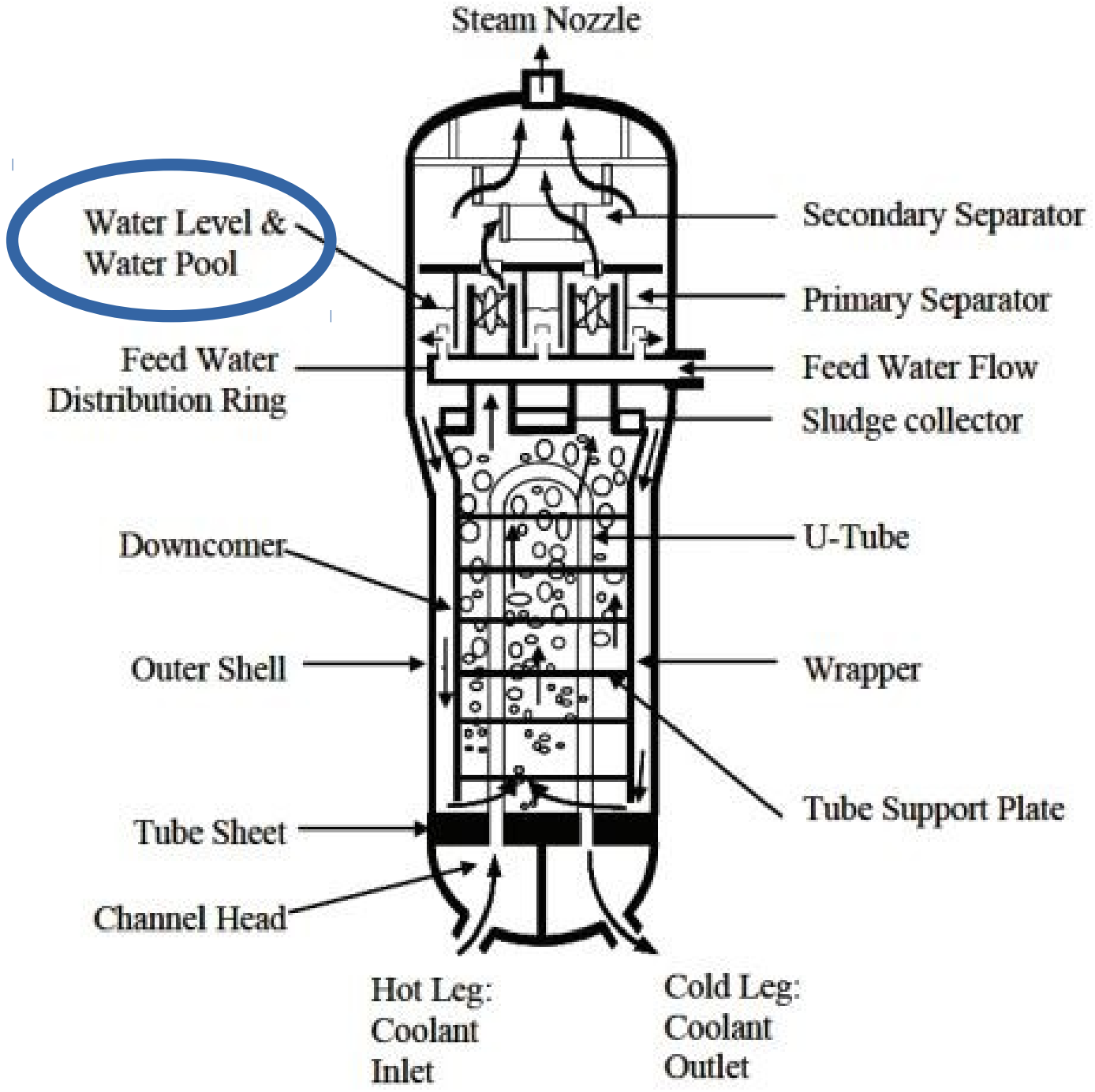


Fig. 3a. Schematic of a vertical PWR steam generator

Much larger than other MHI designs

San Onofre has only two SGs per unit and they are very large. Other plants have smaller and more SGs

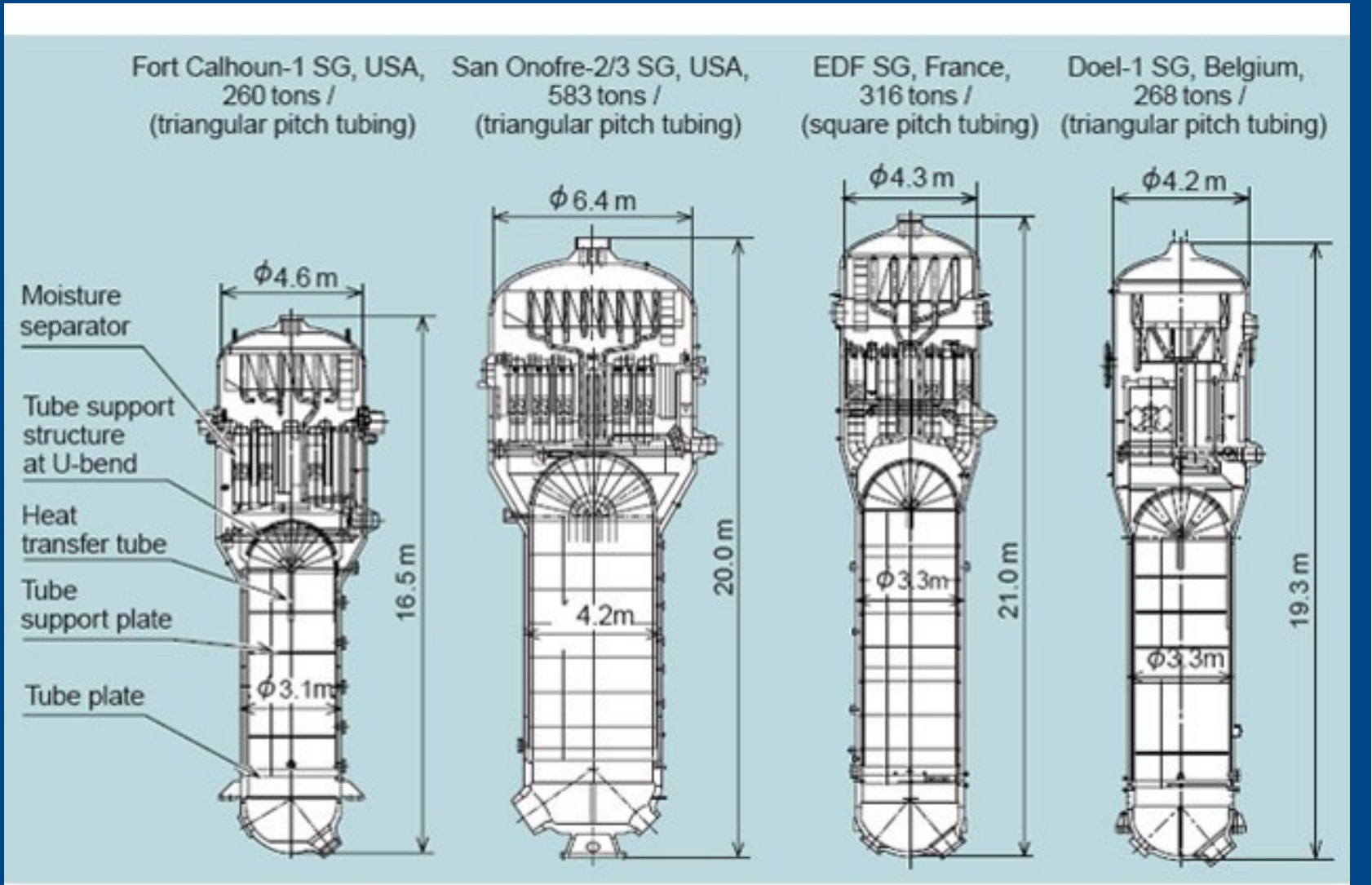
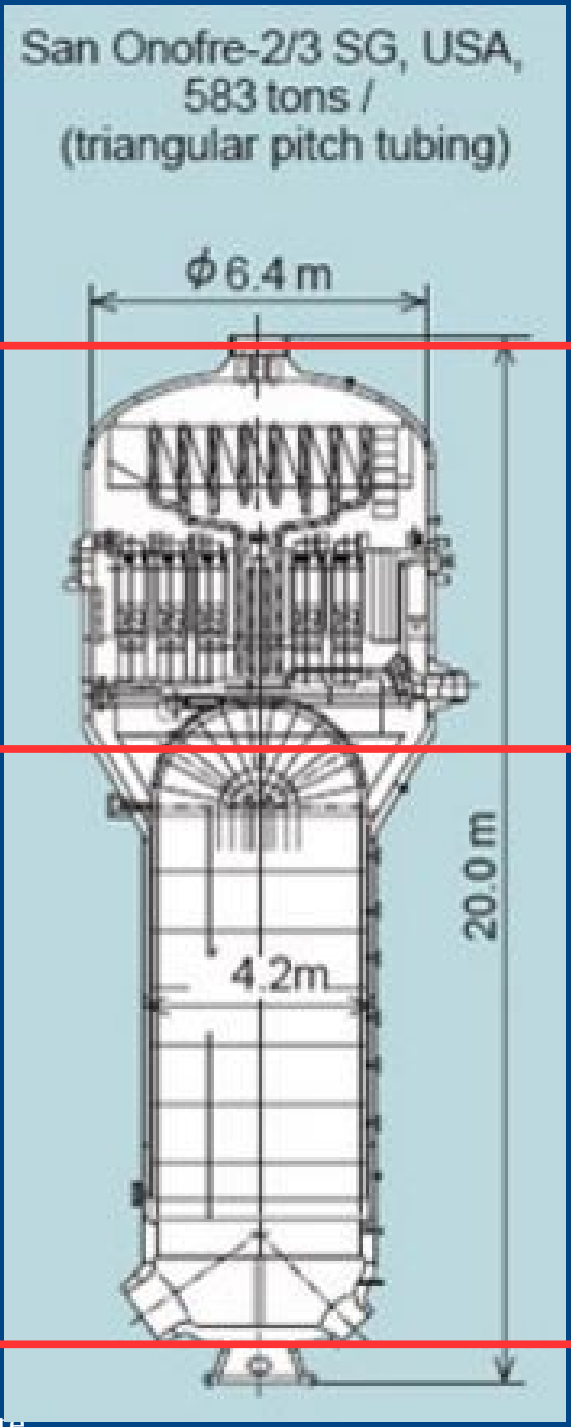


Fig. 1 Comparison of steam generators for export
Designs differ between individual customers because the specifications of replacement components are determined for each individual power plant.

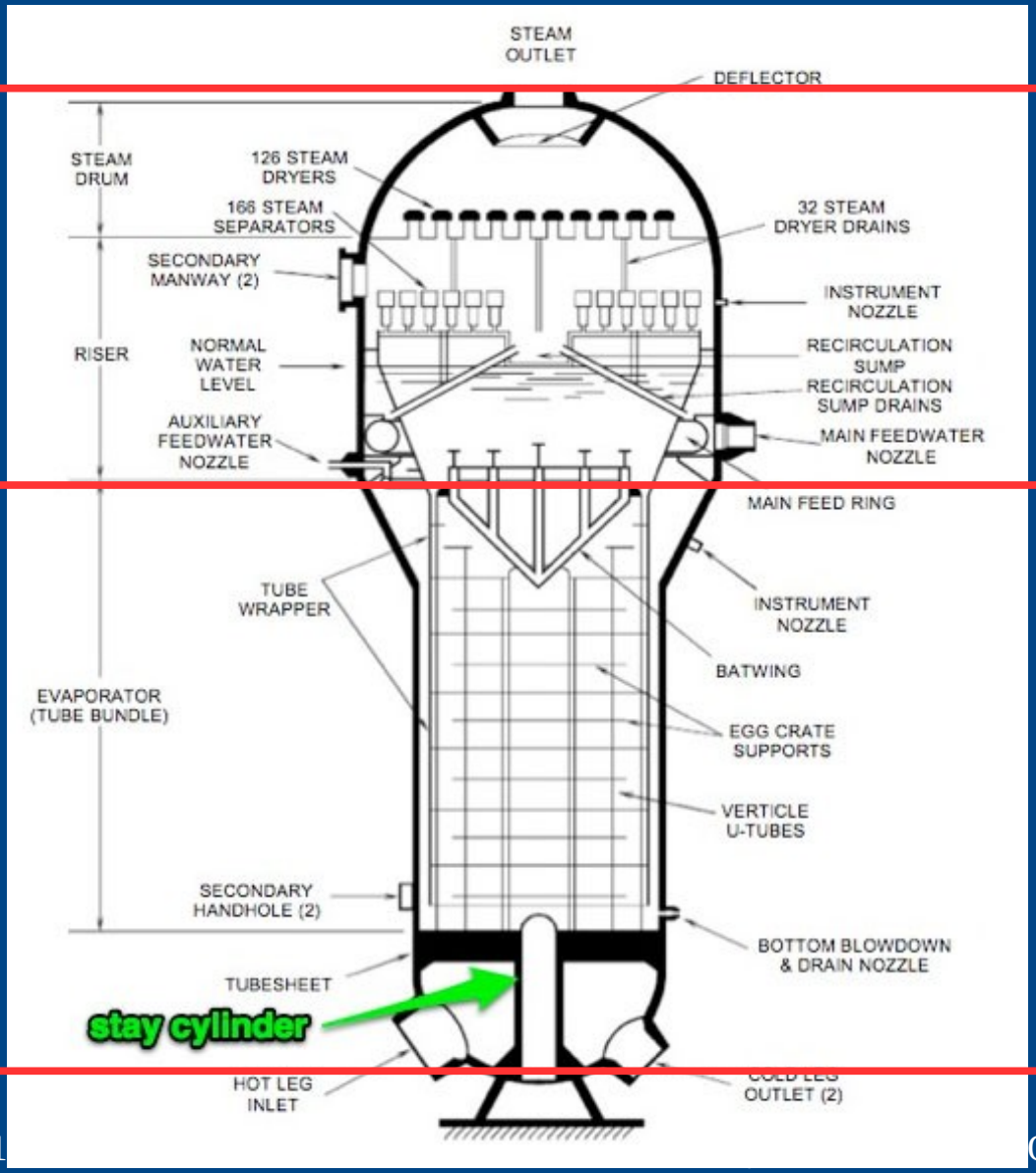
- Most Westinghouse U-Tube PWR designs have three or four steam generators
- All of the CE nuclear reactors use only two steam generators (14 out of 104 reactors in the U.S.)
- Each steam generator is 50% larger than those built by Westinghouse for a similar reactor power output.
- The replacement steam generators at San Onofre are some of the largest steam generators that have ever been designed or manufactured.

NOTE
> TALLER TUBE BUNDLE
> REMOVED STAY CYLINDER
> ALL NEW ANTI-VIBRATION BARS

REPLACEMENT STEAM GENERATOR (RSG)



ORIGINAL STEAM GENERATOR (OSG)



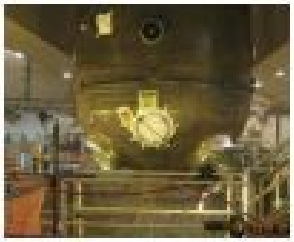
Changes from OSG to RSG

- Tubes use Alloy 690 instead of 600 steel
- Reactor flow rate was changed (increased)
- Added 377 tubes
- Modifications were made to the “egg crate” tube separator
- Removed stay cylinder
- U-bend region circular instead of flat.
- New Anti-Vibration Bar (AVB) design.
- 10% thinner tubes

Designers bragged about their good work days before the accident in Nuclear Engineering International, Jan 2012 edition

Improving like-for-like RSGs

The SG03 is lifted onto a purpose-built platform, skidded into the building, and then set into its final position by the containment vessel's internal crane



Although in a recent project Mitsubishi Heavy Industries supplied what were nominally replacements-in-kind of original steam generators at the San Onofre Nuclear Generating Station, the specifications in fact included many new requirements to improve longevity, reliability, performance and maintainability. By Bogusław Olech and Tomoyuki Inoue

SONGS is a two-reactor Pressurized Water Reactor (PWR) nuclear power plant (NPP) located in California, USA. SONGS consists of two twin units (unit 2 and unit 3) each rated at 3568 MWt (1180 MWe). SONGS is majority owned and operated by Southern California Edison Company (Edison). SONGS unit 2 began commercial operation in 1983 and unit 3 in 1984.

Each of the SONGS units were originally equipped with two CE Model 3246 recirculating steam generators. The OSGs were designed for a 40-year service life.

Over the years of operation of the PWR plants, it became evident that the steam generator tubes, made predominantly of Alloy 600, were susceptible to inter-granular attack (IGA) and primary water stress corrosion cracking (PWSCC). These corrosion mechanisms were resulting in tube degradation necessitating plugging large numbers of tubes. In addition, the SONGS OSG design has shown to be susceptible to tube through-wall wear and severe corrosion at the tube supports. It became evident that the OSGs would have to be replaced much sooner than stipulated by their design service life.

Replacement of the steam generators has typically been performed when the utility concluded that they were reaching their economic end-of-life. This occurs when forecasts of maintenance and repair costs exceed the amortized benefits of the reduced costs achievable with the replacement steam generators. Continuing to operate with highly degraded steam generators can involve substantial economic risks from forced outages, extended refueling outages, as well as the direct costs of inspections and repair. Several plants have been required by safety analysis to conduct mid-cycle inspection and repair outages. The repair levels (including plugging, sleeving, or using alternative repair criteria) at the replacement plants averaged 25%. Edison has set a 21.6% plugging level as the technical end-of-life of the SONGS steam generators. Forecasting when this would occur resulted in a range of years depending on the level of confidence in the projection. The SONGS worst case forecast indicated that the 21.6% plugging level could be reached as early as 2012.

All the considerations mentioned above prompted Edison to undertake a conservative decision to replace the SONGS steam generators in both units during their respective cycle 14 refueling outages. The contract for design and fabrication of the RSGs was awarded to MHI and the unit 2 RSGs were delivered and replaced in 2009; unit 3 RSGs were delivered and replaced in 2010.

Design bases

The SONGS CE recirculating steam generators employed heat transfer tubing made of Alloy 600 Mill Annealed (MA) and the carbon steel egg-crate type tube supports with belvings in the tube bundle U-bend region. Because of the unit two-loop design, the SONGS steam generators were one of the largest in the industry. The major shortcoming of such large steam generators, as seen during their operating history, was tube wear, particularly in the U-bend region.

At SONGS, the steam generators have the following design functions:

- To function as a part of the reactor coolant system (RCS) pressure boundary (the primary side and the tubes)
- To remove heat from the RCS and transfer it to the main steam system (MSS)
- To remove heat from the RCS to achieve and maintain safe shutdown following design-basis accidents (except for a large break LOCA) and other transients
- To provide high-quality steam to the main turbine

The steam generators also have the following design bases:

- To transfer a total of 3458 MWt with two steam generators from the RCS to the MSS
- To produce 15.17x10⁶ lbs/hr (6.88 x10⁶ kg/hr) of saturated steam at a pressure

Emergency Shutdown
January 31, 2012, 5:31pm

On January 31, 2012, at 3:05 p.m. … Operations personnel determined the leakage to be about 75 gallons per day, using a mass balance calculation (.06 gpm), from steam generator 3E0-88. This leak rate was below the Technical Specification 3.4.13, "RCS Operational Leakage," limit of 150 gallons per day for primary- to-secondary leakage through any one steam generator.

At 4:10 p.m., operations personnel evaluated that the primary-to-secondary leak rate exceeded 75 gallons per day on steam generator 3E0-88 and that the leak was increasing at greater than 30 gallons per day per hour, and consequently, initiated a rapid power reduction to be ≤ 50 percent power in one hour and in Mode 3 within the next two hours per Abnormal Operating Instruction SO23-13-14. In accordance with Abnormal Operating Instruction SO23-13-14, when reactor power was less than 35 percent, operations personnel tripped the reactor at 5:31 p.m. to enter Mode 3.

LEAK INCREASING 40% PER HOUR ACROSS 1400 psia PRESSUER AND RADIATION BOUNDARY.
OPERATORS SAFELY SHUT DOWN THE REACTOR BEFORE CASCADING TUBE FAILURES OCCURRED.

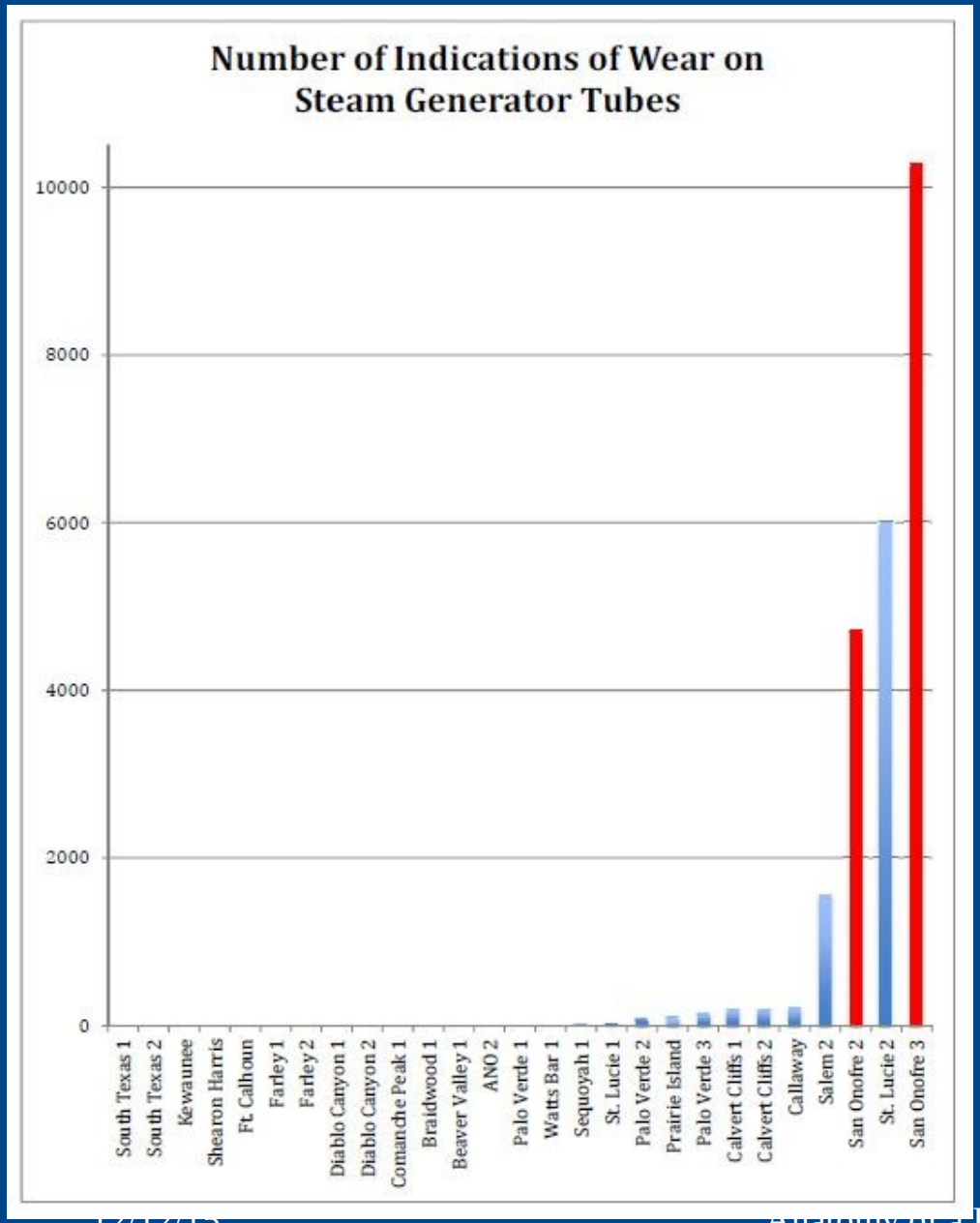
No NRC review was “premise”

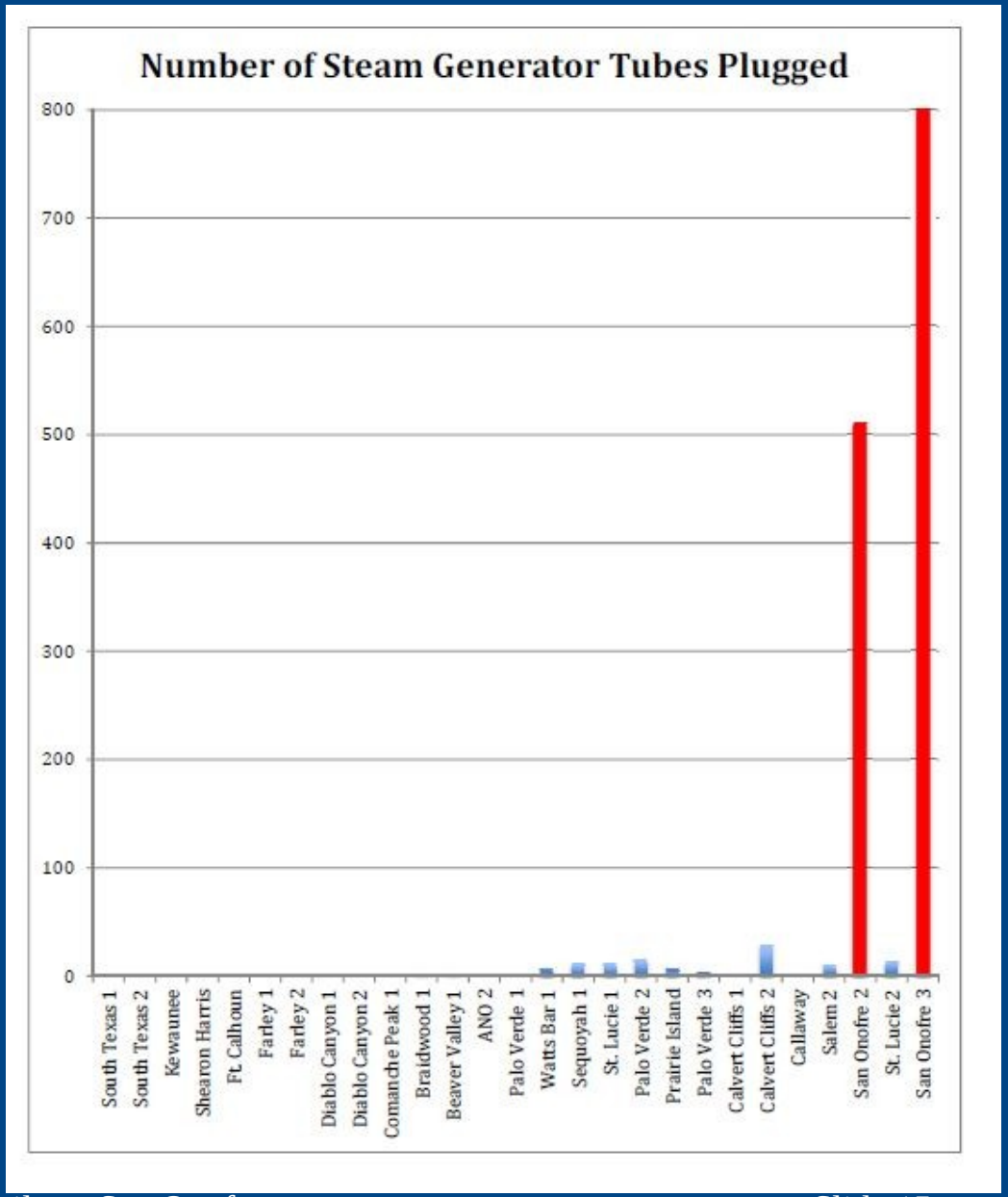
At SONGS, the major premise of the steam generator replacement project was that it would be implemented under the 10CFR50.59 rule, that is, without prior approval by the US Nuclear Regulatory Commission (USNRC). To achieve this goal, the RSGs were to be designed as ‘in-kind’ replacement for the OSGs in terms of form, fit and function. The

Palo Verde RSGs had no problem

- Palo Verde Units 1, 2, and 3 have essentially the same design for their replacement steam generators. They were all “designed by Asea Brown Boveri/Combustion Engineering (ABB/CE) (now Westinghouse) and manufactured by Ansaldo, and are considered a modified System 80 design (no specific model number).” There are 12,580 tubes for each steam generator; (see ML082890538, pg 3 of PDF, pg 1 of enclosure.)
- Palo Verde did not attempt to avoid NRC review and went through the traditional License Amendment.

After first fuel cycle: Far outside the norm



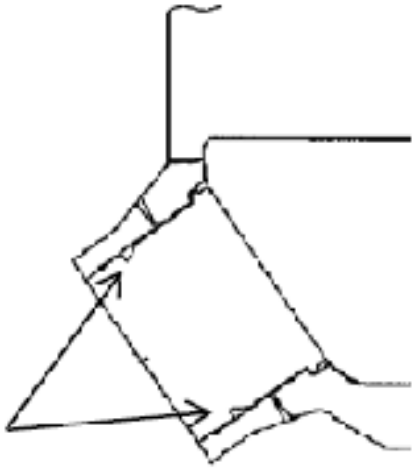


Flow Limiter added, too small?

On page 30 of the NRC AIT Report, there is a discussion of the flow limiters:

Flow Limiter for Primary Inlet Nozzles – The replacement steam generators were designed with a flow limiter located in the primary inlet nozzle (see figure below) in order to make the reactor coolant system flow similar to the flow rate of the original steam generator and not exceed the maximum allowable reactor coolant system flow rate. The licensee's evaluation for the engineering design package determined that although the original steam generators had a number of plugged tubes, the reactor coolant system flow rate of the original steam generators was near the design requirement. Because the replacement steam generators has 377 more tubes than the original steam generators, and contained tubes with u-bends versus "square bends", the pressure drop of the replacement steam generators with no plugged tubes would be much less than the original steam generators resulting in a higher flowrate.

The flow limiter was designed to ensure the total "best estimate" reactor coolant flow rate with the replacement steam generators installed would not exceed 106.5 percent of the design volumetric flow rate of 396,000 gallons per minute at a reactor coolant system cold leg temperature of Tcold = 540.9°F. For Unit 2 replacement steam generators, the flow limiter diameter to nozzle inner diameter ratio was 0.94 while the ratio for Unit 3 steam generators was 0.915 due to Unit 3 reactor coolant pump replacement. The flow limiter dimensions resulted from a scaled model test performed by Mitsubishi and it was designed to be machined as part of the nozzle base metal.



Flow Limiter

Thinner tube effects neglected

According to this description, no adjustment was made due to the change of thickness, which was decreased by 10.4%

Original inside radius = (0.75/2 = 0.375) – 0.048 = 0.327; Area = 0.3359 sqinch

Redesigned inside radius = (0.75/2 = 0.375) – 0.043 = 0.322; Area = 0.3257 sqinch

Increase = .3359 / .3257 = 103.13% => reduce flow by 0.9696

In other words, flow is increased by 3.13% due to thinning of the tubes alone.

Assuming the figures DID NOT take this into account, the flow limiters should have been sized to decrease the flow by an additional 3.13%. They should have been:

Unit 2: 0.94 * 0.9696 = 0.911
Unit 3: 0.915 * 0.9696 = 0.887

---> Did the calculations for the flow limiters take into account the 3.13% increase due to thinning of the tube wall thickness by 10.4%?

(THE NRC DID NOT ANSWER OUR QUESTION)

Why were design changes made?

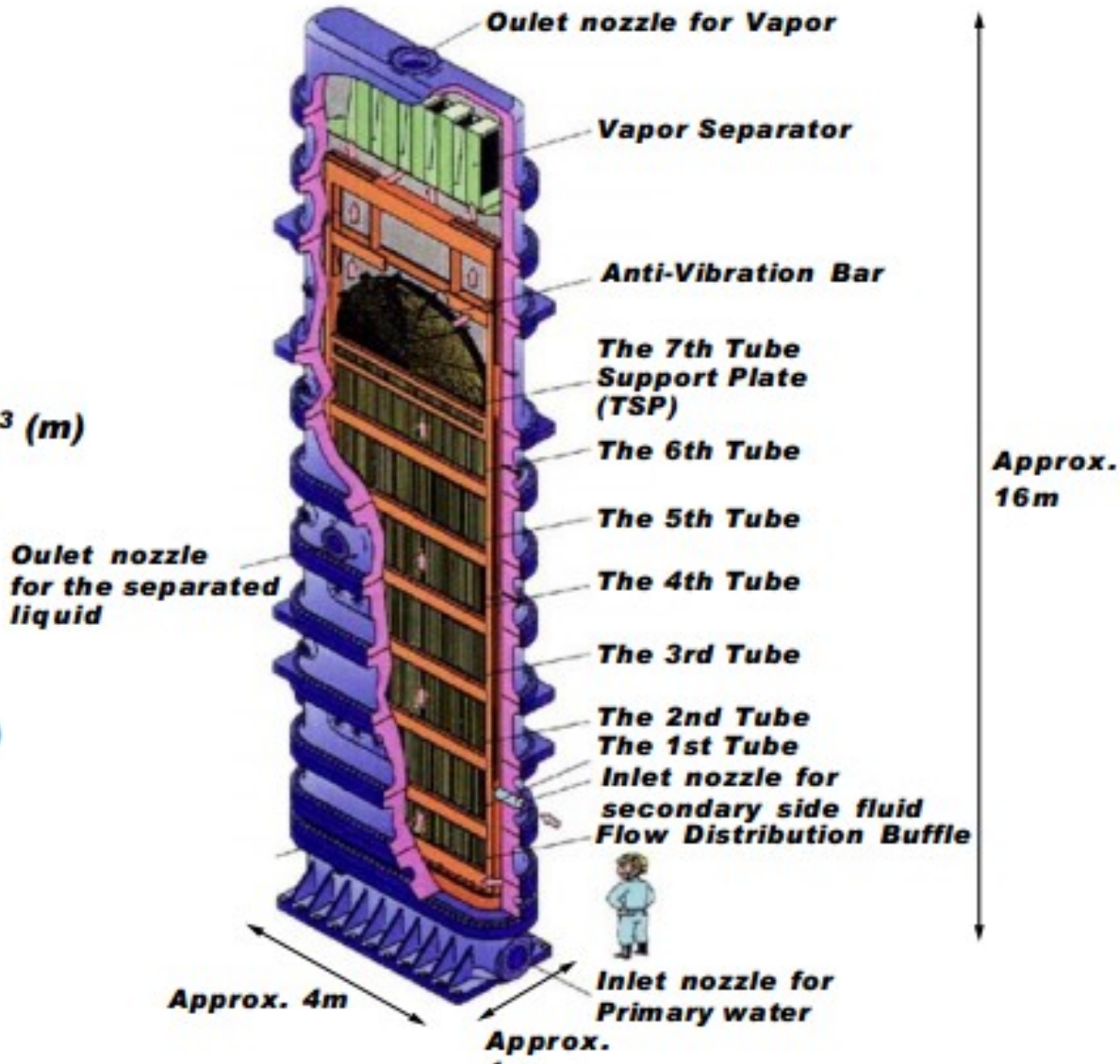
- Change from alloy 690 from alloy 600 was a standard change throughout the industry to avoid stress corrosion cracking.
- Thermal conductivity of alloy 690 about 10% lower than alloy 600.
- They made the tubes 10% thinner. This accounts for the change in thermal conductivity.
- But they made more changes... 377 tubes were added (about +4%) and stay cylinder removed.
- U-bend is semicircular vs. “Flat U”. That increased the flow rate.
- Flow rate wound up being too high, void fraction too high.
- SCE WAS TRYING TO UPRATE THE STEAM GENERATORS THROUGH THESE MULTIPLE CHANGES.

MHI Model testing of square tube array

2. Full scale freon test for square tube array SGs

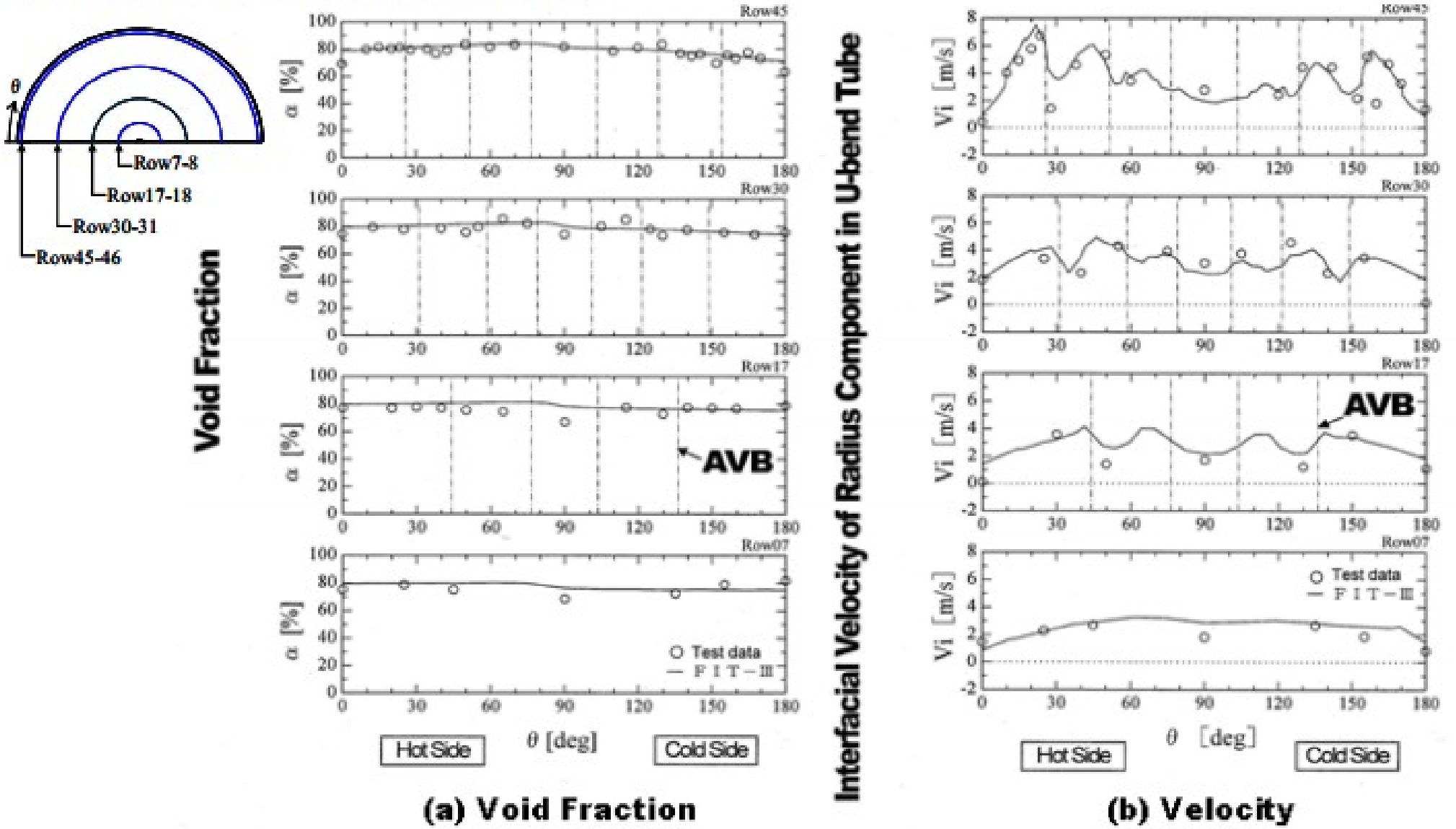
- **U-bend tube bundle:**
  - **Number of tubes: 46 × 5 (-)**
  - **Outer diameter of tube: 22.23 × 10^{-3} (m)**
  - **Thickness of tube: 1.27 × 10^{-3} (m)**
  - **Tube pitch : 32.54 × 10^{-3} (m)**
  - **Tube array : Square pitch**
  - **Material of tube: Inconel 690**
  - **Maximum bending radius: 1.52 (m)**

→ **Same as actual SG**



Void Fraction and Velocity

Qualification Results of FIT-Ⅲ



Modeling Error

Turbulence model is ignored in FIT-III. Important two phase model is slip model to calculate void fraction. The following Smith model is used for FIT-III. This model is validated by Freon test for square array shown in Appendix-1. The tuning factor in the slip model should be correlated by the void fraction data. The reason why the Smith correlation was selected is Zivi and Smith correlations have the tuning factors, and the Smith correlation was the latest one.

$$\frac{1}{\alpha} = 1 + \frac{\rho_g (1-x) e}{\rho_l x} + \frac{\rho_g (1-x)(1-e)}{\rho_l x} \left[\frac{\frac{\rho_l}{\rho_g} + \frac{e(1-x)}{x}}{1 + \frac{e(1-x)}{x}} \right]^{1/2}$$

$e =$ | |

α; void fraction x; quality e; entrainment coefficient

ρ_g; vapor density ρ_l; liquid density

Thus, FIT-III has been validated under the condition where the homogeneous void fraction is smaller than | | for steam generator.

Void Fraction vs. Steam Quality

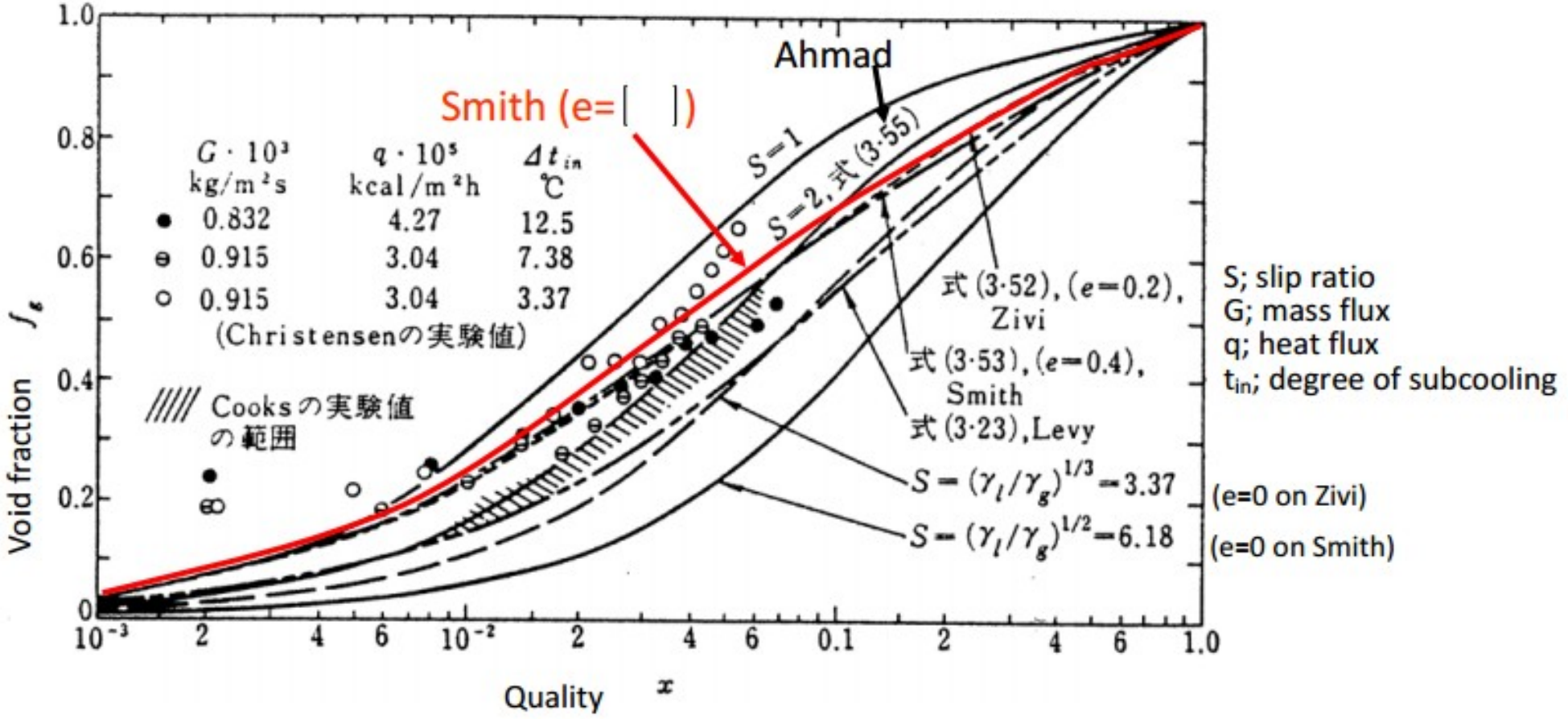


Fig.2 Relation between quality and void Fraction

(Reference; Akagawa, 1974, 'Gas-Liquid Two-Phase Flow" (in Japanese), P52) (Ref.[7])

New steam turbines designed expecting higher steam pressure

TIMELINE

- 2005-12-15, the CPUC issued Decision D.05-12-040 approving the Steam Generator Replacement Project (SGRP)
- 2006 -- SCE was aware of AVB design problems but told the NRC they were “improved”
- 2010-2011 -- RSGs installed. Immediately put into rates prior to reasonableness review.
- 2012-01-31 – A radiation leak in Unit 3 resulted in an emergency shutdown. Unit 2 was already off line due to a refueling outage.
- Nine months later – SCE and SDG&E submitted notices to the CPUC regarding the shutdown per requirements of PUC 455.5.
- 2012-10-25 -- The CPUC instituted an investigation into the outage, breaking the investigation into four phases.
  - Phase 1 – response of SCE to the outage during 2012
  - Phase 1A – Replacement Power
  - Phase 2 – Ratemaking treatment of the remaining plant
  - Phase 3 – Investigation into the causes of the outage – reasonableness review of the SGRP was folded into this phase. THIS PHASE NEVER STARTED
  - Phase 4 – was a catch all for loose ends. (also not started)

“Nunn Letter,” SCE to MHI, November 30, 2004

SOUTHERN CALIFORNIA EDISON®
An EDISON INTERNATIONAL® Company

November 30, 2004

Dwight E. Nunn
Vice President

Mr. Akira Sawa
General Manager
Mitsubishi Heavy Industries, LTD
Kobe Shipyard & Machinery Works
1-1, Wadasaki-Cho 1-Chome
Hyogo-Ku
Kobe 652-8585
Japan

Dear Mr. Sawa:

Subject: Replacement Steam Generators
San Onofre Nuclear Generating Station, Units 2 & 3

(Nunn Letter, Continued)
SCE was intimately involved

Understanding the difficulty in transitioning from the standard Mitsubishi Heavy Industries steam generator design to a new and larger two-loop design, San Onofre has made it a goal to partner with Mitsubishi Heavy Industries and maintain a close relationship with your engineering and fabrication organization to assist them in this design evolution. To this end we are performing detailed, intrusive evaluations of your design documentation and your approach to design evolution on this job. A recent example

AVBs: a known problem

- Anti-Vibration Bar design (and installation) is by far one of the most challenging tasks that will face Mitsubishi Heavy Industries and San Onofre; in fact, it is in our opinion the single most significant task facing the industry for steam generators of our size today. Since the San Onofre steam generators are one of the largest steam generators ever built and large steam generators appear more susceptible to wear (in fact, our current steam generators have experienced a high percentage of plugged tubes due to wear), it is a paramount concern of ours that we ensure a reliable support design. We consider this engineering challenge perhaps the most critical issue at this time. Recent industry experience with Anti Vibration Bar supports has demonstrated the difficulty in developing a successful design (the recent experience at a United State's plant emphasized this point when more that 180 tubes were found to have wear indications after only one cycle of operations, some of these indications were up to 20% through wall). Our discussions with Mitsubishi Heavy Industries to date have not resulted in a plan that will successfully address this industry concern. Both San Onofre and Mitsubishi Heavy Industries are having difficulty in formulating such a plan.

"Both San Onofre and Mitsubishi Heavy Industries are having difficulty in formulating such a plan."

June 7, 2006 NRC Presentation

No mention of having difficulty with AVB design.

Some Key Design Improvements

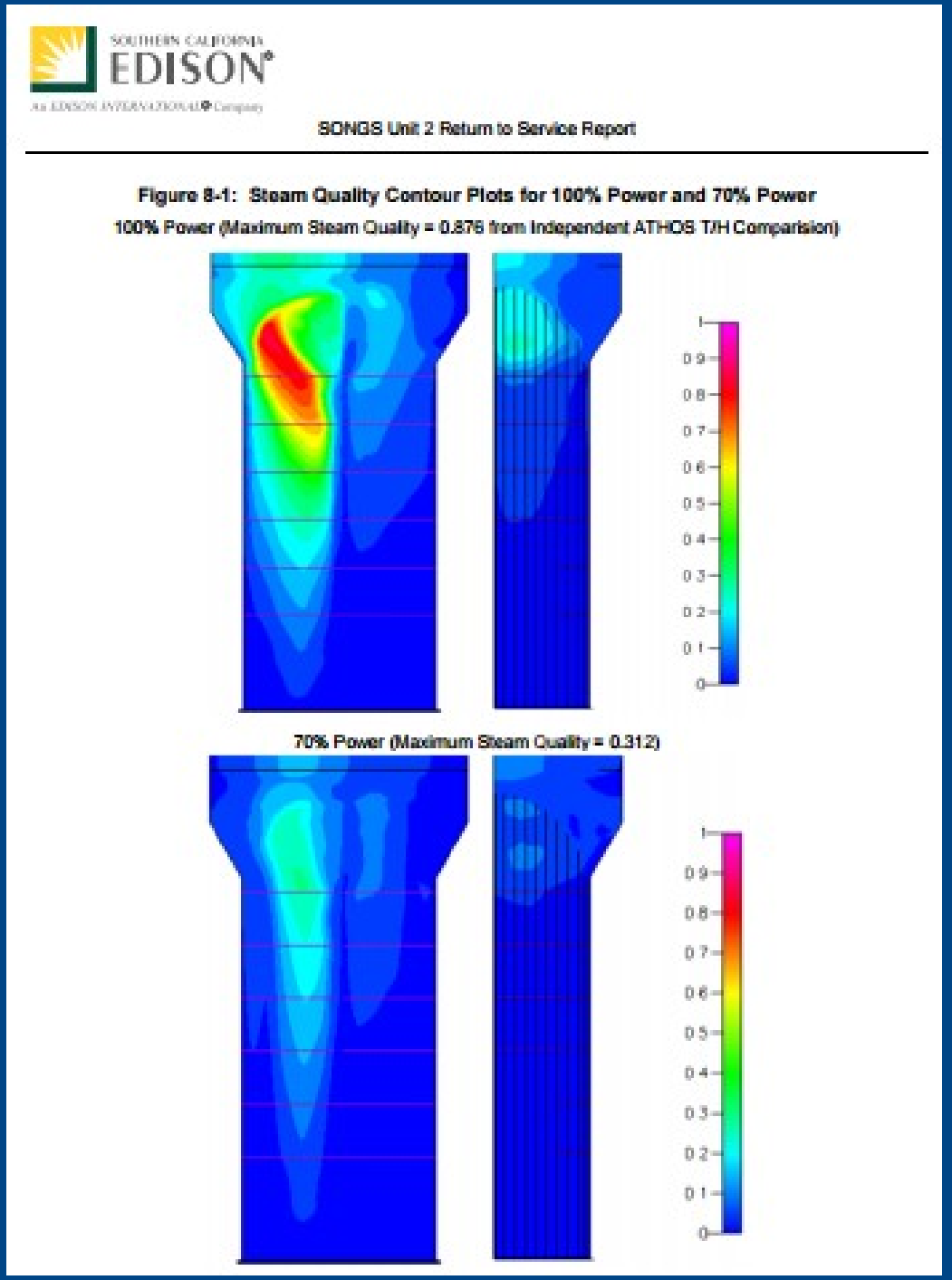
- Larger Surface Area
- Alloy 690 Thermally Treated Tubing
- Improved AVB Design
- Integral Steam Nozzle
- Improved Material for Tube Supports
- Forged Shell

S/G 3A Lower and Middle Shell
S/G 2A Balance Ring, Extension Ring, & Tubesheet

12

TIMELINE -- settlement

- Oct, 2012 -- SCE proposes to restart Unit 2 at 70% power. This gave them a bargaining chip.



TIMELINE -- settlement

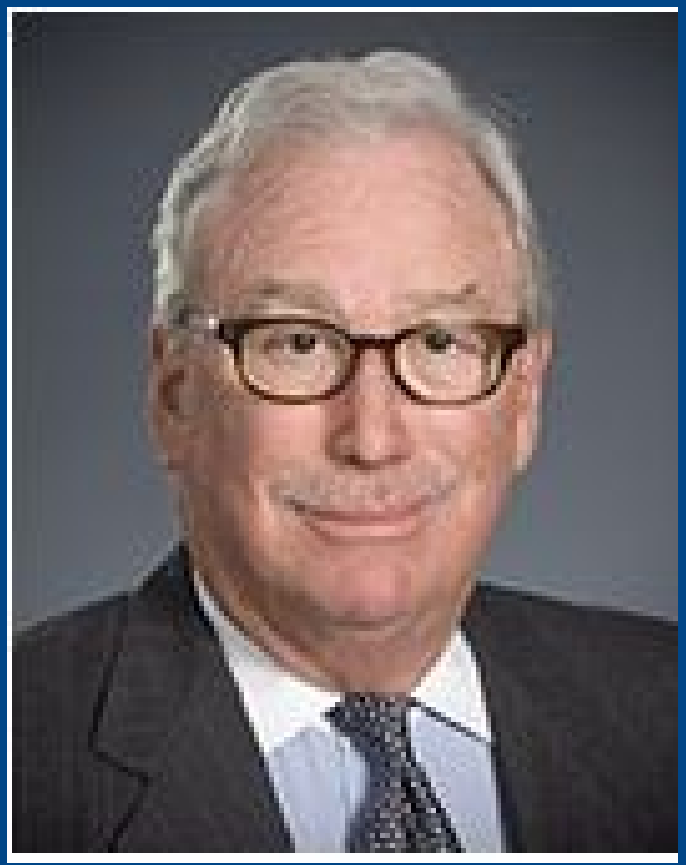
- Dec 5, 2012 -- ALJ Darling talked with SCE's Russell Worden to plan the phases of the case to place investigation into phase 3.

ALJ DARLING (CPUC)

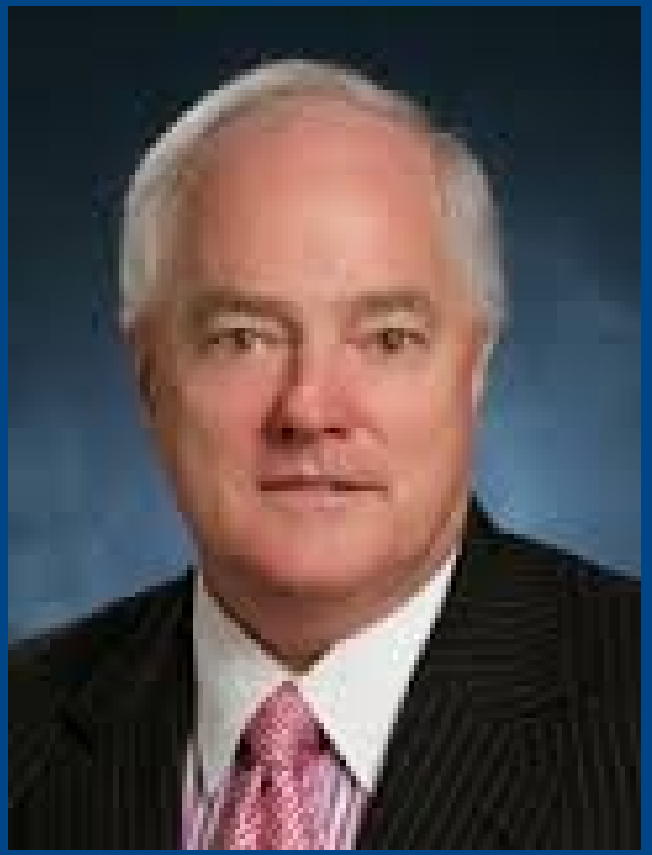
RUSSELL WORDEN (SCE)

TIMELINE -- settlement

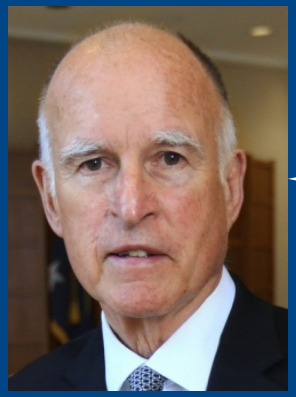
- March 26, 2013: CPUC Pres. Peevey met with SCE executive Pickett in Warsaw, Poland and sketched out the major terms of the settlement.



MICHAEL PEEVEY (CPUC)



STEPHEN PICKETT (SCE)



Gov. Brown

Kathleen Brown
(sister)
Sempra Board Member
Peevey Gala Organizer
Former Schwartzenegger aide
VERY WELL CONNECTED

Micheal Picker
CPUC Pres.
Former Brown advisor on San Onofre

Michael Peevey
Former CPUC President

Michel Florio
CPUC Commissioner
Formerly attorney for TURN

Ted Craver
CEO Edison International

Partners in crime

CPUC approves Edison energy deals

Former Schwarzenegger aide among those providing power

By Jeff McDonald | 5:49 p.m. Nov. 19, 2015

Last week

CEO Susan Kennedy of Advanced Microgrid Solutions speaks during a panel discussion at the National Clean Energy Summit 8.0 at the Mandalay Bay Convention Center on August 24, 2015, in Las Vegas (Photo by Ethan Miller/Getty Images)

Susan Kennedy
Former CPUC commissioner 2003-2005 (approved RSG Proj.)

Now energy company developer and close friends with Kathleen Brown.

6

The California Public Utilities Commission approved a series of purchasing agreements for Southern California Edison on Thursday that includes contracts with a San Francisco startup founded by a former commission member.

TIMELINE -- settlement

- May 2013: SCE and SDG&E Started secret settlement negotiations with TURN and ORA.
- June 6, 2013: SCE announced the permanent shutdown of the plant
- March 27, 2014, the final settlement agreement was disclosed with no opportunity for other parties to impact the proposal.
- May 14, 2014, a half-day evidentiary hearing was conducted regarding the terms of the $3.3 billion proposed settlement.

Reasonableness Review Avoided

- CPUC Decision D.05-12-040 approving the Steam Generator Replacement Project (SGRP)
  - Order #5: If the SGRP cost exceeds $680 million, or the Commission later finds that it has **reason to believe the costs may be unreasonable** regardless of the amount, the entire SGRP cost shall be subject to a reasonableness review.
    - Since the Steam Generators failed, a reasonableness review is in order, as this is certainly "reason to believe that the costs may be unreasonable" and the OII stated such a reasonableness review would occur.
- 12/5/2012 -- ALJ Darling talked with SCE to plan that investigation into the failure would be placed in Phase 3 along with the reasonableness review, which was overdue.
- The settlement scuttled phase 3 and thus avoided the reasonableness review and any investigation into the failure.
- The disgraceful evidentiary Hearing on the proposed settlement processed a billion dollars an hour.

Record Insufficient to evaluate the settlement

- Commission Policy is that the settlement will be evaluated with respect to the “whole record” but Phase 3 was never started, and so the record is incomplete.
- There is nothing in the record to provide the Commission with sufficient evidence that the settlement is a fair conclusion of claims of ratepayers.
  - SCE President Ron Litzinger admitted this was the case in the evidentiary hearings on May 14.
- There is nothing in the record that provides any evidence of the risks and potential revenue from insurance carrier NEIL and MHI litigation, yet settlement wants ratepayers to get in the middle.
  - Commission has no means to oversee litigation, which is a serious problem with the 3rd party returns element.

Any Settlement Should:

- … **Not Be Based On Future Events**
  - Settle the matter now, if possible. No requirement that we trust the company will act properly in the future
  - No ratepayer or Commission involvement in litigation with MHI and insurance carrier NEIL.
  - No payments for the next 10 years.
- … **Reward Desired Actions**
  - No one does anything without money at stake.
  - SCE is proposing that the ratepayers cover their butts now and then be reimbursed later. SCE has no incentive to salvage the plant effectively nor to seek settlement with 3rd parties over the first threshold.
- … **Be Open and Verifiable By The Public**
  - No secrets.
  - Litigation is all closed to oversight by the Commission and the public.
- **THIS SETTLEMENT FAILS ON ALL COUNTS.**

The Commission MUST complete the investigation

- Nuclear power is very dangerous. Failures of this magnitude must be investigated to root out the failure of the system.
- The CPUC approved the SGRP and should review its own procedures as it now appears that that decision was imprudent as well.
- The investigation will cost far less than the $3.3 billion settlement that is proposed, and far more was already lost in this debacle.
- Two of the investigations folded into this proceeding were not even started, have no evidence in the record The Commission has no business ignoring these important investigations.
- Commission has no reason to accept the settlement!
- The NRC completed their investigation into the outage at SONGS. Our CPUC should also do as they promised and complete their investigation.

Proposed Settlement

> Unfair To Ratepayers
> Bad Commission Policy
> No refunds to ratepayers

UNPRECEDENTED FAILURE

- There are no other cases of an engineering failure resulting in the abandonment of an entire power plant.
- Similar plants ARE retired early due to regulatory or risk assessment changes. These are prudent.
  - All returned net investment in base plant with no return on investment.
- A number of projects failed but the plant was repaired.
  - The Commission did not help the utility get out of their mess.
- The proposed settlement provides the net investment return and a return on investment.
- The Utilities expect the ratepayer to bail them out of their imprudent business decisions. To do so is bad policy as it encourages such imprudent decisions to continue.

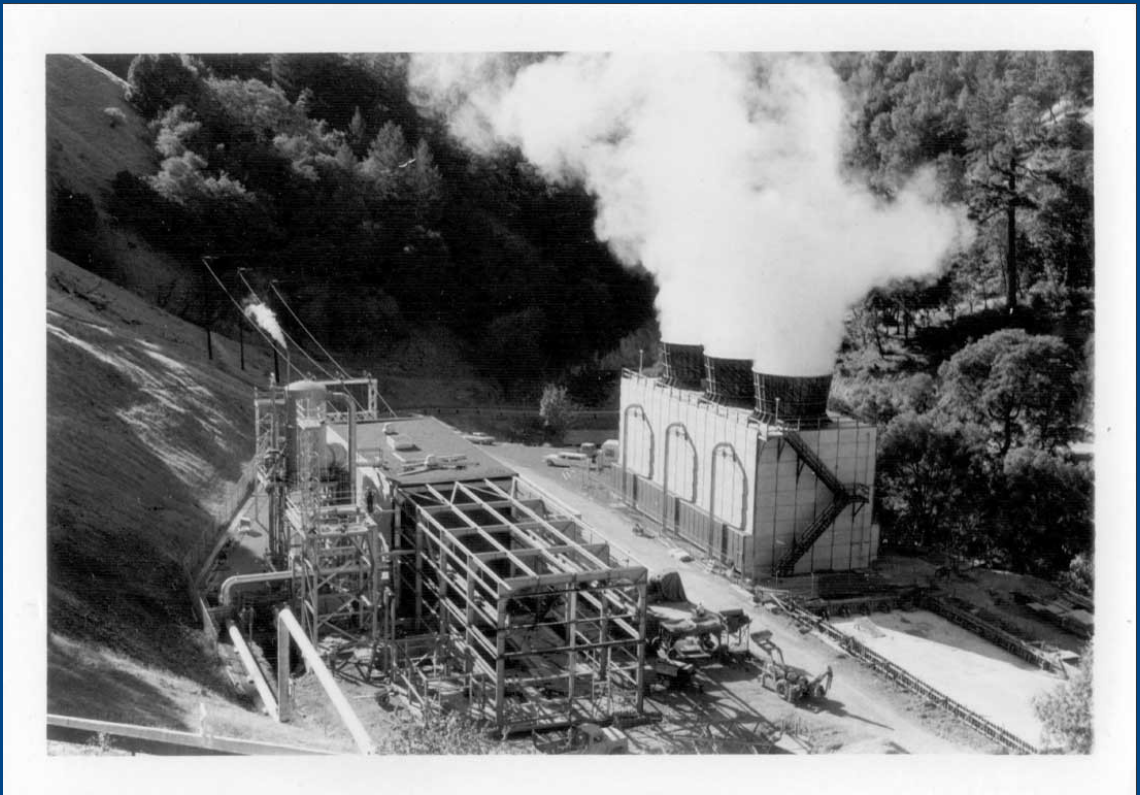
Recent Commission Decisions

Abandoned Plants & Engineering Failures

Humboldt Bay Unit 3

- Humboldt Bay Power Plant Unit No. 3, located near Eureka, CA, was a natural circulation boiling water nuclear reactor.
- Began commercial operation in August, 1963
- Shut down in 1976 for a planned refueling outage.
- On May 21, 1976, the NRC issued an order modifying Unit 3's operating license based on new information about seismic activity and risk.
- Plant was prudently retired early. There was no emergency shut down. There were no engineering mistakes.
- Operator PG&E received **100% net investment value** at **0% ROI**.

PG&E Geysers 15



- Geyers geothermal generating facility started in 1960.
- Steam generation peaked and then fell dramatically, PG&E retired Unit 15 in 1989 for this reason.
- Prudent retirement. No engineering mistakes or imprudent management decisions.
- PG&E Received 100% net asset value of the plant with 0% ROI.

Other Plants Abandoned Due to Regulation or Risk Changes

- **SDG&E Encina 1, Silvergate and LNG facilities**
  - Prudent retirements due to Sunrise Powerlink completion
  - 100% Net investment returned, 0% ROI
- **Hill Street Water Facility**
  - Prudent retirement due to overcapacity and cost for upgrades
  - 100% Net Investment returned, 0% ROI
- **Mohave Generating Station 2005 Closure**
  - Prudent retirement due to Clean Air Act
  - 100% Net Investment returned, 0% ROI

Mohave Generating Station – 1985 Accident

- Mohave was a coal-fired power plant near Laughlin, NV operated primarily by SCE.
- In 1985, a weld in a high-pressure 30 inch diameter steam pipe ruptured, blasting steam over 1000ºF through a six foot by 20 foot breech, damaging the control room and other areas of the plant. Six people were killed and ten other people were seriously injured.
- Commission investigation into this failure found that SCE acted unreasonably and imprudently.
- The Commission left it up to SCE to repair the plant and did not provide any monetary assistance, from ratepayers.
- The plant was not shut down permanently due to this failure, unlike SONGS. (But it was later retired prudently, due to Clean Air Act).

Helms Pumped Storage Project

- Located 50 mi east of Fresno, it uses Helms Creek and the pumped-storage hydroelectric method to generate electricity.
- Although largely successful, the "Lost Canyon Crossing" was initially a failure and resulted in litigation with the subcontractor(s).
- The Commission said “PG&E should not look to ratepayers in the first instance to bear any portion of the Lost Canyon reconstruction costs.”
- We believe this “hands off” approach is appropriate for SONGS as well.

Songs Prop. Settlement is a Ripoff

CASE	PRUDENT?	Net Investment	ROI
Humbolt Bay PP Unit 3	YES Seismic Risks	100%	0%
PG&E Geysers 15	YES Steam Too Low	100%	0%
SDG&E Encina 1, Silvergate	YES No longer needed	100%	0%
Hill Street Water Facility	YES No longer needed	100%	0%
Mohave 2005 Closure	YES Clean Air Act	100%	0%
Mohave 1985 Accident	NO	0%	0%
Helms Lost Canyon Crossing	NO	0%	0%
SONGS Failure (Proposed Settlement)	NO	WE SAY: 29%* PS SAYS: 100%	WE: 0% PS: 2.62+%

* OUR PLAN PROVIDES 29% coverage of total loss but not by all by ratepayers, and we rely on SCE's insurance and MHI Litigation to cover the rest.

SCE was Imprudent

- **Presumption is imprudence;**
  - utility bears burden of proof of prudence in reasonableness reviews
  - SCE is avoiding the investigation and the opportunity to show they were prudent, and this the presumption prevails.
- **Avoiding the License Amendment Process was Imprudent**
  - Cited by NRC for violating the “like for like” regulations (10 CFR 50.59)
  - This was the key SCE management decision that led to the failure
- **SCE knew about the problems long ago**
  - “as far back as 2005-2006, the joint Southern California Edison/Mitsubishi anti-vibration bar design team had identified worrisome problems with Edison’s proposed design for the steam generators MHI was contracted to build.” (Friends of the Earth)
  - SCE wanted to avoid a license amendment process and directed MHI to ignore the concerns.

OUR POSITION...

The Investigation must be completed.

If a settlement is negotiated, we recommend...

COPS recommendation

- **Ratepayers should pay ZERO for RSG project!**
  - RSGs were completely useless! Original Steam Generators (OSGs) would have lasted until 2016 according to 2005 estimates.
  - SCE spent a lot of other money upgrading the plant for the longer life.
  - SGRP was of no value prior to Feb 1, 2012 either.
- **Penalize SCE for the imprudent emergency shutdown.**
  - Costs were incurred due to the emergency shutdown that would not have happened had the original steam generators been used and the plant shut down without any emergency.
- **Penalize to SCE for causing loss of the entire plant.**
  - SCE should not be rewarded a penny for their imprudent practices that resulted in loss of the entire plant.

Base Plant

- **Remaining Value of the Base Plant = NWO only**
  - "Nuclear Waste Operation" is the only valuable portion of the plant.
  - Includes Fuel Pools and related cooling, dry cask storage facility, Security, and related functions.
  - About 7.5% of the net asset value of the plant.
- **Transfer the NWO to the Decommissioning Activity**
  - Essentially "sell" this portion of the plant that is still useful to the decommissioning activity, taking funds from the Decommissioning Trusts. Our estimate is about $420 million.
- **No return of net asset value**
- **0% ROI from ratepayers.**

CWIP, M&S, Nuclear Fuel, O&M

- In general, we separate CWIP and other funds into NWO-related and non-NWO-related.
- NWO-CWIP - credited to the cost basis of the NWO so it can be “sold” to the Decommissioning operation.
- All other CWIP and other funds - aggressively salvaged by SCE and retain 100% of the proceeds. All other amounts are written off with the net asset value of the plant.
- Unlike Proposed Settlement, our plan incentivizes the utility to effectively salvage these assets.
- The 5% return in the PS is too small. It means no salvaging will occur, or will just give assets away to friends and neighbors.

Replacement Power

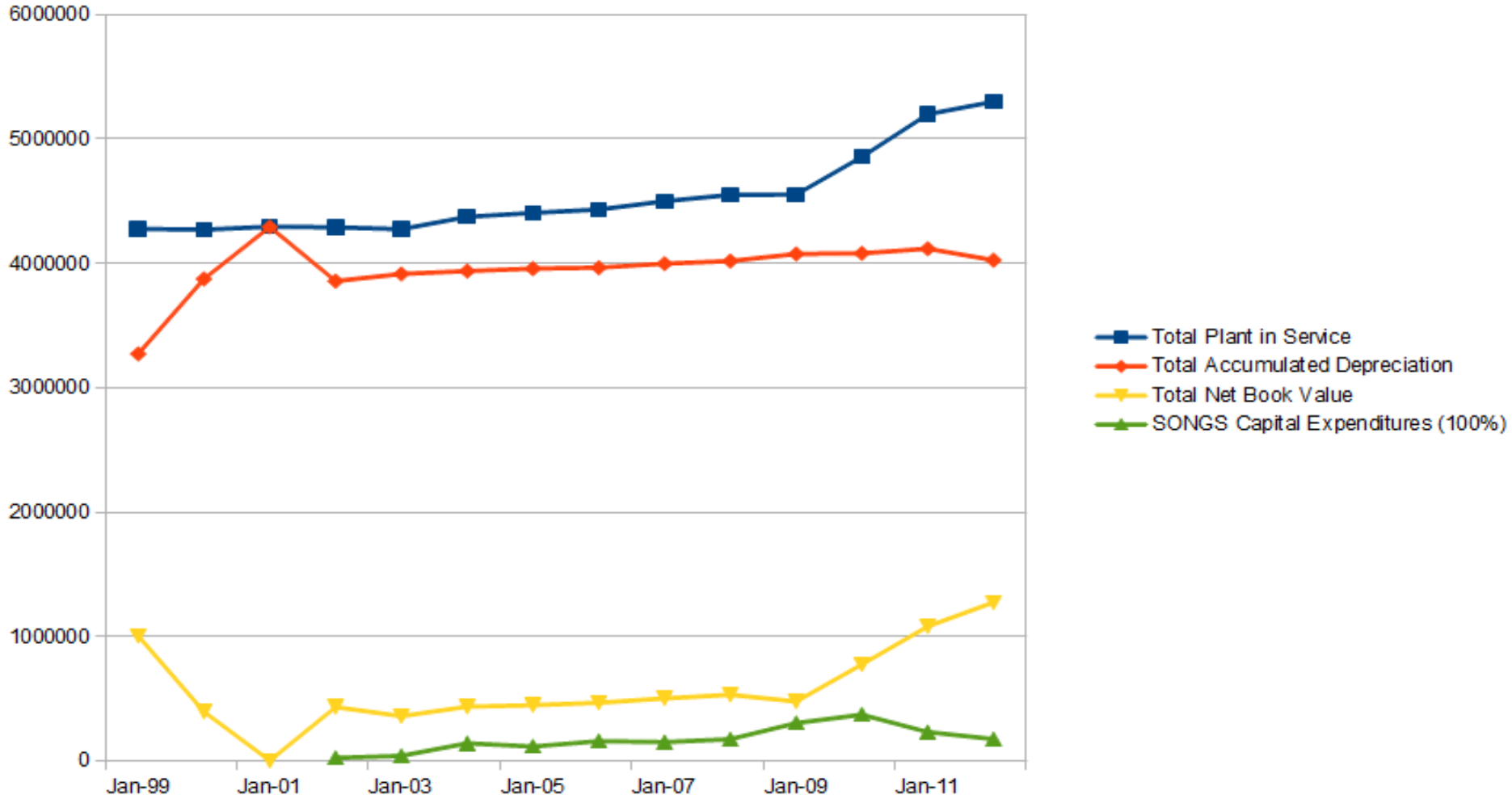
- We agree on this item.
- Replacement power should be paid at market rates
- No “foregone sales” compensated.
- This bookkeeping entry would only be useful if the plant were restarted, but now the question is moot.
- We can note that the entire replacement power proceeding was a waste of time and a distraction from the main issues in Phase 3.
- This sort of inefficiency must stop!

Third Party Recoveries

- These are SCE's internal business -- ratepayers should not be involved in this litigation nor in any way benefit.
- We have no reason to believe that SCE was not imprudent and so to take their side in this matter is ridiculous, as it implicitly sends the signal that they were prudent. There is nothing in the record to support that finding.
- Utilities suggest ratepayers should cover utility losses up front, and then ratepayers share in the proceeds of the insurance and MHI litigation. This is bad policy!
- Our suggestion: **0% involvement by ratepayers**, utilities recover all they can from their insurance and subcontractors.
- Follows Commission precedent in other engineering failures such as HELMS and MOHAVE.

Original Investors Already Paid

NOTE THAT “Total Net Book Value” is ZERO in Jan 2001 – the original investors were already fully compensated. Subsequent investments were gambles that the plant would last another 40 years.



SCE comes out even (or ahead) "on their own" (our proposal)

Item Description	Amount ($Millions)
April 3, 2014, Proposed Settlement Ratepayer Bailout	3299
CDSO Suggested Ratepayer Cost (Replacement power and CWIP applied to NWO)	564
CDSO Proposed Decom. Fund Purchase of NWO including NWO-related CWIP	419
=Net Loss (pre salvaging and pre 3rd party recoveries)	2316
NEIL insurance maximum loss coverage	980
Salvaging Operation of O&M, Canceled CWIP, Fuel (CDSO Estimate)	300
MHI Suit Proceeds (CDSO Estimate, 25% of demand)	1000
=Net Loss after Salvaging and 3rd party recoveries	35

Settlements Compared

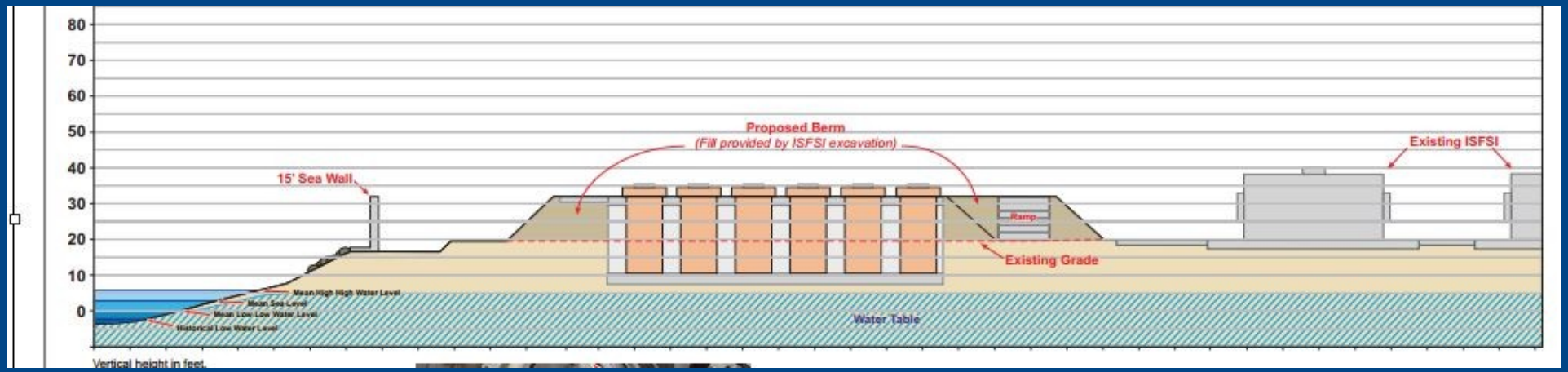
	PS-SCE	PS-SDGE	PS-TOTAL	CDSO POSITION Ratepayer Pays	CDSO POSITION Decom. Fund pays
1. RSG	0	0	0	-45.39	0
2. Base Plant	1115	244.5	1359.5	0	350
3. CWIP				0	69
4. M&S				0	0
5. Nuclear Fuel	394	88.3	482.3	0	0
6. Replacement Power	389	128.2	517.2	517.2	0
7&8. O&M	673	266.6	939.6	92	0
9. 3rd Parties	0	0	0	0	0
TOTAL			3298.6	563.8	419

TURN and other settling parties continue to claim that $3.3 billion is a savings of $1.4 billion, but that is a falsehood, since the $1.4 billion is the reduction from the original absurd SCE request of $4.7 billion.
UNDER THE SAME CONCEPT, **our proposal saves ratepayers $4.2 billion!**

$3.3 Billion Bailout is a ripoff

- $3.3 Billion bailout is a rip-off.
  - Providing a RETURN ON INVESTMENT has never been the provided even in prudent retirements.
- OUR PROPOSAL **Saves Ratepayers $4.2 billion**
- Failed Projects Must Be Disincentivized
  - It is bad policy to allow investors to recover their principle plus a return on an imprudent abandonment.
  - This case is unprecedented. Investors should not get the principle either.
- SCE may come out about even anyway
  - Losses of $35M or less!
- Original Investors have already recovered the original investment in SONGS
  - Most of the net asset value is either a myth or recent investments predicting long extended life of the plant.

Nuclear Waste “Dump”



Waste Dump Issues

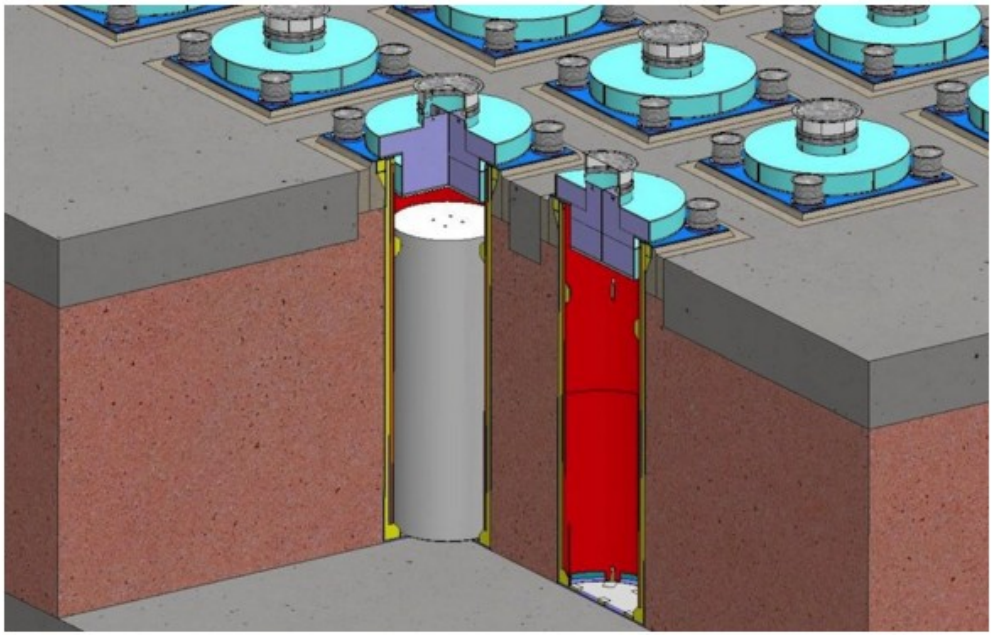
- Uses relatively thin 5/8” stainless steel canisters housed in concrete overpack.
- Horizontal NUHOMS type previously used. Can add housings one at a time.
- Holtec UMAX system is built all at once.
- Location is probably the worst that could be found for a permanent waste facility:
  - Salt air, tsunami inundation area, earthquake zone, terrorist target as it is near freeway, 8.4 million people.

EXISTING NUHOMS HORIZONTAL ABOVE GROUND SYSTEM -- UNITS CAN BE BUILT AS NEEDED.

PROPOSED HOLTEC UMAX SYSTEM IS VERTICAL AND BELOW GROUND

HI-STORM UMAX

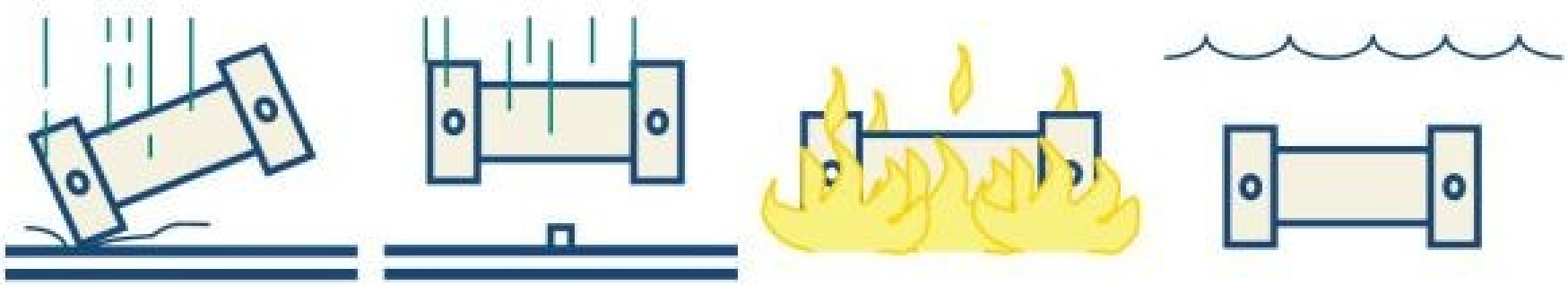
Holtec International Storage Module Underground MAXimum Capacity



HI-STORM UMAX (Holtec International Storage Module Underground MAXimum Capacity) is an underground Vertical Ventilated Module (VVM) dry spent fuel storage system engineered to be fully compatible with all presently certified multi-purpose canisters (MPCs) under USNRC CoC 72-1014 (HI-STORM 100 dry cask storage system) and CoC 72-1032 (HI-STORM FW dry cask storage system).

Limited Transportation Requirements
No full scale testing

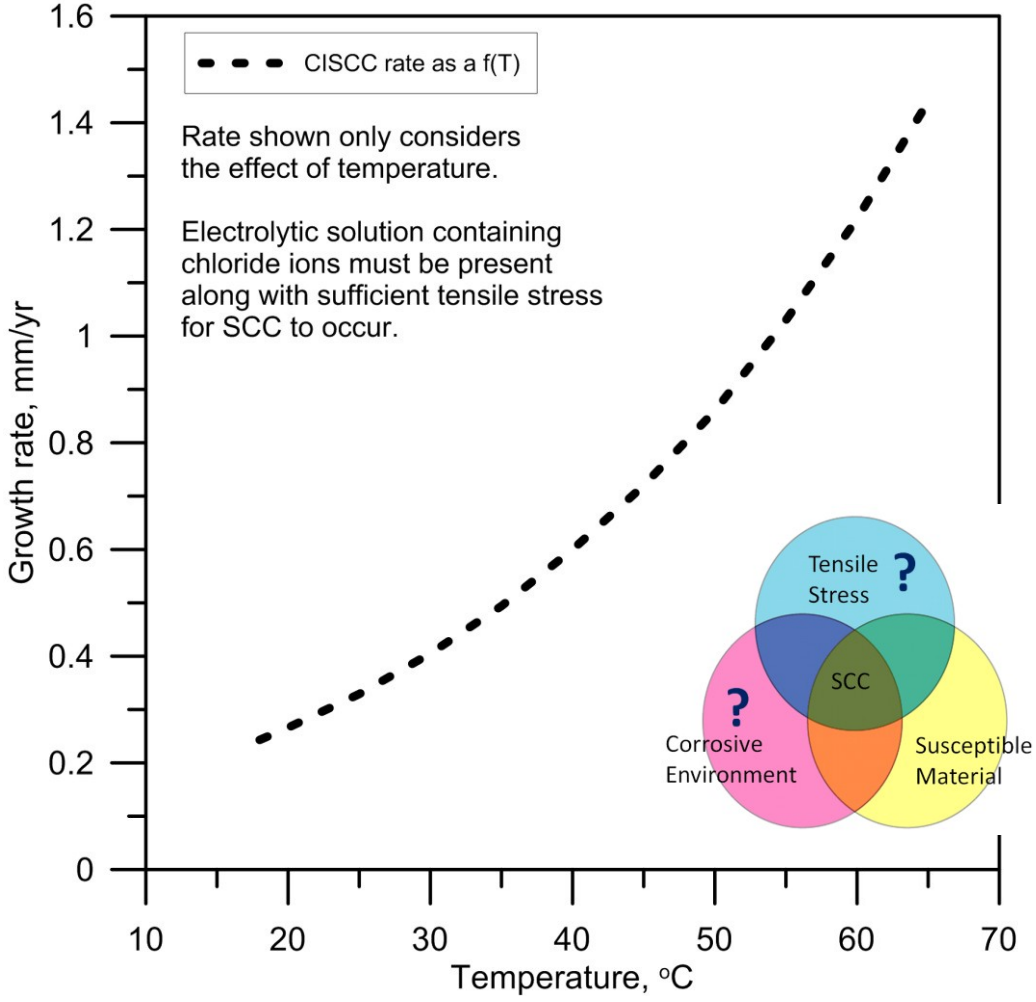
Ensuring Safe Spent Fuel Shipping Containers



The impact (free drop and puncture), fire, and water immersion tests are considered in sequence to determine their cumulative effects on a given package.

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment
AUGUST 2014

CISCC Growth Rate vs Temperature



- Baseline rate of 0.29 mm/yr at 23°C from Kosaki (2008)
- Activation energy of 31 kJ/mol from Hayashibara et al. (2008)
- DOES NOT show crack growth rates of actual components
  - Composition and deliquescence behavior of atmospheric deposits
  - Site specific environmental data
  - Residual stress profile
- Plant operating experience*
  - Turkey Point: 0.11 mm/yr
  - San Onofre: 0.25 mm/yr
  - St. Lucie: 0.39 mm/yr

*Assuming crack initiation at the start of plant operation and continuous growth

Waste: Big Picture

- Yucca Mtn may still be used but differently than earlier envisioned.
- Canisters optimized for temporary use at reactor sites.
- Canisters too big for perm. disposal.
- Canisters too heavy for conventional rail.
- Current trend is to just leave all the waste at each of the plants, with 100 year time frames.

Where to put the waste?

- Three better options exist and have not been adequately investigated:
  - Palo Verde Plant in AZ.
  - In the Mojave Desert (Fishel Proposal)
  - In Camp Pendleton but further east, off the coast away from the freeway.
- These are still considered temporary with the waste moved to a geologic disposal site later.

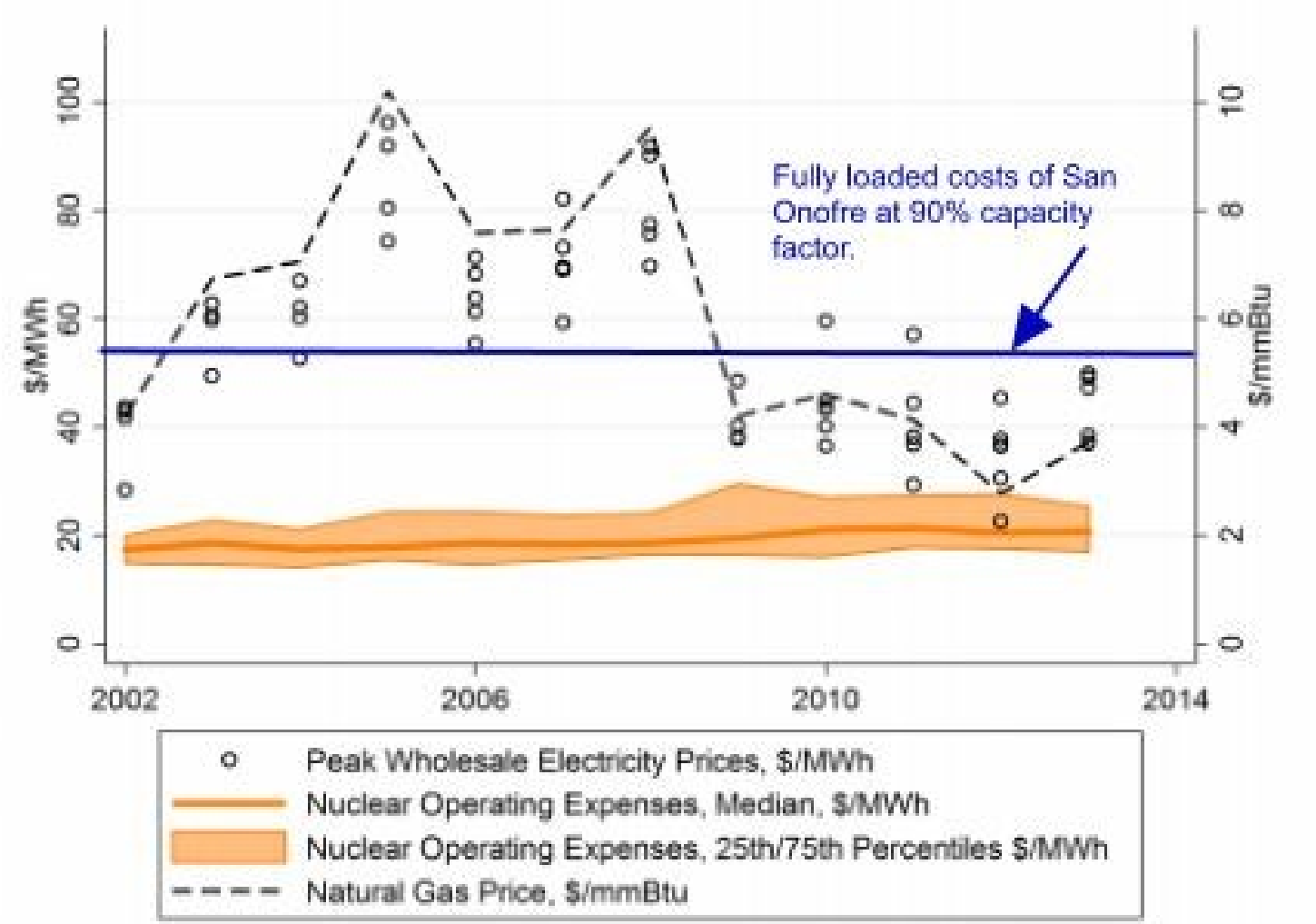
Current Status

- Filed request for rehearing the settlement to CPUC. Supposed to be ruled on within 120 days; now nearly a year old.
- Federal lawsuit regarding settlement -- has been appealed.
- State lawsuit on approval of nuclear waste facility at San Onofre without any studies for other locations.

Nuclear is our largest blunder

- Nuclear power is expensive.
  - Power from San Onofre costs 2x market rates even during 2012, when cost should have been highest.
- Waste will cost even more.
  - No one is really factoring in the cost of dealing with waste for a million years.
- Any technology that generates waste faster than you can recycle it is irresponsible.
- Large accidents happen regularly.

Figure 1: Declining Profitability of U.S. Nuclear Power Plants



Note: This figure plots wholesale peak electricity prices in real $/MWh at various ICE hubs around the country. The dashed black line shows Henry Hub natural gas prices (in $/mmBtu), the driver of wholesale peak electricity prices. The orange lines show the mean, 25th percentile, and 75th percentile operating expenses at U.S. nuclear plants, in real $/MWh. Electricity and natural gas prices are from EIA; operating expenses are from EUCG, Inc.