

A THREE MILE ISLAND ALERT SAFETY BULLETIN

SPECIAL POINTS OF INTEREST:

- A new metal alloy and an aggressive design caused a defect in the new steam generators allowing some tubes to bang together and wear thin.
- Unexpected thermal expansion cited as the root cause.
- Data indicates a reactor transient could cause sufficient thermal expansion of the tubes to cause them to self-destruct by banging together.
- There has been no testing of the fluttering steam tubes under these higher temperatures as required by Nuclear Regulatory Commission (NRC) safety regulations.
- Three Mile Island Alert requested that the NRC address this problem five years ago but the problem has been ignored.
- Terminology — page 7
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“Defects within Three Mile Island’s new Steam Generators could be Very Risky.”

Scott D. Portzline

In early 2010, Exelon Corporation completed installation of new steam generators as part of a \$300 million dollar upgrade to extend the life of Unit #1 at the Three Mile Island Nuclear Generating Station. The steam tubes inside the original steam generators had worn thin and needed to be replaced.



One of two new steam generators crossing the bridge to Three Mile Island .

After only 22 months of operation, premature wear was discovered inside the **new** steam generators. Some of the steam tubes had been vibrating and banging against each other. A few of them had worn through the tube walls more than halfway of the acceptable limit of 40 percent.



“Damage mechanism was not expected based on operational history of similar steam generators.”

Exelon’s Summary of Tube-to-Tube wear

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Exelon is in violation of its reactor license

TMI Alert files a Petition for NRC Enforcement Action concerning TMI’s the new steam generators.

See page 5

Potential for a Loss of Coolant Accident at TMI

If the steam generator tubes rupture, the ability to remove heat from the reactor becomes limited. However there is one scenario where a cascading decapitation of steam tubes can cause a severe loss of coolant accident. It is known as a guillotine rupture accident. If a high pressure jet rushes from a failed tube and

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The Root Cause according to Areva

According to Areva, the French manufacturer of the new steam generators, four problems cause the tube-to-tube premature wear. Firstly, the safety margin for tube buckling was not conservative. Also, the shell of the steam generators did not expand as much as designers believed would occur. This resulted in the tubes compressing from end-to-end with greater rates than expected causing bowing and tube-to-tube wear. On top of that, the tubes weren't mounted in the shell with the amount of tension as called for in the design. This exacerbates the problem by allowing the tubes to bow even further. The flow of water between the tubes causes fluttering of the tubes sufficient to produce tube-to-tube wear.

TMI Alert says the root cause was actually one of an over-aggressive design instead of employing the "safety first" mantra.

See Big Problems at Areva on page 4

AREVA Root Cause Findings

Root Cause determined to be a combination of 4 Contributing Causes:

- 1. Margin to buckling was non conservative in design. → Reduced margin to bowing
- 2. EOTSG shell cooler than design value. → Higher compressive loads
- 3. Tube preload less tensile than value in design analysis. → Higher compressive loads
- 4. Lateral loads/accelerations are sufficient to cause tube-to-tube wear. → Excitation of compressed tubes causes wear

A slide from Exelon's "Tube-to-tube investigation summary."

Unexpected Thermal Expansion Rates

Exelon is in violation of its Reactor License

Continued from page 1

In April of 2013, the root caused was determined to be a greater than expected thermal expansion rate of the steam tubes. The high temperatures of the pressurized water pumped through and around these tubes causes the tubes to expand and bow sideways.

Areva manufactured the new steam generators using a new “metal alloy 690” which is causing problems at other reactors including Arkansas Nuclear One.

Whenever new components are introduced into a system involving safety, the NRC requires analysis of any specific technical changes, such as these “new metal alloys” in order to meet valid licensed parameters.

The NRC is satisfied that the steam generator tube wear problem is understood and under control for normal operating conditions. However, there is no analysis or actual testing under higher pressures and temperatures.

This means that Exelon is in violation of its license agreement.

END

Steam Generator Assessment Guidelines

“During a transient condition the thermal expansion can be significant.”

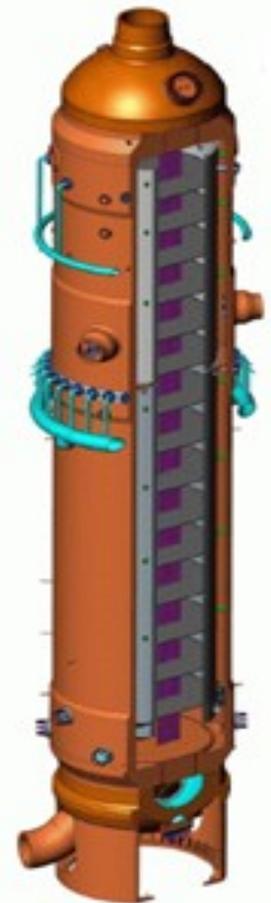
“The largest tube axial tensile loads occur during postulated accident conditions.”

“...the resulting accident tube loads are plant specific.”

“Analyses must be performed on tube loads for the accident conditions based on direct input from the plant system thermal hydraulic analyses.”

Electric Power Research Institute

Inside the new steam generators, the tubes are packed together tighter (a 1/4 inch gap) than in previous designs in an attempt to create a greater quantity of steam. Under hot conditions, the gap between tubes is only 1/8 of an inch.



Exelon and Areva have not performed a scientific analysis of the steam tube fluttering under transient conditions (e.g. very high temperatures) which actually occurred during the 1979 TMI accident.



Arnie Gundersen of
Fairewinds Energy Education

Nuclear engineers, and court accepted experts witnesses Arnie Gundersen and David Lochbaum agree that an analysis must be done.



David Lochbaum formerly of
The Union of Concerned Scientists

Big Problems at Areva - Falsification Scandal

Areva, manufacturer of many big-ticket nuclear components used in the US, including TMI's steam generators, is having a big problem with safety certification. Areva's Director General admitted that 400 documents assessing whether parts of nuclear plants met required standards may have been "falsified" over the last five decades.

France's independent Nuclear Safety Authority said it recently detected a "very serious anomaly" in a new re-

actor vessel it had manufactured. Two more of those reactors are to be sold to Britain. Therefore, France's nuclear regulatory told its British counterpart that components made at Areva's Le Creusot forge may contain "inconsistencies, modifications or omissions."

Areva's Creusot Forge specializes in the supply of large forgings and castings for the nuclear

industry. It is one of a few facilities that can produce the heavy nuclear-grade forgings required for large components such as steam generators, reactor pressure vessels and primary pumps.

France had to close two of its reactors due to the scandal since safety was not assured.

The outages have led to higher power prices and **cost the electric utility \$1 million Euros per day.**

Steam Generator Defects Permanently Close US Reactor

NRC says tubes were not properly tested by the manufacturer prior to installation.

Hundreds of jobs were lost.

The steam generators manufactured for the San Onofre nuclear plant in California by the Mitsubishi Corp. proved to be defective. Now, Southern California Edison is seeking \$7.6 billion dollars from the Japanese manufacturer. Mitsubishi used the wrong computer software to calculate coolant hydrodynamics through the steam tubes. This error allowed for vibrations and behavior that caused tubes to rub together thereby producing premature wear.

The California Public Utilities Commission ordered customers of Southern California Edison to pay \$3.3 billion dollars of the costs. Customers will keep paying millions of dollars a month for a power plant that has not produced any electricity since 2012.



San Onofre—too costly to repair after faulty replacement steam generators were installed.

Customers to pay \$3.3 billion dollars for the defective design but get no electricity.

Faulting software errors by Mitsubishi Heavy Industries, federal regulators have determined the steam generator design flaws that ultimately shuttered the San Onofre nuclear plant, likely amounted to violations of its license.

★ TMI Alert had asked the NRC to resolve this safety issue five years ago. Due to the NRC's inaction, TMI Alert is now filing a docketed petition requesting the NRC to take enforcement action.

TMI Alert files petition for NRC Enforcement Action

On March 11, 2019, Three Mile Island Alert's Scott Portzline filed legal documents with the Nuclear Regulatory Commission to take an enforcement action at Three Mile Island. The request is to resolve the question of a potentially dangerous and risky condition in the new steam generators which operational data suggest could lead to another severe accident.

Installation of the steam generators was completed in early 2010 as part of a \$300 million dollar upgrade to extend the life of Unit #1.

However unexpected flaws with the steam tubes were discovered during a refueling outage 22 months after their installation. Some of the tubes were vibrating and banging into each other causing premature wear through the thin tube walls. The high temperatures of the pressurized water pumped through and around these tubes cause the tubes to expand and bow sideways.

Determinately, the flaw was caused by using a new metal alloy which expanded under thermal loads at a greater rate than projected by the design engineers. The aggressive design also packs steam tubes closer together - ¼ inch clearance - than the previous design.

Exelon has never tested the new steam generators using the new metal alloy for how

the fluttering tubes behave under transient conditions; especially concerning is higher than normal temperatures. This represents a license violation.

Three Mile Island Alert has requested that the NRC resolve this safety issue five years ago. Due to the NRC's inaction, TMI Alert is now filing a docketed petition asking the NRC to take enforcement action.

Portzline, of TMI Alert said, "I met with TMI's new NRC Resident Inspector recently and he was unaware of the steam generator concerns. I am baffled as to how an important safety issue like this, is not communicated to the newly appointed Resident Inspector. He was receptive to my assertions, however we've decided not to wait any longer."

"We are seeking action through the official NRC's docketed safety channel. Some of the NRC staff from

Licensing agreed with me five years ago and said they would look into it."

"I never heard back. So, I suspect they didn't want to open that can of tightly packed worms!"



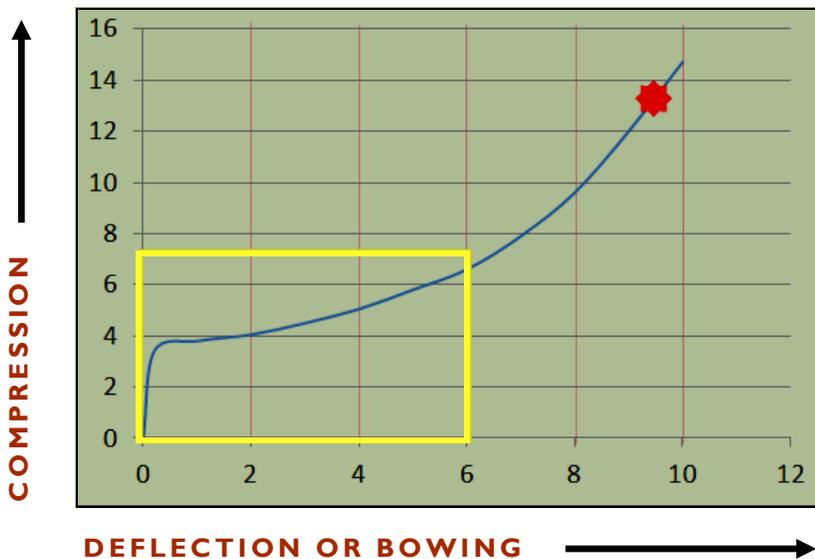
Scott D. Portzline



We know that as the temperature of the water in the steam generators increase, the more the steam tubes experience end-to-end compression. Using data collected from operating the new steam generators, the more the tubes compressed, the more lateral deflection or bowing occurred.

If we assume that this rate of bowing continues as the temperature increases, then by using the measured temperature inside the steam generators during the 1979 accident which was nearly double, (the actual temperature might have been higher due to the ~ 900°F degree limit of instrumentation) we can extend the plot to indicate that the bowing would become so great that the vibrating tubes would self-destruct by banging into each other.

STEAM TUBE BEHAVIOR



This graph plots the relationship of tube compression to deflection. The yellow boxed area is the plotted graph from Exelon's steam tube-to-tube wear investigation of 2013.

The graph has been extended to extrapolate how great the lateral deflection or bowing would be if temperatures rose to 1100°F degrees as marked by the red star. Normal operating temperatures are ~ 550°F.

Since the actual behavior is unknown, testing must be performed.

Most of the tube-to-tube wear involved two adjacent tubes contacting each other and wearing evenly, but there were a few instances of three tubes coming into contact and wearing.
 NRC November 2011

Scott D. Portzline
 TMI Alert

Terminology

axial tensile loads — a force that tends to cause a body to become longer.

compression loads — when the shell of the steam generator did not expand at the same rate as the internal steam tubes as designers intended, the tubes in effect are pushing against the top and bottom of their mounts. This additional mechanical load causes the tubes to bow.

EOSTG — the steam generator, stands for Enhanced Once Through Steam Generator.

hydraulic analyses — the study of liquids through pipes and channels.

hydrodynamics — the branch of science concerned with forces acting on or exerted by liquids.

preload tensile — the steam tubes are installed during the manufacturing process by pulling on each end of the tube to make it very tight or stiff. The tubes are in effect pulling on the top and bottom of their mounts after installation. The intention is to alleviate the potential for bowing caused by thermal expansion while in operation. (see compression loads)

reactor transient — any change in the reactor coolant system temperature, pressure, or both, attributed to a change in the reactor's power output.

steam generators — an apparatus or unit for the production of steam. In a nuclear reactor, these are the primary means to remove heat from the reactor vessel.

tube buckling — the unwanted bowing or lateral deflection of the steam tubes.

ABOUT SCOTT D. PORTZLINE

For 33 years Scott D. Portzline has researched the issue of sabotage and terrorism of nuclear power plants. By studying more than 40,000 pages of documents on the Three Mile Island core melt from the National Archives, the NRC's public document rooms and various national nuclear laboratories, Portzline became familiar with safety issues at Pressurized Water Reactors like those used at TMI to generate electricity.

It is because of his familiarity with real world incidents that he identified the problem presented at TMI if higher than normal temperatures occur in the new steam generators and was able to recognize the safety concern that others had overlooked. In his initial discussion with the NRC, the staff was unaware of how high the temperatures had risen inside the steam generators during the 1979 emergency.

Portzline's research has been recognized by the US Department of Energy, the Department of Homeland Security and the various military branches. He has testified to the NRC, the Advisory Committee on Reactor Safeguards, the US Senate, the Pennsylvania Legislature, the Three Mile Island Citizen's Advisory Panel and other governmental bodies. In 2017, Portzline received two citations from the State of Pennsylvania. Scott also researches the problem of lost and stolen nuclear materials in the US.

Loss of Coolant Accident

Continued from page 1

Each steam tube wall is 2/3^{ds} the thickness of a dime.

cuts through an adjacent tube, the process can repeat itself in a rapidly cascading failure. A report on experiments by the Rockwell International states "[damage] occurred on the surrounding tubes due to the high temperature reaction." A large break loss of coolant accident can result.

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TMI Alert's Recommendations to the NRC

- Exelon (TMI Unit#1 Licensee) must be ordered to perform a proper safety analysis of its replacement steam generators in order to meet it licensing requirements.
- Analyses must be preformed using temperatures which are possible within the steam generators during accident conditions and by using direct input from the plant systems' thermal hydraulic behavior.
- Static tests cannot shed light on the fluttering problems.
- Random turbulence, flutter, harmonic disturbances and chaos can only be understood by actual physical testing of each specific system partly due to the pulse created by the reactor pumps' impellers.
- Computer simulations are insufficient and are not a substitute for the understanding of good physics or for good scenario creation.

Containment Bypass Accident

The rupturing of the steam tubes could result in a nightmare scenario designated by the industry as a "containment bypass accident." In a containment bypass accident, a large amount of radiation is released from the turbine building without any time for an evacuation of the public.

About Three Mile Island Alert

Three Mile Island Alert is a non-profit citizens' organization dedicated to the promotion of safe-energy alternatives to nuclear power and is especially critical of the Three Mile Island nuclear plant. Formed in 1977 (two years before the accident) TMIA is the largest and oldest nuclear watchdog group in central Pennsylvania.

We have provided testimony to the US Senate, the US Nuclear Regulatory Commission, the Pennsylvania House of Representatives, the Pennsylvania Public Utility Commission and have received certificates of commendation from several governmental bodies.