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~~Nuclear Weapon Data • Sigma 1~~

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Secondary Lifetime Assessment Study (U)

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

Prepared by
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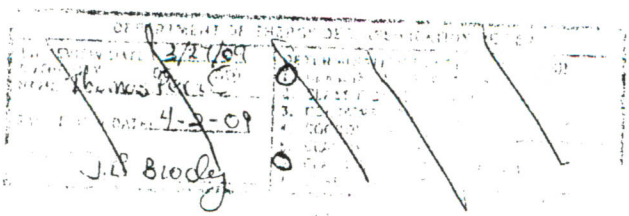

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Secondary Lifetime Assessment Study (U)

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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.

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DPAG

DPAG Secondary Lifetime Assessment Study (U)

December 2000

Robert Bonner (Y-12)
Stephen Lott (SNL)
Howard Woo (LLNL)

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Classification Officer
Date: 12/14/00
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Acknowledgements

DPAG

- LANL: (b)(6)
- LLNL (b)(6)
- Y-12: (b)(6)

* - Points of contact

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page 2

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). (b)(6)

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Presentation Outline

DPAG

- 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

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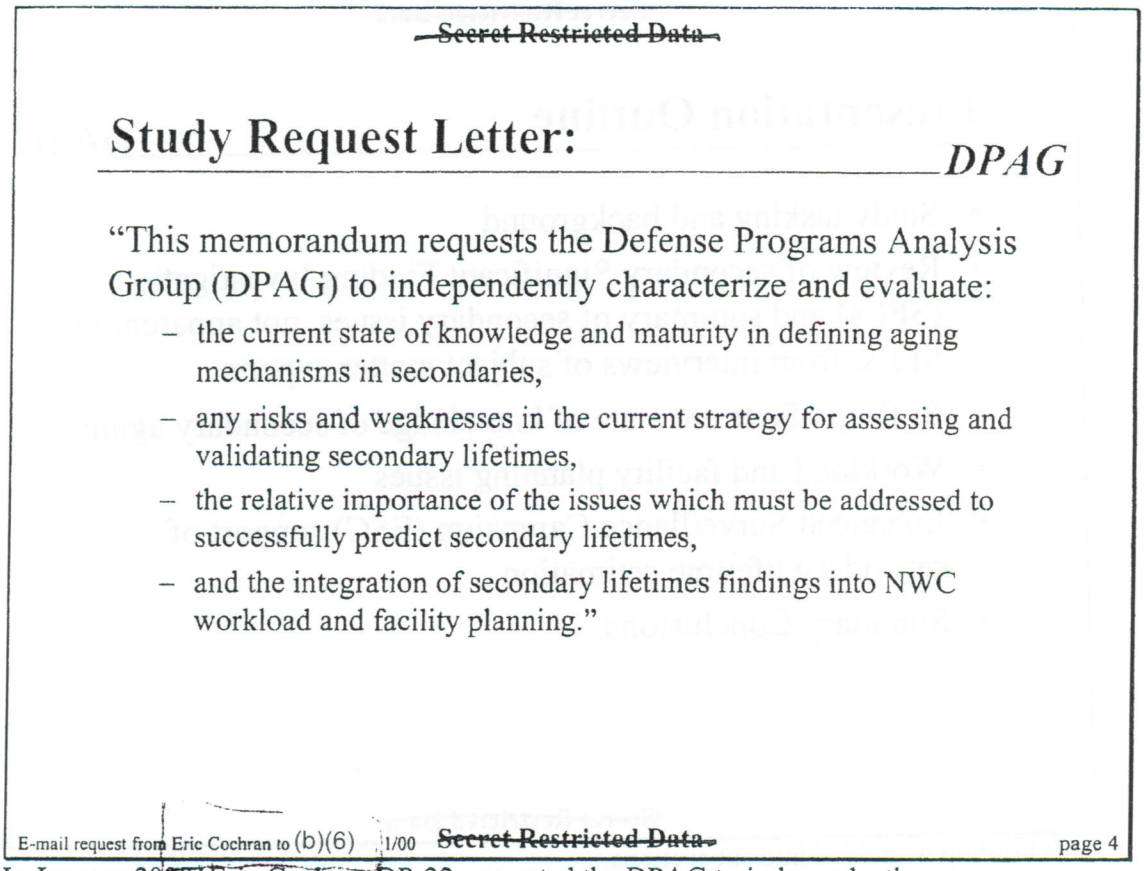
page 3

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.



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.

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Definition of "Lifetime"

DPAG

- 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.

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page 5

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.

~~Secret Restricted Data~~

Generic Secondary Assembly and Terms

DPAG

DOE b(3)

DOE b(3)

DELETED,

DOE b(3)

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).

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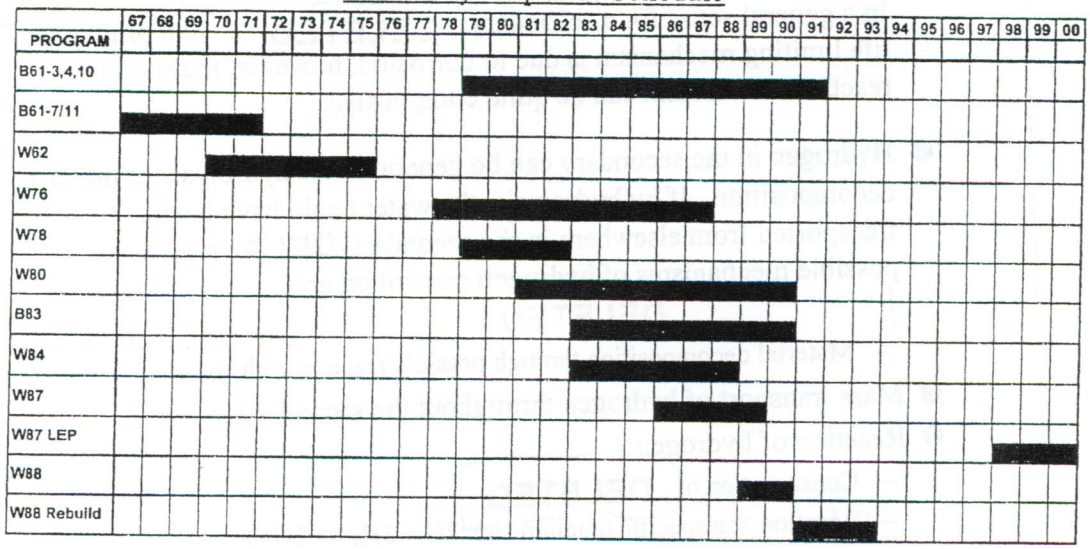
Some of the Secondaries in the Stockpile are Over 30 Years Old

DPAG

Secondary Shipment Schedule



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page 7

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 on-going.

This data was compiled by (b)(6) of Y-12.

~~Secret Restricted Data~~

Many of the Secondary Aging Concerns are Related to Uranium Corrosion

DPAG

In a general sense for a secondary DELETED the principal 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 DELETED Some possible mechanisms of hydrogen generation are:
   DELETED
   - Material decomposition through possible reaction with water
2. Mass transport of hydrogen throughout the secondary
3. Reaction of hydrogen
   - Consumption of DELETED
   - Reaction at a specific uranium site; $2U + 3H_2 \Rightarrow 2UH_3$

~~Secret Restricted Data~~

page 8

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(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

   DELETED

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

   DELETED

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 DELETED would be far less serious than an equivalent amount of localized corrosion

DELETED

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

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Presentation Outline

DPAG

- Study tasking and background
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- Summary/Conclusions

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page 9

This section is a review of the enduring stockpile secondary Significant Finding Investigations (SFIs), both open and closed, and a summary of comments made to the study team during the interview process.

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Our Information was Obtained From SFI Reports and From Designers & Engineers *DPAG*

- 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.

~~Secret Restricted Data~~ page 10

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.

~~Secret Restricted Data~~

B61 Secondary SFI's since 1980

DPAG

DELETED

DOE b(3)

DOE b(3)

This slide shows the B61 SFIs 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 DELETED from a more sensitive lot. 87-28-B61-11 involved another

90-24-B61-08 A loose nut DELETED 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 N_2 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.

DELETED 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 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

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

~~Secret Restricted Data~~

The B61-7/11 Secondary Has Some Specific Aging Concerns

DPAG

DOE b(3)

DELETED

DOE b(3)

Comments from interviews
Drawing from SAND94-2174

~~Secret Restricted Data~~

page 12

This slide shows a figure of

DELETED

DOE b(3)

Mods 3, 4, and 10 units

DELETED

DOE b(3)

- DELETED

DOE b(3)

- A second concern results from the presence

DELETED

DOE b(3)

DOE b(3)

It is not possible to quantify the impact of this "flood plain"

DELETED

DOE b(3)

~~Secret Restricted Data~~

DELETED the B61 Units Significantly Impacts Measured Corrosion DPAG

DOE b(3)

DOE b(3)

DOE b(3)

DELETED

Data from B61 QE reports ~~Secret Restricted Data~~ page 13

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_3 corrosion is expressed in terms of grams of uranium corroded. If a DELETED 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 DELETED

DOE b(3)

DOE b(3)

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 DELETED

DOE b(3)

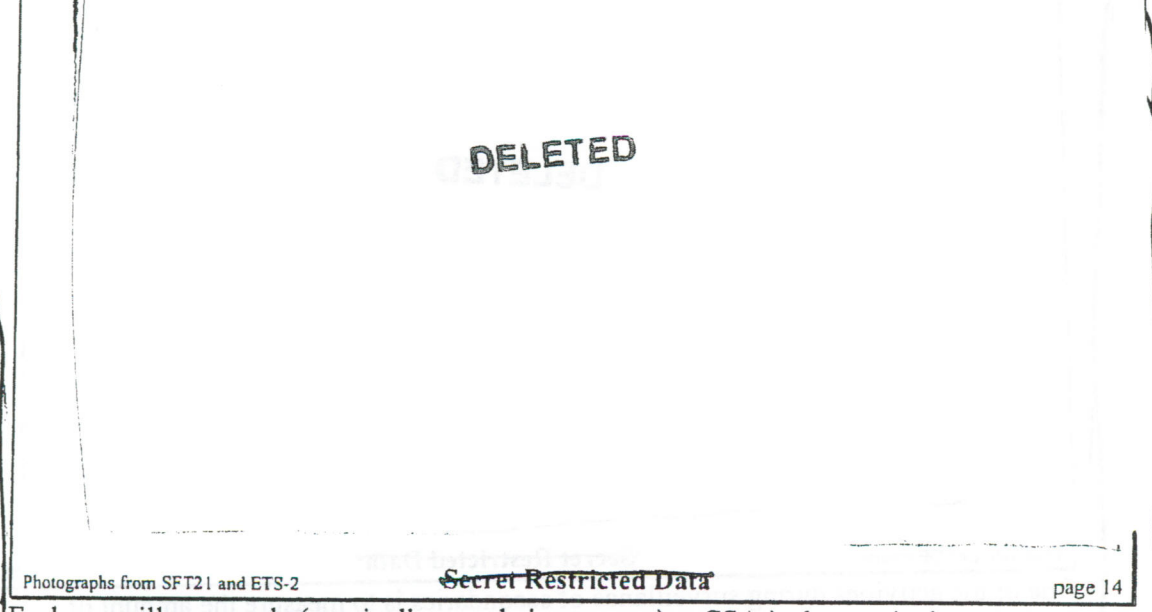
DOE b(3)

The four arrows associated with the DELETED data signify that this data is preliminary and the data values should be viewed as a minimal measured corrosion level for these units.

DOE b(3)

~~Secret Restricted Data~~

Some B61 DELETED Show Corrosion DPAG



Photographs from SFT21 and ETS-2 ~~Secret Restricted Data~~ page 14

Each surveillance cycle (nominally a cycle is one year), a CSA is destructively examined. This slide shows photographs of DELETED from two different surveillance CSAs. ETS-2 (the right photo) was built in 1967 and disassembled in 1984. Note the development of DELETED The photograph in the lower right hand side shows the staining from the UH_3 corrosion product (i.e., "flood plain"). The left photograph shows DELETED during cycle 21 surveillance. This CSA was built in 1967 and disassembled in 1992. Although these DELETED no SFI was issued at the time of disassembly.

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

~~Secret Restricted Data~~

LANL Has Correlated Corrosion DELETED to Processing Parameters DPAG

- All units were B61-0 or B61-1,
- DELETED has been modeled based on age of unit, volume of gas pumped during certification, and certification time.
- DELETED
- Uranium composition, not included in model, DELETED

DELETED

(scale is in inches)

~~Secret Restricted Data~~

page 15

LANL has performed an analysis to understand the impact of processing parameters and the age of the unit on DELETED A LANL analysis showed that DELETED can be predicted (0.92 correlation) by using a statistical model based on the age of the unit, the volume of gas removed during certification time on station during certification. Note that the so for some of the units, a significant

All of the DELETED

The plot shows two sub-populations in the data. The data associated with the ▪ symbol are from units with DELETED prior to April 1969 and the units associated with the × symbol are from the units manufactured with

DELETED

DOE b(3) DOE b(3) DOE b(3) DOE b(3) DOE b(3) DOE b(3) DOE b(3) DOE b(3) DOE b(3)

~~Secret Restricted Data~~

LANL Recent Analysis Indicates the Potential Impact of DELETED DPAG

DELETED

DELETED

This plot shows the DELETED for the B61-3 based on a series of underground nuclear tests (UGT). ~~Typically,~~ the secondary yield is

DELETED

Prior to the UGT, the unit was radiographed at the surface. DELETED assembly. Due to handling of the unit from the surface to the UGT location down hole,

DELETED

~~Secret Restricted Data~~

Summary of B61 SFI's, QE Reports and Interview Discussions

DPAG

- The DELETED (B61-7/11) have significantly higher DELETED (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.

~~Secret Restricted Data~~

page 17

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

- The DELETED (Mods 7/11) have DELETED
- Corrosion related DELETED have been noted in the QE reports since 1975 (SLT5). The first SFI on this issue was opened in 1998.
- The impact of the DELETED
- While there is only one UGT data point, DELETED

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W62 Secondary SFI's since 1980

DPAG

DOE b(3)

DELETED

DOE b(3)

page 18

There is only one W62 SFI since 1980 (FPU - 1970).

99-43-W62-02 SFI currently open.

however during cycle 28,

DELETED

opening of an SFL

DOE b(3)

DOE b(3)

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.

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The only CSA SFI on the W62 Occurred Recently on Cycle 28 (SFI 99-43-W62-02) DPAG

- Cycle 20 DELETED
- Cycle 28 had same DELETED

triggered an SFI.

DELETED

page 19

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, DELETED In addition, on cycle 28 there is a

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

~~Secret Restricted Data~~

DOE b(3)

W76 Secondary SFI's since FPU

DPAG

DELETED

DOE b(3)

page 20

This slide shows the W76 SFIs from 1980 to the present (FPU - 1978).

93-05-W76-02 This SFI was opened due to SLT15 (S/N 1499).

DELETED

This SFI initiated significant effort to radiograph W76 CSAs.

94-11-W76-02 SFI currently open. During radiography, the internal assembly was found

DELETED

no uranium hydriding was noted.

94-24-W76-04 Due to SFI 93-05, an analysis was conducted to examine the correlation of

DELETED

Two additional units were identified with similar certification profiles and were disassembled.

an SFI was opened.

94-25-W76-05 During surveillance, a

DELETED

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

DELETED

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

DELETED

Six of the 12 were returned to PX and radiographed. None of the six had corrosion like S/N 1499, however, two units had

DELETED

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

~~Secret Restricted Data~~

Multiple UH, Sites Were Found on the DELETED from W76 SLT15 DPAG

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

DELETED

Photograph from W76 SLT15 ~~Secret Restricted Data~~ page 21

This is a photograph from the Y-12 OE report for SLT 15.

DELETED

shown in the photograph) prior to disassembly. as

Although the uranium corrosion on this unit is DELETED

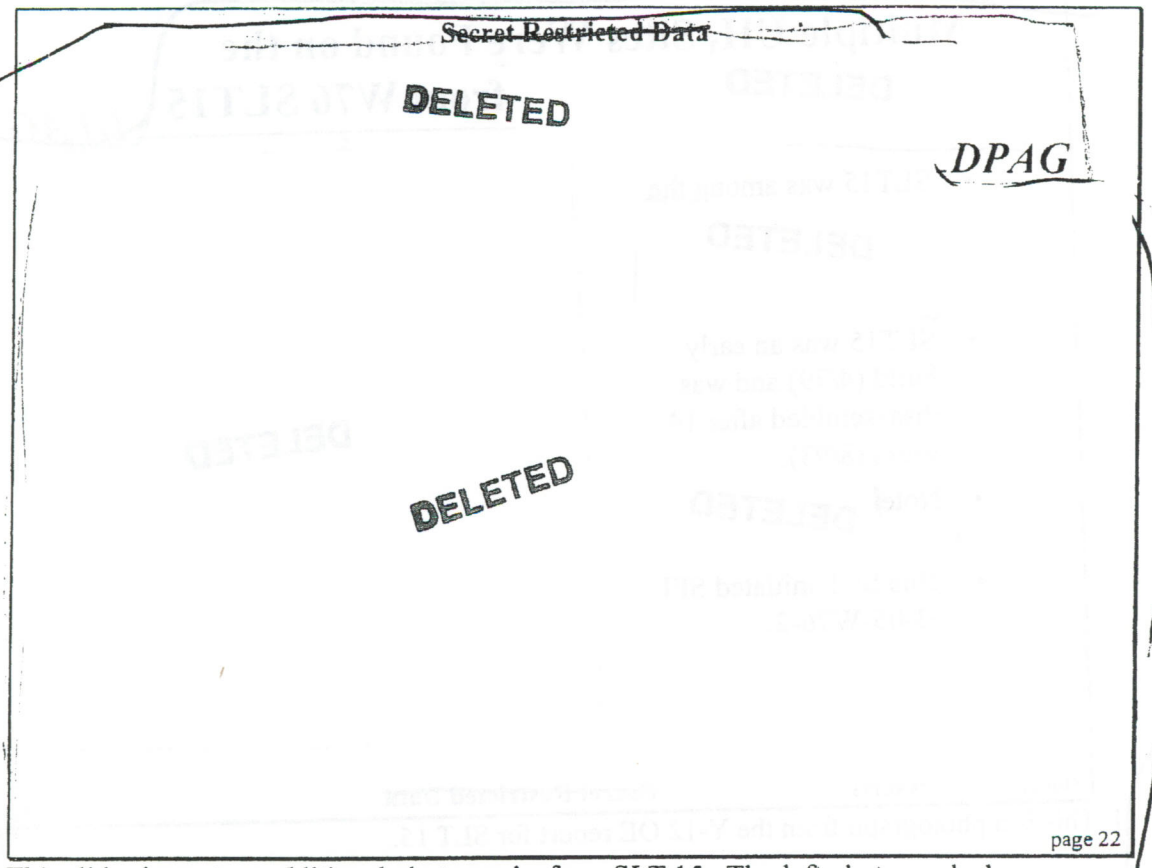
although in a different location than for the W62 SLT 28.

DOE b(3)

DOE b(3)

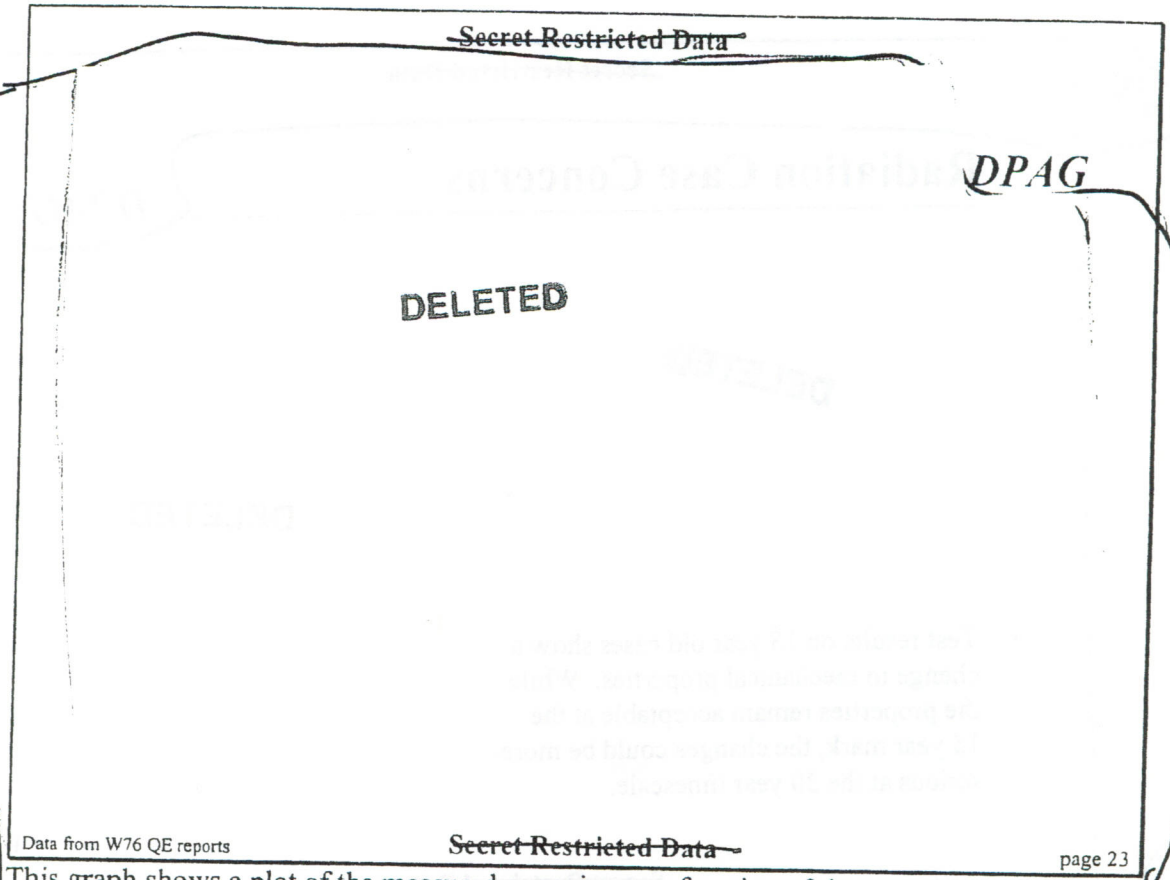
DOE b(3)

DOE b(3)



This slide shows two additional photographs from SLT 15. The left photograph shows the DELETED

DOE b(3)



DOE b(3)
DOE b(3)

This graph shows a plot of the measured corrosion as a function of the age of the W76 secondaries at dismantlement. While the data is somewhat scattered, the measured corrosion DELETED appears to increase over time while the measured corrosion units appears to be constant over time. Note that the measured corrosion for SLT 15 (the data point with the upward arrow) was considerably higher than the trend would have predicted.

DOE b(3)
DOE b(3)

As stated with the B61 corrosion data (slide 13), there are a number of concerns with the accuracy of the corrosion measurement. however. the data does illustrate that the incorporation of DELETED

DOE b(3)

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DOE b(3)

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Radiation Case Concerns

DPAG

DOE b(3)

DOE b(3)

DELETED

DELETED

- 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.

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page 24

DELETED

DOE b(3)

(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

DOE b(3)

DELETED

~~Secret Restricted Data~~

Summary of W76 SFI's, QE Reports and Interview Discussions

DPAG

- 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.

~~Secret Restricted Data~~

page 25

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

DELETED

An SFI is open to resolve this issue.

- There are 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.

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W78 Secondary SFI's since FPU

DPAG

DELETED

page 26

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 DELETED No impact on safety or reliability was assessed.

99-36-W78-06 SFI currently open. DELETED

00-21-W78-01 SFI currently open. Two units chosen for D&I studies. DELETED

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

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DOE b(3)

DPAG

DOE b(3)

DELETED

These photographs illustrate DELETED Cycle 21. The larger photograph and the associated enlargement in the lower left hand corner of the slide shows the loss of the

DELETED

DOE b(3)

For comparison purposes, the small photograph in the upper left hand corner is from a previous surveillance unit and illustrates DELETED

DOE b(3)

DOE b(3)

~~Secret Restricted Data~~ DELETED

There is a Concern with the W78

DPAG

- 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 functioning W78
  - DELETED
  - 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.

DELETED

DOE b(3) DOE b(3) DOE b(3) DOE b(3)

~~Secret Restricted Data~~ page 28

DELETED secondaries disassembled by Y-12 have had Two of 24 W78
A "failure" is defined by a system in which
DELETED
Both of these units were certified in 1980 and were disassembled in the 1990's.

DELETED

DOE b(3) DOE b(3) DOE b(3)

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W80 Secondary SFI's since FPU

DPAG

DELETED

page 29

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

DELETED

DOE b(3)

DOE b(3)

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DOE b(3)

B83 Secondary SFI's since FPU

DPAG

DELETED

DOE b(3)

page 30

This slide shows the B83 SFIs from first production unit (FPU - 1983) to the present.

84-37-B83-07 DELETED were later deemed to not be problem and production procedures were changed.

87-21-B83-04 At the Kansas City plant, a leak was noted on DELETED LLNL initiated a change in design.

89-05-B83-01 A slow leak was noted in DELETED LLNL surmised that the system would have functioned as desired.

99-19-B83-02 SFI currently open. During a D & I of DELETED While this SFI is still open, interviewees stated that this SFI will probably be closed with no impact to the stockpile since DELETED cut with a water cooled blade, presumably left wet, and was not inspected for some period of time afterward.

99-30-B83-05 SFI currently open. Incomplete bonding between the surfaces of the DELETED

99-37-B83-06 SFI currently open. The bond on DELETED This was the first proof test at Y-12 since the transfer of the testing responsibility from Rocky Flats to Y-12; therefore the test itself is also in question.

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Comments on B83 Secondary SFI's since FPU

DPAG

- 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 SFIs are relatively new and assessments have not been determined.

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page 31

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

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DOE b(3)

W84 Secondary SFI's since FPU

DPAG

DELETED

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DOE b(3)

DOE b(3)

The W84 has had only one SFI since FPU (1983).

86-01-W84-01 During SLT, DELETED attributed to marginal initial quality of the solid state bond, residual and induced stresses, proof-test damage, and UO_2 formation. A number of production changes were implemented including a reduction in the proof-test from 35,000 psi to 6000 psi, upgrade cleaning equipment at Rocky Flats, and eliminating a proof-test at Y-12.

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W87 LEP Secondary SFI's since FPU *DPAG*

DOE b(3)

DELETED

page 33

Because the uranium

DELETED

DOE b(3)

The W87 LEP does not have any SFIs since it has only been in production for two years and only one REST (Refurbishment Evaluation Stockpile Test) unit has been evaluated as of 12/1/00.

~~Secret Restricted Data~~

Minimal WR Secondary Surveillance Data is Available for the W87 LEP

DPAG

- The W87 LEP has been in production for 2 years. First REST D&I unit was in October 2000.
- In FY01, a program to evaluate W87 LEP secondary shelf and SLT units is expected to be initiated. The W87 LEP is different enough from the W87-0 to warrant some level of effort. Scope of proposed program is consistent with past practices:

Program	Total Shelf Units Built		Program	Total Shelf Units Built
B61	20		B83	16
W69	3		W84	12
W76	12		W87	0
W78	6		W87 LEP	11*
W80	18		W88	19

* - 4 secondary assemblies + equivalent cost of 7 more for the shelf life program

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page 34

A concern with the W87 LEP is the material changes introduced from the modification of the W87 to the W87 LEP. LLNL has proposed a program to fabricate, store, and evaluate W87 LEP CSA related shelf life assemblies to gather data on material compatibility [DELETED]. This slide identifies the scope of previous shelf life programs (3-20 units) and compares it to the proposed W87 LEP program (~11 units). The proposed program is for 11 equivalent units and includes 4 secondary assembles and an equivalent cost of 7 secondary assembles in shelf life samples.

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W88 Secondary SFI's since Rebuild (colloquially 88-2)

DPAG

DOE b(3)

DELETED

DOE b(3)

page 35

This slide shows the W88 SFIs from first production unit of the rebuilt units to the present. The initial build design had DELETED This first change is unofficially referred to as the W88-1. Due to flight dynamics concerns, a second change was instituted in which DELETED This second change is unofficially referred to as the W88-2.

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DOE b(3)

97-04-W88-01 DELETED This was first W88-2 unit D & I 'ed. From a review of the build data, cycle 5 underwent significant longer certificatior DELETED

DOE b(3)

DOE b(3)

The possible cause of DELETED is discussed in greater detail in the following slides.

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99-40-W88-03 SFI currently open. During disassembly of cycle 10, DELETED

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DOE b(3)

Y-12 has Observed that for Secondaries

DPAG

DELETED

DOE b(3)

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DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DELETED (Y-12, Development) has published a report concerning DELETED of different systems as a function of age at disassembly. The data on this slide are for the W80, however, the W76 and W78 data are similar. Note that although the data are scattered, there is on average DELETED time. For the W80, the average DELETED per year. has done similar analyses for the W76 and W78 and the average DELETED are plotted on the following slide as a function of DELETED

"Historical Data Review and Analysis for FY1999: IMOM Evaluations, A Possible New Finding, and A W88 Mod 2 Update (U)," report Y/DZ-2212

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Y-12 has Noted a Strong Correlation of

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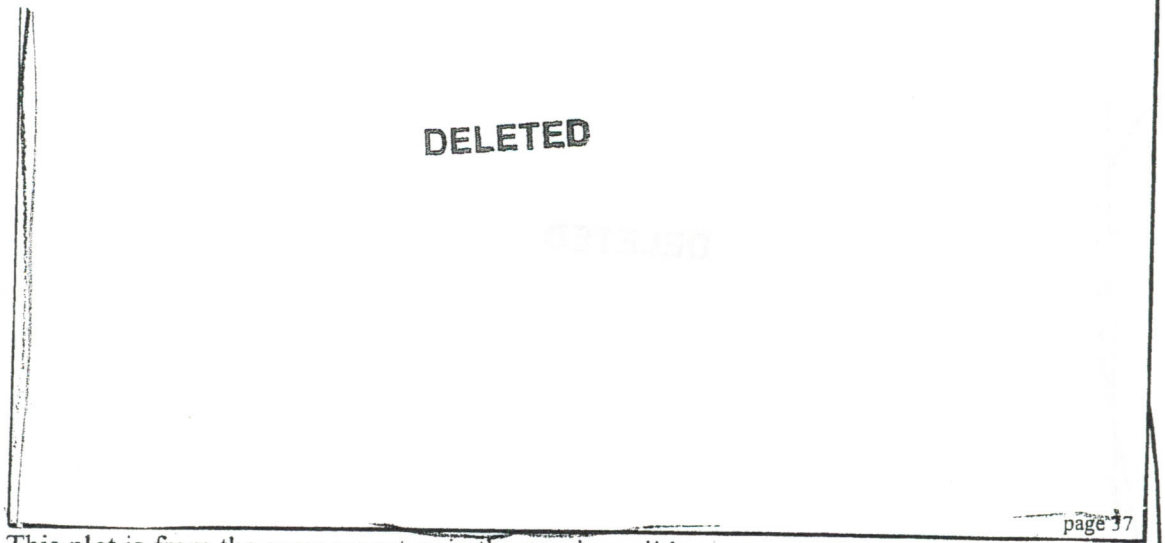

DOE b(3)

This plot is from the same report as in the previous slide.

DELETED

Note that the data for the W76, W78, and W80 fall nearly on a straight line, i.e., there appears to be a strong correlation between the weight

DOE b(3) DELETED

DELETED for these three systems. For the W88, indicated by the vertical line).

DOE b(3) DELETED

DELETED

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per year would be expected (following the red arrows), assuming all other factors equal.

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Y-12 has also Noted that DELETED

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DOE b(3)

DELETED

page 38

DELETED over 8 years Also

DOE b(3)

can be plotted as shown in the solid line in the above figure shown in the figure is the DELETED SLT 5 through SLT 10. The distinction of protium versus deuterium is discussed on the following page. Note that the actual total

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DELETED

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Y-12 has Estimated Remaining

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DELETED

DOE b(3)

- However, caution must be taken. The projections are speculative since only 6 CSA's have been evaluated and two of the CSA's were not picked randomly for D & I.

DELETED

DOE b(3)

~~Secret Restricted Data~~

page 39

The authors of the Y-12 Development paper have made an estimate of the average time for

DELETED

LANL and Y-12 have concluded that the

DOE b(3)

During the production of the W88-2,

DOE b(3)

DELETED

Caution must be taken when interpreting these figures:

- The error bands of the measured
  - SLT 10 is high.

DELETED

for SLT 5

DOE b(3)

- The data is only based on only six SLT CSA's.
- Two of the CSA's were not picked randomly.

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Presentation Outline

DPAG

- Study tasking
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- Conclusions

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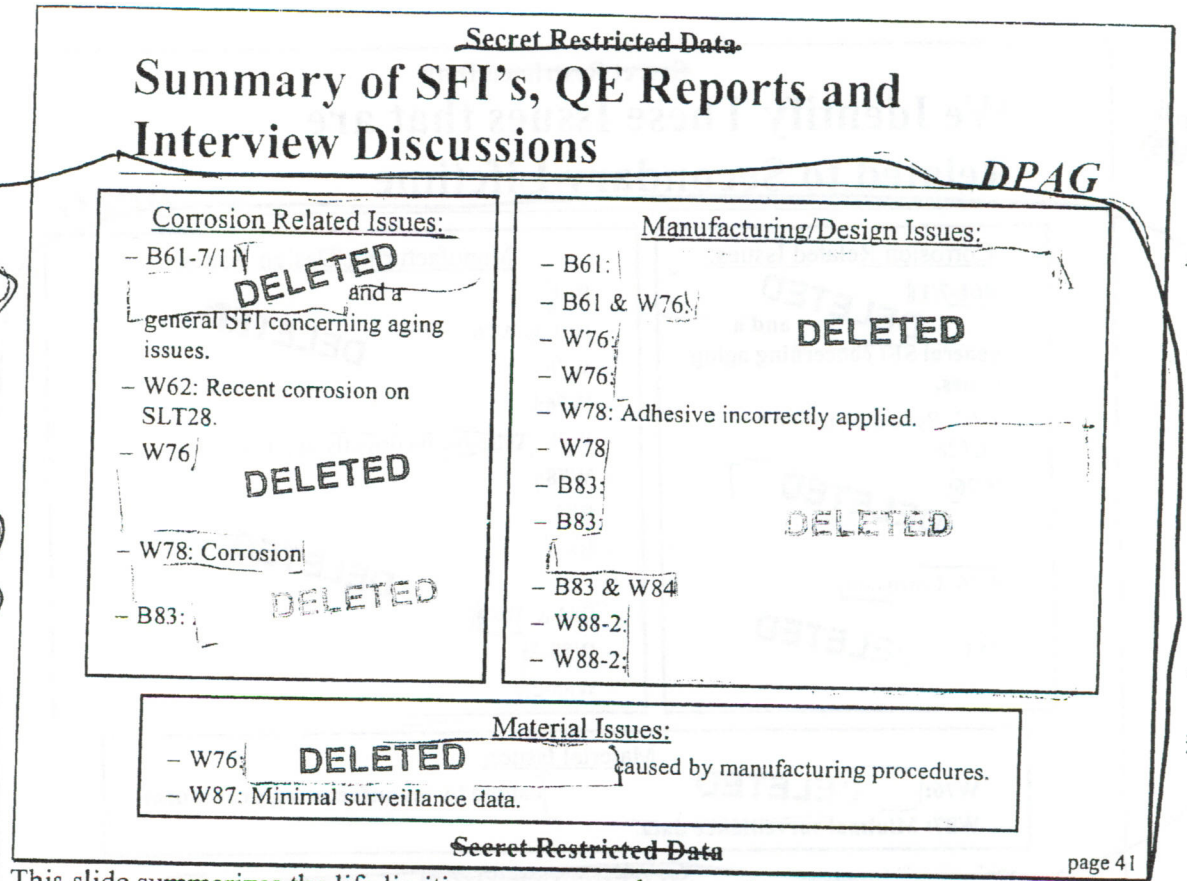
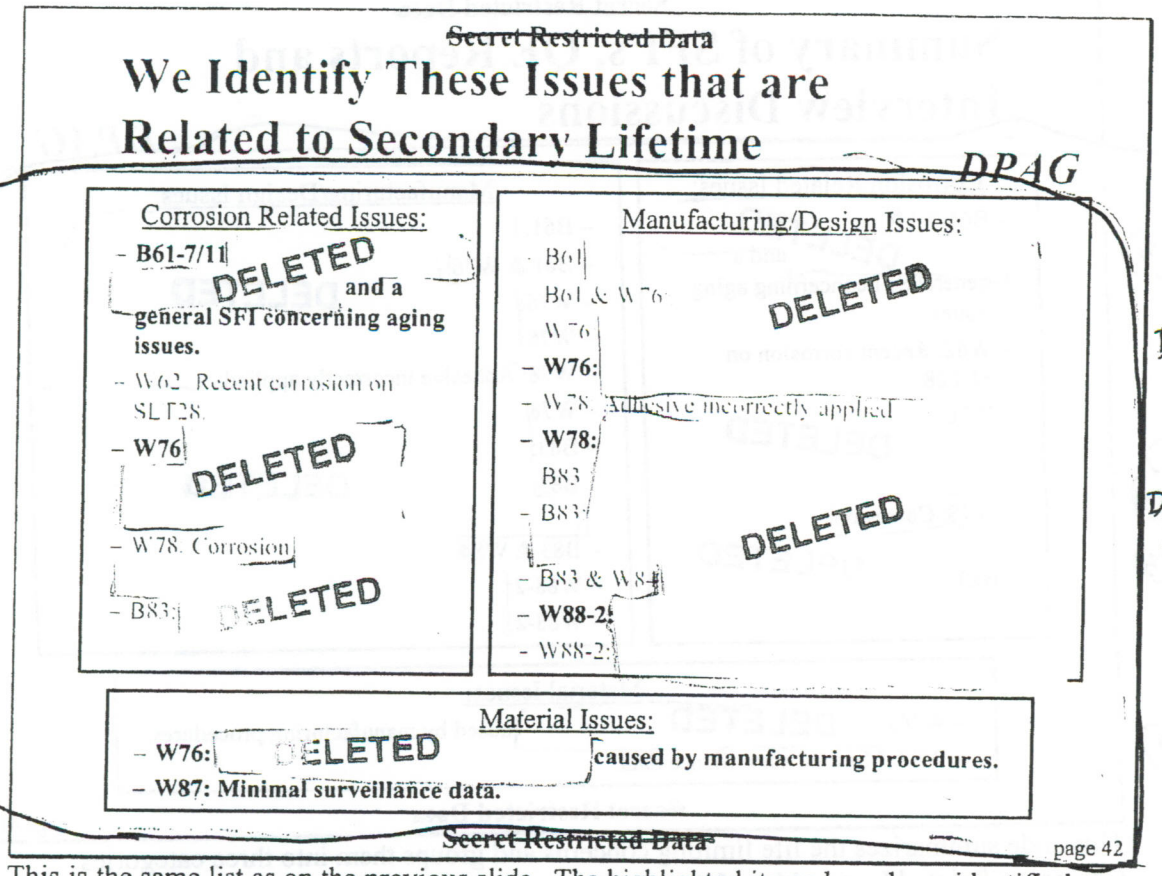
page 40

In this third section, the issues raised in the second section of this report are summarized. Life limiting concerns are ranked based on assessed relative severity. Recommendations are made concerning which systems need refurbishment and which systems need close monitoring.



This slide summarizes the life limiting concerns and groups them into three categories: *Corrosion Related Issues*, *Manufacturing/Design Issues*, and *Material Issues*.

The two items listed under the *Material Issues* category involve systems in which unknown materials properties may or may not be of concern. It is suspected that when these two concerns are resolved, they will either migrate into one of the other two categories or off the list entirely.



This is the same list as on the previous slide. The highlighted items have been identified by the study team to be issues of greatest concern while the items that are in lighter type are items of lesser concern. This judgement was based on the discussions with interviewees, and reviews of the Quality Evaluation and the SFI records.

Under the *Corrosion Related Issues*, the B61-7/11 is highlighted due to the concern with DELETED The W76 DELETED is highlighted due to the DELETED The W62 is not highlighted since the SFI recently issued is only the first SFI on the W62 secondary and the total measured corrosion is not increasing over time. The W78 is not highlighted since only DELETED The B83 is not highlighted since it appears that DELETED is related to the D&I procedures.

Under the *Manufacturing/Design Issues*, the following manufacturing related issues do not involve concerns that will progress with age: CSA DELETED the B61; assembly issues with the W76 and W78 (adhesive on wrong part); B83 DELETED fabrication; and W88-2 DELETED are manufacturing and/or testing related. The DELETED does not appear to be life limiting, however, the related SFI is not closed yet. The W76 DELETED is highlighted pending a decision on whether DELETED over time or not. A reduction in the W78 or the W88 DELETED may be a life limiting concern.

Under the *Materials Issues*, the two items are highlighted due to a lack of data or understanding of impact and pose a potential for life limiting concerns.

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Our Roll-up of Secondary Aging Concerns and Interview Impressions into "A", "B", & "C" Lists

DPAG

• B61-7/11	A
• W76	A
• W76 DELETED	B
• W78	B
• W87 LEP*	B
• W88-2	B
• B61-3	C
• B61-4	C
• B61-10	C
• W62	C
• W80	C
• B83	C
• W84	C

- "A" - Most significant concerns
- "B" - Significant concerns.
- "C" - No significant concerns.

* - W87 LEP is on "B" list due to lack of data

~~Secret Restricted Data~~

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DOE b(3)

DOE b(3)

Based on the review of the secondary lifetime issues on the previous slide, the study team has organized the weapon systems into a A/B/C list where "A" signifies the most concern, "B" signifies some level of concern, and "C" signifies little concern. Note that the B61 family has been expressed in terms of the four secondary types (see slide 12) and the W76 has been expressed as two types DELETED

DOE b(3)

The systems with the most significant concern are the DELETED

DOE b(3)

The "B" list is comprised of DELETED

DOE b(3)

As data becomes available, these systems will probably move off of the "B" list to either the "A" list or the "C" list.

The "C" list is comprised of systems on the previous slide in light type where issues have not existed or are not progressing over time.

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The "A" List Systems will be Addressed by SLEP

DPAG

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- B61-7/11: P&PD 2000-0 states that CSAs will be refurbished beginning in FY04.
- W76: DELETED P&PD 2000-0 states that CSAs will be refurbished beginning in FY08.

DOE b(3)

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For the W76, most of the DELETED The systems on our "A" list have been identified for refurbishment that would address the secondary concerns in the P&PD 2000-0.

DOE b(3)

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For the "B" List Systems, the Following Issues Should be Closely Monitored:

DPAG

- The W76 radiation case may be a materials property issue. Need to understand the cause and effect of DELETED material properties of aged cases. This is being addressed by a project in the Enhanced Surveillance Campaign.
- The uncertainty in the W78 DELETED DELETED could impact secondary expected lifetime.
- Additional REST surveillance data and secondary shelf life samples for the W87 LEP are needed to get information on new design.
- The higher than expected W88-2 DELETED may shorten lifetime. Need to closely monitor to predict lifetime.

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The systems identified on our "B" list (systems with "significant concern") involve technical concerns that require further clarification to understand their impact on the stockpile.

- Funding has been allocated to measure the physical properties of the W76 radiation case (ESC LA-38) and to monitor the W88-2 DELETED (nominally one per year through the Stockpile Evaluation Program).
- The DELETED has not been identified and scope of impact on stockpile is unknown.
- Initial funding for the W87 LEP shelf life program is planned for in FY01.

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Presentation Outline

DPAG

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~~Secret Restricted Data~~

page 46

In this fourth section, the workload and facility planning requirements at Y-12 are reviewed and the lead time requirements identified for processes to support refurbishments.

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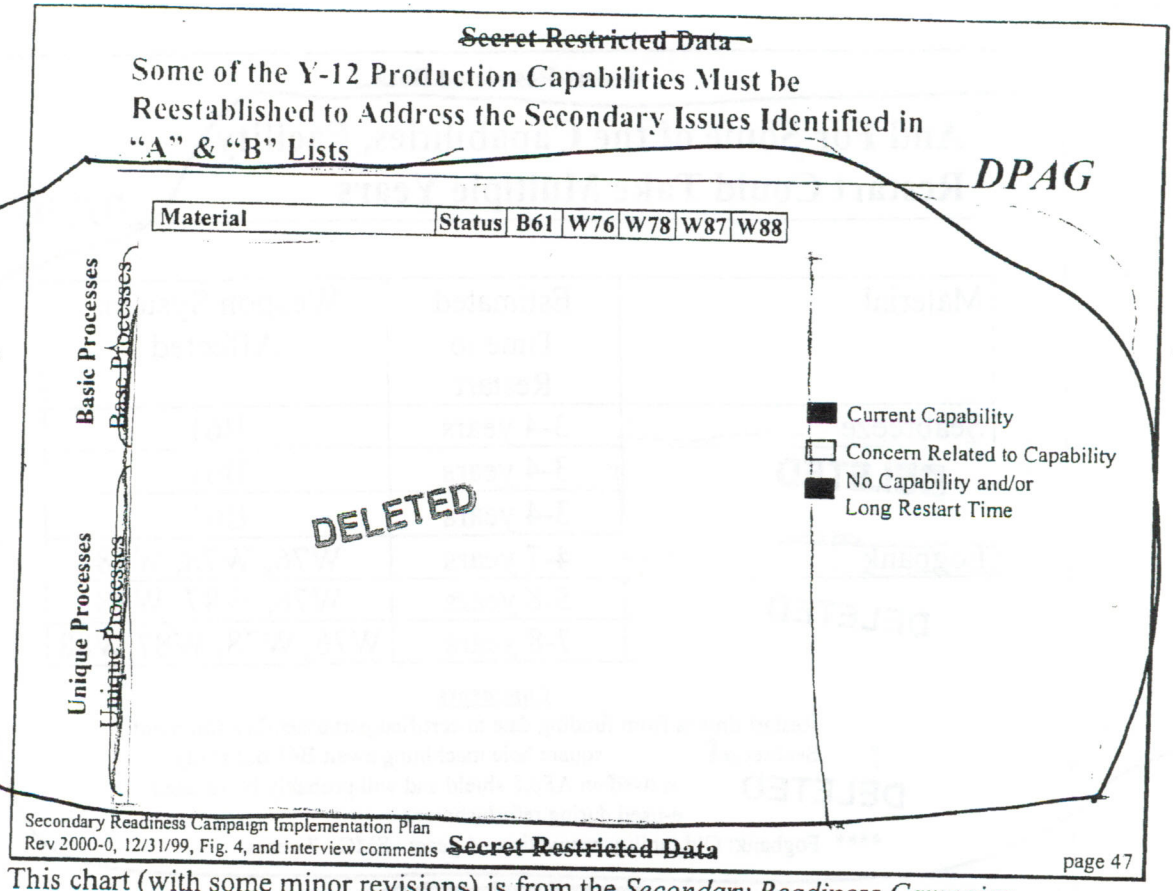

This chart (with some minor revisions) is from the *Secondary Readiness Campaign Implementation Plan, rev 2000-0*. The required processes for weapons on the "A" (B61 and W76) and "B" (W78, W87, and W88) lists are denoted by the X's in the table. The Implementation Plan judged whether the individual processes have current capability (green), have concerns with current capability (yellow), or have no capability or require a long restart period (red). Some minor revisions were made to the Implementation Plan status indicators due to comments made to the study team.

DELETED

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And For Some of the Capabilities, Facility Restart Could Take Multiple Years

DPAG

Material	Estimated Time to Restart	Weapon Systems Affected
Seabreeze*	3-4 years	B61
DELETED	3-4 years	B61
	3-4 years	B61
Fogbank****	4-7 years	W76, W78, W88
DELETED	5-8 years	W76, W87, W88
	7-8 years	W76, W78, W87,W88

Comments

Restart time is from funding date to certified part/assembly shipment.

* Seabreeze square hole machining await B61 6.2 study.

DELETED is used on AF&F shield and will probably be re-used.

e-used during refurbishment

**** Fogbank: Old facility renovation ~4 years. SMC ~7 years.

Interview comments ~~Secret Restricted Data~~ page 48

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The processes that could significantly impact implementing the SLEP refurbishment schedule, and that are denoted on the previous slide with a red status indicator, are listed on this slide with the estimated time to restart the processes along with the weapon systems affected. Note that the estimated restart time is defined as the period from the funding date to the shipment date of the first certified part / assembly given adequate funding.

The results of the B61 Phase 6.2 study will direct whether all new Seabreeze DELETED parts will be needed or whether these parts will be reused, DELETED will be reconstituted. Each of these processes will require about 3 to 4 years to be restarted.

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For the W76, processes to produce Fogbank parts will require 4 to 7 years depending on whether a dedicated Fogbank facility is constructed/refurbished (4 years)

DELETED

DOE b(3)

The current W76 refurbishment plan calls for reuse of the AF&F shield and thus the DELETED will not be required. may be reused and therefore the need may not be required.

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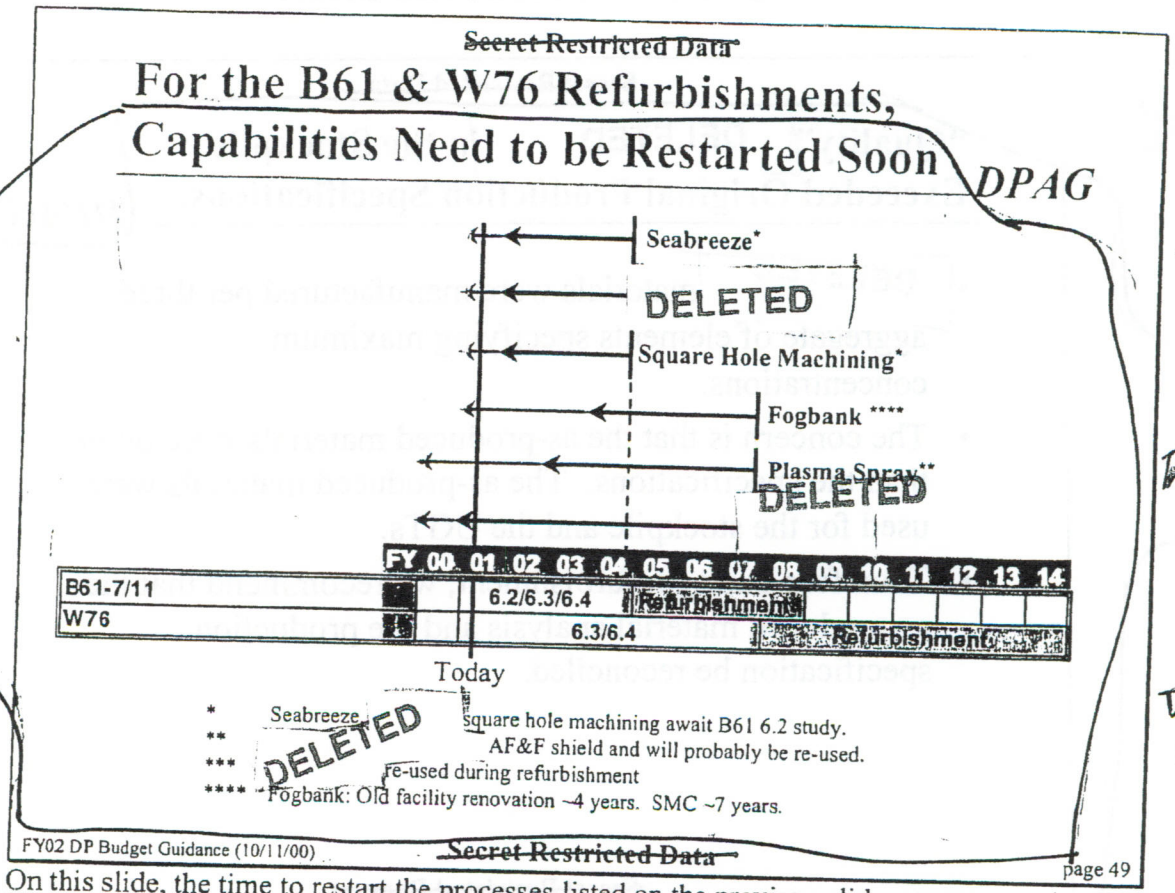

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On this slide, the time to restart the processes listed on the previous slide are compared with the SLEP schedule for the B61 and W76. The 6.X dates are from the FY02 DP Budget Guidance, dated 10/11/00. The black arrows indicate the minimal time for restarting the capabilities while the gray arrows indicate the maximum estimated time for restart.

For the B61 related processes, capabilities need to be restarted as soon as possible, assuming the Phase 6.2 study indicates they are required. The present date is already past the maximum estimated time for restarting the Seabreeze, DELETED and square hole machining processes.

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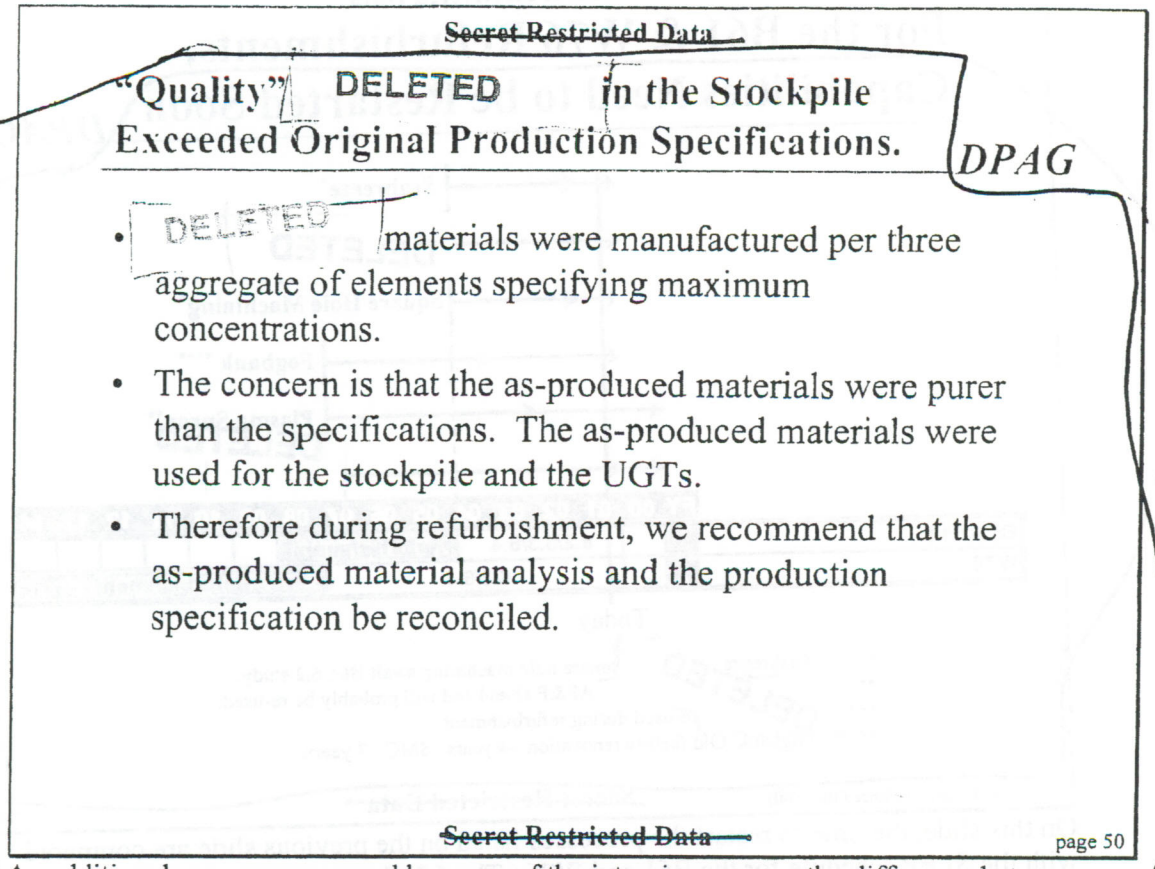
For the W76 related processes, funding was allocated in FY00 to begin construction of the SMC which is expected to be on-line in mid FY07 in time for the refurbishment of the W76.



An additional concern expressed by some of the interviewees was the difference between the original specifications and the as-produced materials used in the stockpile and UGTs. DELETED materials were manufactured per three criteria, specifying the maximum aggregate sums of elemental impurity concentrations. For each batch of DELETED a trace elemental analysis was performed and the sums calculated. The from 1978 to 1990 is shown on the following slide. Note that the blue lines are the Y-12 process limits while the red lines are the maximum concentration specifications. The as-produced materials were significantly purer than the specifications. The study team concurs with the interviewees and recommends that during production of these materials for refurbishment, the newly produced materials should attempt to match the as-produced impurity concentrations not the old specifications.

~~Secret Restricted Data~~

DELETED Significantly Better than the Requirements Over the Period 1978-1990 DPAG

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DELETED

- The red line is the maximum allowable concentration of the aggregate sum of elemental concentrations based on z-values.
- The blue lines are the Y-12 process limits.

~~Secret Restricted Data~~

page 51

The three charts of this slide show DELETED produced from 1978 to 1990. The abscissa on the three charts are the aggregate sums of elemental impurities

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DELETED

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On each of the charts, the blue lines are the Y-12 process limits while the red line is the maximum allowed total concentration for each of the three sums.

~~Secret Restricted Data~~

Summary of Workload and Facility Planning Issues

DPAG

- In order to support issues identified in "A" list, some of the Y-12 production capabilities must be reestablished which will require many years.
- What is the qualification criteria of new parts to replace old parts? This concern is with other materials DELETED example shown. New parts will be different, however, what are the differences and what is acceptable?
- Qualification criteria of old parts for reuse during refurbishment is also lacking. What is the acceptance criteria? What diagnostic techniques will be used to assist in acceptance?
- Production capacity/capability may not be available if work emerges from the "B" list systems.

~~Secret Restricted Data~~

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Therefore, to support weapon refurbishments for systems identified on the "A" list, some of the Y-12 production capabilities must be reestablished, and the time for reestablishing these processes is measured in many years.

Qualification of replacement parts will be an issue during the refurbishment process. New parts will be different and the level of acceptance of these differences needs to be established. This concern is broader than DELETED

Qualification of old parts will also be an issue during the refurbishment process and acceptance criteria need to be established.

The comments in this section are predicated on refurbishment activities being restricted to the "A" list and have not included the potential of additional work emerging from the "B" list systems.

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Presentation Outline

DPAG

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~~Secret Restricted Data~~

page 53

This fifth section reviews how the Enhanced Surveillance Campaign (ESC) is supporting secondary lifetime assessment. The potential for success of the ESC in reaching Goal #1 is discussed.

~~Secret Restricted Data~~

Green Book States Two ESC Goals for Secondaries

DPAG

- Goal #1: … determine when these major components as well as cases need to be replaced.
  - Lifetime assessment for each CSA type will be based on experimentally validated models. It will include a kinetic, thermodynamic probabilistic description of uranium hydriding and hydrogen source terms*.
  - Scientific basis for refurbishment timing for most CSAs by the end of FY05.
- Goal #2: … develop and implement new, non-destructive examination tools for early detection of potential changes in behavior.
  - Non-destructive tools for imaging important physical and chemical features will be provided.
  - Introduction of new diagnostics by the end of FY04.
  - This study did not address Goal #2.

* *ESC is responsible to establish a set of tools that will be used by DSW and certification campaigns.*

DRAFT FY 2001 Stockpile Stewardship Plan, p 20-3 ~~Secret Restricted Data~~ page 54

The FY2001 draft Stockpile Stewardship Plan (*aka*, Green Book) states two ESC goals for secondaries. The first goal is to perform a lifetime assessment of major secondary components and radiation cases to determine when they need to be replaced. The *Green Book* claims this assessment will be based on experimentally validated models which will give a basis for refurbishment of most CSAs by the end of FY05. The second goal is to develop a set of diagnostic tools for non-destructive examination, and detection of chemical and physical changes. These diagnostics tools are to be provided by the end of FY04. Although new diagnostics may be useful in obtaining important data from stockpile CSAs, this study did not address Goal 2 because of time constraints.

~~Secret Restricted Data~~

ESC Goal #1: Lifetime Assessment *DPAG*

- Based on our study, we believe the secondary lifetime modeling will have significant challenges.
  - The nucleation site for secondary uranium hydride corrosion is not well understood and we do not have initial condition data on metallurgy.
  - Location of corrosion is the critical issue. Predicting total corrosion will not be indicative of lifetime.
  - Therefore, models need to predict why corrosion is worse on a particular unit or site, not total corrosion and this requires knowledge on corrosion nucleation.
    - Is the initiation site associated with a "crop" circle near inclusions, grain boundaries, or oxide layers?
    - In addition, there are macroscopic questions.
      - Why do DELETED
      - To what extent do manufacturing processes & assay features impact corrosion?
      - Why do DELETED

~~Secret Restricted Data~~

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After interviewing subject matter experts, the study team concluded that predictive secondary lifetime assessment models will have significant challenges.

The nucleation site for uranium corrosion has not been identified and as-built data does not exist for the initial conditions of the metallurgy. For example, part to part information on trace elemental concentrations and processing parameters is unknown, however, this information is critical to validating a model for predicting the initiation of corrosion on existing stockpile units. The location of corrosion initiation is the critical issue. For example, an array of DELETED far less serious than the same total corrosion concentrated at DELETED which could change the geometry of the secondary. Therefore, prediction of secondary lifetime must include an understanding of corrosion initiation location and nucleation, as well as the metallurgy.

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There are a differing theories on the corrosion nucleation site. Some scientists believe that the nucleation site is near and around inclusions in the uranium (i.e., crop circles), others believe that the nucleation site is associated with grain boundaries, while yet others believe the site is associated with defects in the uranium oxide layer.

Beyond theorizing where the location of the nucleation site is, there are macroscopic questions. DELETED (slides 19 and 27). The extent of how manufacturing processing and assay features impact corrosion need to be captured in the models.

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ESC Goal #1: Lifetime Assessment (cont'd)

DPAG

- Information about initial conditions is essential to a quantitative corrosion model:
  - Current LANL approach is to predict initial conditions from certification
  - However, DELETED records show that the certification process was not consistent. Therefore, the initial conditions will be different from unit to unit.
  - Therefore, DELETED will have to be analyzed to understand the range of initial conditions in order to bound the lifetime assessment model results.
- Need to define initial condition data to be collected during refurbishment.

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page 56

In order to model the corrosion processes in a secondary, the initial conditions are required. One of the current LANL approaches is to attempt to predict the initial conditions (e.g., species concentrations) from One of the difficulties in this approach is that consistent from unit to unit, i.e., if a unit had DELETED is being analyzed to understand the range of initial conditions in order to bound the lifetime assessment model predictions. During the future refurbishments, specific initial condition data should be collected for potential future modeling activities.

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ESC Goal #1: Lifetime Assessment (cont'd)

DPAG

- Better materials data is required. DELETED parameters may be the most challenging and have the most influence on predicting lifetimes. Some examples of outstanding issues are:
  - What are the unknowns DELETED
    - Simple water source or something else?
    - What is the generation mechanism
  - What are the kinetics / mechanisms of with water?
  - Why is the ratio of H_2
  - What is the diffusivity of

DELETED

~~Secret Restricted Data~~

page 57

An additional concern with modeling a secondary is the availability of physical property data. While there has been recent progress in understanding some processes (e.g. DELETED kinetics), there are significant challenges on many materials such DELETED probably the most challenging material which will have the most influence on predicting secondary DELETED There are some basic unanswered questions DELETED

- Is a water source (i.e., slowly releases water into the secondary) or are there reactions occurring within are pertinent to lifetime prediction?
- DELETED
- Some of the interviewees conjectured that some of the water is consumed within the DELETED hydrogen as opposed to the water diffusing out DELETED to form hydrogen. The kinetics and reaction mechanisms of water need to be clarified.
- Beyond reaction pathways, mass transport information is needed. Measurements of the diffusivity of water DELETED over many orders of magnitude.

Significant effort is still required to gain experimental information prior to quantitatively modeling any secondary DELETED

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ESC Goal #1: Lifetime Assessment (cont'd)

DPAG

- Our Conclusions for "Lifetime assessment … based on experimentally validated models" are:
  - ESC is addressing these technical challenges, however, the difficulty in solving these technical challenges should not be underestimated.
  - In order to successfully model the secondary lifetime due to corrosion, some essential information is still needed such as initiation and propagation of corrosion, physical parameters, hydrogen generation kinetics, initial conditions, and piece part processing parameters.
  - Based on the technical issues raised by this study, it is not expected by FY05 that prediction of corrosion initiation or propagation based on experimentally validated models will be conclusive.
  - Although modeling may not be definitive, R&D supported by ESC will increase knowledge of the secondary WR materials for future refurbishments and for certifying life extension of the secondaries.

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Based on interviews with subject matter experts, our conclusions for "Lifetime assessment …based on experimentally validated models are" (i.e., ESC goal #1):

- ESC is currently addressing the many technical challenges, however, there are significant issues that will have to be overcome prior to successfully modeling currently deployed systems.
- Without knowledge of corrosion initiation/propagation kinetics or physical parameters, the models will not be predictive. While with significant effort it may be possible to overcome these scientific challenges, there are additional challenges. Knowledge of initial conditions of the as-built currently deployed secondaries and the as-built piece part processing parameters will be very difficult or impossible to obtain, and without this information, modeling and assessing the lifetime of the as-built secondaries will not be quantitative.
- Based on these concerns it is not expected that the models will be conclusive by FY05.
- Although lifetime modeling may not be definitive, ESC is supporting experimental R&D which will increase the knowledge of materials used in secondaries. This basic information will be important for future refurbishment and certifying life extensions.

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Presentation Outline

DPAG

- 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

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The original four taskings (slide 4) are used as the format for summarizing the issues and defining conclusions.

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Summary/Conclusions on Taskings: *DPAG*

"the current state of knowledge and maturity in defining aging mechanisms in secondaries"

- The dominant life limiting mechanism for a secondary is UH_3 corrosion which is typically initiated because of the presence of free hydrogen in a secondary.
- DELETED
- A well functioning DELETED shown to mitigate most corrosion concerns.

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DOE b(3)

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It is well accepted among the interviewees that the dominant life limiting mechanism for a secondary is uranium hydride corrosion which is typically initiated by the presence of free hydrogen in a secondary. The location of the corrosion is of greater concern than the total amount of corrosion.

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Summary/Conclusions on Taskings: (cont'd)

DPAG

"the integration of secondary lifetimes findings into NWC workload and facility planning"

- The B61-7/11 secondaries need to be refurbished due to UH_3 corrosion that could DELETED Prudence implies addressing DELETED W76 as soon as possible after B61-7/11 refurbishment. Refurbishment for both is planned in P&PD 2000-0.
- To ensure that Y-12 production facilities for required materials will be available, we recommend that planned restart of these facilities and allocations of appropriate funding be consistent with SLEP requirements.
- Additional workload may occur if issues develop such as the W76 DELETED W78 & W88.

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Summary/Conclusions on Taskings: (cont'd)

DPAG

"the relative importance of the issues which must be addressed to successfully predict secondary lifetimes"

DOE b(3)

- Currently, secondary lifetimes cannot accurately be predicted. Models cannot predict initiation, location, or growth of corrosion.
- Additional experimental data on the WR materials is required for future modeling efforts, and would be useful for refurbishments and certification of secondary life extension programs.
- Emphasis should be placed on technical issues identified in the W76 case, W78 & W88 DELETED W87 LEP assessment data.

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Summary/Conclusions on Taskings: (cont'd)

DPAG

"any risks and weaknesses in the current strategy for assessing and validating secondary lifetimes"

- While the modeling effort is useful for organizing and driving the experimental efforts, the models are not expected to be mature enough to assess on an individual basis secondary lifetimes or provide a scientific basis for refurbishment timing by FY05.
- Key experimental information is still required to support the modeling effort.
- The lack of initial condition/as-built data on some materials may require overly conservative boundaries on the model predictions which may result in a more conservative replacement schedule.
- While ESC may develop knowledge that is useful for improving the refurbishment process, identification for the need of a secondary refurbishment will continue to be based on the Stockpile Evaluation Program for the foreseeable future.

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