Is an ANS-8.3-Compliant CAAS Justifiable – Time to Recognize Reality??

- What is the purpose and practical goal of ANS-8.3?
- What does accident experience tell us?
- Is a "personnel-present" slow transient credible in the USA today?
- A proposed, new Minimum Accident of Concern (MAC)
- Is your CAAS technically and cost-effectively justified?

Thomas P. McLaughlin, Consultant - Retired Los Alamos

ANS 2018 Annual Meeting, Philadelphia, PA

ANS-8.3 Philosophy and Intent

- Alert Personnel of a Possible Criticality Accident and Initiate Immediate Evacuation, thereby Reducing the Likelihood of Injurious or Lethal Radiation Exposure.
- Installation of an ANS-8.3-Compliant CAAS Implies that a thorough, technically defensible Needs Assessment has been done – including:
  - A credible, ENDURING criticality accident
  - Personnel are LIKELY at risk of injurious radiation exposure
  - Other, associated risks are understood
  - Costs are considered – Detector spacing/MAC, training, maint.

Criticality Accidents – What do We Know?

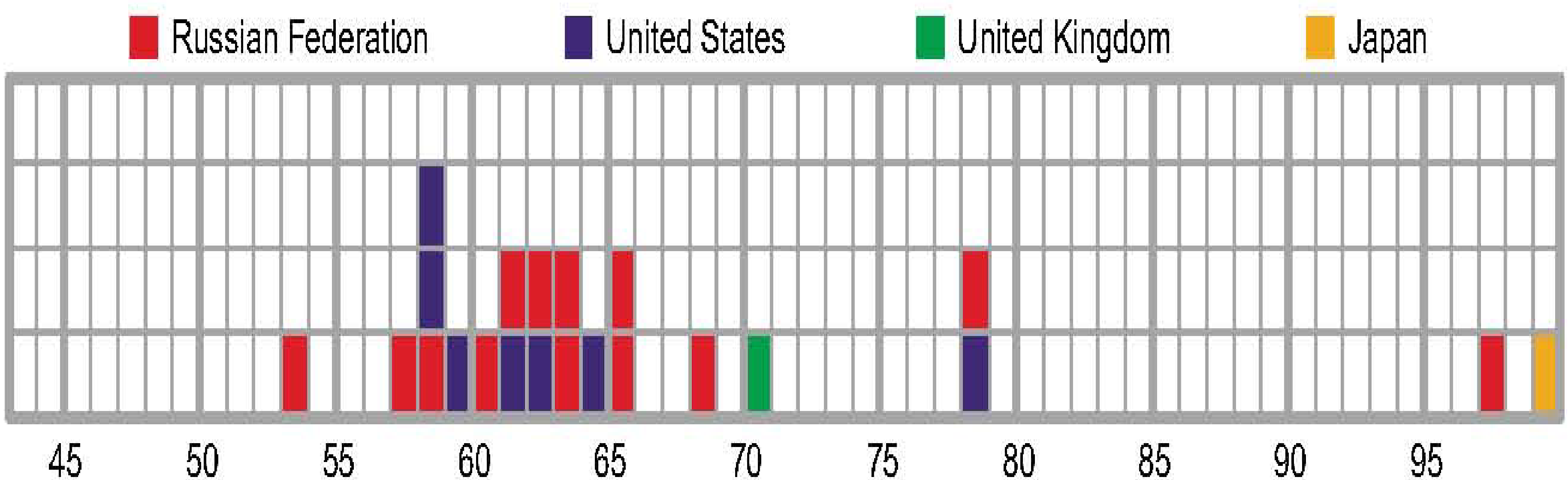


Figure 1. Chronology of process criticality accidents.

Criticality Accidents – What do We Know? (continued)

- All? occurred in **UNFAVORABLE GEOMETRY** vessels on the process/operating floor
- All occurred with LTA MC&A Programs
  - Some in routine process vessels
  - Some in one-of-a-kind operations/vessels
  - Some during “routine” operations
  - Some during process upsets/recoveries
  - Some had significant first spikes; some not
- **NONE** resulted from natural phenomena events or in large waste-tank operations

Criticality Accidents – What do We Know? continued

- Unfavorable geometry vessels have been "essentially" eliminated in areas with fissile material in solution in "large" volumes **AND** MC&A programs have been greatly improved

- Liquid waste operations involving large tanks are "unlikely" to result in significant personnel exposures from a criticality accident

- Criticality accidents resulting from natural phenomena events are "unlikely" to result in significant personnel exposures

What are the Implications of this "Reality"? What can we conclude?

- Criticality accidents in process operations have been "essentially" eliminated – "incredible"?

- Criticality accidents in large (waste) tanks and in liquid collection locations following a severe natural phenomena event will not "credibly" result in significant personnel exposures?

- Current MAC is overly conservative
  - Vanishing likelihood of a personnel-present slow transient ("slow cooker")

What are Possible Justifications for an ANS-8.3-Compliant CAAS?

- 10’s – 100’s of different process operations with rich solutions? I.e., “roll-up”
- Laxity in large vessel control on the process floor?
  - Combined with lapses in the MC&A program?
- Fear of the unknown?
- Unwillingness to consider change?
- **Technically weak Needs Assessment**

Current MAC

- ~ “60 rad/minute at 2 meters” since 1969
- Intended, and thought, to detect a slow transient of “only a few cents excess reactivity” (no longer technically sound?)
  - “Incredible” with rigorous large-volume container controls in areas with large fissile solution volumes AND rigorous MC&A program
  - “Unlikely” in large, liquid-waste operations and subsequent to natural phenomena events
- **No Longer Justified?**

Proposed, New MAC

- 1.0 +14 fissions/second/liter peak power
- Supported by accident experience and by accident simulation experiments
- Consistent with calculated peak-reactivity excursion of ~50 cents +/-??
- Allows greater detector spacing than current MAC

Conclusions

- Current MAC not justified - New MAC needed
- ANS-8.3 does not adequately address “unlikely” natural phenomena events and “unlikely” accidents in large waste tanks - that are at the same time “unlikely” to result in injurious radiation exposures
  - Both being deliberated by ANS-8.3 WG now
- ANS-8 standards do not adequately address the (impact of) today’s rigorous “large container control measures” AND rigorous MC&A programs
- “Community” (operators/practitioners/regulators) needs a vigorous discussion on these issues

RUSSIAN FEDERATION ACCIDENTS

Figure 2. Map of the Russian Federation showing the sites of the process criticality accidents, the capital, Moscow, and Obinisk, the location of the regulating authority, IPPE.

UNITED STATES ACCIDENTS

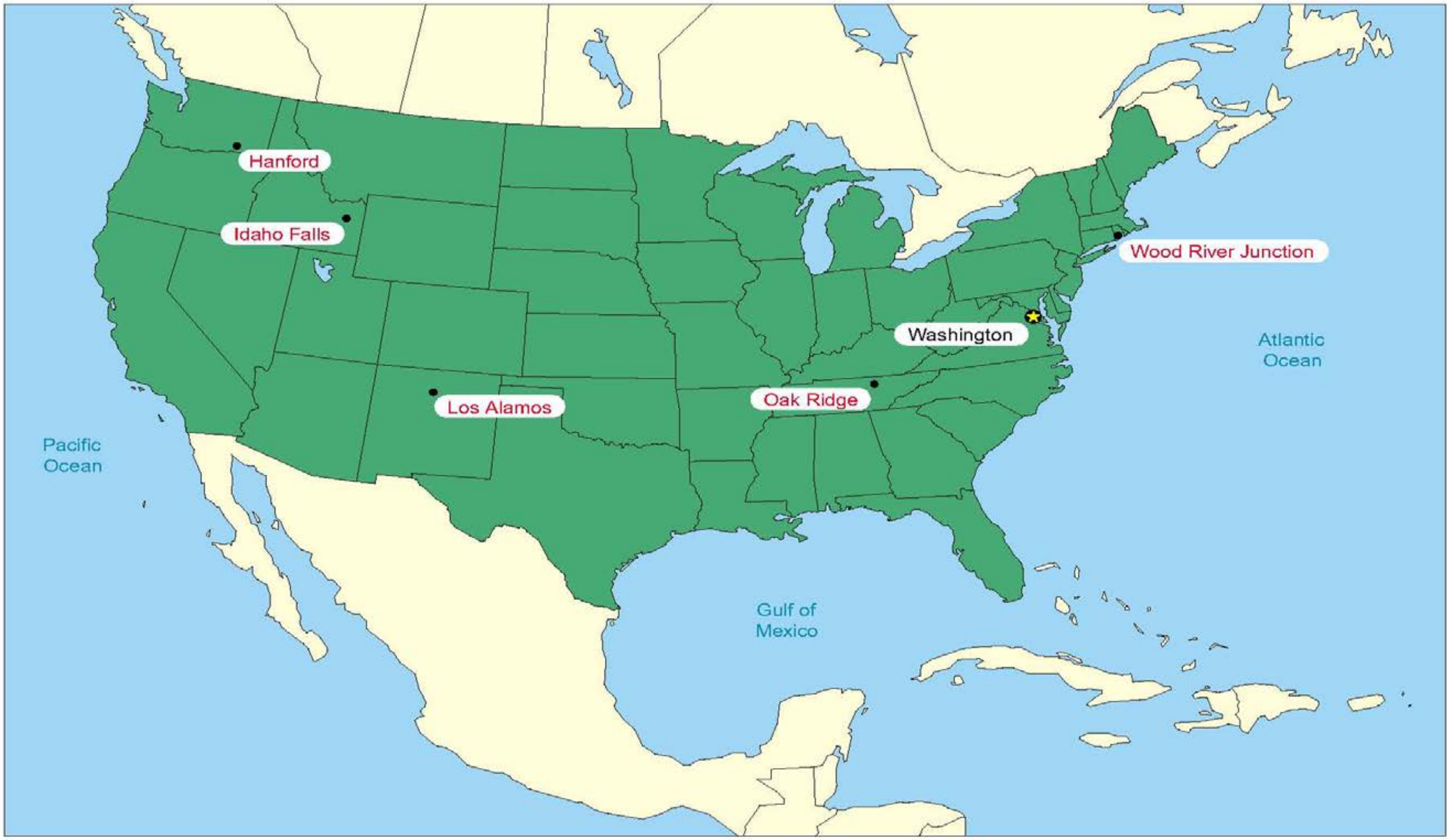


Figure 3. Map of the United States showing the sites of the process criticality accidents, and the capital, Washington.

BRITISH ACCIDENT

Figure 4. Map of the United Kingdom showing the site of the process criticality accident and the capital, London.

JAPANESE ACCIDENT

Figure 5. Map of Japan showing the site of the process criticality accident and the capital, Tokyo.

OBSERVATIONS

- Accident Frequency: zero; 1/yr; 1/10 yrs; ???
- Storage Operations: none
- Transportation Operations: none
- Significant Exposures: Only Immediate Vicinity
- Shielded Operations: Negligible Exposures
- None Attributed Solely to Equipment Failure

OBSERVATIONS

- None Attributed to Faulty Calculations
- Many Occurred During Non-Routine Operations
- Administrative Considerations Determined Facility Down-time
- No New Physical Phenomena

LESSONS LEARNED - OPERATIONAL

- **Avoid unfavorable geometry vessels in areas with high-concentration solutions**.
- Put important instructions, information, and procedural changes in writing.
- Understand processes thoroughly so that credible abnormal conditions are recognized and analyzed.

LESSONS LEARNED - OPERATIONAL

- Fissile material accountability (MC&A) is integral to a good NCS program.
- Operator understanding of NCS implications of proper response to process upsets is important.
- Operations involving both organic and aqueous solutions require extra diligence.

LESSONS LEARNED - OPERATIONAL

- Remote readouts of radiation levels where accidents may occur should be considered.
- Operations personnel should be made aware of criticality hazards and stop work policies.
- Operations personnel should be trained to understand the basis for why they must always follow procedures.

LESSONS LEARNED - OPERATIONAL

- Hardware that is important to criticality control and whose failure or malfunction would not necessarily be apparent to operators should be used with caution.

- Criticality alarms and adherence to emergency procedures have saved lives and reduced exposures.

LESSONS LEARNED – SUPERVISORY, MANAGERIAL AND REGULATORY

- Process supervisors should ensure that operators are knowledgeable and capable.
- Equipment should be designed with ease of operation as a key goal.
- Policies and procedures should encourage self-reporting of upsets and err on the side of learning more, not punishing more.

LESSONS LEARNED – SUPERVISORY, MANAGERIAL AND REGULATORY

- Senior management should be aware of the criticality accident hazard and its **likelihoods** and consequences.
- Senior management and regulators should be aware of operations with a criticality accident hazard.
- Regulators should ensure that those they regulate are knowledgeable and capable.
- Regulations should promote safe and efficient operations.

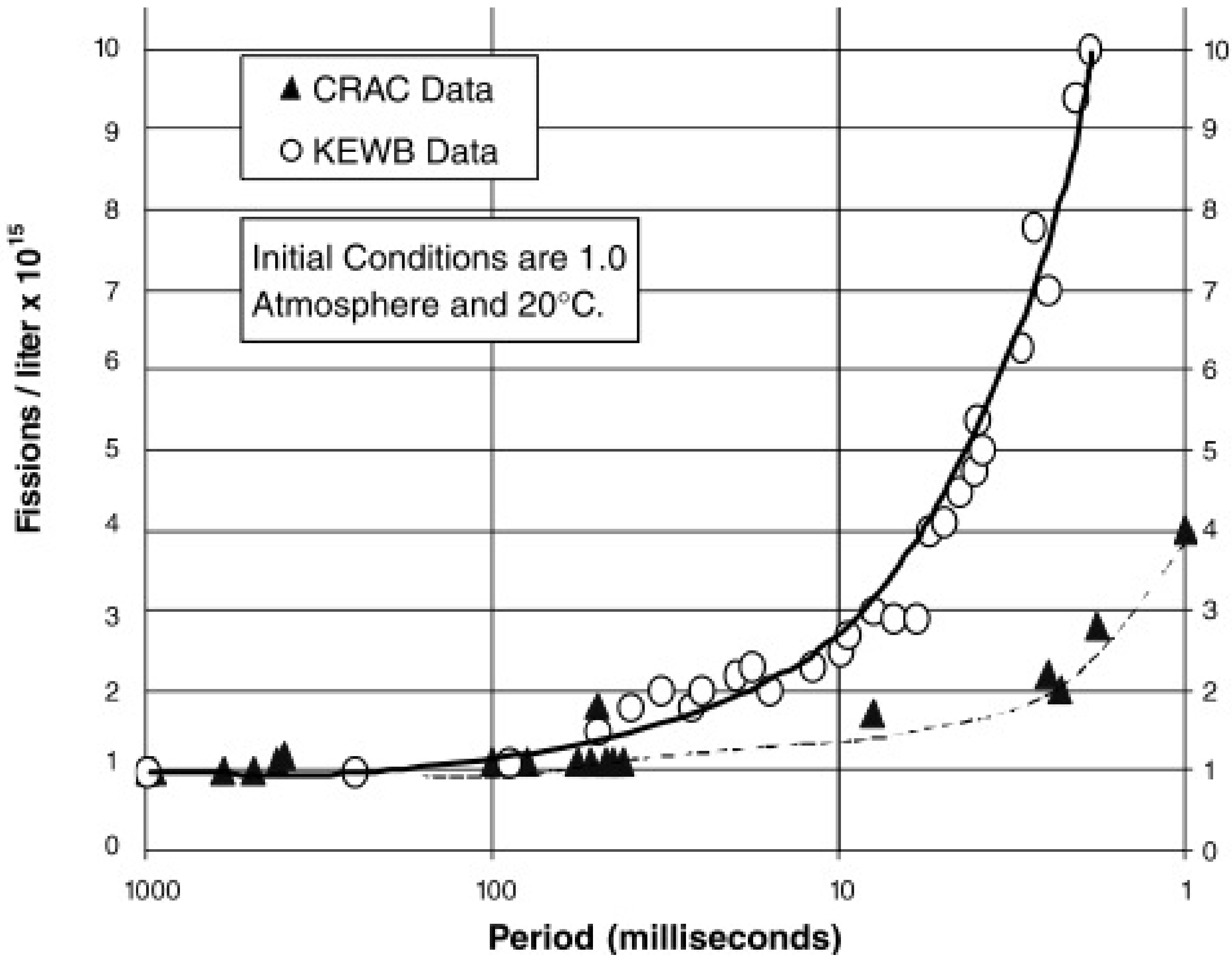
CONCLUSIONS

- Likelihoods of criticality accidents are extremely low, but will never be zero.
  - **Elimination of unfavorable geometry process vessels has been THE key factor in the dramatic accident rate decrease**
- Diligence is required to maintain a proper, acceptably low, accident risk **while balancing the need for process ease and efficiency.**

NEW(?) INSIGHTS

- Accident frequency down dramatically since mid-60's **AND WE KNOW WHY**
- ANS-8 Standards are essentially unchanged
- Federal Regulations INCREASED – 10 CFR 830
- **We are remiss to not be reaping benefits from lower accident likelihoods/risks**

MAXIMUM SPECIFIC FIRST SPIKE YIELD VS PERIOD - SOLUTIONS



MAXIMUM SPECIFIC FISSION YIELD - FIRST 10 MINUTES

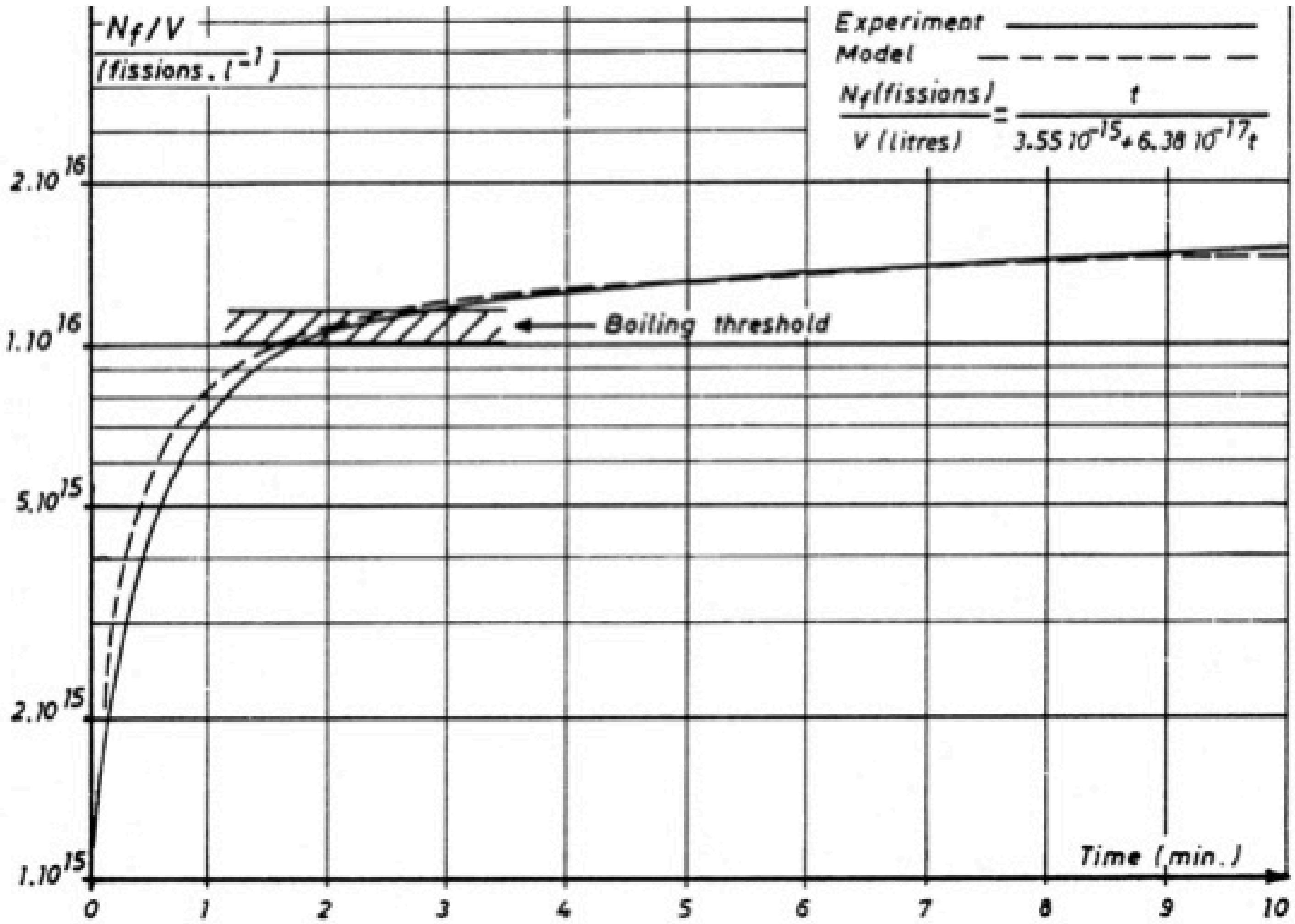


Figure C.2 – Maximum specific fission yield resulting from criticality solution excur-

CRITICAL VOLUMES AND CONCENTRATIONS

- 20 Liters - ONE
- **30-80 Liters - SIXTEEN**
- > 100 Liters - FOUR

- < 100 g/l - NINETEEN
- > 100 g/l - TWO

DELAYED CRITICAL VS PROMPT CRITICAL ACCIDENTS

- **“No First Spike” = 7 = Slow approach to critical state - “Slow Cooker”**
- Yes - First Spike (~1.0+15 fissions/l) = 9
- Unknown (no data) = 5

OBSERVATIONS

- Criticality Accidents Do **NOT** Occur in Favorable Geometry Vessels
- **Unfavorable Geometry Vessels ~100% Removed from Rich Solution Process Operations During 60's in Both US & USSR**
- NO Hands-On Accidents in US since 1964
- TWO Hands-On Accidents in USSR since 1965
  - 1968 (misconduct); 1997 (neglected slab tanks)

CONCLUSIONS

- Accidents with Routine, Rich Solution, Processing "Essentially" Eliminated for Hands-on Operations
  - Thus, Slightly-Above-Delayed-Critical Accidents with Personnel Present "Essentially" Eliminated
  - **That is, Slow Transients (Slow Cooker) with Personnel Present "Essentially" Eliminated**

WHAT'S LEFT?

- Extreme Upset Conditions – Seismic, Floods, Fires, ?? - Solutions Flow; Dry Powders Become Moderated – BUT, Evacuation likely
- Canyon, Hot Cell and Waste Tank Operations – Unfavorable Geometry, but generally heavily shielded
- These situations are **unlikely** to expose personnel; thus there should be greater accident likelihood tolerance, per ANS-8 philosophy.

ANS-8 AND REGULATORY IMPLICATIONS ??

- ANS-8.3 “Minimum Accident of Concern”
- ANS-8.1 “Process Analysis” Subsection 4.1.2
- ANS-8.10 General Intent
  - Only “Shielding and confinement” …..or
  - Broadly “When Personnel are not present”??
- ANS-8.23 Applies to all Re-entry operations
  - Including First Responders, Firefighters, etc.

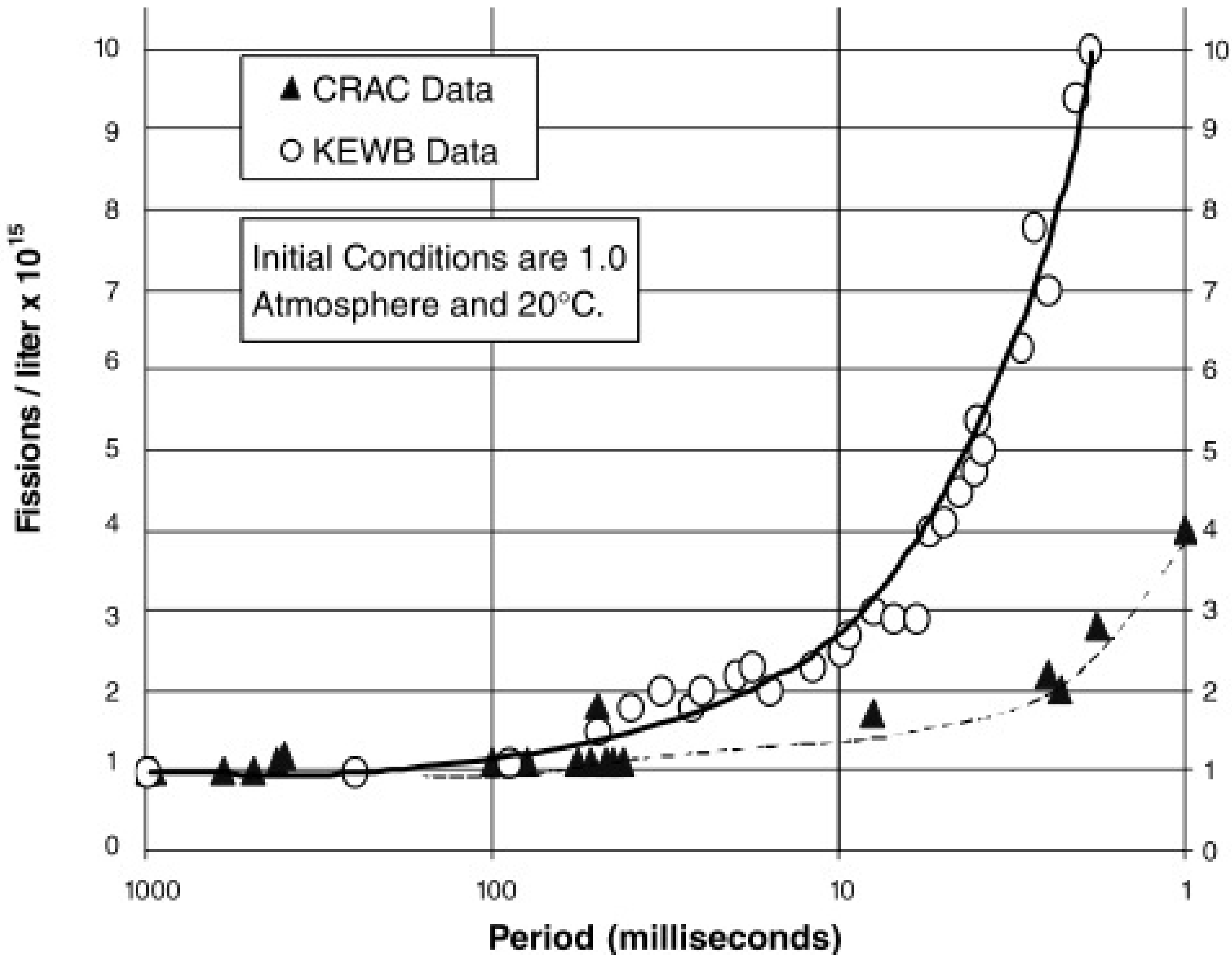
ANS-8.3 - MAC

- Detection Criterion: Historically/Currently - 20 rad in one minute at 2 meters
- Developed to detect Slow Transients, down to few cents above delayed critical excursion to protect personnel from “slow/unnoticed” exposure
- Recent analyses indicated DC non-conservative; **MAJOR COST IMPLICATIONS if more detector heads needed**

ANS-8.3 - MAC

- If "**Slow Transient with Personnel Present 'Essentially' Eliminated**"
- What is a realistic, practical MAC?
- ANS-8.3 WG considering/proposing:
  – (Near) Prompt critical first spike (conservatively) consistent with experimental data
  – 1.0 E+15 fissions/liter in **10-second** spike
  – I.e., 1.0E+14 fissions/s per liter
- **EASIER(less costly) TO DETECT**

MAXIMUM SPECIFIC FIRST SPIKE YIELD VS PERIOD



ANS-8.1 – PROCESS ANALYSIS

- **Historically/Currently, 4.1.2**:

"Before a new operation with fissionable material is begun or before an existing operation is changed, it **SHALL** be determined that the entire process will be subcritical for **all** normal and credible abnormal conditions."

- Often (mis)applied universally, even when personnel are not (likely) at risk

ANS-8.1 – PROCESS ANALYSIS

- DOE/CSSG considering adopting, and proposing (2016-04) to ANS-8 Standards:
  - "… **all** normal conditions and, *when personnel are present*, under credible abnormal conditions. When personnel are not at significant risk from the radiation consequences of a criticality accident then the word 'credible' should be replaced by 'unlikely,' consistent with ANS-8.10 guidance. This requirement is not applicable to response and recovery operations for which guidance is provided in ANS-8.23"

ANS-8.10 – SHIELDING AND CONFINEMENT

- DOE/CSSG considering proposing (2016-04) to ANS Standards:
  - Revise Title, Scope and Contents to make it unambiguous that the standard covers all situations (such as evacuation) when personnel are not at risk of significant radiation exposure from a criticality accident.

- DOE/CSSG considering adopting this (always intended) philosophy

ANS-8.23 – EMERGENCY PLANS AND PROCEDURES

- DOE/CSSG considering proposing to ANS Standards:
  - Make it clear (in appropriate locations in ANS-8.1 and 8.23) that 8.23 guidance applies to all re-entry situations, including firefighters and other emergency response personnel
- DOE/CSSG considering adopting this (always intended) philosophy

CONCLUSIONS

- ANS-8 guidance not **explicitly** consistent with data/reality and intended philosophy.
- Major(focused) re-writes needed to:
  - ANS-8.1; 8.3; 8.10; and 8.23
  - **CAN CRIT. ALARMS BE JUSTIFIED???**
- CSSG 2016-04 Tasking Response “may” expedite ANS-8 and DOE/NRC regulatory process. **CHANGE IS COMING**