Review of NIOSH Strategy for Reconstructing Doses to Workers at Test Area North (TAN)

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Scope of Programs, Campaigns, Research and Activities at Test Area North (TAN)

- Aircraft Nuclear Propulsion Program (ANP) (1952–1961)
- Initial Engine Test (IET)
- Heat Transfer Reactor Experiments (HTREs)

  (Above 3 to be expanded upon later)
- Technical Support Facility (TSF)
  - TAN 607 Hot Shop
  - LOFT (TAN 650)
  - Storage Pool
  - Storage Pads (TAN 790 and 791)
  - Radwaste Liquid Disposal System
  - Storage Building
  - Radiography Facility (TAN 607)
- Water Reactor Research Test Facility (WRRTF)
  - Low Power Test Facility (LPTF)
  - Shield Test Pool Facility (STPF)
- Specific Manufacturing Capability (SMC)

Focus and Scope of TAN Review

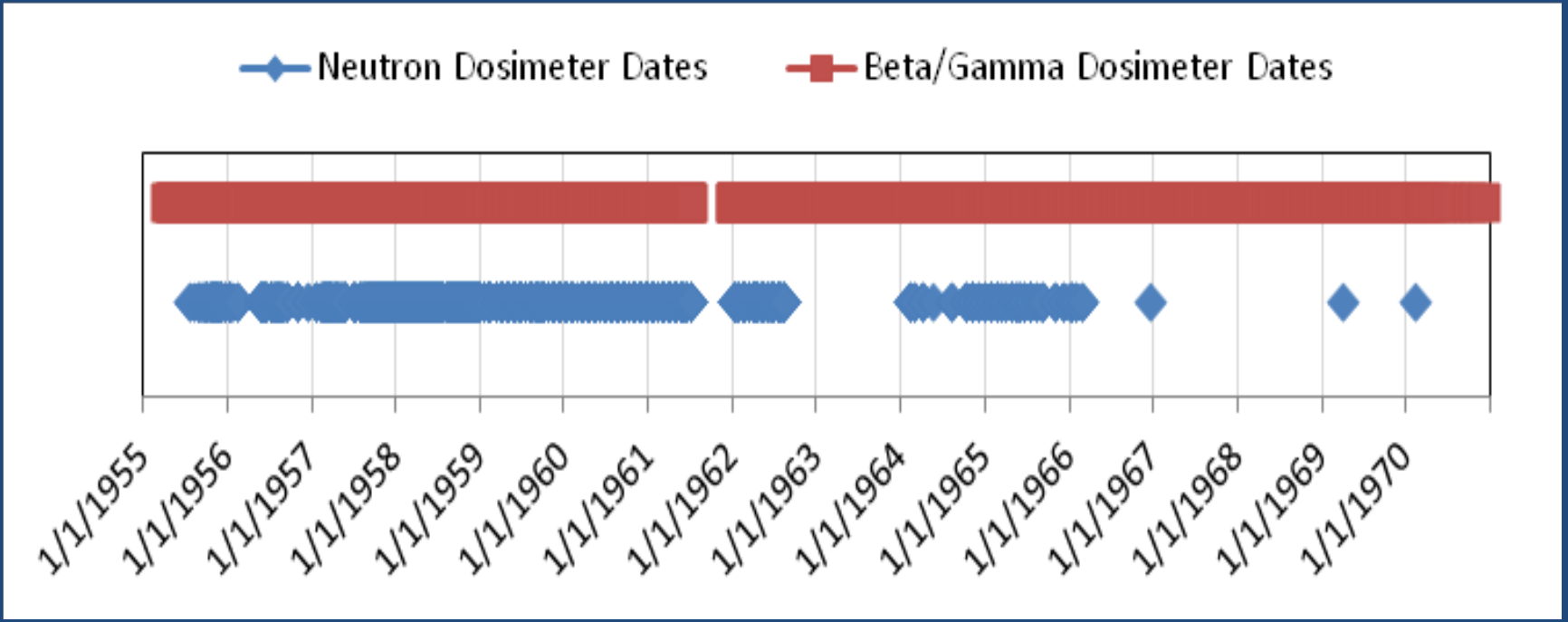
- An evaluation of the completeness of the external dosimetry data at the various TAN facilities
- Applicability of ORAUT-OTIB-0054 and Tables 5-22 and 5-23 of internal dosimetry TBD to the performance of internal DR for facilities at TAN that handled and stored spent and irradiated fuel
- The unique circumstances associated with exposures to airborne effluents from the ANP, which are not addressed in OTIB-0054

REVIEW OF EXTERNAL DOSIMETRY DATA

Review of TAN External Dosimetry Data

- Methods – Performed a search of SRDB records using search terms including: dosimetry, dosimeter, external, personnel, badge, exposure, and film. The following were found and used to assess external data completeness:
  - 37 documents
  - 12,177 pages of records
  - 181,183 beta/gamma readouts
  - 6,665 neutron readouts

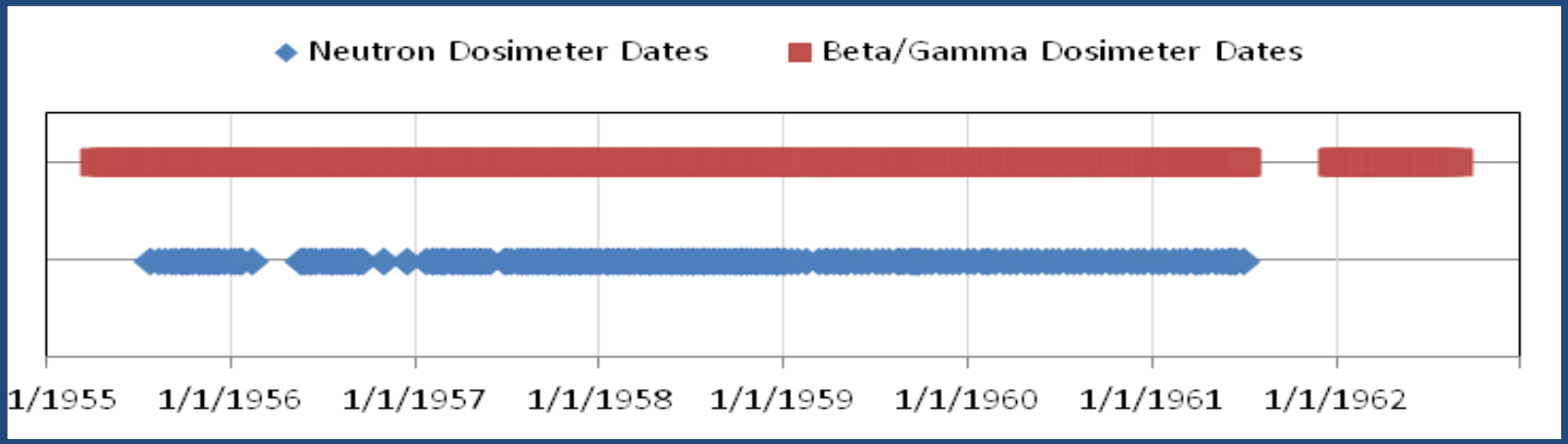
External Dosimetry – TAN as a Whole



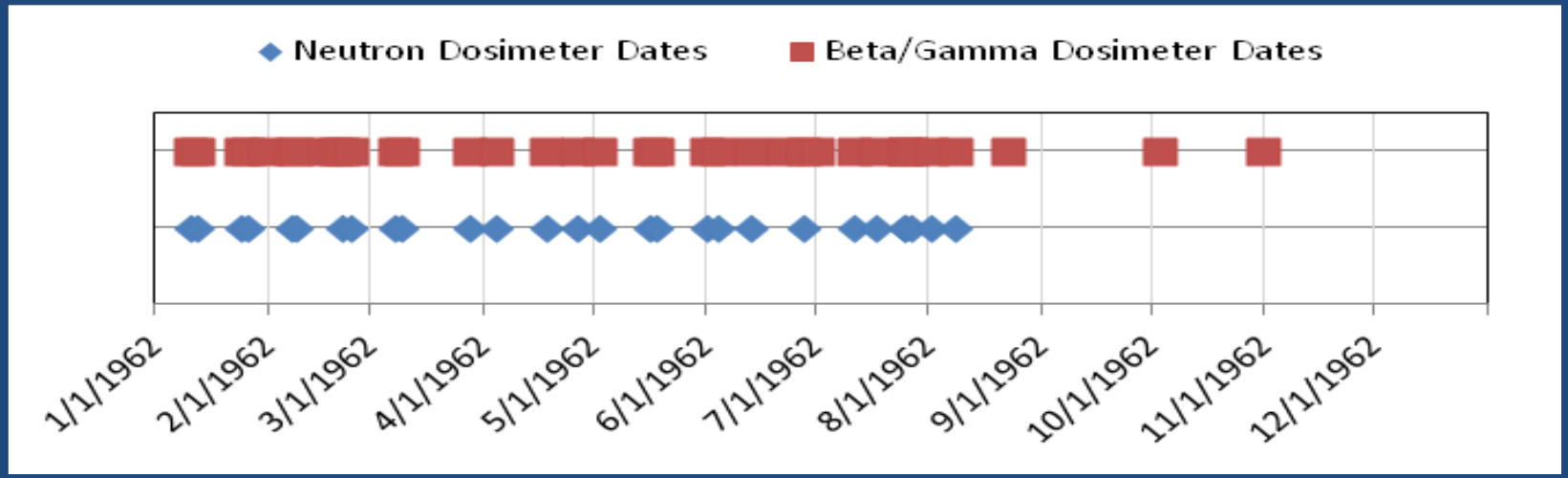
Each point on this graph represents a date for which a beta/gamma or neutron dosimeter change-out was observed within the SRDB documents for a worker corresponding to any area of TAN. There is a small temporal gap in 1961 in the beta/gamma dosimeters, and several gaps in the neutron dosimeters.

External Dosimetry – Sub-Areas of TAN

- Dosimeters Marked ‘ANP’

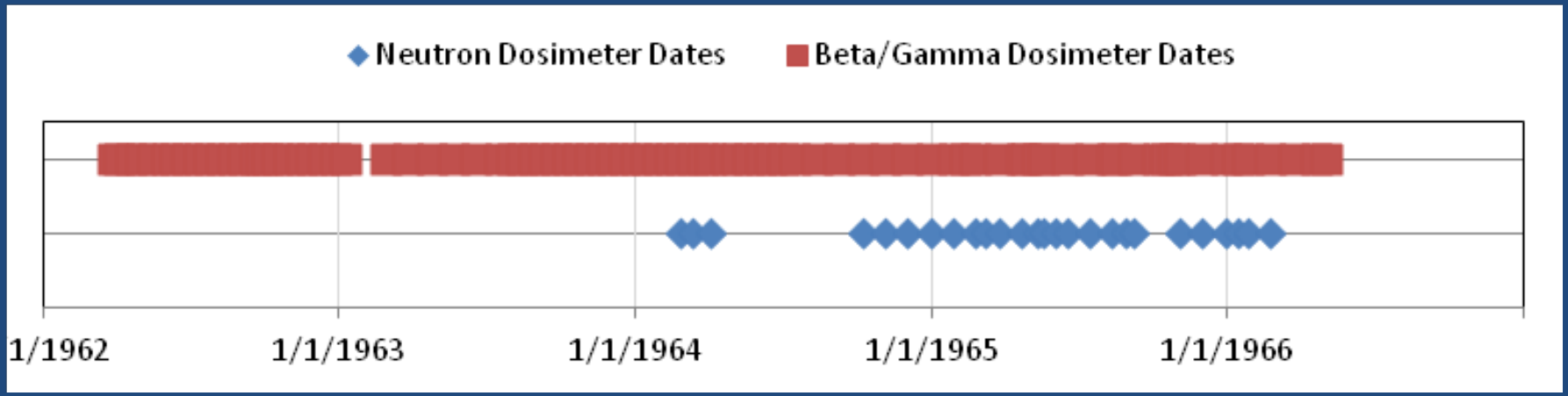


- Dosimeters Marked ‘STPF’

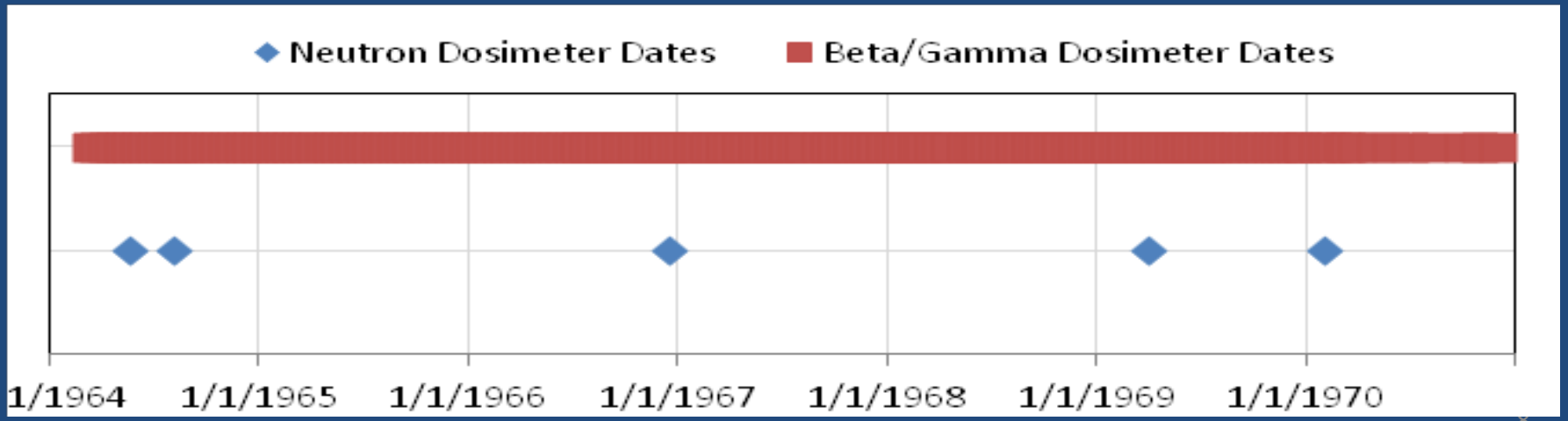


External Dosimetry – Sub-Areas of TAN

- Dosimeters Marked ‘IET or STEP’ (Both seen with code 68)



- Dosimeters Marked ‘TSF’



External Dosimetry – Sub-Areas of TAN

- LPTF
  - Only documents that were labeled ‘excerpts’ were found for LPTF, contained few dozen beta/gamma dosimeters, and few neutron dosimeters.
- ‘TAN’ Only
  - Hundreds to thousands of beta/gamma dosimeters from 9/1962 to 12/1964 only had TAN marked within the dosimetry record. No neutron dosimeters were marked as being ‘TAN’ only.

Observations for TAN

- External dosimetry for TAN as a whole appears to be fairly complete from mid-1955 through part of 1970, with a small gap from June through December 1961
- It is not possible to group the data by subdivisions of TAN; i.e., the data lack adequate granularity
  - Important because activities and research throughout TAN were extremely diverse. It will be difficult to build external dosimetry co-worker models for each subdivision of TAN.
- Neutron dosimetry data appears spotty. The possible reasons for this require further investigation
  - May need additional data capture

Observations for TAN

- We do not believe we can consistently assign external monitoring data to the different work areas, operations, and campaigns within TAN, at least given the data reviewed.
- NIOSH might not be able to build co-worker models for many of the subdivisions of TAN, if co-worker models are necessary. This could be an important SEC issue.

USE OF OTIB-0054 TO RECONSTRUCT INTERNAL DOSES TO TAN WORKERS

Applicability

- TAN opened in 1952 for ANP, with support facilities and programs including TSF, IET, WRRTF. These facilities handled irradiated and spent fuel.
- Irradiated fuel and components from reactors/research facilities were often stored at TAN hot cells, hot shop, and storage pool. All of these facilities had potential for internal exposures

- Irradiated and spent fuels included:
  - ANP Fuel
  - System for Nuclear Auxiliary Power (SNAP) and associated transients (SNAPTRAN)
  - Special Power Excursion Reactor Test (SPERT)
  - Loss of Fluid Test (LOFT) Facility
  - Fuel from Heat Transfer Reactor Experiment (HTRE)
  - Disassembly of SL-1
  - Storage of TMI fuel and debris

Methods*

- ORIGEN simulations to determine if:
  - The ratio of inventories of reference FPs to other FPs, as used in OTIB-0054 (reflect 'conventional' reactors) are reasonable, if not bounding, as compared to these ratios for TAN irradiated fuel
  - The ratio of reference FPs to TRUs as in Tables 5-22 and 5-23 of the TBD (reflect 'conventional' reactors) are reasonable, if not bounding, as compared to these ratios for TAN irradiated fuel
- Evaluated for the purpose of internal DR based on gross beta/gamma urinalyses

*Use of ORIGEN simulation and/or Tables 5-22, 5-23 are <u>not</u> considered useful/appropriate for internal exposure assessment for workers handling spent/irradiated fuel associated with ANP.

Observations/Conclusions

- Based on this modeling exercise for conventional reactor fuel, OTIB-0054 approach is generally claimant favorable when the fuel is not highly enriched, maintains integrity following burn-up, and is at a high power level (e.g., 200 MW)
  - However, this does not follow SC&A's observations regarding indicator radionuclides and assumptions used, based on actual measurements (slide 17).
- Underscores the importance of limiting our observations to general trends and consistent behavior
  - For example, dose estimates based on a 200-day burn model will generally overestimate dose from actinides, when the actual reactor was operated for significantly less time

Observations/Conclusions (continued)

- For spent nuclear fuel associated with ANP, use of OTIB-0054 is inappropriate for the following reasons:
  - Highly enriched (i.e., 93.4%) fuel used in IETs contains limited amounts of U-238, which will result in limited production of Pu-239/240 and other actinides
  - Wafer-thin ribbons of UO_2 and absence of cladding ensured high release fraction by recoil and/or diffusion of many FPs. Most notably are volatile radionuclides (iodine, cesium, etc.)
  - Release and depletion of FPs from fuel elements must further be assumed by the fact that for some IETs, intentional fuel failure (and unintentional fuel failure) resulted from temperatures exceeding 3,200°F

Observations/Conclusions (continued)

- *SC&A's Evaluation of the NIOSH SEC ER Proposed Use of FAP Bioassay Indicator Radionuclides (in Conjunction with OTIB-54 and TBD-5) for assessment of FAP and Actinide intakes at INL* (October 2015) observes that:
  - Actinide intakes assigned using NIOSH's recommendations in TBD-5, Table 5-22 and based on Sr-90 intake values, or Table 5-23 based on Cs-137, are sometimes significantly less than those derived from measured values.
    - Contradicts modeling results
  - Further INL document research is needed to evaluate NIOSH's recommended ratio values, especially for actinides and Cs-137/Sr-90. Records with quantitative radionuclide analyses are especially important.

INTERNAL EXPOSURES FROM AIRBORNE EMISSIONS AT ANP

Aircraft Nuclear Propulsion Program

- After WWII, concern over surprise attack by the Soviet Union generated interest in development of nuclear-powered surveillance aircraft that could remain airborne for long periods of time
- Nuclear reactor for aircraft propulsion would require deviations from conventional reactor design, including fuel designs

Heat Transfer Reactor Experiments (HTREs)

- To test viability of a reactor for aircraft propulsion, 3 different reactors were built (HTRE 1, 2, and 3)
- All 3 were direct cycle, air-cooled
  - Air from turbojet engine compressed and forced past wafer-thin concentric ribbons of nuclear fuel enriched to 93.4%
  - Air heated to 1,250 °F by fuel temps of up to 3,000°F powered turbine engine

Initial Engine Tests (IETs)

- Testing program for 3 HTRE assemblies designated as Initial Engine Tests (IETs), IET#1 through IET #26
- IETs #1, #2, #5, #7, and #9 did not require nuclear power, and had no potential for release of radioactivity or human exposure

Environmental Radioactive Release Quantities with 21 IETs

- In a 1991 two-volume INEL-HDE Task Group Report (*Idaho National Engineering Historical Dose Evaluation),* DOE estimated total release of 755,440 Ci comprised of 51 radionuclides
- Highest releases were from IET #3, #4, and #10, with combined estimated release of ~682,000 Ci (90% of total)

Objective

- Under contract to the CDC, SC&A was tasked to critically review previous IET release estimates reported by the INEL-HDE Task Group in behalf of IET #3, IET #4, and IET #10.
- SC&A's review (issued in 2003) identified errors in the INEL-HDE Task Group model that underestimates environmental releases several fold.
  - For example, the INEL-HDE Task Group estimated the release of 270,000 for IET #10, which is 7.65-fold lower than the revised SC&A estimate of 2,020,000 Ci.
- Key members of the INEL-HDE Task Group attended both meetings and agreed with SC&A's revised estimates for IETs #3, #4, and #10.

Methods

- Review of DOE and CDC reports on the emissions associated with the various IETs that comprised the ANP

Observations

- Independent analyses of airborne emissions associated with the major IETs, as performed by SC&A under contract to CDC, revealed that the DOE significantly underestimated the airborne emissions for the IETs with the largest airborne emission
- Outdoor exposures associated with releases from the ANP need to consider the results of CDC's investigations into these source terms
- Challenges associated with reconstructing outdoor onsite exposures associated with these releases

Comments and Questions?