The W-84 has had only one SF1 since FPU (1983).

DELETED

84-01-W84-01 During SLT, proof test damage and UO2 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.
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.
Minimal WR Secondary Surveillance Data is Available for the W87 LEP

- 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:

<table>
<thead>
<tr>
<th>Program</th>
<th>Total Shelf Units Built</th>
<th>Program</th>
<th>Total Shelf Units Built</th>
</tr>
</thead>
<tbody>
<tr>
<td>B61</td>
<td>20</td>
<td>B83</td>
<td>16</td>
</tr>
<tr>
<td>W69</td>
<td>3</td>
<td>W84</td>
<td>12</td>
</tr>
<tr>
<td>W76</td>
<td>12</td>
<td>W87</td>
<td>0</td>
</tr>
<tr>
<td>W78</td>
<td>6</td>
<td>W87 LEP</td>
<td>11</td>
</tr>
<tr>
<td>W80</td>
<td>18</td>
<td>W88</td>
<td>19</td>
</tr>
</tbody>
</table>

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

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. 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 assemblies and an equivalent cost of 7 secondary assemblies in shelf life samples.
This slide shows the W88 SFIs from first production unit of the rebuilt units to the present. The initial build design had

This first change is unofficially referred to as the W88-1. Due to flight dynamics concerns, a second change was instituted in which

This second change is unofficially referred to as

W88-2.

From a review of the build data, cycle 5 underwent significant certification procedures.

The possible cause of

is discussed in greater detail in the following slides.

During disassembly of cycle 10,
Y-12 has observed that for secondaries, Y-12 Development has published a report concerning '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 per year has done similar analyses for the W76 and W78 and the average are plotted on the following slide as a function of "Historical Data Review and Analysis for FY1999: IMOM Evaluations, A Possible New Finding, and A W88 Mod 2 Update (U)," report Y/DZ-2212
Y-12 has noted a strong correlation of...

This plot is from the same report as in the previous slide. 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 for these three systems. For the W88, indicated by the vertical line, per year would be expected (following the red arrows), assuming all other factors equal.
Presentation Outline

- Study tasking
- 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
- Conclusions

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.
Summary of SFI’s, QE Reports and Interview Discussions

Corrosion Related Issues:
- B61-7/1
- DELETED and a general SFI concerning aging issues.
- W62: Recent corrosion on SLT28.
- W76
- DELETED
- W78: Corrosion
- B83: DELETED

Manufacturing/Design Issues:
- B61:
- B61 & W76
- W76
- W76
- W78: Adhesive incorrectly applied.
- W78
- B83
- B83
- B83 & W84
- W88-2
- W88-2

Material Issues:
- W76: DELETED
- W87: Minimal surveillance data.

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.
We Identify These Issues that are Related to Secondary Lifetime

Corrosion Related Issues:
- B61-7/11
- W62: Recent corrosion on SLT28
- W76
- W78: Corrosion
- BR3

Manufacturing/Design Issues:
- B61
- B61 & W76
- W76
- W78: Adhesive incorrectly applied
- W88-2
- W88-2-

Material Issues:
- W76: [DELETED]
- W87: Minimal surveillance data

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 the W76 is highlighted due to 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 the B83 is not highlighted 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: the B61; assembly issues with the W76; fabrication; and W88-2. are manufacturing and/or testing related. The does not appear to be life limiting, however, whether or not is highlighted pending a decision on a reduction in the W78 or the W88 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.
Our Roll-up of Secondary Aging Concerns and Interview Impressions into "A", "B", & "C" Lists

- B61-7/11  A
- W76  A
- W76  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

Based on the review of the secondary lifetime issues on the previous slide, the study team has organized the weapon systems into an 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.

The systems with the most significant concern are the

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.
The "A" List Systems will be Addressed by SLEP

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

For the W76, most of the systems on our "A" list have been identified for refurbishment that would address the secondary concerns in the P&PD 2000-0.
For the "B" List Systems, the Following Issues Should be Closely Monitored:

- The W76 radiation case may be a materials property issue. Need to understand the cause and effect of material properties of aged cases. This is being addressed by a project in the Enhanced Surveillance Campaign.
- The uncertainty in the W78 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 may shorten lifetime. Need to closely monitor to predict lifetime.

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 (nominally one per year through the Stockpile Evaluation Program).
- The identified and scope of impact on stockpile is unknown.
- Initial funding for the W87 LEP shelf life program is planned for in FY01.
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
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- Summary/Conclusions

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.
Some of the Y-12 Production Capabilities Must be Reestablished to Address the Secondary Issues Identified in "A" & "B" Lists

<table>
<thead>
<tr>
<th>Material</th>
<th>Status</th>
<th>B61</th>
<th>W76</th>
<th>W78</th>
<th>W87</th>
<th>W88</th>
</tr>
</thead>
</table>

- Current Capability
- Concern Related to Capability
- No Capability and/or Long Restart Time

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

<table>
<thead>
<tr>
<th>Material</th>
<th>Estimated Time to Restart</th>
<th>Weapon Systems Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seabreeze*</td>
<td>3-4 years</td>
<td>B61</td>
</tr>
<tr>
<td></td>
<td>3-4 years</td>
<td>B61</td>
</tr>
<tr>
<td></td>
<td>3-4 years</td>
<td>B61</td>
</tr>
<tr>
<td>Fogbank</td>
<td>4-7 years</td>
<td>W76, W78, W88</td>
</tr>
<tr>
<td></td>
<td>5-8 years</td>
<td>W76, W87, W88</td>
</tr>
<tr>
<td></td>
<td>7-8 years</td>
<td>W76, W78, W87, W88</td>
</tr>
</tbody>
</table>

Comments:
- Restart time is from funding date to certified part/assembly shipment.
- Seabreeze is square hole machining await B61 6.2 study.
- Fogbank: Old facility renovation ~4 years. SMC ~7 years.

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 parts will be needed or whether these parts will be re-used. Each of these processes will require about 3 to 4 years to be restarted.

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).

The current W76 refurbishment plan calls for reuse of the AF&F shield and thus the will not be required. May be reused and therefore the need may not be required.
For the B61 & W76 Refurbishments, Capabilities Need to be Restarted Soon

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 and square hole machining processes.

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.
"Quality" deleted in the Stockpile Exceeded Original Production Specifications.

- Materials were manufactured per three aggregate of elements specifying maximum concentrations.
- The concern is that the as-produced materials were purer than the specifications. The as-produced materials were used for the stockpile and the UGTs.
- Therefore during refurbishment, we recommend that the as-produced material analysis and the production specification be reconciled.

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. Materials were manufactured per three criteria, specifying the maximum aggregate sums of elemental impurity concentrations. For each batch of 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

- 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.

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

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.
Summary of Workload and Facility Planning Issues

- 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 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.

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 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.
Presentation Outline

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• Summary/Conclusions

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.
Green Book States Two ESC Goals for Secondaries

- **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.

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.
ESC Goal #1: Lifetime Assessment

- 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...
      - To what extent do manufacturing processes & assay features impact corrosion?

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 corrosion concentrated at far less serious than the same total secondary. Therefore, prediction of secondary lifetime must include an understanding of corrosion initiation location and nucleation, as well as the metallurgy.

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

- Information about initial conditions is essential to a quantitative corrosion model:
  - Current LANL approach is to predict initial conditions from certification records, however, it appears that the certification process was not consistent. Therefore, the initial conditions will be different from unit to unit.
  - Therefore, the set of initial conditions 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.

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 the difficulties in this approach is that consistent from unit to unit, i.e., if a unit had 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.
ESC Goal #1: Lifetime Assessment
(cont'd)

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 **DELETED** with water?
- Why is the ratio of **DELETED**?
- What is the diffusivity of **DELETED**

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. kinetics), there are significant challenges on many materials such as  

**DELETED**. There are some basic unanswered questions:

- Is a water source (i.e., slowly releases water into the secondary) or are there reactions occurring within **DELETED** are pertinent to lifetime prediction?

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

- 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.

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.
Presentation Outline

- Study tasking and background
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- Summary/Conclusions

The original four taskings (slide 4) are used as the format for summarizing the issues and defining conclusions.
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 UH₂ corrosion which is typically initiated because of the presence of free hydrogen in a secondary.

DELETED

- A well functioning showed to mitigate most corrosion concerns.

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.
Summary/Conclusions on Taskings: (cont’d)

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

- The B61-7/11 secondaries need to be refurbished due to UH₃ corrosion that could lead to prudence implying addressing 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 & W78 & W88.
Summary/Conclusions on Taskings:
(cont’d)

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

- 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, and W87 LEP assessment data.
Summary/Conclusions on Taskings:
(cont’d)

“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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