Secondary Lifetime Assessment Study (U)

Robert B. Bonner, Stephen E. Lott, and Howard H. Woo

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.

RESTRICTED DATA. This document contains Restricted Data as defined in the Atomic Energy Act of 1954. Unauthorized disclosure subject to Administrative and Criminal Sanctions.

Classified by: B. D. Green, Classification Officer
Classification & InfoSec Dept. 7121
01/10/01
Derived from: TCG-NAS-2, Rev. 3/97

Further dissemination only as authorized by the Director of Military Application or directed by the DOE Weapon Data Control Officer (DP-45); requester must possess DOE Q clearance or equivalent. Restricted Data access authorization, need-to-know, and facility approval for receipt and storage of classified documents by the DOE Office of Security assure.

NOTICE: Reproduction of this document requires the written consent of the originator, his successor, or higher authority.
Issued by Sandia National Laboratories, operated for the United States Department of Energy by Sandia Corporation.

NOTICE: This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government, nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represent that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government, any agency thereof, or any of their contractors or subcontractors. The views and opinions expressed herein do not necessarily state or reflect those of the United States Government, any agency thereof, or any of their contractors.
Secondary Lifetime Assessment Study (U)

Robert B. Bonner
Planning and Integration
Y-12 National Security Complex
P.O. Box 2009
Oak Ridge, TN 37381

Stephen E. Lott
Defense Programs Analyses
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185-0423

Howard H. Woo
Defense Technologies Engineering Division
Lawrence Livermore National Laboratory
P.O. Box 808
Livermore, CA 94550

Abstract (U)

This report documents a Defense Program Analysis Group (DPAG) study requested by DP-22 to independently assess secondary lifetimes of the enduring stockpile. The study reviewed Significant Finding Investigations (SFIs) and summarized comments made to the study review team during the interview process. A rank ordering of issues concerning secondary lifetimes was made. Issues and concerns are compared to the Y-12 plant capabilities. Lastly a comparison is drawn between the issues concerning secondary lifetimes and the support that the Enhanced Surveillance Campaign (ESC) is furnishing secondary lifetime estimation.
Acknowledgement

The authors would like to thank all of the individuals who were interviewed and provided information for this study. A draft version of the study was presented at LANL, LLNL, and Y-12 and many useful suggestions were made and incorporated into the study. The authors would like to acknowledge (b)(6) (LLNL), (b)(6) (LLNL), (b)(6) (LANL), (b)(6) (LANL), and (b)(6) (Y-12) for assisting as points-of-contact during the course of this study. In addition, the authors would like to thank (b)(6) (LANL), (b)(6) (LLNL), and (b)(6) (LANL) for reviewing this final document.
DPAG Secondary Lifetime Assessment Study (U)
December 2000

Robert Bonner (Y-12)
Stephen Lott (SNL)
Howard Woo (LLNL)
During the course of the study, the individuals listed on this slide were interviewed to gain their perspective on age related secondary issues in the enduring stockpile. At LLNL and LANL, the designers, system engineers, surveillance engineers, and material scientists were interviewed, some of them multiple times. At Y-12, the production engineers, project engineers, and development scientists were interviewed.

In order to facilitate the study, LANL, LLNL, and Y-12 identified point(s) of contact (POC) for the study team to interact with. The LANL POC were (b)(6) (MST-6) and (b)(6). The LLNL POC were (b)(6) (LLNL Enhanced Surveillance Campaign program manager) and (b)(6) (A-Division).
Presentation Outline

- Study tasking and background
- Review of secondary Significant Finding Investigations (SFI's) and summary of secondary issues, not apparent in SFI's, from interviews of subject matter experts
- Roll-up of current state of knowledge of secondary aging
- Workload and facility planning issues
- Enhanced Surveillance Campaign (ESC) support of secondary lifetime estimation
- Summary/Conclusions

This briefing is divided into six sections.

- The first section reviews the study tasking and some pertinent background material.
- The second section is the longest section in the briefing and is a review of the Significant Finding Investigation (SFI) reports, both open and closed, and summarizes comments made to the study team during the interviews.
- The third section summarizes the issues discussed in the second section, and identifies and ranks life-limiting concerns. Recommendations are made on which systems need refurbishment and which systems need close monitoring.
- The fourth section reviews the Y-12 workload and facility planning requirements based on the recommendations made in the third section. Lead time requirements are identified for processes to support refurbishments.
- This fifth section reviews the Enhanced Surveillance Campaign (ESC) secondary lifetime assessment goals and an analysis of ESC Goal #1 - Lifetime Assessment.
- The last section summarizes the study findings based on the taskings stated in the first section.
Study Request Letter:  

"This memorandum requests the Defense Programs Analysis Group (DPAG) to independently characterize and evaluate:

- the current state of knowledge and maturity in defining aging mechanisms in secondaries,
- any risks and weaknesses in the current strategy for assessing and validating secondary lifetimes,
- the relative importance of the issues which must be addressed to successfully predict secondary lifetimes,
- and the integration of secondary lifetimes findings into NWC workload and facility planning."

In January 2000, Eric Cochran DP-22 requested the DPAG to independently assess secondary lifetimes. This slide presents the salient points from the correspondence. Note that this study focused on analyzing secondary lifetimes, and therefore, it was not designed to be a comprehensive review of the Enhanced Surveillance Campaign (ESC) CSA/Case MTE. In addition, note that the study tasking was to address risks and weaknesses, and therefore, shortcomings in the current approach are identified as opposed to articulating programmatic strengths or successes. In the Summary/Conclusions section, the study findings are arranged to address these four taskings.
Definition of "Lifetime"

The term "Lifetime" used in this study refers to the time when the assessed degradation of secondary performance creates the need to modify the weapon to maintain original certification.

Short of understanding precise end-of-life, it is valuable to understand potential service life extension.

The definition of Lifetime as used in this study is the time when the assessed degradation has created a need to modify the weapon to maintain the original certification.

Assessed, in lieu of conducting an underground test (UGT).

Original certification, because lifetime is dependent on maintaining original certification, and not reducing capability to extend lifetime.

Beyond attempting to predict when a weapon lifetime is exhausted, it is valuable to understand what are the potential actions to extend lifetimes for the individual systems.
This slide illustrates the basic terms used to describing secondaries. A simplified schematic of a W88 secondary is shown as an example. Many of the secondary components and materials have unclassified code names, e.g., Fogbank or Seabreeze. These terms will be defined when they are introduced.

The terms “Canned Sub-Assembly” (CSA) and “secondary” are not synonymous. All CSAs contain secondaries, but not all secondaries are CSAs since some secondaries are not sealed in a “can” (e.g., W84).
As a reminder, some of the secondaries in the enduring stockpile are over 30 years old. The oldest secondaries are in the B61-7/11 which were produced from 1967 to 1971 for the B61-0/1 and reaccepted for the B61-7 build from 1985 to 1990. Note that the "W88 Rebuild" line consists of both the first and second rebuilds. Descriptions of these two rebuilds are detailed on slide 35. The W87 LEP started in 1998 and is currently ongoing.

This data was compiled by (b)(6) of Y-12.
Many of the Secondary Aging Concerns are Related to Uranium Corrosion

In a general sense for a secondary life limiting mechanism is due to corrosion, however, the specific reaction mechanism can be quite complicated:

1. Hydrogen in the secondary can be generated via hydrolysis or material decomposition. If by hydrolysis, the water could have been transported from elsewhere in the secondary. Some possible mechanisms of hydrogen generation are:
   - Material decomposition through possible reaction with water
2. Mass transport of hydrogen throughout the secondary
3. Reaction of hydrogen
   - Consumption of
   - Reaction at a specific uranium site; $2U + 3H_2 \rightarrow 2UH_3$

Many of the secondary aging concerns are related to uranium corrosion and any changes in geometry or material distribution that might result; therefore, a review of uranium hydride corrosion is helpful. In essence, uranium hydride formation in a secondary is a three step process; hydrogen production, hydrogen transport, and hydrogen reduction.

1. Hydrogen is typically produced from a reaction of water

2. Hydrogen is transported throughout the secondary...
3. ...and reacts with a uranium component.

If the free hydrogen reacts with a uranium component, then the concern is with the location of the resulting corrosion ($UH_3$). A uniform sheen of corrosion would be far less serious than an equivalent amount of localized corrosion.
Presentation Outline

- Study tasking and background
- Review of secondary Significant Finding Investigations (SFI's) and summary of secondary issues, not apparent in SFI's, from interviews of subject matter experts
- Roll-up of current state of knowledge of secondary aging
- Workload and facility planning issues
- Enhanced Surveillance Campaign (ESC) support of secondary lifetime estimation
- Summary/Conclusions
Our Information was Obtained From SFI Reports and From Designers & Engineers

- Significant Findings Investigation (SFI) reports from 1980 (or FPU) to the present concerning secondaries and radiation cases for the enduring stockpile were reviewed.
- Designers and engineers responsible for weapon systems at LLNL, LANL, and Y-12 were interviewed to gain their perspective on concerns that have and have not been documented in the SFI reports.
- Historically, not all concerns have generated SFI's due to an evolution in the application of the SFI process.

The information used to construct an assessment of secondary lifetimes was from two principal sources:
- SFI database and associated files, and Y-12 Quality Evaluation (QE) reports.
- Interview comments with subject matter experts.

For each of the weapon systems, the SFI data was reviewed from 1980 (or FPU) to the present. 1980 was chosen based on the availability and completeness of the SFI data.

The individual designers and engineers were interviewed to gain their perspective on potential lifetime issues and concerns. The information from these subject matter experts sometimes gave a different perspective than the SFI data.

- A particular concern may have not yet initiated an SFI, but data is still being accumulated by designers and engineers.
- Simply counting the number of SFIs pertaining to an issue may not give an appropriate perspective of the relative seriousness of the concern.
- The SFI process at LANL and LLNL has changed in the recent past. Historically, issues were sometimes addressed at LANL and LLNL without documentation through the SFI process.
This slide shows the B61 SFI's from 1980 to the present.

85-54-B61-13 & 87-28-B61-11, 85-54-B61-13 involved

DELETED

were found. It was concluded that the two faulty units could have been found from a more sensitive lot. 87-28-B61-11 involved another

90-24-B61-08 A loose nut

Engineers concluded that the CSA would have functioned correctly since the leak rate was very slow.

94-12-B61-05 During cycle 25 surveillance, the N₂ concentration (14% measured versus ~0% expected) and the total pressure (340 torr measured versus 250 torr expected) were abnormally high. The CSA was rechecked and was found to be leak tight.

Based on argon concentration, the conclusion was that air was introduced to CSA prior to crimp-off during production.

97-03-B61-02 SFI currently open

DELETED

as noted by radiography.

98-19-B61-07 SFI currently open. Data compiled from 15 previous Stockpile Lab Tests (SLTs) noted a number of concerns.

DELETED
One of the activities during surveillance of secondaries is to measure the amount of corrosion present in the secondary during disassembly and inspection (D&I) at Y-12. The amount of UH corrosion is expressed in terms of grams of uranium corroded. If a is also measured. There are a number of concerns with the accuracy of the corrosion measurements, however, the data is still indicative of the impact. This slide shows a plot of the measured corrosion versus the age of the secondary at dismantlement. The data is from the Y-12 Quality Evaluation (QE) reports for the B61 family. While the data is somewhat scattered, the measured corrosion. The four arrows associated with the data signify that this data is preliminary and the data values should be viewed as a minimal measured corrosion level for these units.
LANL Recent Analysis Indicates the Potential Impact of

This plot shows the based on a series of underground nuclear tests (UGT). Typically, the secondary yield is

Prior to the UGT, the unit was assembly. Due to handling of the unit from the surface to the UGT location down hole.
Summary of B61 SFI's, QE Reports and Interview Discussions

- The **DELETED** (B61-7/11) have significantly higher (B61-3/4/10).

- **DELETED** have been observed since SLT 5 (1975).

- On average, units with an **DELETED** than previous units.

- Impact on **DELETED** based on the one available set of UGT data.

To summarize, the B61 family issues from the SFIs, QE reports, and interview discussions are:

- The **DELETED** (Mods 7/11) have **DELETED** have been noted in the QE reports since 1975 (SLT5). The first SFI on this issue was opened in 1998.

- The **DELETED** impact of the

- While there is only one UGT data point,
There is only one W62 SFI since 1980 (FPU - 1970).

99-43-W62-02 SFI currently open, however during cycle 28, it will open. An SFL.

All of the interviewees on the W62 secondary had very favorable comments on aging and design related concerns and no other significant issues were raised.
The only CSA SFI on the W62 Occurred Recently on Cycle 28 (SFI 99-43-W62-02) 

- Cycle 20

- Cycle 28 had same

Triggered an SFI.

This slide compares photographs from a typical surveillance unit (cycle 20) with the surveillance unit that triggered the W62 SFI (cycle 28). Note that in both photographs, there is a [DELETED] on cycle 28. In addition, on cycle 28 there is a [DELETED].
This slide shows the W76 SFI's from 1980 to the present (FPU - 1978).

93-05-W76-02 This SFI was opened due to SLT15 (S/N 1499). This SFI initiated significant effort to radiograph W76 CSAs.

94-11-W76-02 SFI currently open. During radiography, the internal assembly was found to have no uranium.

94-24-W76-04 Due to SFI 93-05, an analysis was conducted to examine the correlation of hydriding with similar certification profiles and were disassembled. Two additional units were identified.

94-25-W76-05 During surveillance, a

95-15-W76-01 Due to SFI 93-05, additional units were sampled and radiographed. Low density spots indicated possible corrosion.

96-12-W76-01 Two surveillance units had abnormal gas compositions indicating that air leaked back into the CSAs after certification.

97-07-W76-01 During investigation of SFI 93-05, 12 Six of the 12 were returned to PX and radiographed. None of the six had corrosion like S/N 1499, however, two units had.
Multiple UH₁ Sites Were Found on the from W76 SLT15

- SLT15 was among the
- SLT15 was an early build (4/79) and was disassembled after 14 years (8/93).
- Note: This SLT initiated SFI 93-05-W76-2.

Photograph from W76 SLT15
This is a photograph from the Y-12 OE report for SLT 15, shown in the photograph) prior to disassembly.

Although the uranium corrosion on this unit is
although in a different location than for the W62 SLT 28.
This slide shows two additional photographs from SLT 15. The left photograph shows

DELETED

DELETED

DELETED
This graph shows a plot of the measured corrosion as a function of the age of the W76. As stated with the B61 corrosion data (slide 13), there are a number of concerns with the incorporation of the corrosion measurement. However, the data does illustrate that the measured corrosion limits appear to be constant over time. Note that the measured corrosion for SLT 1 (the data point with the upward arrow) was considerably higher than the trend would have predicted.
Radiation Case Concerns

- Test results on 15 year old cases show a change in mechanical properties. While the properties remain acceptable at the 15 year mark, the changes could be more serious at the 30 year timescale.

(resulting from the production process) has been noted as shown in the photograph by the variation in surface color. The variation in surface color is surmised to be due to the different.
Summary of W76 SFI's, QE Reports and Interview Discussions

- Some of the [DELETED]

- It is unclear how long this issue may have existed in the stockpile. SFI 94-11-W76-02 is open to resolve this issue.

- Changes in properties of the radiation case may be accelerated due to [DELETED]

- Impact on performance of these issues is not well yet characterized.

To summarize, the issues concerning the W76 from the SFIs, QE reports, and interview discussions are:

[DELETED]

- There are [DELETED] An SFI is open to resolve this issue.

[DELETED] However, the degree that these variations impact the weapon performance is unknown. There is a task under the Enhanced Surveillance Campaign (ESC) that addresses this issue.
This slide shows the W78 SFIs from first production unit (FPU - 1978) to the present.
94-13-W78-01 On cycle 15, adhesive was noted joining the inner surface of...
reliability was assessed.
99-36-W78-06 SFI currently open.
00-21-W78-01 SFI currently open. Two units chosen for D&I studies.
For comparison purposes, the small photograph in the upper left-hand corner is from a previous surveillance unit and illustrates the association with the lower right-hand corner of the slide shows the loss of the

DELETED

DELETED

DELETED

DELETED

DELETED

DELETED

DELETED

DELETED

DELETED

DELETED

DELETED

DELETED

DELETED

DELETED

DELETED

DELETED
There is a Concern with the W78

- Two of the 24 W78 secondaries disassembled by Y-12 had
- DELETED
- Based on shelf life program and D & I of CSA's, a well...

- On SLT 12 and SLT 17.
- SLT 12 was certified in August 1980 and D & I in April 1991.
- SLT 17 was certified in April 1980 and D & I in June 1997.

A "failure" is defined by a...

Both of these units were certified in 1980 and were disassembled...

Two of 24 W78 secondaries disassembled by Y-12 have had a failure in the 1990's.

DELETED
DELETED
DELETED
DELETED
DELETED
DELETED
DELETED
DELETED
DELETED
SECRET RESTRICTED DATA

Secret Restricted Data

W80 Secondary SFI's since FPU

DELETED

There have not been any W80 secondary SFI's filed FPU (1983) to the present. Interviews with subject matter experts did not raise any indication of concern with this system.

DELETED
Comments on B83 Secondary SFI's since FPU

- The three older SFI's (84-37-B83-07, 87-21-B83-04, 89-05-B83-01) were assessed to have no impact to the stockpile. Production procedures were changed due to two of the SFI's (84-37-B83-07, 87-21-B83-04).
- The other SFI's are relatively new and assessments have not been determined.

Although there are six B83 secondary SFI's from FPU to the present, the three older SFI's were assessed to have no impact on the stockpile and production procedures were changed as a result of two of the SFI's. The SFI's opened in FY99 are relatively new and the final assessments are yet to be completed.