Post-Fukushima WANO: The Safety Culture Challenge

World Nuclear University Summer Institute
Oxford

George Felgate
WANO Managing Director
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WANO

WANO

- Formed in 1989 (following Chernobyl)
- Not for profit – every commercial operator is a member
- London office and four Regional Centres
  - Paris
  - Atlanta
  - Moscow
  - Tokyo
- Four major programs
  - Peer reviews
  - Technical support
  - Operating experience
  - Professional and technical development

W A N O

WANO's Mission

To maximise the safety and reliability of nuclear power plants worldwide by working together to assess, benchmark and improve performance through mutual support, exchange of information and emulation of best practices

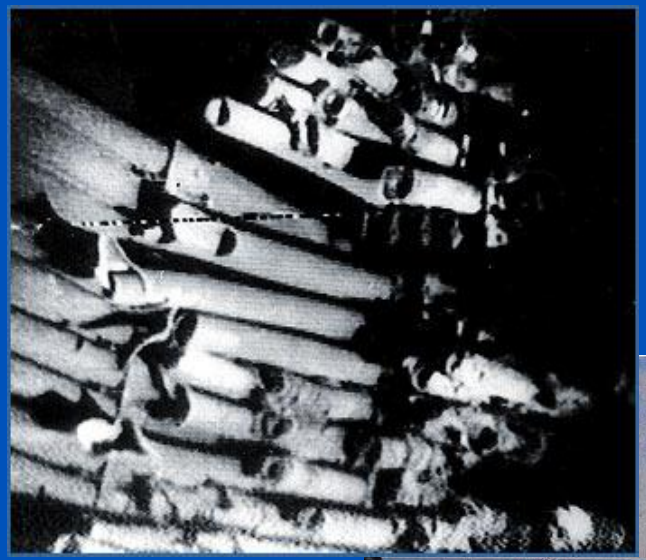
Unique Characteristics of Nuclear Energy

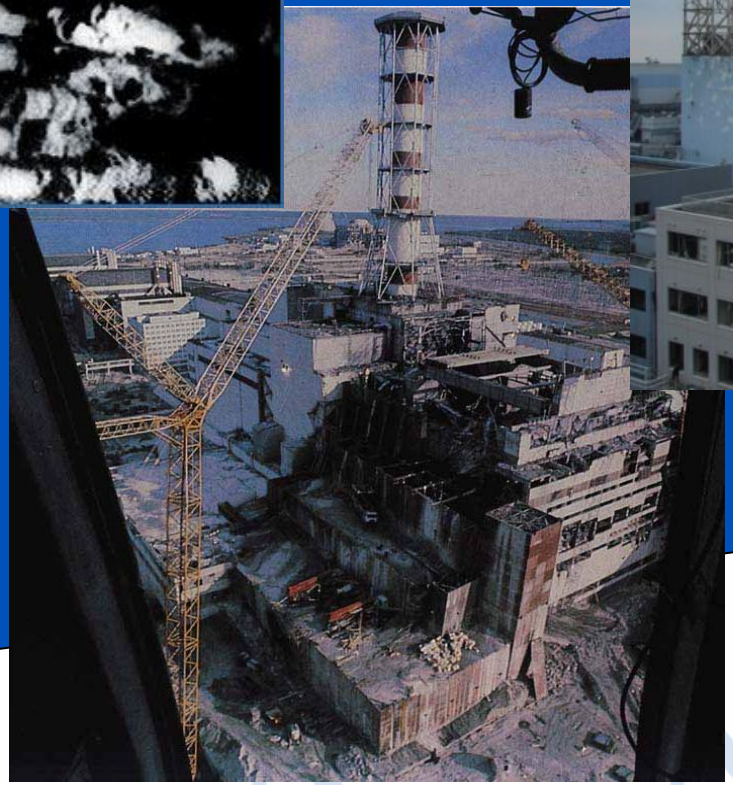
- Tremendous stored energy
- Decay heat is generated long after a reactor is shutdown
- Radioactivity and radioactive waste are byproducts

- These translate to our three nuclear safety functions:

- Controlling reactivity
- Core cooling
- Containment

Three Major Core-Damaging Accidents in 32 Years





Compare

- Three Mile Island
  - PWR
  - New plant
  - Removal of decay heat
  - Core destruction
  - Nearly no release to the environment
  - No fatalities
  - Event initiator: Human performance
  - Root cause: Training
- Chernobyl
  - RBMK
  - New plant
  - Management of stored energy
  - Reactor destruction
  - Large release to the environment
  - Many fatalities
  - Event initiator: Human performance
  - Root cause: Safety culture
- Fukushima
  - BWR
  - Old plant
  - Removal of decay heat
  - Multiple reactor destruction / fuel pool damage
  - Large release to the environment
  - No fatalities
  - Event initiator: External event
  - Root cause: ??

Questions to Consider

- Based on everything you know, what is the “root cause” of the Fukushima event?

- Did WANO fail?

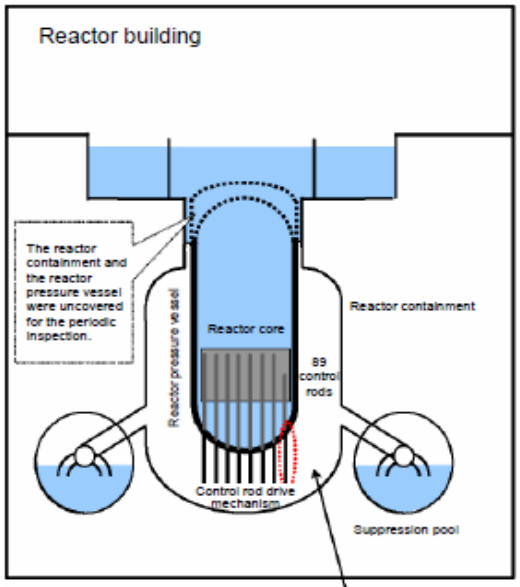
W A N O

General Conclusions

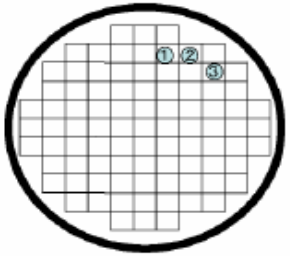
- PSA has its limitations
- Plant age and plant design are not the issues at Fukushima
- Two of three major industry events have been the result of failure to remove decay heat
- WANO, and to some extent the industry, have been focused on prevention, and to a lesser degree on mitigation

- We must learn from Fukushima but we must not forget the lessons from TMI and Chernobyl

Shika NPP



Locations of the control rods



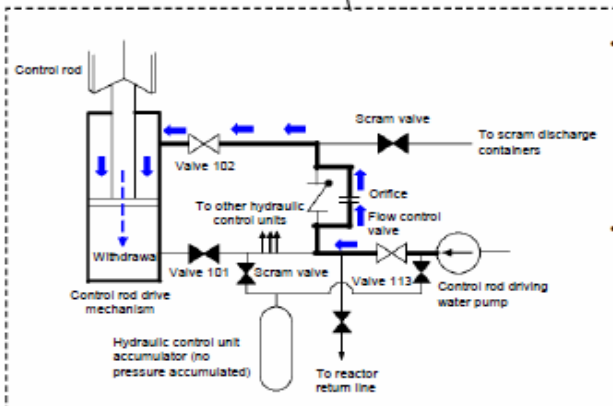
[Withdrawn control rods]

(1) Control rod [26-39]
Position 16 (withdrawn by about 1/3)

(2) Control rod [30-39]
Position 20 (withdrawn by about 2/5)

(3) Control rod [34-35]
Position 8 (withdrawn by about 1/6)

All the other control rods were completely inserted.



- Because valve 101 was closed with the flow control valve opened and the valve to the reactor return line closed, the pressure represented by arrows was brought about, and the control rods were withdrawn unexpectedly.
- Though the reactor went critical and a reactor automatic shutdown signal was generated, they were not with urgency reinserted because valve 101 was closed, and no pressure was accumulated in the hydraulic control unit accumulator.

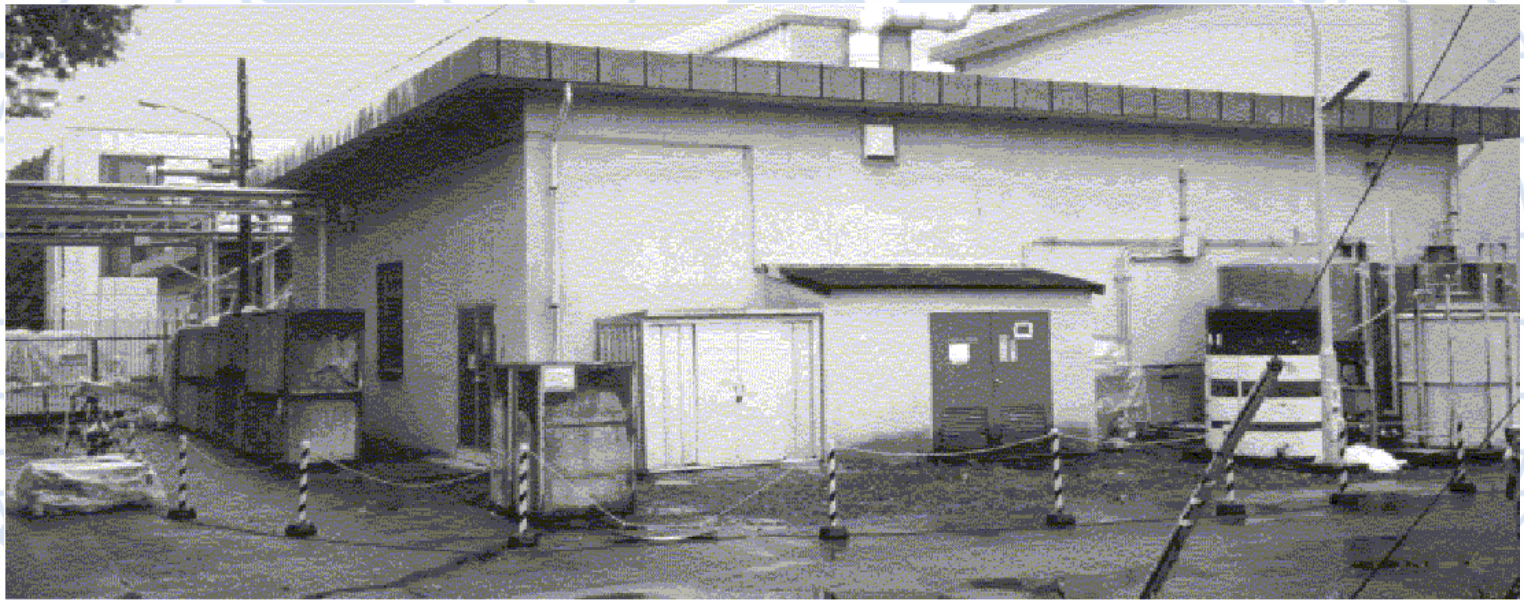
Davis Besse

Paks Chemical Cleaning Vessel

The Cleaning vessel located in the pit

Tokai Uranium Processing Plant

- Fuel (uranium oxide powder) purification was being carried out



Fuel Conversion Building

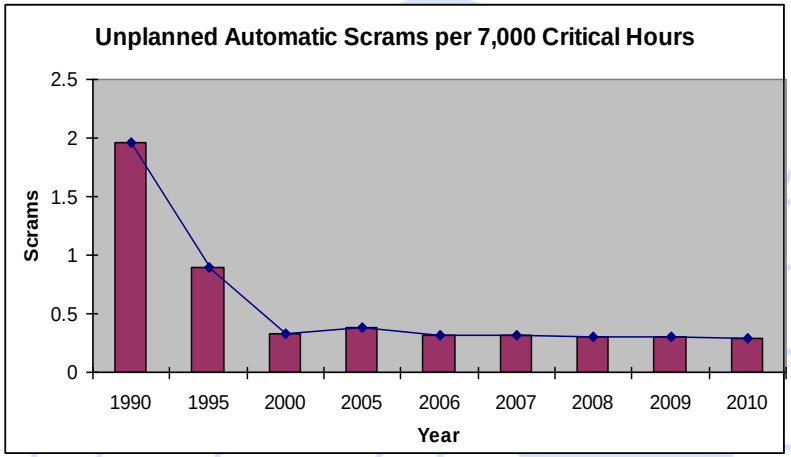
Industry Performance

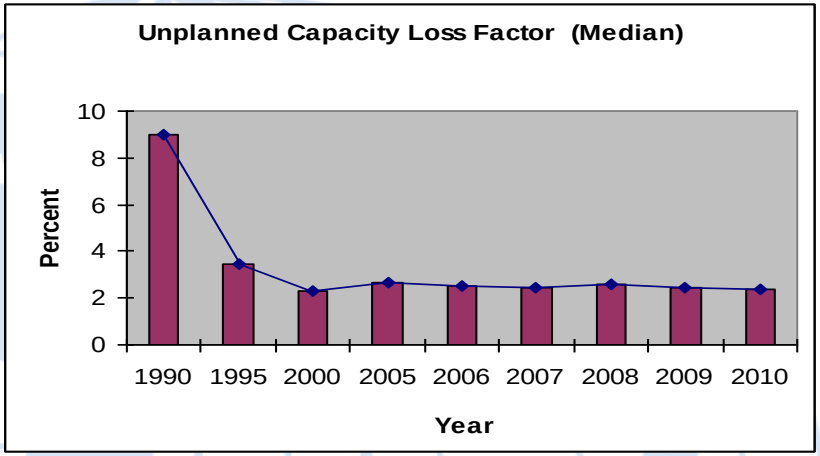
- Separate from the important lessons to be learned from Fukushima-Daiichi, we must remain aware of events occurring in the other 437 nuclear units around the world. Serious events continue to occur
  - SER 2009-1, ‘Failure of Control Rods to Insert on Demand’
  - SER 2009-2, ‘Unrecognised Reactor Pressure Vessel Head Flange Leak’
  - SER 2009-3, ‘Human Error during Scram Response Results in Inadvertent Safety Injection’

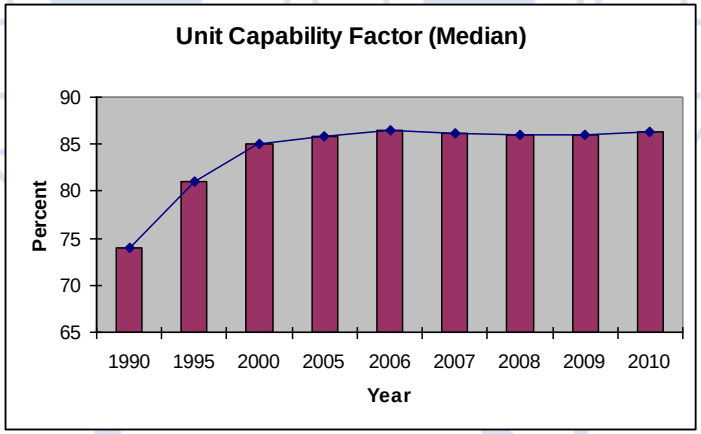
Industry Performance (continued)

- Performance indicators have increased over the last 20 years
  - However, performance has plateaued over the last 5 years
  - Gap between top quartile and bottom quartile has not closed

WANO Performance Indicators







WANO Performance

- A peer review has been completed at every nuclear station in the world
  - WANO goal is a peer review every six years
  - Follow-up reviews are performed between peer reviews in most Regions
  - Twenty-one stations do not meet the peer review goal (up to 10-13 years between reviews)
  - Repeat areas for improvement are a concern
- Reporting of operating experience has been increasing steadily
  - WANO goal is one event report per unit per year
  - There are about 30 silent units (do not report)
  - Use of operating experience is a concern [62% of the most important events in 2010 were directly related to existing operating experience]

WANO Post-Fukushima Commission

The WANO Governing Board, during a meeting on 30 March, chartered a Commission in response to the Fukushima Daiichi accident.

- Purpose: To recommend changes to WANO's programs and organization to implement lessons arising from the accident
- Every WANO Region is represented; chaired by Tom Mitchell, CEO of OPG
- The Commission will complete its work and the changes will be presented to WANO members at the BGM in October

Commission Members

- Tom Mitchell—Ontario Power Generation (chair)
- Allan Kupcis—Former WANO President
- John Herron—Entergy Nuclear
- Vladimir Asmolov—Rosenergoatom
- Yuriy Nedashkovsky—NNEGC
- Vladimir Hlavinka—CEZ
- Dominique Miniere—EDF
- GAO Ligang—CGNPC
- Phillipe van Troeye—Electrabel
- Jörge Michels—EnBW
- H K Park—KHNP
- Hideki Toyomatsu—Kansai Electric
- Takeo Fujie—JANTI
- William Coley—Former British Energy CEO

Likely Changes to WANO

- Clearly defined role for WANO in an emergency
- Emergency preparedness as a core peer review area (and severe accident management)
- Review of on-site fuel storage as part of WANO peer reviews
- Some role for WANO in examining design-related issues
- Greater member accountability to member obligations

Nuclear Safety Concerns

- Post-Fukushima lessons
- Fukushima distraction
- Sixty-six plants under construction (sixty-six plants starting up)
- Transfer of knowledge to the next generation

Key Points You Should Take Away

- Fukushima will offer important industry lessons; but we should not forget TMI and Chernobyl
- Human performance (safety culture) is still the leading cause of core damaging events
- Our industry must shift its mindset from “prevention” to “prevention and mitigation”
- Our industry (and WANO) will emerge from the Fukushima event with an even stronger commitment to nuclear safety

Questions?

Back-up Slides

Fukushima SOER

- SOER 2011-2 Issued 17 March to WANO Members
- Fundamental Requirements
  - Verify capability to mitigate conditions that result from beyond design basis events
  - Verify capability to mitigate station blackout (SBO) conditions is functional and valid
  - Verify the capability to mitigate internal and external flooding events
  - Identify potential vulnerability to loss of function of important equipment needed to mitigate fire and flood events during seismic events and develop mitigating strategies
- Responses Due to London office by 13 May
- Responses received from all commercial reactors except Fukushima Daiichi and Daini

SOER 2011-2 Response – Noted Gaps

General Pattern of Gaps

1. Equipment that would be needed in a seismic event is not seismically rated (218)
2. Many procedures require development, revision, or initial implementation (203)
3. Equipment supporting SAMGs is not stored or staged properly (151)
4. Preventive Maintenance – new PMs need to be developed or current ones revised (88)
5. Modifications must be implemented to support performing all SAMG strategies (80)
6. Many types of equipment that should be available for use are either unavailable or inoperable (79)
7. Training needs to be created, revised, or implemented (72)

Next SOER

- Fuel Pool Cooling SOER projected in July
- Likely Recommendations will relate to:
  - Verify spent fuel pool (SFP) cooling and makeup contingencies during shutdown conditions or when time to boil is relatively short in any operating condition
  - Establish continuous monitoring of SFP time to boil
  - Validate adequacy of abnormal operating procedures for responding to loss of SFP cooling or inventory
  - Revise emergency operating procedures to specifically incorporate monitoring of SFP level and temperature

Final Thought: Should We Have Been Better Prepared?

External Events

- Hurricane—Turkey Point 1992, Waterford 2005
- Flood—Blayais 1999, Cooper 1993
- Windstorm—Hunterston 1998
- Tsunami—Madras 2004
- Earthquake—Kashawazaki-Kariwa 2007
- Tornado—Browns Ferry 1974
- Grid Blackout—US & Canada 2003, Brazil 1999