Argonne National Laboratory – West
SEC Petition Evaluation Report

SEC00224

Timothy D. Taulbee, PhD, CHP

Research Health Scientist

National Institute for Occupational Safety and Health

ORAU Evaluation Team

- W. Mitch Findley – Team Leader (EBR-I, ZPR-III)
- Brian Gleckler (EBR-II, FCF, HFEF)
- Jason Davis (ZPPR, TREAT, L&O)
- J. Michael Mahathy (BORAX, AFSR)
- Data Capture Support Team
  - William Connell
  - Jennifer Warner
  - Art Gutzman
  - Guy Babin

Petition Overview

- Petition Received on December 4, 2014
- Petition Qualified on March 13, 2015
- Notification to Petitioner and ABRWH in June 2015 that NIOSH would exceed 180 day deadline due to site complexity and need for multiple data capture efforts onsite.
- Further delay in September 2015 due to dosimetry records issue between ANL-E and INL
- Evaluation Report sent to ABRWH on February 24, 2016
- Evaluation Report sent to Petitioner March 8, 2016

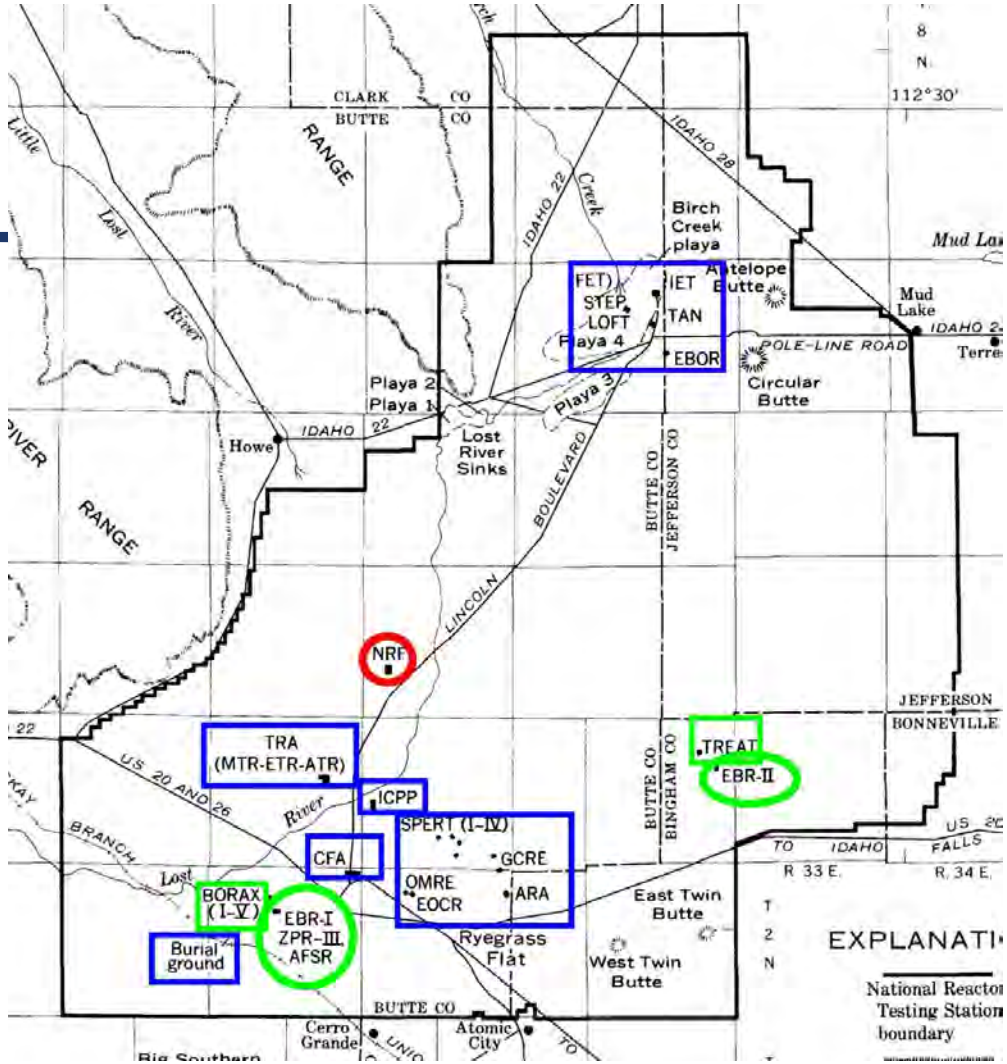
Proposed Class

All employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked at the Argonne National Laboratory-West between April 10, 1951 and December 31, 1957 for a number of work days aggregating at least 250 work days, occurring either solely under this employment, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.

ANL-W

Operating Areas (green)

- West Area
  - 1951-1967
  - EBR-I, ZPR-III, AFSR, BORAX (I-V)
- East Area
  - 1958 – 2005
  - EBR-II, ZPPR, TREAT, FCF, HFEF-N, L&O



ANL-W Major Operating Facilities

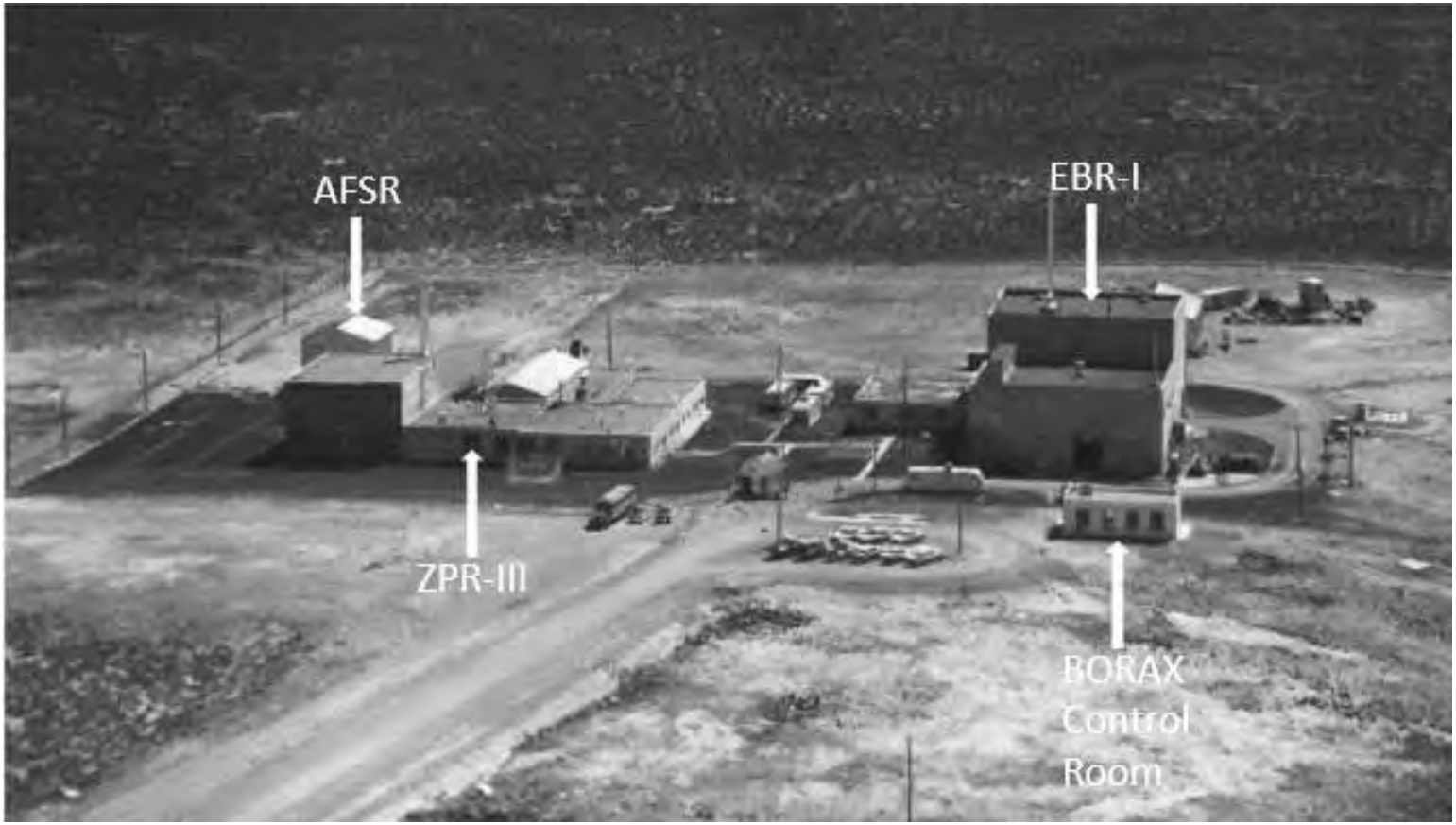
West Site

1. Experimental Breeder Reactor #1 (EBR-I)
2. Zero Power Reactor #3 (ZPR-III)
3. BOiling water ReActor eXperiments (BORAX)
4. Argonne Fast Source Reactor (AFSR)

East Site

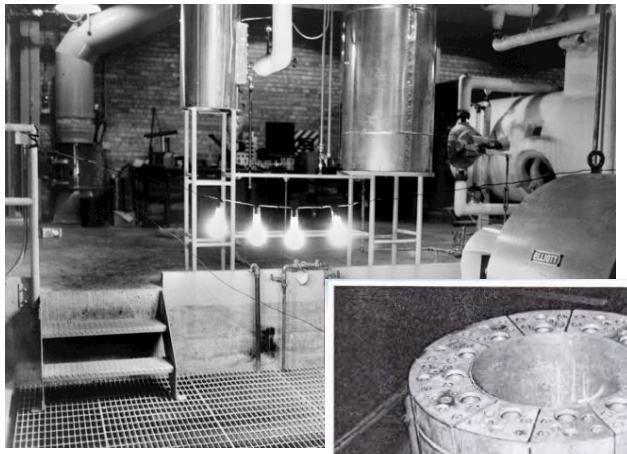
5. Transient REActor Tests (TREAT)
6. Experimental Breeder Reactor #2 (EBR-II)
7. Fuel Cycle Facility (FCF) later (HFEF-S)
8. Hot Fuel Examination Facility (HFEF-N)
9. Laboratory and Office Building (L&O)
10. Zero Power Plutonium Reactor (ZPPR)

West Area (1951-1967)



Experimental Breeder Reactor #1

- December 1951
  First reactor to generate electric power
- In 1953 analysis of EBR-I fuel and blanket demonstrated the breeding concept and produced slightly more fuel than was used
- November 1962
  First reactor to generate electricity using a plutonium core

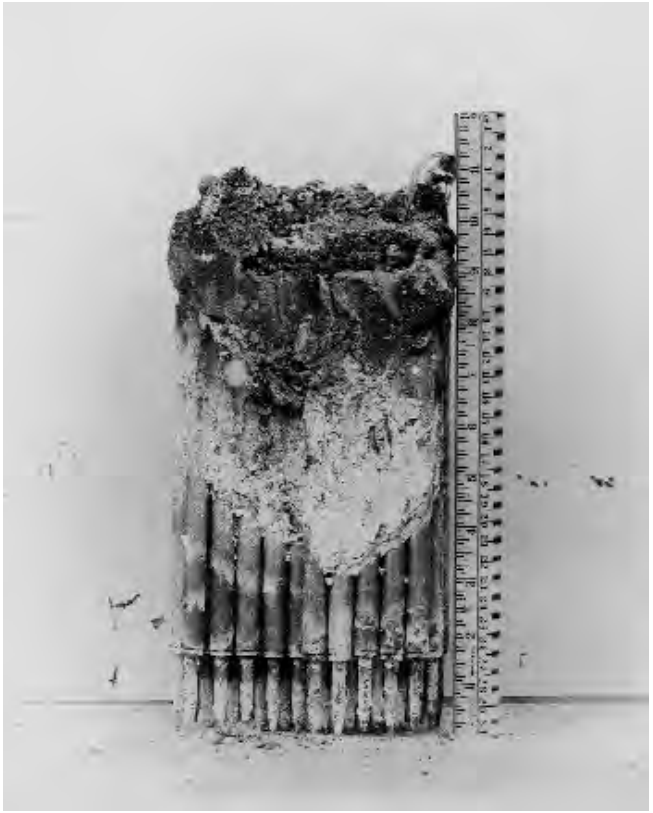


EBR-I Radiological Exposures

- Primary exposure was Mixed Fission Products (MFP)
- Limited actinide exposure due to cladding of both the fuel and blanket
- Blanket brick rupture - April 1955
  - Plutonium bioassay for 16 workers week after incident
  - No other Pu bioassay has been found although monthly reports have indicated a couple of other instances when blanket bricks ruptured.

EBR-1 Core Melt

- Core melted down in November 1955 during reactivity test.
- Building was evacuated and shutdown for several days.
- Special coffin built to remove core and send it to ANL-E for analysis.
- Uranium and mixed fission product bioassay for some workers.



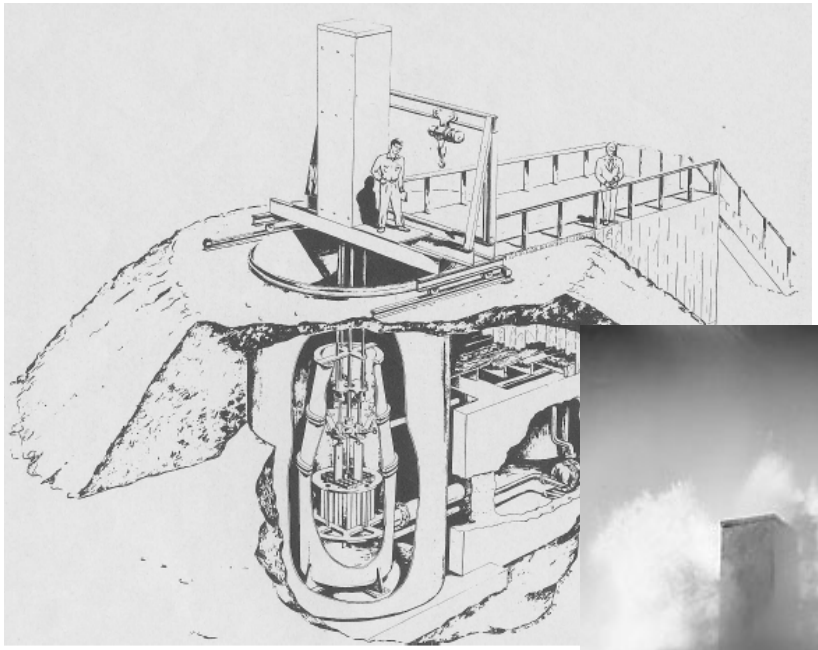
Stacy, 2000

BOiling water ReActor eXperiments (BORAX) #1

- Built in 1953
- Determine the self-limiting characteristics of water-cooled reactors
- Small reactor in a tank of water
- Could only be used during the summer months because the reactor was not housed

BORAX #1

- Reactor tank filled with water and brought to critical and boiling conditions
- Test reactivity and effects by quick removal of controls
- Water would blow out of reactor like a small geyser

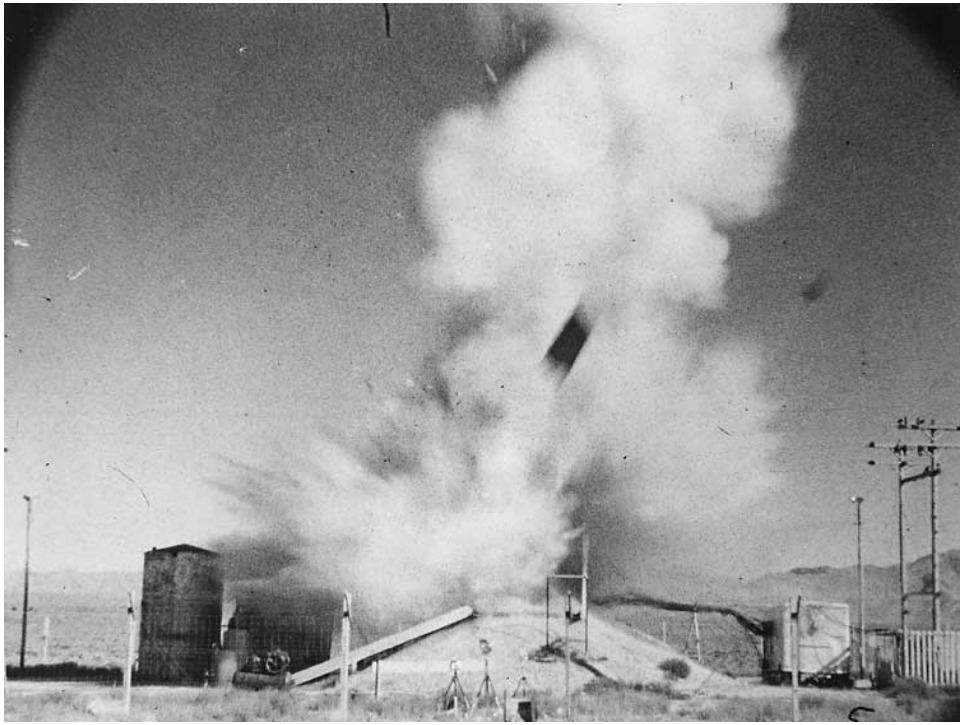


Haroldsen, 2008

Haroldsen, 2008

BORAX #1

- Final test July 1954
- Deliberate introduction of large reactivity
- Reactor exploded due to rapid steam buildup.
- Fuel, control rods, and other activated equipment scattered across the area.



http://www.ne.anl.gov/About/reactors/lwr3.shtml (2016)

BORAX #1 - Recovery

- Interview with worker who participated in the test and gave a detailed account of the event.
  - Photographer had to go in to get the film of the explosion. He then had to be decontaminated from fresh mixed fission products.
  - The following days were spent rotating workers into pit where the reactor was to recover gold foils so that they could determine the power the reactor attained before exploding.
- Basically workers were standing in the remains of the reactor digging and sorting through mixed fission and activation product sludge.

BORAX #2

- Boiling Water Reactor (BWR) tests continuation.
- No turbine-generator thus no electrical generation.
- March 1955 turbine added to demonstrate contamination would not be a problem.

http://www.ne.anl.gov/About/reactors/lwr3.shtml (2016)

BORAX #3 (BORAX #2 with Turbine)

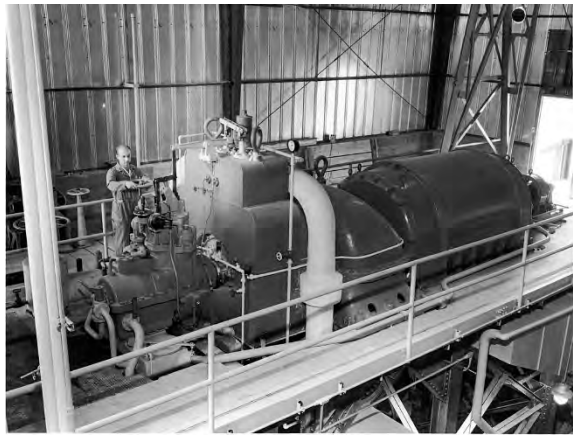
- July 1955 supplied the first atomic generated power to the city of Arco, Idaho.

THE ARCO ADVERTISER

Serving America's Newest Atomic Center — Voice of the Last River Country Since 1909 — 10 Cents Per Copy

VOL. XLVI—Number 24 — Arco, Butte County, Idaho — Friday, August 12, 1955

Arco First City In United States Lighted By Atomic Power



External and Internal Dosimetry

- ANL-E reported that they believed they did not have any ANL-W dosimetry
- INL reported that they believed they had all of the ANL-W dosimetry

- Blind test of 50 cases with some known to have worked at ANL-E before going to ANL-W and some cases known to have only worked at ANL-W
  - Both have parts of early dosimetry but neither appears to be complete.

Incomplete External Monitoring Data (1951-1957)

- ANL-E in Illinois
  - Individual dosimeter readings for most (not all) of test case workers from 1952 through March 1955
- Idaho National Laboratory (INL)
  - Annual summaries from 1952 through 1957 for ANL-W workers who were still employed in 1958
  - De-identified individual dosimeter readings (1954 - 1957)
  - Individual dosimeter readings (1958 – 2005)
- Potential external dosimetry data gap from 1955 through 1958 if a worker terminated before 1958.

EBR-I Complex Internal Monitoring

- Bioassay monitoring campaign in June 1952 for gross alpha and uranium
- Extremely limited (very few samples) for mixed fission product bioassay prior to 1958.
  - No mixed fission product bioassay for people known to have worked during BORAX-1 recovery in 1954
- Neither ANL-E nor INL provided bioassay in 1955 (rupture brick and core melt) for test cases known to have been involved.
  - Bioassay records were located in other radiological boxes

EBR-I Radiological Monitoring (Air)

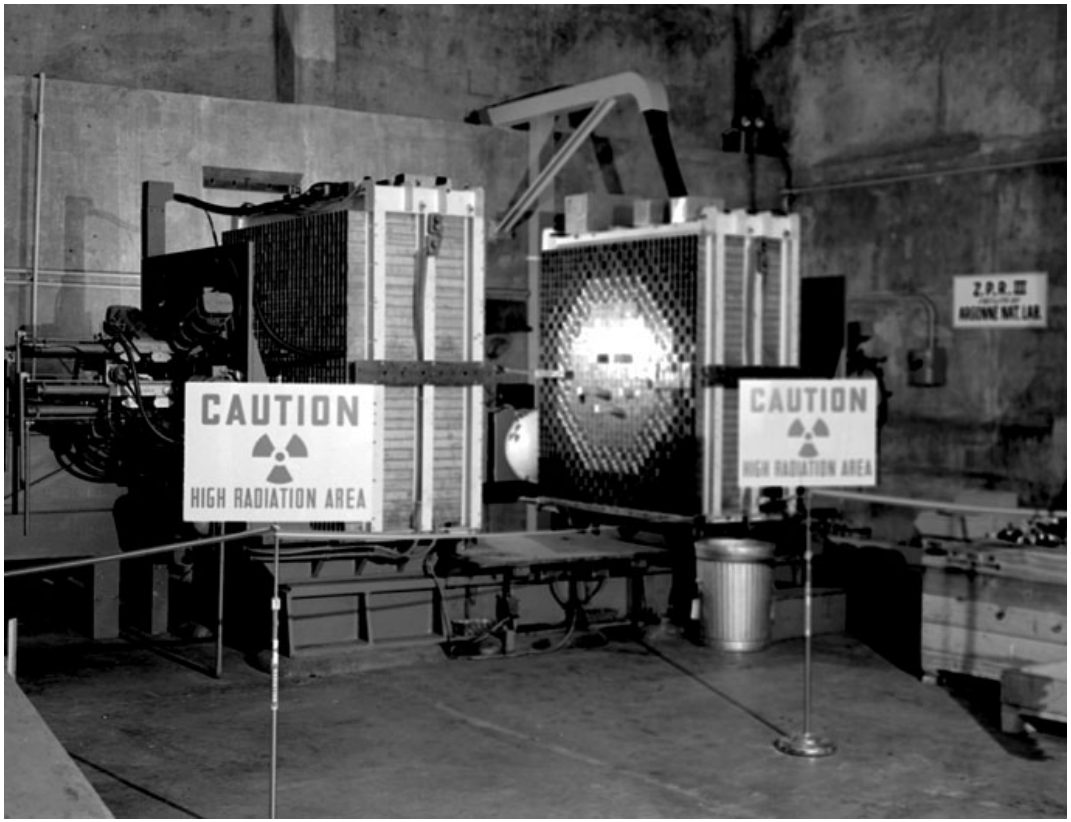
- No air monitoring data available in 1951-1954 and 1957.
- Limited 1955 and 1956 air monitoring data. Files appears to be an individual Health Physicists copy not the original and likely not complete. When available air monitoring data generally limited to reactor top, main floor, and basement.
- After 1958, bioassay data available as well as extensive air monitoring and smear data indicating clean areas or very low level contamination. Occasional hot spots identified on routine surveys and cleanup thereafter.

EBR-I, BORAX Summary

- Without mixed fission product exposure information (bioassay or air monitoring), cannot estimate mixed fission product dose and associated actinide exposures from EBR-I and BORAX.
- Potentially incomplete external monitoring data for workers at the West site (EBR-I, BORAX)) who terminated before 1958.
- Recommend adding class to Special Exposure Cohort (SEC) due to inadequate mixed fission product monitoring and potentially incomplete external monitoring data prior to 1958.

Zero Power Reactor - III

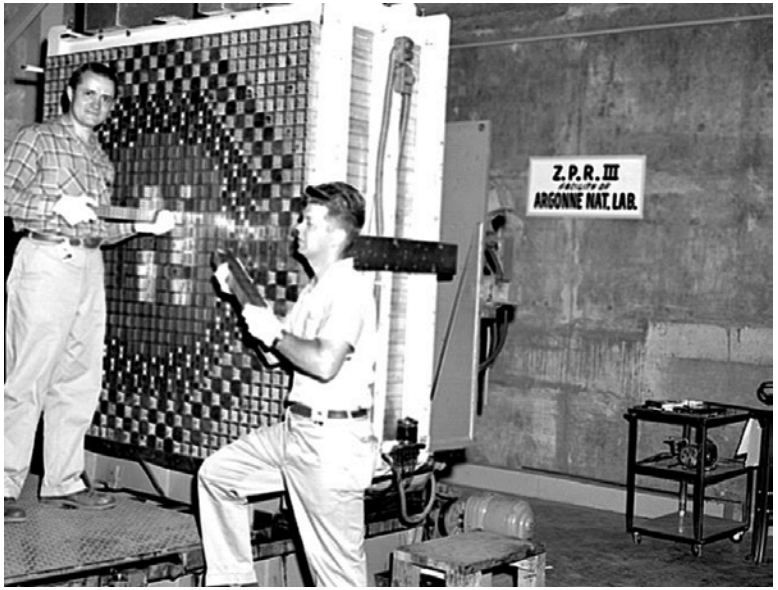
- Design was two halves of a reactor loaded with fuel drawers of various configurations.
- One half is moved towards other to achieve criticality.



http://www.ne.anl.gov/About/reactors/frt.shtml (2016)

Zero Power Reactor - III

- Initial drawers were uranium, depleted uranium, enriched uranium, sodium, etc…



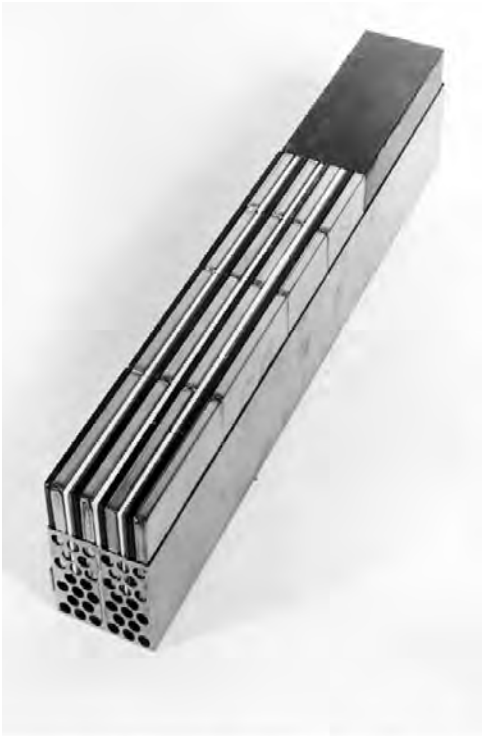


Figure 3. Typical Loaded ZPR Drawer.[a]

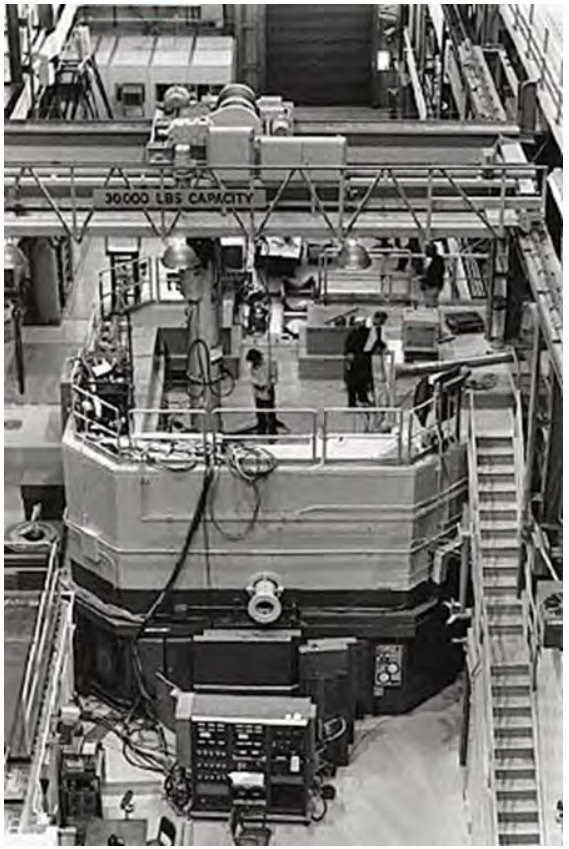
ZPR-III Radiological Exposures

- Minimal fission product exposure as the reactor was operated at very low power
- Some potential for uranium exposure in handling fuel plates and pins that were only painted and not clad
- Exposure to plutonium was very well controlled and caution was used. Verification that cladding was intact performed through multiple contamination surveys of plutonium fuel plates.

East Area (modern view)

Transient REActor Tests (TREAT)

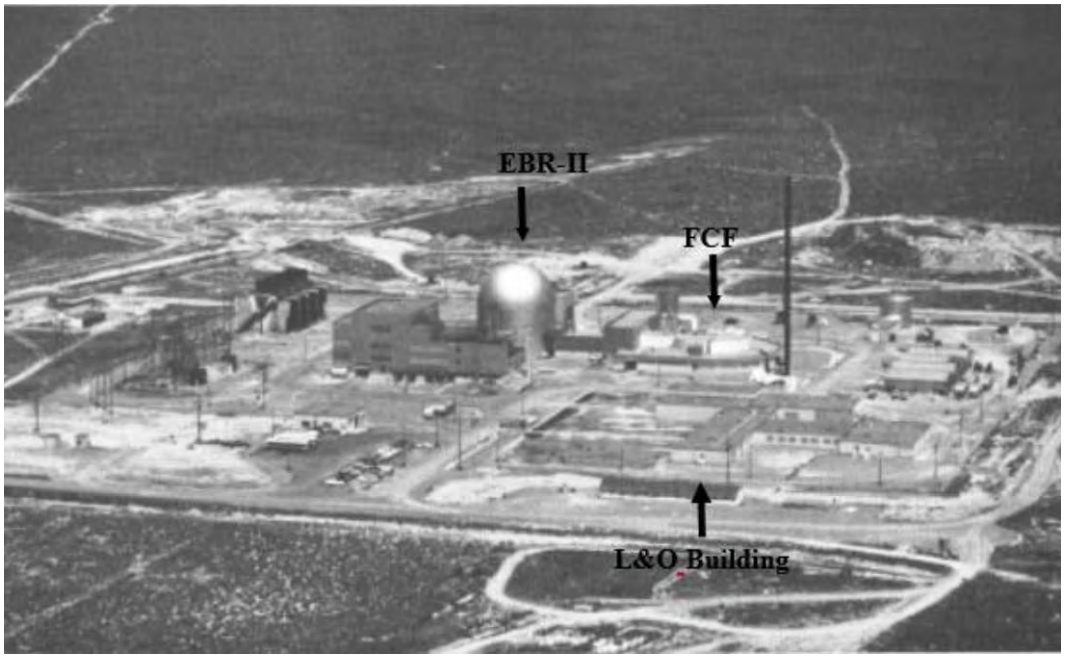
- Started Operation 2/59
- Study fuel meltdowns
- Metal-water reactions and interactions
- Transient behavior of fuels in high-temperature systems
- Neutron radiography
- Remote operation during some transients
- Health Physics monitored and cleared building for reentry



http://www.ne.anl.gov/About/reactors/frt.shtml (2016)

Experimental Breeder Reactor II

- Originally designed and operated with emphasis on demonstrating a complete breeder-reactor power plant with onsite reprocessing of metallic fuel.
- Dry Critical 9/61
- Sodium cooled reactor, “Wet Critical” 11/63



ANL-PIO, undated, early 1960s

EBR-II Radiological Exposures

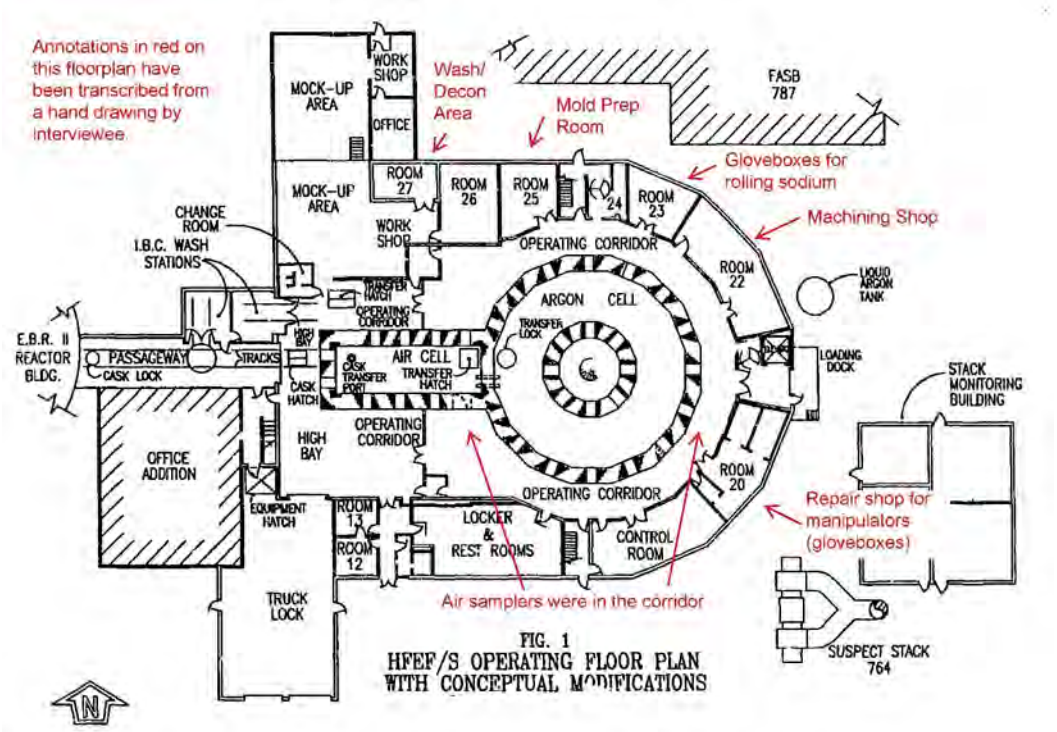
- External dose – some but not tremendous as design (sodium) tends to keep fission products (including volatiles like iodine) bound in system/pool and away from workers while they decay. Some areas did have moderate levels of exposure.
- Workers expressed concern with exposure while cleaning and removing the dross (oxidized tin-bismuth) from the rotating plugs used to move fuel. This area was right above the argon blanket gas. Exposure is primarily due to activation products but some mixed fission products.

EBR-II Radiological Monitoring

- Internal dose primarily beta/gamma. No actinide exposures without beta/gamma exposure. Thus beta/gamma can be used to bound actinides.
- Urinalysis and extensive whole body counting (WBC) of the workforce. Monthly reports indicate approximately 30-35 workers per month. (360-420 per year).
- Workplace monitoring
  - Continuous air monitors throughout building and on exhaust.
  - Routine surveys of the building included checks for alpha contamination.

Fuel Cycle Facility (FCF) Operations

- Operations from 1964-1969 demonstrated a fully functional reprocessing facility.
- Air cell mostly for transfer of materials
- Argon Cell (hot cell filled with Argon)
- Outer rooms initially for support then cold line



FCF Radiological Exposures

- Argon Cell NOT entered until 1978. Extensive monitoring during this refurbishment work. – *Health Physics*

- Air Cell entries were infrequent (according to interviews)
  - Effort to decontaminate before entry.
  - Health physics monitoring before, during and after entry.
  - Usually air samples were taken during work in cell.
  - Beta/gamma contamination levels much higher than alpha and dominated exposure.

- Sub-cell work in basement health physics always accompanied operations and surveyed before and after work.

FCF Radiological Monitoring

- Urine bioassay and whole body counts for workers at FCF
- Routine air monitoring in the passageway, main floor, basement, and roof.
- Routine radiation and contamination surveys (including alpha) throughout the building.

- For most of the work, beta/gamma always present thus actinide exposures can be bounded with ratio as indicated in Technical Basis Document (TBD).

FCF Rad Exposure - Exceptions

- Work in the mold preparation room 25 involving thoria prior to 1967.
  - Air monitoring and routine alpha contamination surveys available in room 25
  - Will develop an exposure model using either air samples or 10% MPC
- Cold Line
  - Continuous low level alpha contamination from uranium in several of the outer loop rooms.
    - Most smears are less than 100 dpm/100cm^2 but some smear results can be as high as few thousand dpm.
    - Air sample data is available and intent is to use air data for exposure model.

Hot Fuel Examination Facility (HFEF-N)

- Operation
  12/1972 - Decon Cell
  3/1975 - Main Cell
- Examine hot or irradiated fuels
- Larger more versatile facility than FCF
- 1978 Neutron RADiography Facility (NRAD)

https://www.inl.gov/wp-content/uploads/2014/10/HFEF-Cell-D12772.jpg

HFEF-N Radiological Monitoring

- Workers on routine whole body count schedule.
  - Ratio method can be used to determine actinide exposure
- Fixed air sampling system (FASS) installed in 1976, *(Health Physics)* however, routine air sampling as early as August 1972
- Routine radiation and contamination surveys were conducted.

Laboratory and Office Building (L&O)

- Started operation 1961
- Analytical laboratories which contained some gloveboxes supported EBR-II and FCF operations.
  - Chemical, metallurgy, and radiological analysis of coolant, fuels, air, etc…
- Hot cells “Junior Caves” would process small samples from fuel cycle.
- Vaults would receive and store some fresh enriched fuel

L&O Radiological Exposure and Monitoring

- Most exposure was beta/gamma, however due to the nature of the activities (chemical separations on samples), some potential for alpha exposure without or limited beta/gamma.

- Highest risk areas were the laboratories and junior caves. However there is extensive radiological monitoring throughout the timeline.
  - Routine air monitoring and contamination surveys in junior cave area and analytical laboratories.

Zero Power Plutonium Reactor (ZPPR)

- Started operation 1969
- Purpose was to construct assemblies that closely resembled various fast reactor designs.
- Design much like ZPR-III (moveable halves) except much larger and versatile.

https://www.flickr.com/photos/argonne/8167913135 (2016)

ZPPR Radiological Exposures

- As with ZPR-III, minimal fission product exposure as the reactor was operated at very low power
- Some potential for uranium exposure in handling fuel plates and pins that were only painted and not clad
- Exposure to plutonium was again very well controlled and caution was used (cladding and verification thereof)
- When a fuel plate was monitored and found to have contamination or if there was some type of mechanical defect with cladding it was bagged and logged as a suspect fuel element

ZPPR Radiological Monitoring

- Five continuous air monitors
  - Each half of the reactor (2), reactor cell near entrance, loading workroom, and storage vault
- Alpha contamination does not seem to be tolerated.
  - Routine smear data indicates relatively low levels of alpha contamination
- Air samples were counted allowing for radon decay until alpha activity was less than 10% MPC.
- Actinide doses can be bounded based on 10% of MPC.

Feasibility of Dose Reconstruction

- Up until 1958 the West site (EBR-I complex) was determined to be infeasible due to limited mixed fission product bioassay and potentially incomplete external dosimetry records.

- Dose reconstruction was determined to be feasible for the East site (EBR-II complex) as there was routine mixed fission product bioassay and air sample data indicating alpha exposures were controlled to less than 10% of the maximum permissible concentration (MPC).

Health Endangerment

- Some workers in the class may have accumulated chronic radiation exposures through intakes of radionuclides at the EBR-I complex of ANL-W.
- NIOSH is therefore specifying that health may have been endangered for those workers monitored at ANL-W who were employed for a number of work days aggregating at least 250 work days.
- What about employees not included in the SEC?
  - NIOSH intends to use monitoring data to conduct partial dose reconstructions for individuals not part of the SEC

Proposed Class

All employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked at the Argonne National Laboratory-West between April 10, 1951 and December 31, 1957 for a number of work days aggregating at least 250 work days, occurring either solely under this employment, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.