CRITICALITY ACCIDENT ANALYSIS

DOES YOUR FACILITY'S ACCIDENT HAVE A JUSTIFIED BASIS?

Thomas P. McLaughlin, Consultant

OVERVIEW

- What is a Justified Basis?
- Regulatory Drivers
- Resources for Determining (Credible) Accidents and Power Histories
- Data Application Example
- Conclusions

WHAT IS A JUSTIFIED BASIS?

- More than an “approved” or “authorized” handbook value
- CREDIBILITY - both in Likelihood and Consequence, i.e., data-based.
  - In spite of compliance with ANS-8.1, Section 4.1.2, Process Analysis:
    - *Before a new process ….. it shall be determined that … subcritical … and credible abnormal conditions.*
  - Roll-up issues?

REGULATORY DRIVERS

- ANSI/ANS-8.23, Nuclear Criticality Accident Emergency Planning and Response, 5.1.1
  - *Potential criticality accident locations and predicted accident characteristics shall be evaluated and documented ….*
  - *This description may be based on professional judgment or a more detailed analysis.*
  - *The description should include the estimated fission yield.*
  - *The likelihood of recurrence should be considered*

REGULATORY DRIVERS

- ANSI/ANS-8.23, Nuclear Criticality Accident Emergency Planning and Response, 5.1.2
  - *An immediate evacuation zone shall be established based on the documented evaluation.*
  - *Emergency response planning shall shall establish a maximum acceptable value for the absorbed dose at the IEZ boundary.*
  - *The basis for the maximum acceptable value shall be documented.*

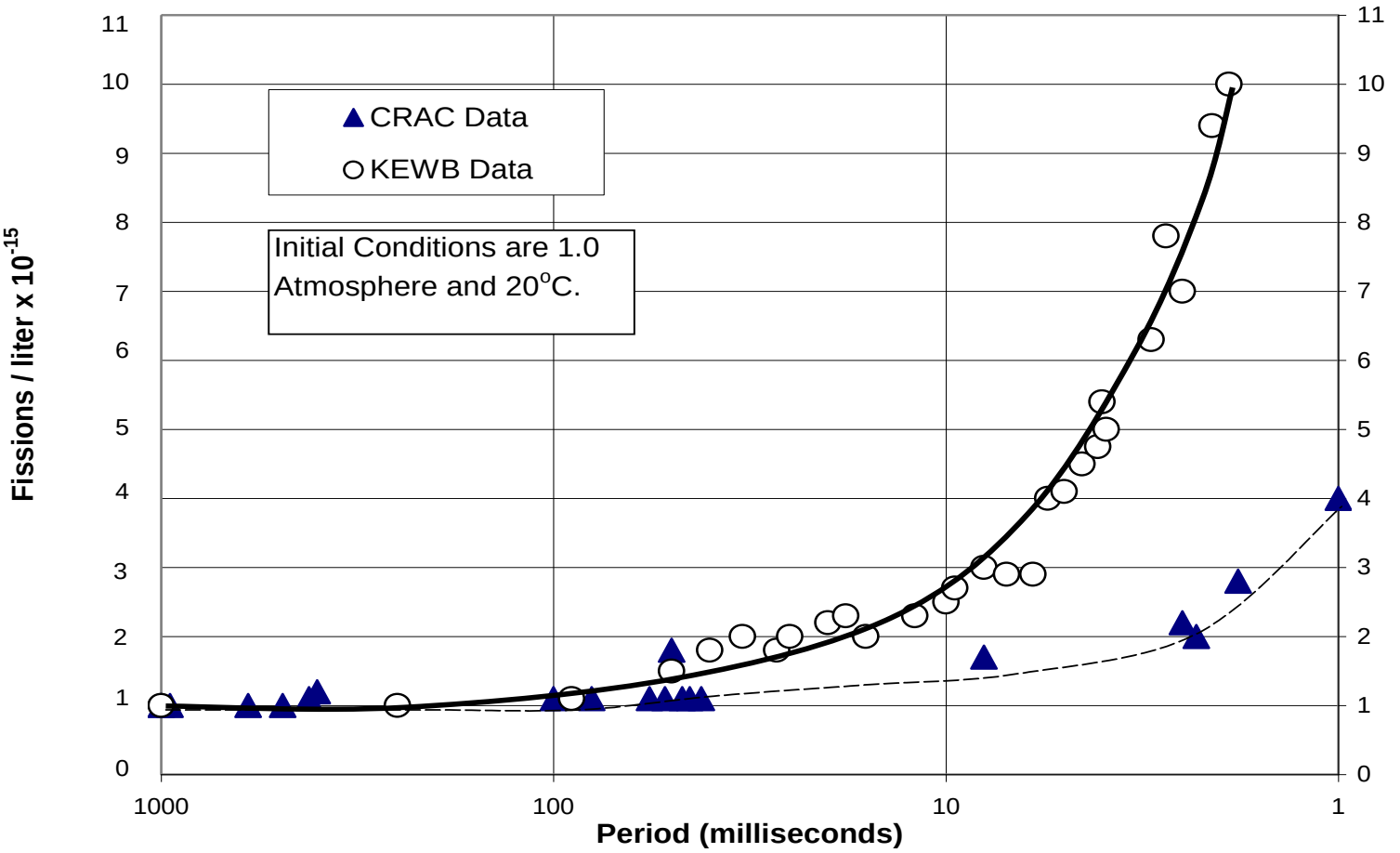
RESOURCES FOR DETERMINING ACCIDENT CREDIBILITY

- Process Supervisors and Operators
- Accident Reports (e.g., LA-13638)
- Analyses of actual and postulated accidents, such as the ICNC'91 review paper: *Criticality Accident Likelihoods, Consequences, and Emergency Planning* by T. P. McLaughlin

RESOURCES FOR DETERMINING POWER HISTORIES

- ANS-8.23 APPENDIX C
  - Accident simulation data: KEWB, CRAC, SILENE, SHEBA, TRACY
  - ORNL Slide Rule
  - Accident Report, LA-13638
  - DOE Handbook 3010-94, *Airborne Release Fractions/Rates for Nonreactor Nuclear Facilities,* Chapter 6
  - NUREG/CR-6410, *Nuclear Fuel Cycle Facility Accident Analysis Handbook*

CRITICALITY ACCIDENT SIMULATION DATA



Specific fissions in first spike vs reactor period

CRITICALITY ACCIDENT SIMULATION DATA

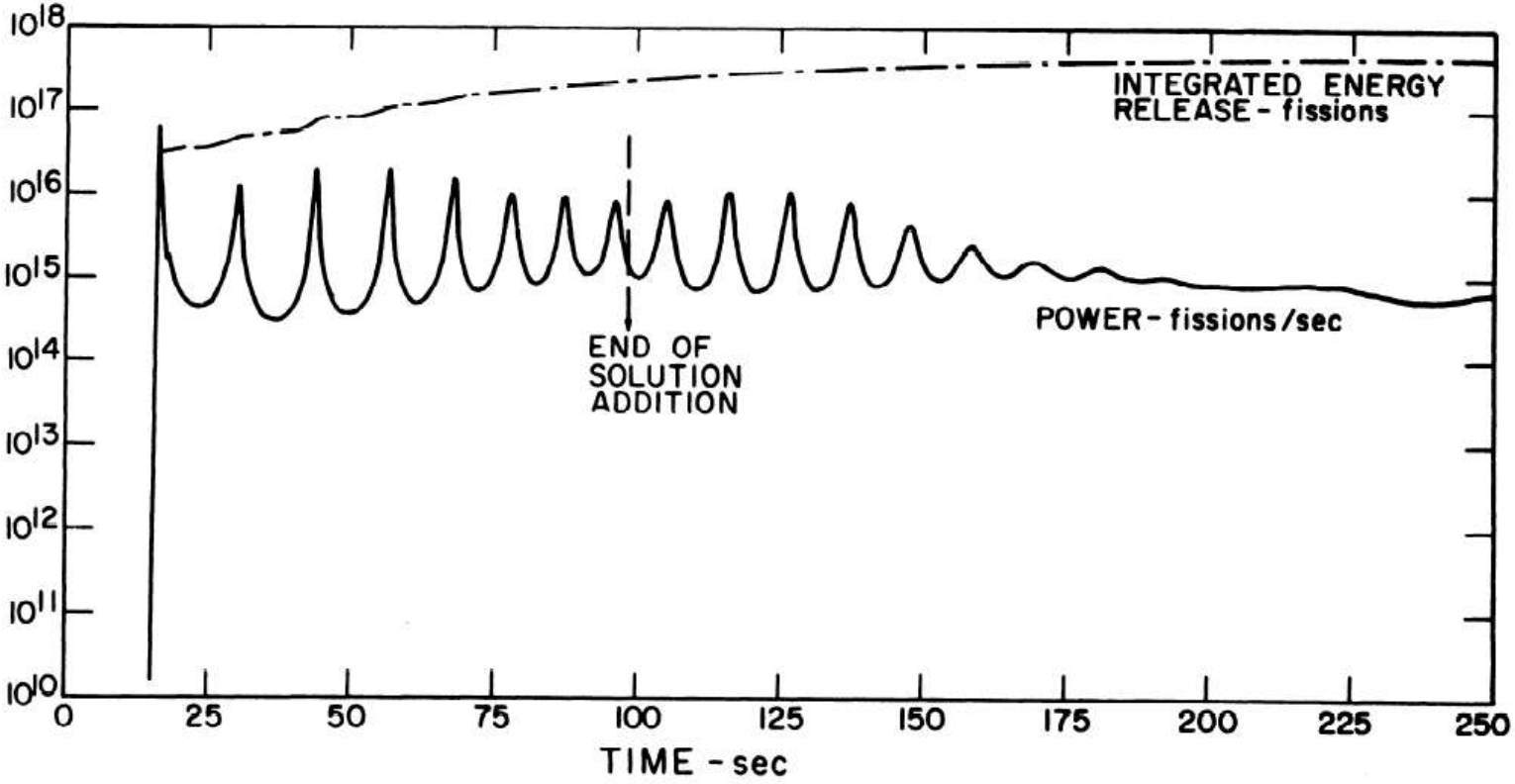
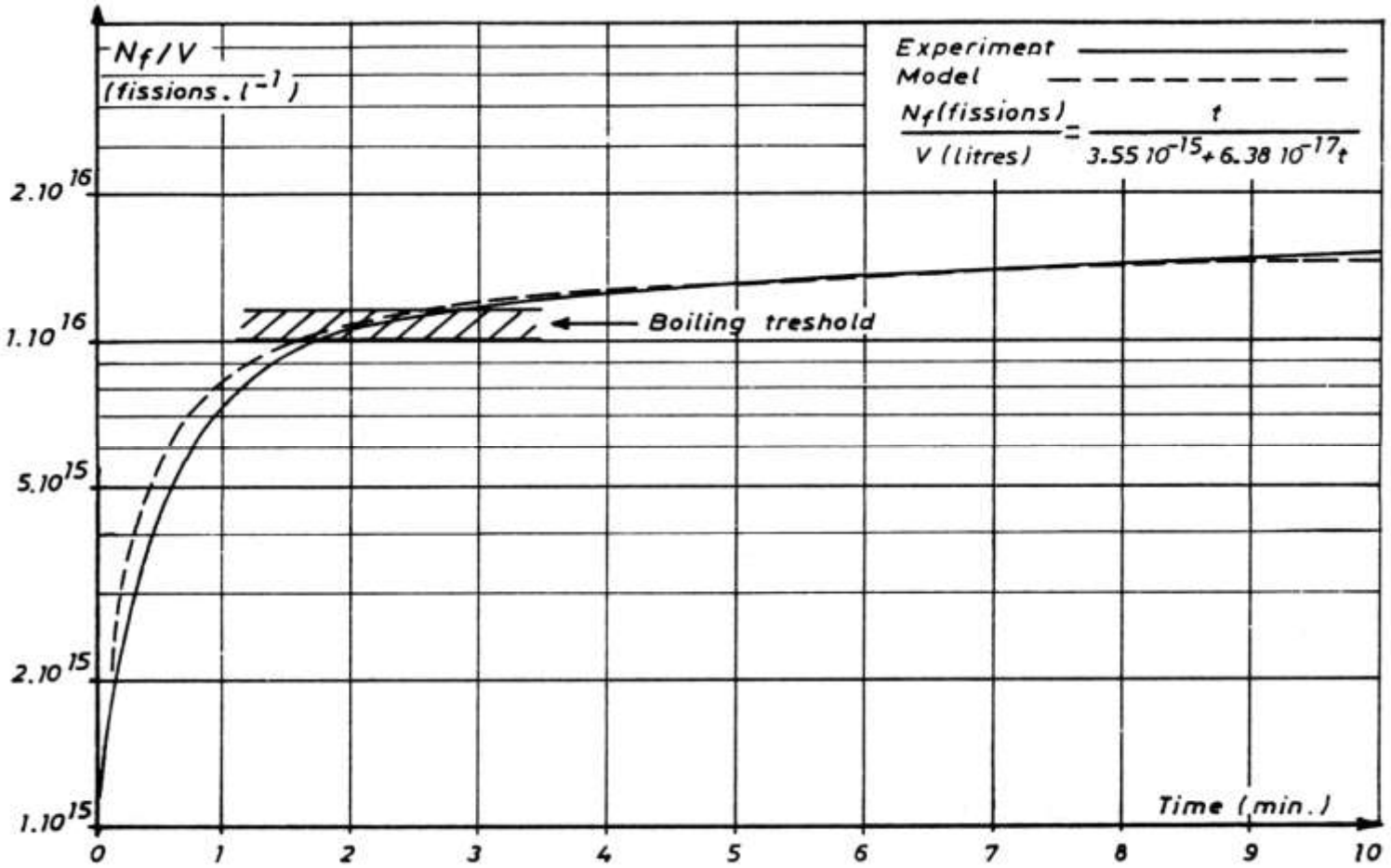


Fig. 5. Fission Rate and Integrated Fission Energy Release in CRAC 19 as a Function of Time.

CRITICALITY ACCIDENT SIMULATION DATA



Bounding fission density vs time, CRAC & SILENE

ORNL SLIDE RULE

- Based heavily on CRAC data
- Very easy to apply and has many additional features/capabilities
- Appears to have a reactivity insertion rate to the half power dependence that results in increasing conservatism at higher ramp rates compared to CRAC data, for the first spike yield.

DOE and NRC HANDBOOKS

- Little discussions of likelihoods with different media
- Recommended bounding total fissions only (with inadequate justification) - no breakdown into first spike and plateau (DOE)
- Describes hypothetical scenario from withdrawn RG's 3.33, 3.34, and 3.35:
  - 1.0+18 in first spike followed by 47 pulses of 1.9+17 at 10 minute intervals over 8 hours for 1.0+19 total fissions. (NRC)

CONCLUSIONS -1

- Accident experience, augmented by common-sense reasoning, supports the contention that non-solution process criticality accidents are inherently much less likely than those that might occur in solution operations.
  - The INCN'91 paper examines this in some detail. Subsequent accident revelations reinforce this paper's conclusions.

CONCLUSIONS -2

- Given the negligible accident rate in non-solution media (one reported, with deliberate violations) it would seem difficult to justify emergency plans and procedures, including a CAAS, for operations with fissile material only in dry forms. This conclusion is based on both risk and cost issues.

CONCLUSIONS -3

- For operations with significant quantities of fissile materials in solution form, there is much relevant (accident simulation) data and more being generated. Practically all site- and process-specific criticality accident characterizations and evaluations should be able to be performed readily by the direct application of these data.